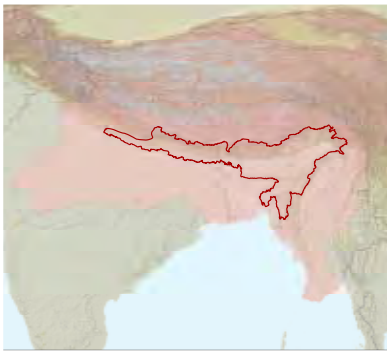
# THE STATUS AND DISTRIBUTION OF FRESHWATER BIODIVERSITY IN THE EASTERN HIMALAYA

D.J. Allen, S. Molur and B.A. Daniel (Compilers)

EASTERN HIMALAYA



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# Contents

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# Executive Summary

Biodiversity within inland water ecosystems in the Eastern Himalaya region is both highly diverse and of great regional importance to livelihoods and economies. However, development activities are not always compatible with the conservation of this diversity, and the ecosystem requirements of biodiversity are frequently not considered in the development planning process. One of the main reasons cited for inadequate representation of biodiversity is a lack of readily available information on the status and distribution of inland water taxa. In response to this need for information, the IUCN Species Programme, in collaboration with Zoo Outreach Organisation (ZOO) conducted the Eastern Himalaya Freshwater Biodiversity Assessment, a review of the global conservation status of 1,073 freshwater species belonging to three taxonomic groups – fishes (520 taxa), molluscs (186 taxa), and Odonata (dragonflies and damselflies) (367 taxa). Other groups that include freshwater species that have been comprehensively (i.e. all known species) assessed are freshwater crabs (assessed in 2008, and 57 species of crab are present within the assessment region), mammals, birds, and amphibians and their assessments can be accessed on the IUCN Red List.

In the process of study, which is based on the collation and analysis of existing information, experts were trained in biodiversity assessment methods, including the application of the IUCN Red List Categories and Criteria and species mapping using GIS software. Distribution ranges have been mapped for the majority of species so providing an important tool for application to the conservation and development planning processes. The full dataset, including all species distribution files (GIS shape files), is freely available in the CD accompanying this report and through the IUCN Red List of Threatened Species™ (www.iucnredlist.org).

Conservation measures are proposed to reduce the risk of future declines in species diversity and the associated ecosystem services that contribute to the livelihoods of millions of people across the region.

The geographic scope of this study is determined by the extended hydrological boundaries of the Eastern Himalaya region and includes all major river catchments with their origin within the Eastern Himalaya Biodiversity Hotspot. The major river systems of the Ayeyarwaddy (Irrawaddy), Kaladan (Kolodyne), Brahmaputra, and Ganga (Ganges) are included within this assessment. Freshwater species native to Nepal, Bangladesh, Bhutan, and parts of Myanmar, China (parts of the provinces of Xizang and Yunnan) and numerous states in northern and northeastern India are assessed. Species introduced to the region prior to 1500 AD are assessed, whilst species introduced after that date are considered non-native to the region and are not assessed.

IUCN Red List Criteria (IUCN 2001), the world's most widely accepted system for measuring relative extinction risk, were employed to assess the status of all species. Information on each species was compiled by a small team, in collaboration with Specialist Groups of the IUCN Species Survival Commission and other relevant experts, who then conducted the assessment and its review. In total, more than 30 experts from the Eastern Himalaya region and elsewhere were involved in the process, either through direct involvement in the two review workshops or through correspondence. All assessments and species distribution maps will be available on the IUCN Red List (www.iucnredlist.org).

## Results

7.2% of species of the 1,073 freshwater taxa assessed are threatened with extinction, with a further 5.4% assessed as Near Threatened. No taxa were assessed as Extinct or Extinct in the Wild.

Many species were assessed as Data Deficient (31.3%), emphasizing the need for extensive new research into species taxonomy, distributions, population trends, and threats.

The greatest number of threatened species are found in Manipur State, India within the Barak River, which flows west into the Meghna River in Bangladesh, and the Manipur and Yu rivers, which flow south to the Chindwin River and eventually to the Ayeyarwaddy River. These areas straddle the *Sittaung-Irrawaddy* and *Chin Hills-Arakan Coast* freshwater ecoregions. Areas with relatively high numbers of threatened species are also found in the upper catchments of the Meghna River in Meghalaya State, India within the *Chin Hills* and *Ganga Delta and Plain* ecoregions, the upper Gandaki River in central Nepal in the *Himalayan Foothills* ecoregion, and in the wider catchments of the Barak River in Manipur in the *Chin Hills* ecoregion. These high concentrations of threatened species are all found within the boundaries of the Eastern Himalaya Biodiversity Hotspot.

Habitat loss and degradation, mainly due to sedimentation, pollution (from urban, agricultural, and industrial sources), forest clearance, and the development of dams are the major causes of species decline.

## Conclusions / Key messages

A major priority for the region is to reduce the currently high number of species assessed as Data Deficient due to insufficient information on their current status and distributions. This requires new initiatives to conduct field surveys in the least known

areas, as well as investments in taxonomic study and the training of young taxonomists. The current lack of information on so many species represents a significant bottleneck in progress towards the effective management and conservation of the regions wetland biodiversity.

The priority areas identified as candidate freshwater Key Biodiversity Areas (KBAs) can help focus development and conservation actions in ways that aim to minimize impacts to freshwater species throughout the region.

Communities with a stake in the long-term future of freshwater species and habitats across the region must be fully engaged in the development and conservation planning processes in order to assure the future sustainability of associated livelihoods and the ecosystem services provided by fully functioning wetland ecosystems.

# Chapter 1. Background

David Allen[1], Kevin Smith[1], Sanjay Molur[2] and B.A. Daniel[2]



The glacier-fed rivers originating in the Himalaya mountain ranges comprise the largest river run-off from any single location in the world (UNEP/GRID-Arendal 2007). The rivers provide drinking water, food, income, transport, power, and jobs for millions of people within the Eastern Himalaya; the Ganga-Brahmaputra alone sustains the highest population density in the world (WATCH 2010). At the same time, the rivers and wetlands of the Eastern Himalaya sustain ecosystems that are vital to biodiversity, and are impacted by a range of factors that include increasing populations, higher levels of water use and abstraction, pollution, and ecosystem modification.

Biodiversity within freshwater ecosystems in the Eastern Himalaya region is both highly diverse and of great regional importance to livelihoods and economies. However, development activities are not always compatible with the conservation of this diversity, and the ecosystem requirements of biodiversity are frequently not considered in the development planning process. One of the main reasons cited for inadequate representation of biodiversity is a lack of readily available information on the status and distribution of inland water taxa, and the aim of this report is to present the outcomes of the *Eastern Himalaya Freshwater Biodiversity Assessment* project that was developed with the intention of compiling and making freely available information on the conservation status and distribution of key groups of freshwater biodiversity to inform conservation and development policy and decision making across the region.

The focus of the project is the Eastern Himalaya region which comprises Bhutan, northeastern India and southern, central and eastern Nepal. Strictly speaking, the Eastern Himalaya region is part of two larger hotspots: the Indo-Burma and the Himalaya Hotspots (CEPF 2005). Throughout this report we refer to the Eastern Himalaya Hotspot to comprise the lowlands of western Nepal and the montane regions of central and eastern Nepal; the state of Sikkim, the northern extent of West Bengal in India including Darjeeling District; Bhutan in its entirety; and the northeastern Indian states of Assam, Arunachal Pradesh, Manipur, Mizoram, Tripura, Meghalaya and Nagaland (CEPF 2005). However, the geographical scope of the assessment encompasses the entirety of the river basins that have their origins within the Eastern Himalaya region; the Ganga (Ganges), Brahmaputra, Ayeyarwaddy (Irrawaddy), and Kaladan (Kolodyne) River catchments (see Figure 2.1). We take this approach (as with other regionally-focused freshwater assessment projects undertaken by the IUCN Species Programme, e.g. Darwall *et al.* 2005; 2009) because of the connectivity of freshwater systems.

The Convention on Biological Diversity (CBD) in its Sixth Conference of Parties in The Hague, Netherlands, in April 2002 resolved to reduce significantly biodiversity loss by 2010 at the global, regional and national levels in an effort to alleviate poverty and benefit the Earth (CBD 2002). This sense of urgency can be epitomized and inferred from the status of the Earth's freshwater ecosystems and their components of biotic and abiotic factors. Freshwater ecosystems are among the highest used, depended upon and exploited by humans for sustainability and well-being. The dependence on water and other resources in this environment has placed enormous pressures on the ecosystem worldwide resulting in direct impacts to species diversity and populations. While ecosystem assessments are broad based, the actual impacts of change can be understood from the status of species in those ecosystems. The relationship

[1] IUCN Species Programme, 219c Huntingdon Road, Cambridge CB3 0DL, UK. david.allen@iucn.org; kevin.smith@iucn.org
[2] Zoo Outreach Organisation, Box 1683, 9A, Lal Bahadur Colony, Peelamedu, Coimbatore 641 004, India. herpinvert@gmail.com; badaniel@zooreach.org

The Ayeyarwaddy River at Myitkyina, Kachin State, Myanmar. © Jack Tordoff/CEPF

between biodiversity and human well-being is being promoted increasingly through the concept of ecosystem services provided by species (MEA 2005; McNeely and Mainka 2009). Using species assessments as a tool is one way of understanding the threats to biodiversity, ecosystems and specifically the impacts of changing ecosystems on human well being. In doing so, compiling information on available knowledge on the role of individual species in the heavily exploited freshwater ecosystem will provide tangible benefits in protecting biodiversity and habitats.

Although the 2010 targets of the CBD were not fully met, the premise of the targets remains fundamentally solid. At the 2010 Nagoya 10th Conference of Parties, the targets were reiterated with more emphasis on achieving them over the next ten years. The expansion of freshwater species' assessments across the globe will contribute to a solid foundation of scientific understanding of the current status as well as the priority areas of action.

## 1.1 Value of freshwater biodiversity

While covering less than 1% of the Earth's surface freshwater ecosystems provide humans with a wealth of goods and services, and provide a home for around 10% of the worlds described species, including a quarter of all vertebrates (Strayer and Dudgeon 2010). Their value to human society is easily seen through the direct services they provide, such as fish for food or water purification for drinking, but they also provide many indirect services which provide almost universal benefits such as nutrient cycling, flood control and water filtration. Putting a dollar value on these services is extremely difficult as many have no market value. However, attempts have been made to estimate the annual value of the direct and indirect services of the world's wetlands, with differing results. For example, the Millennium Ecosystem Assessment (MEA 2005) values the total goods and services derived from inland waters globally at up to USD 15 trillion, whilst another study estimates a value of USD 70 billion (Schuyt and Branden 2004). Tropical inland fisheries alone have been valued at USD 5.58 billion per year (Neiland and Béné 2008).

Asia has the largest fisheries production of all the worlds' continents and many livelihoods are dependant upon freshwater biodiversity which provide food security to the poorest of communities. In India 5.5 million people are employed in inland fisheries, 72% of them women. In Bangladesh, 50 million household members are supported through inland fisheries, providing on average over 50% of total protein intake, of which 50–80% is from small native species (Dugan *et al.* 2010).

Community use of wetlands. © IUCN Nepal

## 1.2 Global status of freshwater biodiversity

### 1.2.1 Species diversity

Freshwater biodiversity constitutes a vitally important component of the planet, with a species richness that is relatively higher compared to both terrestrial and marine ecosystems (Gleick 1996). The freshwater ecosystem supports various orders of animals, plants and fungi, contributing to a quarter of vertebrate diversity and almost as much of invertebrate diversity described to date. The order Odonata, a group largely dependent upon freshwater ecosystems, is known by 6,500 described species (Trueman and Rowe 2009), and the phylum Mollusca with eight extant classes is composed of nearly 93,000 species, 70,000 of which are known gastropods (Haszprunar 2001). Although comparatively better studied than the marine ecosystem, the rapidly increasing species diversity of freshwater fishes contributes nearly 50% of all the fish presently described (Froese and Pauly 2010).

South and Southeast Asia is one of the most speciose areas on the planet containing 20% of all known freshwater vertebrate species and 25% of known aquatic plants (Balian *et al.* 2008). The Eastern Himalaya region (CEPF 2005) is part of the Indo-Burma and Himalaya Biodiversity Hotspots. This means that the region contains exceptional levels of plant endemism (at least 1,500 endemic species) and has lost 70% or more of its original habitat (Myers *et al.* 2000). While the Hotspot system is a terrestrially focused one, it still highlights the importance of the area for freshwater species conservation due to the massive levels of habitat loss which will severely impact freshwater systems and the likely congruence between plant endemism and vertebrate endemism within Hotspots (Myers *et al.* 2000). There are more than 175 species of mammals and 500 species of birds within the Hotspot, however endemism is relatively low among higher taxonomic groups (compared to other Hotspots) as the Himalaya has a relatively recent origin (CEPF 2005).

The Critical Ecosytem Partnership Fund (CEPF) have developed a set of conservation outcomes for the Eastern Himalaya region. Conservation outcomes are the full set of quantitative and justifiable conservation targets in a hotspot that should be achieved to prevent biodiversity loss: (i) species (extinctions avoided); (ii) sites (areas protected); and (iii) landscapes (corridors created) (see CEPF 2005). The principal basis for defining species outcomes are the global threat assessments contained within the *2002 IUCN Red List of Threatened Species*, which is based

The development of transport links and other construction activities can have major impacts on freshwater systems, as shown by the sedimentation caused by road construction. © Ryan Moll/Sabrina Harster

on quantitative, globally applicable criteria under which the probability of extinction is estimated for each species. To date, the conservation outcomes (in terms of ii. and iii., above) are primarily focused on terrestrial species, since the 2002 IUCN Red List contained few assessments of freshwater species from within the region. It is hoped that this assessment will contribute to the process of addressing priority sites for the conservation of freshwater species within the Eastern Himalaya region.

### 1.2.2 Major threats to freshwater biodiversity

Major threats to freshwater biodiversity can be grouped under five interacting categories: over-exploitation; water pollution; flow modification; destruction or degradation of habitat; and invasion by exotic species, with global scale environmental changes being superimposed upon all of them (Dudgeon *et al.* 2006). These globally escalating threats have led to freshwater biodiversity falling into a state of crisis (Vörösmarty *et al.* 2010) and becoming more imperilled than their marine or terrestrial counterparts (Strayer and Dudgeon 2010).

Climate change is likely to become a leading threat that will face freshwater biodiversity within the Eastern Himalaya region in the future (e.g. Gopal *et al.* 2010; Pathak *et al.* 2010; Woodward *et al.* 2010). Shifting climate patterns and increasing frequency of droughts and floods will alter river flow regimes, and other factors such as water temperature which will seriously impact freshwater species, especially those that rely upon seasonal cues and changes to complete lifecycles. By 2050 it is expected that climate change will have had a larger impact on river flows than dams and water withdrawals have up to now (Döll and Zhang 2010).

In South Asia, population growth and its related development has led to a heavily degraded water quality (Babel and Wahid 2008) with threats such as deforestation leading to sedimentation, poor waste water treatment, agricultural and industrial expansion and pollution, and huge levels of water abstraction and dams leading to reduced flow and saltwater intrusion. Overharvesting, of both target species and as by-catch, has also led to population declines of many freshwater species including the Ganges River Dolphin (*Platanista gangetica* ssp. *gangetica*) now classified as Endangered (Smith *et al*. 2004).

### 1.2.3 Species threatened status

In keeping with the principles of the Convention on Biological Diversity, biodiversity trends and loss can be monitored by assessing the status of species, which is one of the widely

*Bagarius yarrelli* (NT) is an example of a large freshwater fish that is heavily targeted for food across the region. Catches have declined in major markets in India over the past 20 years, large fish have disappeared from Pakistan, and catches have declined by 60% in Cambodia (Z. Hogan, pers. comm.). © Courtesy of Zeb Hogan

used indicators. It also helps in setting priorities for species conservation. There are several methods of determining species status and the most commonly used tool is the IUCN Red List Categories and Criteria (IUCN 2001), which allows consistency in approach across different taxonomic groups. It helps in determining the relative risk of extinction and providing the basis for understanding if a species is Extinct, threatened (Critically Endangered, Endangered or Vulnerable), Near Threatened, of Least Concern, or lacking sufficient basic data for assessment (Data Deficient). The IUCN Red List of Threatened Species™ publishes the results of the global assessments (www.iucnredlist.org). The IUCN Red List also provides basic information on species taxonomy, distributions, habitat and ecology, threats, population trends, use and trade, livelihood information, ecosystem services provided, and research and conservation priorities.

The representation of freshwater species assessed and published in the IUCN Red List is poor. Globally, only crabs, birds, amphibians, and freshwater mammals (e.g. otters, river dolphins) have been fully assessed; nearly one-third of amphibians have been assessed as threatened with extinction. In addition, freshwater species from some regions (e.g. Mediterranean, Africa) have been assessed, but the vast majority of this ecosystem across the world is yet to be systematically addressed. Fifty-six percent of the endemic fishes of the Mediterranean Basin, 54% of Madagascar fish endemics and 38% of all European fishes have been assessed as threatened (Smith and Darwall 2006; IUCN 2004; Kottelat and Freyhof 2007). This is a major concern compared to globally threatened amphibians (32%), mammals (23%) and birds (12%). A study conducted by UNEP-WCMC (Groombridge and Jenkins 1998) reported declines in populations of freshwater-related vertebrates, and WWF (2004) indicates about a 50% population decline in 323 species of vertebrates in the three decades since 1970. The freshwater assessments, if completed systematically across the globe, could yield higher proportions of threatened species and Data Deficient (potentially threatened) species especially considering the statistics for amphibians (32% threatened, approximately 2.5% extinct and 43% declining in populations; Stuart *et al.* 2004).

## 1.3 Situation analysis for the Eastern Himalaya region

This assessment is primarily focused on the Eastern Himalaya Biodiversity Hotspot (see Figure 2.1), however due to the high level of interconnectivity within freshwater systems it is valuable to include all the catchments that cover area, and therefore the entire Ganga, Brahmaputra, Kaladan and Ayeyarwaddy basins are included with the project region.

The largest of the rivers within the region is the Ganga-Brahmaputra-Meghna system, covering most of northern India,

A boat on Lake Indawgyi, Kachin State, Myanmar. © Jack Tordoff/CEPF

Bhundyar women in Uttarakhand, India. © Georgina Peard/IUCN

A fish catch in Katchin State, Myanmar. © Jack Tordoff/CEPF

part of China and all of Nepal, Bhutan and Bangladesh. It has a catchment area of 1.75 million km$^2$ and is home to 535 million people, representing the largest concentration of poor in the world with half its population living in poverty (Babel and Wahid 2008). The Ganga starts in the northern state of Uttarakhand in western Himalaya and flows a total length of approximately 2,500 km creating the alluvial plains in northern India and the unique *terai* on its northern banks. The Brahmaputra originates in Tibet and enters India in the northeastern state of Arunachal Pradesh. It flows through the Himalaya and the alluvial plains of Assam before meeting the Ganga in Bangladesh. Together, the two rivers create an enormous delta in Bangladesh and the Indian state of West Bengal, supporting the world's largest mangrove, the Sunderbans.

The Kaladan (Kolodyne) River forms the border between parts of Myanmar and India. From its source in Mizoram, India, the river runs through Chin State in Myanmar and flows into the Bay of Bengal at Sittwe in Arakan State. The lower part of the river opens up to form a fertile plain that covers a total area of 3,640 km$^2$. Approximately one million people live in the settlements along the river. The river is likely to be severely impacted by development projects within its catchment, including the Kaladan Multi-Modal Transit Transport Project, and the development of the Shwe gas project.

As with most other large rivers in the region, the Ayeyarwaddy is the subject of numerous potential dams on the mainstream and its tributaries, with seven dams currently in the planning stage. The largest of the seven, the Myitsone dam, is located at the confluence of the Mali and N'Mai Rivers at the start of the Ayeyarwaddy (Burma Rivers Network 2010).

### 1.3.1 Regional threats

The majority of threats to biodiversity are linked to human population growth and economic development, and the corresponding increasing demand for natural resources and space.

The major classes of threat to freshwater biodiversity are habitat degradation, over-exploitation, alien species invasion, river flow modification, and water pollution (Dudgeon *et al*. 2006). For a detailed review of threats present with the region see CEPF (2005).

The Eastern Himalaya project region is already home to almost 10% of the world's population (Babel and Wahid 2008; World Bank 2010), and current trends show a dramatic growth in the population over the next 40 years, meaning the demand for natural resources and especially water is going to drastically rise. For example, India's population is expected to increase by 50% from just over 1 billion to more than 1.5 billion by 2050, Nepal's population will increase over the same time period from 23 million to 50 million, Bhutan from 2 million to over 5 million, and Bangladesh from 137 million to over 250 million

*Jhum* shifting agriculture, shown here in northeastern India. © Payal Molur

(UN 2004). Other threats for wetland includes change in land use pattern; fast growing urban development projects expedite the conversion of wetlands for industrial, agricultural and various other urban projects. Commonly the wetlands are filled in with building wastes, and are also eliminated gradually by removal of tree cover and soil unfriendly practices. Another major threat in this region is unsustainable use of wetlands for grazing and fishing.

Dams are another key threat to aquatic systems and species that is likely to greatly increase in number and impact within the region. Globally there are more than 45,000 dams above 15 m in height (Nilsson *et al.* 2005), and there are many current (see Figure 6.11) and planned dams within the region, both on tributaries and on mainstream channels. The Ganga has a significant power potential of approximately 150,000 megawatt (Babel and Wahid 2008), and there are a large number of dams planned across many northeastern Indian states, parts of Myanmar, and elsewhere in the region. Dams result in a range of upstream and downstream impacts, not least disruption of migratory routes and of breeding patterns, changes to flow regimes, and sedimentation; development of dams is also associated with indirect impacts, through the economic activity (Nilsson *et al.* 2005) and human settlement that they encourage (Smakhtin and Anputhas 2006). In 1998 (Ray 1998) there were 25 dams across the Ganga River in three states of northern India holding nearly 33.5 billion $m^3$ of water in reservoirs, a number and overall storage capacity that is likely to greatly increase. In addition to hydropower development, there are major projects for water abstraction for irrigation purposes across the region.

### Deforestation

The average forest cover in the Ganga basin in six Indian states is 19.1% of the total area, with Haryana having the lowest (2.4%) and Himachal Pradesh the highest (59.3%). Deforestation in the Ganga catchment is very high due to extensive felling of trees even in government owned tracts of land (Ray 1998). Deforestation rates in the middle Brahmaputra region also show a rapid decline in forest cover in the northeastern part of India (Kakati 2004), and the trends are repeated in Nepal and parts of Myanmar. Deforestation results in increased siltation and the resulting destruction of niche habitats, of particular concern for some habitat-specific species. Soil erosion from rains has been calculated as 40 tonnes for 2 acres (0.81 ha) of deforested land compared to 0.3–1 tonnes from forested land (Ray 1998) indicating a huge threat to ecosystems. Forest clearance and degradation also results from shifting agriculture practices (termed *jhum* in northeastern India) in some parts of the region.

### Pollution

The middle and lower reaches of both the Ganga and the Brahmaputra rivers suffer from considerable pollution as a

Weaving mats from grasses harvested from the Tanguar *haor* wetland. © IUCN Bangladesh

Urban development and access to consumer products can have negative impacts, with pollution washed into to rivers. © Sabrina Harster/Ryan Moll

consequence of the high human density, including untreated sewage, industrial effluents, and agro-chemicals.

#### Overharvesting

The over-harvesting of freshwater biodiversity is a major concern within the Eastern Himalaya, with fisheries largely un- or under-regulated, and existing legislation inadequately enforced, and there is little research or available information on levels of exploitation or species population trends. Studies by Patra *et al.* (2005) and Mishra *et al.* (2009) indicate drastic declines in fish populations of several species in lower West Bengal, but further research is needed into population trends across the rest of the region of the majour exploited fish species. Destructive fishing practices such as blast, poison and electro-fishing are widespread in hill areas, as is the use of monofilament, small mesh size fishing nets. Non-target species are affected by bottom trawling and other unregulated commercial fisheries in the plains.

Freshwater mussels are utilized as a protein-rich food and is important in all parts of the region (including Nepal, India and Bangladesh), and are also extensively used in the production of ornaments, construction materials, as feed in shrimp farms, fish hatcheries and for poultry. The impacts of heavy utilisation of freshwater molluscs across the region is still to be properly studied and understood.

### 1.3.2 Regional use and value of wetlands and their biodiversity

Rivers and wetlands are a key component of the hydrological cycle to maintain freshwater supplies, and a vital source of water and food supply for humans. Wetlands are essential to local communities and this is notably so in countries such as Myanmar, Bangladesh, India, Nepal and Bhutan, where many communities are directly dependent upon resource that wetlands provide. However, sustainable practices of the past are rapidly disappearing due to the explosive growth in human populations and over exploitation of natural resources.

All species, irrespective of their economic value or distribution, play an important role in supporting ecosystems. The role played by every species in maintaining balance in the freshwater ecosystem provides immense value and benefits, if when lost will reflect in additional inputs from humans to maintain the systems' functionality.

## 1.4 The precautionary approach to species conservation

Even when the economic value of a freshwater system and its associated biodiversity has been determined as high, in many cases it still remains a difficult task to justify the need to conserve all species. This is particularly true where the diversity is already exceptionally high, such as in the freshwater fish communities of some catchments within the Eastern Himalaya. In such cases fishery managers may argue that it would be easier to manage a fishery of just a few fast-growing and commercially valuable species than to manage the multi-species fisheries typical of these catchments. However, we know too little about species-ecosystem interactions to be sure of the likely impacts of removing either single species or groups of species from a system. The message given here is to adopt the precautionary approach where it is assumed that all species are important and may one day be key components of the fisheries or their supporting foodwebs.

## 1.5 Objectives of this study

A lack of basic information on freshwater species distributions and threatened status in the Eastern Himalaya region has long been a key obstacle facing freshwater ecosystem managers in the region. Specifically, the *Eastern Himalaya Freshwater Biodiversity Assessment* project, coordinated by IUCN with Zoo Outreach Organisation aimed to:

i) provide the required biodiversity information through establishing a core of regional experts and training them in biodiversity assessment tools;
ii) collate information for assessments of conservation status and distributions of biodiversity throughout the inland waters of the Eastern Himalaya region; and
iii) store, manage, analyse and make widely available that biodiversity information within the IUCN Red List and throughout the region and global presence of IUCN and partners.

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Wild water buffalo, Kaziranga, Assam, India. *Bubalus arnee* is Endangered due to declining population and hybridisation. © Jack Tordoff/CEPF

# Chapter 2. Assessment methodology

David Allen[1], Kevin Smith[1] and William Darwall[1]



## 2.1 Selection of priority taxa

Recent large-scale biodiversity assessments (e.g. Global Amphibian Assessment (in 2004, 2006 and 2008; and the Global Mammal Assessment in 2008) have focused on a limited range of taxonomic groups, most often including those groups that provide obvious benefits to humans through direct consumption, or the more charismatic groups, such as mammals, birds, amphibians and reptiles. In the case of aquatic systems it is wetland birds and fish that have received most attention.

It is important that we take a holistic approach by collating information to conserve those other components of the foodweb essential to the maintenance of healthy functioning wetland ecosystems, and which are often vital to sustaining local communities through the provision of food and other ecosystem services. As it is impractical to assess all freshwater species due to financial constraints, a number of priority taxonomic groups were selected to represent a range of trophic levels within the foodwebs that underlie and support wetland ecosystems and livelihoods. Priority groups were selected to include those taxa for which there was thought to be a reasonable level of pre-existing information. The taxonomic groups selected for this assessment were: fishes; molluscs; and odonates (dragonflies and damselflies). These groups (with selected families of aquatic plants in some areas) have been comprehensively assessed by IUCN's Freshwater Biodiversity Unit (FBU) through a number of regionally focused assessment projects since 2004 (see for example, Darwall *et al.* 2005; 2009).

Although fishes provide a clear benefit to the livelihoods of many people throughout the region, either as a source of income or as a valuable food supply, benefits provided by the other taxa may be indirect and poorly appreciated but nonetheless equally important. Given the wide range of trophic levels and ecological roles encompassed within these four taxonomic groups, it is considered that information on their distributions and conservation status, when combined, will provide a useful indication of the overall status of the associated wetland ecosystems. Repeated assessment of these four groups, being relatively well-studied and easily surveyed, has the potential to provide an indicator of environmental change over time in this region of rapid development and high population growth.

### 2.1.1 Fishes

Arguably fishes form the most important wetland product on a global scale, and are certainly the most utilized wetland resource across the region; Asia accounts for 63% of total fish production (Briones *et al.* 2004), and fish account for 30% of typical diets across Asia as a whole (WorldFish 2010). They provide the primary source of protein for nearly one billion people worldwide and food security for many more. For the purposes of this assessment freshwater fishes are defined as those that spend all or a critical part of their lifecycle in fresh waters. Those species entirely confined to brackish waters are also assessed. There are an estimated 13,000 freshwater fish species in the world (Lévêque *et al.* 2008), and by 2009 only around 2% (approximately 275 species) of fishes from the parts of the region covered by this project had had their risk of extinction assessed using the IUCN Red List Categories and Criteria at the global scale.

### 2.1.2 Molluscs

There are an estimated 5,000 freshwater molluscs for which valid descriptions exist, in addition to a possible additional 10,000 undescribed species (Balian *et al.* 2008). Of these currently known species, only around 27.7% (1,374) have had their

[1] Freshwater Biodiversity Unit, IUCN Species Programme, Cambridge, UK CB3 0DL. david.allen@iucn.org; kevin.smith@iucn.org; william.darwall@iucn.org

conservation status assessed for the IUCN Red List globally in 2009 (fewer than 14 species within this project area), and their value to wetland ecosystems is poorly appreciated.

Freshwater molluscs are essential to the maintenance of wetland ecosystems, primarily due to their control of water quality and nutrient balance through filter-feeding and algal-grazing and, to a lesser degree, as a food source for predators including a number of fish species, and in some parts of the world they compose a significant food resource, especially for the rural poor. In some regions they are one of the most threatened groups of freshwater taxa (Kay 1995). The impact of developments such as dams, and siltation caused by deforestation and agricultural clearance has not been adequately researched and there is little awareness of the complex life histories of some groups such as unionid mussels that rely on the maintenance of migratory fish runs to carry their parasitic larvae to the river headwaters. Many species are also restricted to microhabitats, such as the riffles (areas of fast current velocity, shallow depth, and broken water surface) between pools and runs (areas of rapid non-turbulent flow).

### 2.1.3 Odonates

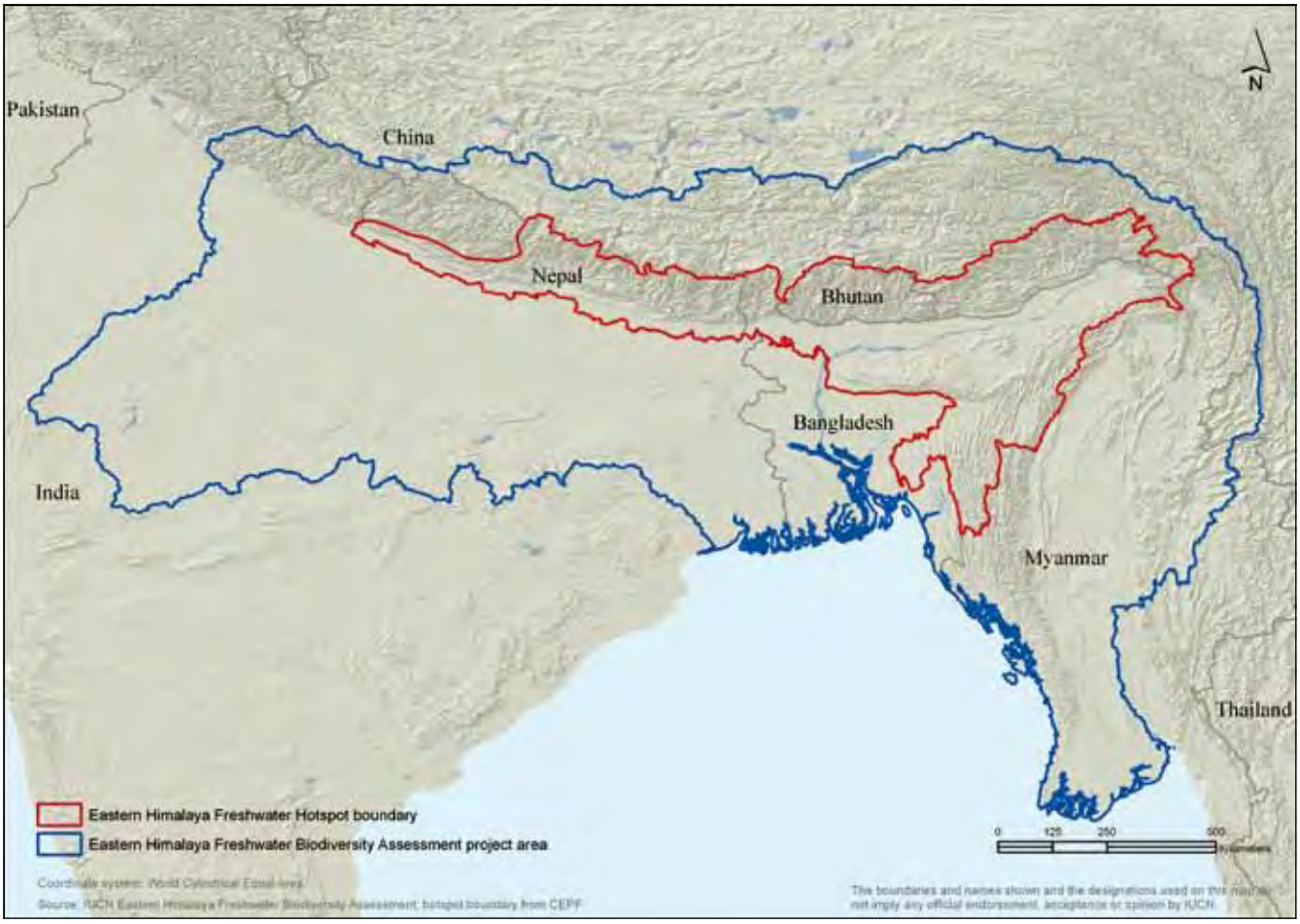
Larvae of almost all of the 5,680 species of the insect order Odonata (dragonflies and damselflies) are dependent on freshwater habitats, with only a few not utilizing freshwater. Larvae that develop in water they play a critical role with regards to water quality, nutrient cycling, and aquatic habitat structure. Odonata are unique amongst the groups assessed here in not being restricted to the aquatic environment for their entire lifecycle, and this gives them some mobility between habitat types.

Odonata are relatively easily surveyed for (though some expertise is required for correct identification), and a full array of ecological types are represented within the group which, as such, has been widely used as a bio-indicator for wetland quality. Of these 5,680 species, fewer than 24% (1,359) had had their risk of extinction assessed globally (and only 61 within the assessment region) using the IUCN Red List Categories and Criteria by 2009. A baseline dataset is needed for the region to facilitate the development of similar long term monitoring schemes in Asia.

## 2.2 Delineation of the scope of the assessment region

The Eastern Himalaya Biodiversity Hotspot is a subset of the Indo-Burma Biodiversity Hotspot. To qualify as a hotspot, a region must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics, and it has to have lost

**Figure 2.1 Map of the assessment region showing (i) the Eastern Himalaya Hotspot boundary (in red) and (ii) the area selected for inclusion in the assessment project, based on the watersheds of the Ganga, Brahmaputra, Ayeyarwaddy and Kaladan rivers.**



at least 70% of its original habitat (Conservation International 2010). Hotspots were thus developed using exclusively terrestrial criteria, and given the interconnected nature of freshwater systems, the decision was taken to expand the focus of the assessment to encompass the basins of all river systems that originate within the hotspot boundary. The assessors contracted to undertake the assessment work (see Section 2.3, below) were first tasked with compiling a list of all species of odonates, fishes and molluscs known to be present within the Ganga, Brahmaputra, Kaladan and Ayeyarwaddy river basins.

## 2.3 Data collation and quality control

The biodiversity assessment required sourcing and collating the best information on all known species within the priority taxa (see Section 2.1). Regional and international experts for these taxa were first identified by ZOO and IUCN, and through consultation with the relevant IUCN Species Survival Commission (SSC) Specialist Groups. These experts were then invited to attend a training workshop (Kathmandu, Nepal, July 2009) where they were trained in the use of the web-based IUCN species database (Species Information Service or SIS), the application of the IUCN Red List Categories and Criteria (IUCN 2001) to assess a species risk of extinction in the wild, and in mapping freshwater species distributions using Geographic Information Systems (GIS). Following the training workshop a number of participating experts were contracted to collate and input into the SIS database, all available information on each of the priority taxonomic groups, and to assess the species Red List status. Spatial data (species locality data, in decimal degrees latitude/longitude) were also collated for the production of species distribution maps (see Section 2.4). The taxonomy of each taxa was checked against current standard taxonomies where available (e.g. Eschmeyer 2010 for fishes; the World Odonata List (Schorr *et al.* 2009)) and the taxon lists were then screened against those species already in the IUCN Red List; those taxa that had not been previously assessed, or which had been but whose assessments were older than five years (assessed in 2006 or earlier) were selected for assessment by the project. All the species assessments were then peer-reviewed at a second pair of workshops (Kolkata, India, March 2010, and Coimbatore, India, June 2010) where each species assessment was evaluated by at least two independent experts to ensure that: i) the information presented was both complete and correct; and ii) the Red List criteria had been applied correctly.

Final analyses were undertaken on merged datasets containing species assessed through this project and species previously assessed.

Regional and international expert participants at the species assessment review workshop, Kolkata, India. © Kevin Smith/IUCN

Participants in the training workshop, Kathmandu, Nepal. © Kevin Smith/IUCN

## 2.4 Species mapping and analysis

All species distributions were mapped to river sub-basins as delineated by the HydroSHEDS (**Hydro**logical data and maps based on **SH**uttle **E**levation **D**erivatives at multiple **S**cales) (Lehner *et al*. 2006) (Figure 2.2) using ArcMap GIS software. It is recognized that species ranges may not always extend throughout a river sub-basin but until finer scale spatial detail is provided each species is assumed to be present throughout the sub-basin where it has been recorded. River basins were selected as the spatial unit for mapping and analysing species distributions, as it is generally accepted that the river/lake basin or catchment is the most appropriate management unit for inland waters.

For each of the assessment groups, point localities (the latitude and longitude where the species has been recorded, collated from published literature, online resources and from assessors own data), published literature and expert opinion were used to identify which sub-basins are known to contain the species ('known' basins). During the review workshop errors and dubious records were deleted from the maps.

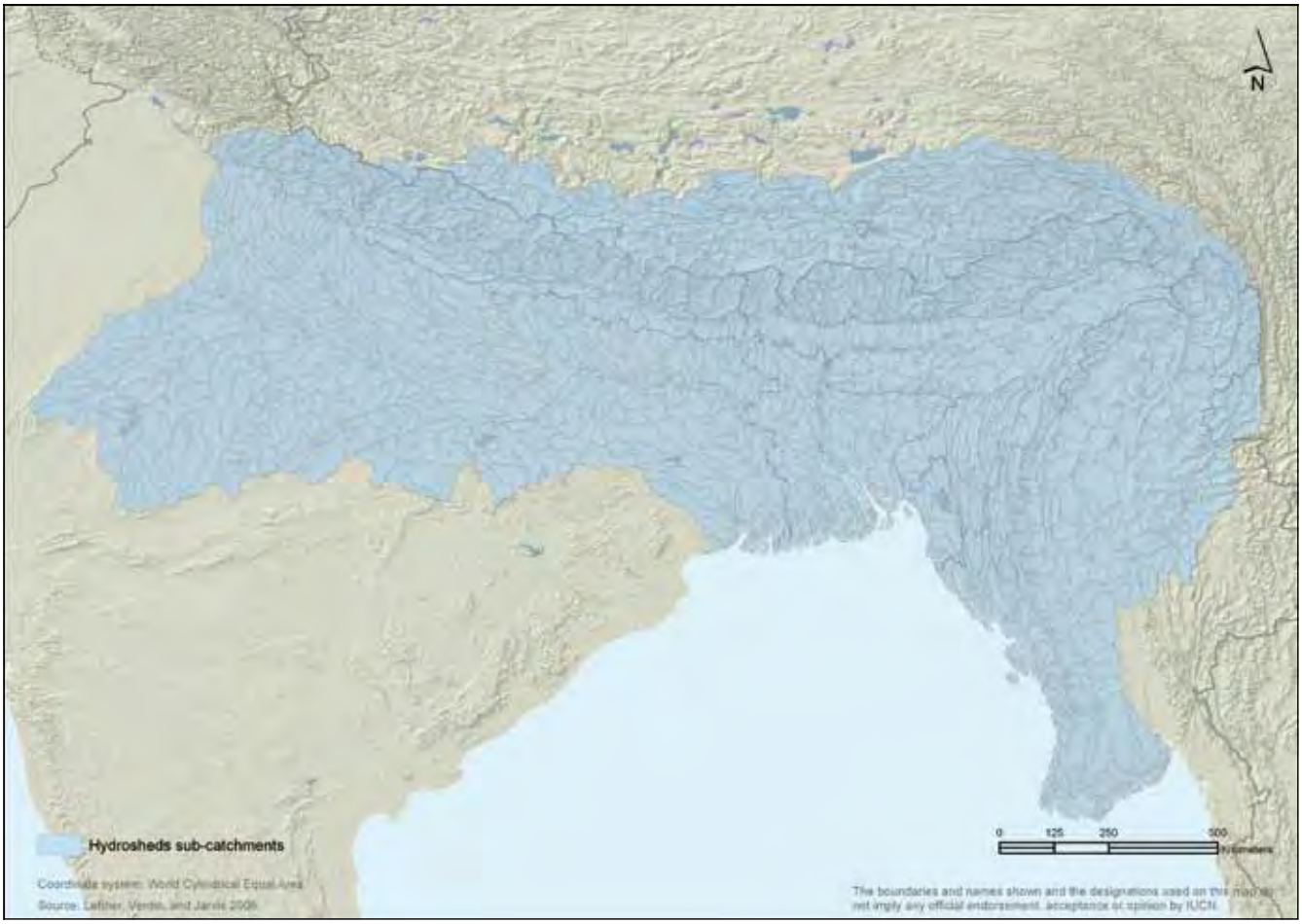
Connected sub-basins, where a species is expected to occur, although presence is not yet confirmed, are known as inferred basins. Inferred distributions were determined through a combination of expert knowledge, course scale distribution records and unpublished information. The preliminary species distribution maps were digitized and then further edited at the review workshop.

For mollusc species maps and for some odonate species, inferred basins were for most species selected by extracting the 'sub-country units' from the SIS database and these administrative boundaries (e.g. Indian states) were used to select the overlapping river sub-basins, resulting in a less refined inferred distribution map. These maps were then reviewed against the species distribution and ecology text (such as altitudinal range), and reviewed by the species assessor prior to submission to the Red List.

Species distributions were also described within the context of the freshwater ecoregions for Asia, as defined and delineated by WWF-US (Abell *et al*. 2008) (Figure 2.3).

Potential Freshwater Key Biodiversity Areas (KBAs) were identified for the Eastern Himalaya Hotspot and reviewed for correspondence with existing protected areas (World Database on Protected Areas; IUCN and UNEP-WCMC 2010) and terrestrial KBAs. KBAs are based on criteria relating to vulnerability and irreplaceability of the site for conservation (Langhammer *et al*. 2007). Irreplaceability refers to the spatial

**Figure 2.2 River basins as delineated by HydroSHEDS and as used to map and analyse species distributions.**



options (i.e. the area and distribution of potentially suitable habitat) for conservation of a species, in other words if a site where a species occurs is lost what other options for its conservation exist. Vulnerability refers to the probability that a site's biodiversity will be lost in the future. The IUCN Freshwater Biodiversity Unit developed a series of criteria to identify river sub-catchments as Key Biodiversity Areas based on vulnerability and irreplaceability (Darwall and Vié 2005).

These are:

1. A site is known or thought to hold a significant number of one or more globally threatened species or other species of conservation concern. This is the vulnerability based criteria as it identifies sub-catchments containing species of this highest risk of being lost in the future.
2. A site is known or thought to hold non-trivial numbers of one or more species (or infraspecific taxa as appropriate) of restricted range. This is the first of the irreplaceability criteria.
3. A site is known or thought to hold a significant component of the group of species that are confined to an appropriate biogeographic unit or units. This is the second of the irreplaceability criteria.

Based on these criteria we identified sub-catchments in the Eastern Himalaya project area that would qualify as candidate freshwater Key Biodiversity Areas.

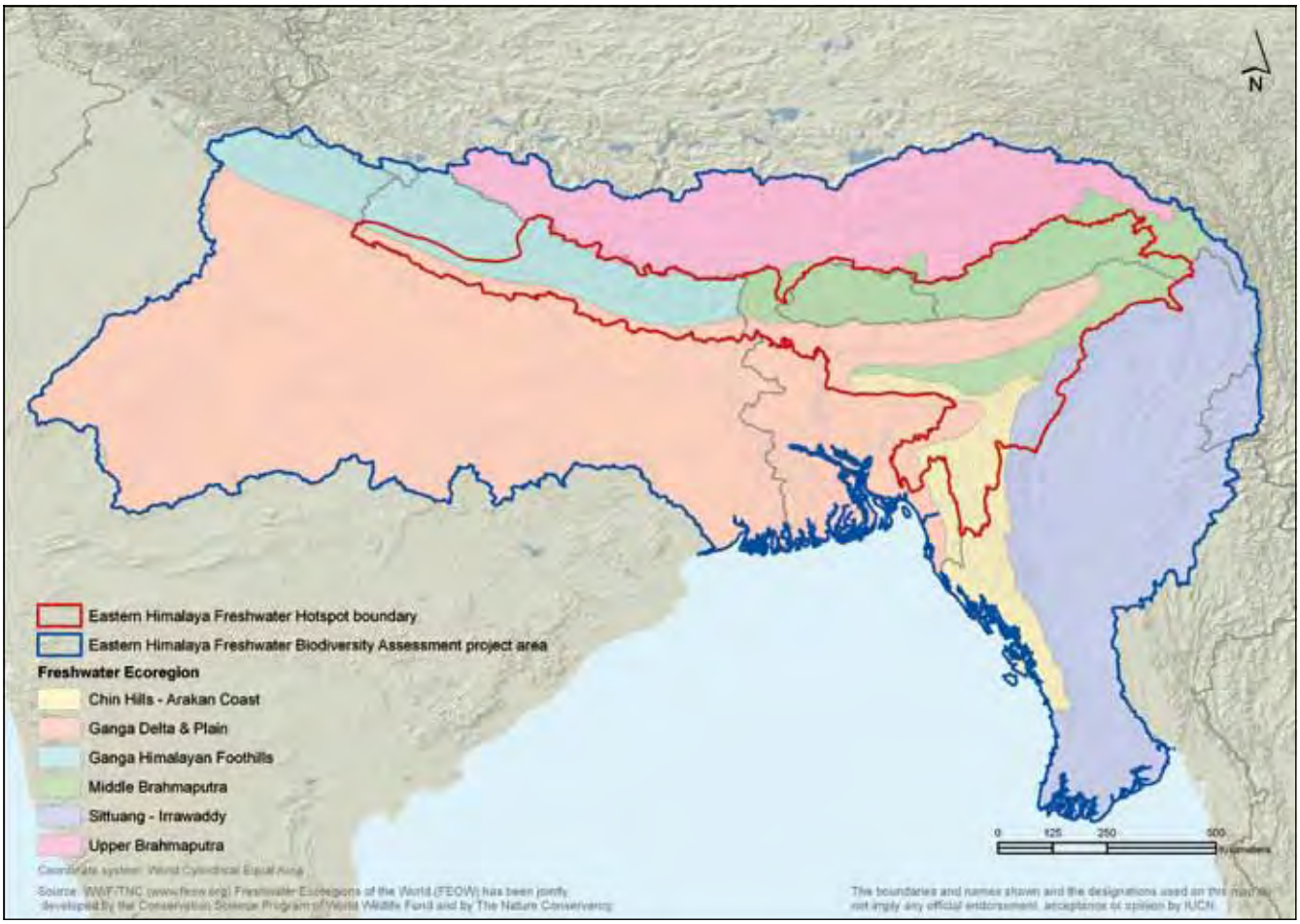
## 2.5 Threat mapping

Information on key threats across the region was gathered through a participative threat mapping exercise run at the project training workshop held in Nepal in 2009. Workshop participants, including regional and international species experts, as well as experts from NGOs from within the region, drew and categorized threats on large scale maps of the region. These maps were then digitized by FBU staff and the final maps distributed to species assessors to help inform the conservation threat assessments.

## 2.6 Assessment of species threatened status

The risk of extinction for each species was assessed according to the *IUCN Red List Categories and Criteria: Version 3.1* (IUCN 2001; see Figure 2.4). As such, the categories of threat reflect the risk that a species will go extinct within a specified time period. A species assessed as "Critically Endangered" is considered to be facing an extremely high risk of extinction in the wild. A species assessed as "Endangered" is considered to be facing a very high risk of extinction in the wild. A species assessed as "Vulnerable" is considered to be facing a high risk of extinction in the wild. All taxa listed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) are described as "threatened". A species is

**Figure 2.3 Freshwater ecoregions within the Eastern Himalay project area (from Abell *et al*. 2008).**



assessed as "Near Threatened" (NT) when it is close to qualifying for or is likely to qualify for a threatened category in the near future. A species is "Least Concern" (LC), often widespread and abundant species, when it has been evaluated against the criteria and does not qualify for a threatened category.

A species is "Data Deficient" (DD) when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on the current knowledge of the species. Data Deficient is therefore not a category of threat and assessment of a species in this category indicates that more information is required and acknowledges the possibility that future research will show that a threatened classification is appropriate.

For an explanation of the full range of categories and the criteria which must be met for a species to qualify under each category, please refer to the following documentation: The *IUCN Red List Categories and Criteria: Version 3.1, Guidelines on Application of the Red List Categories and Criteria*, and *Guidelines for Application of IUCN Red List Criteria at Regional Levels: Version 3.0,* which can be downloaded from www.iucnredlist.org/info/categories_criteria.

The following criteria were set for the inclusion of a species in the assessment were agreed during the initial workshop and were applied in the completion of this Red List assessment:

1. Any species having less than 5% of its range within the Eastern Himalaya region should not be assessed, the main assessment being completed for the neighbouring region.
2. Species present in the Eastern Himalaya region prior to 1500 were treated as being "naturalized" and subject to a Red List assessment. Those species arriving in the region post 1500 were not assessed.

For each species the Red List Category is either written out in full or abbreviated as follows:

| | |
|---|---|
| Extinct, EX | Vulnerable, VU |
| Extinct in the Wild, EW | Near Threatened, NT |
| Critically Endangered, CR | Least Concern, LC |
| Endangered, EN | Data Deficient, DD |

Workshop threat mapping exercise. © David Allen/IUCN

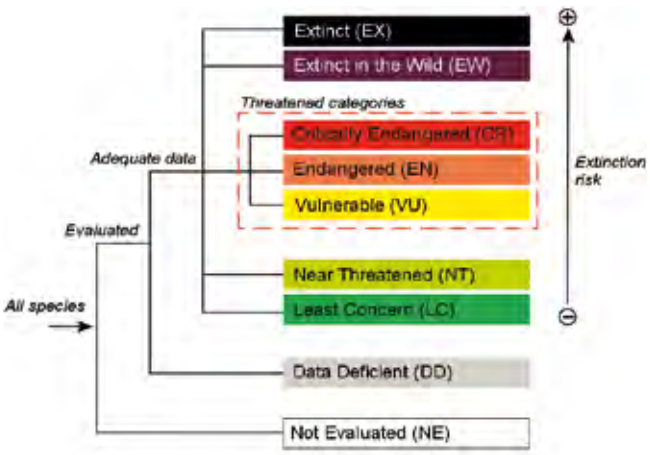



**Figure 2.4 IUCN Red List Categories at the Global Scale.**

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Sunset at Kaziranga National Park, Assam, in the Eastern Himalaya Hotspot. © Jack Tordoff/CEPF

# Chapter 3. The status and distribution of freshwater fishes of the Eastern Himalaya region

Waikhom Vishwanath[1], Heok Hee Ng[2], Ralf Britz[3], L. Kosygin Singh[4], Shivaji Chaudhry[5] and Kevin W. Conway[6]



## 3.1 Overview of Eastern Himalaya fish fauna

Abell *et al*. (2008) presented a global map of 426 freshwater ecoregions based on the distributions and compositions of freshwater fish species. This represents an invaluable resource for global and regional conservation planning efforts. According to Abell *et al*. (2008), the Eastern Himalaya assessment region encompasses six freshwater ecoregions (see Figure 2.3); the *Ganga Delta and Plain*, *Ganga Himalayan Foothills*, *Upper Brahmaputra*, *Middle Brahmaputra*, *Chin Hills-Arakan Coast*, and the *Sittaung-Irrawaddy* ecoregion. The Sittaung basin was not included in the Eastern Himalaya assessment; instead it is being considered in the parallel Indo-Burma regional assessment.

[1] Department of Life Sciences, Manipur University, Canchipur 795003, Manipur, India. wvnath@gmail.com
[2] Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore, 6 Science Drive 2 #03-01, Singapore 117546. heokhee@nus.edu.sg
[3] Department of Zoology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK. r.britz@nhm.ac.uk
[4] Zoological Survey of India, Hilltop, Gopalpur-on-Sea, Orissa 761002, India. lkzsi5@yahoo.com
[5] G.B. Pant Institute of Himalayan Environment and Development, North East Unit, Itanagar, Arunachal Pradesh 791113, India. shivaji.chaudhry@gmail.com
[6] Department of Wildlife and Fisheries Sciences and Texas Cooperative Wildlife Collection, Texas A & M University, 210 Nagle Hall, 2258, TX 77843, USA. k.conway@tamu.edu

Abell *et al.* (2008) state that the region has a species richness consisting of around 500 fish species (inferred from their figure 2). According to Abell *et al.* (2008) the *Irrawaddy* ecoregion contains more endemic species of freshwater fish (between 119–195) than any of the other Eastern Himalayan freshwater ecosystems (*Ganga Delta and Plains* and *Chin Hills-Arakan*, 28–40 endemics; *Ganga Himalayan Foothills*, 12–19; Middle and Upper Brahmaputra, 1–11). Kottelat and Whitten (1996) estimated the Ganga River drainage to contain 350 and Brahmaputra and Ayeyarwaddy river drainages to contain 200 species of fishes respectively. Clearly, estimates of fish diversity across the region vary widely.

### 3.1.1 Geomorphological factors affecting distribution of the Eastern Himalaya fishes

The region under assessment is the Eastern Himalaya aquatic biodiversity hotspot and should not be confused with the biodiversity hotspot of Myers *et al.* (2000) and Roach (2005) that are based on terrestrial flowering plants. Due to the connectivity of aquatic systems, the scope of the assessment encompassed the entirety of river basins that originate within the Eastern Himalaya Hotspot (the Ganga, Brahmaputra, Irrawaddy (Ayeyarwaddy) and Kaladan (Kolodyne) River basins as well as minor coastal basins). As such, the assessment region overlaps with the Himalaya and a part of the Indo-Burman terrestrial hotspot. Kottelat and Whitten's (1996) map of 'hotspots' for freshwater biodiversity in Asia based on fishes also included major parts of northeastern India and Myanmar.

The Eastern Himalaya is a biodiversity rich region. The diversity is attributed to the recent geological history (the collision of Indian, Chinese and Burmese plates) and the Himalayan orogeny which played an important role in the speciation and evolution of groups inhabiting mountain streams (Kottelat 1989). The evolution of the river drainages in this part of the world has been the subject of several studies that utilize geological evidence to reconstruct the palaeodrainage patterns during much of the Cenozoic (65.6 million years ago to the present) (e.g. Brookfield 1998; Clark *et al.* 2004). Molecular phylogenetic studies of the fishes of this region (e.g. Guo *et al.* 2005; Rüber *et al.* 2004) have indicated that vicariance events in the Miocene (23.0 to 5.3 million years ago) may have played a substantial role in shaping the current distribution pattern of the freshwater fishes of the region.

The fish fauna of the Eastern Himalaya region may be subdivided into three drainage-based geographic units:

1. The Ganga-Brahmaputra drainage, that flows in the *Ganga Himalayan Foothills*, *Ganga Delta and Plain* ecoregions and the *Upper* and *Middle Brahmaputra*;
2. The Chindwin-Irrawaddy drainage in the *Sittaung-Irrawaddy* freshwater ecoregion;
3. The Kaladan/Kolodyne drainage and a number of short drainages along the western face of the Rakhine Yoma of Myanmar in the *Chin Hills-Arakan* freshwater ecoregion.

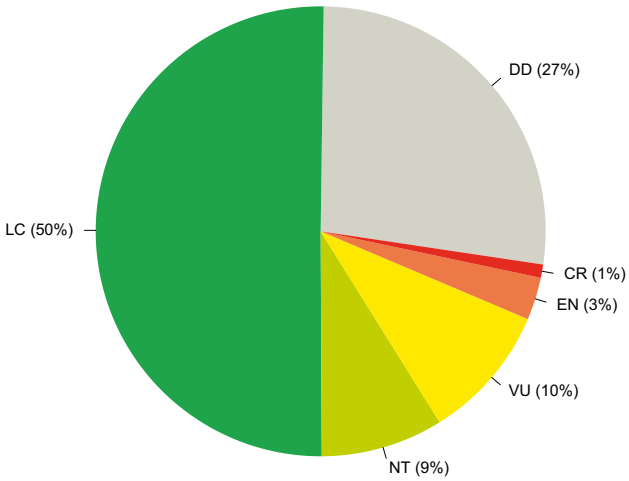
Fishers in the Tanguar *haor*, Sunamganjg, Bangladesh. © IUCN Bangladesh

## 3.2 Conservation status

Half of the fish species in the Eastern Himalaya are categorized as Least Concern (LC) (Figure 3.1). These fishes are distributed mostly in the Gangetic Plains, deltaic regions of Bangladesh, the lower Assam plains, and northern parts of Arunachal Pradesh and its adjoining areas in China and the lower Ayeyarwaddy. Although the Gangetic Plains is one of the most densely populated areas in the Indian subcontinent, many of the fish species assessed as Least Concern are either widely distributed through the region, or their population sizes are postulated to be relatively large. One or both of these factors may serve to buffer these populations from any adverse effects associated with anthropogenic encroachment. Unfortunately, the empirical data required to strongly support their assessment status is lacking for a number of these species and, in many cases, the assessment as Least Concern is more often based on inference from sampling data. In addition, many of the species currently assessed as Least Concern may require reassessment in the future, given that they are suspected to belong to species complexes containing several morphologically similar (cryptic) species that may exhibit more geographically circumscribed ranges (one such example is *Aplocheilus panchax*).

The next highest number of species (27.1%) is in the Data Deficient category. Species in this category possess one or more of the following features: 1. Small body size, with little commercial value (either as food or as ornamental fishes), 2. Very recent recognition as distinct taxonomic entities, 3. Known only from the type series and/or a very small number of museum records, 4. Little or no information on their biology, and 5. Taxonomic uncertainties surrounding the validity of the species. For all these groups, there are often no data on their occurrence, population trends and so on. A detailed discussion of the issues surrounding the data deficiency is provided in Section 3.3.

**Figure 3.1 The proportion (as %) of freshwater fish species in each Red List Category in the Eastern Himalaya assessment region.**




Harvesting fish from an agricultural irrigation channel between Taungoo and Mandalay, Ayeyarwaddy Division, in Myanmar. © Ritva Roesler

Of the remaining species, a total of 70 (13.5%) are categorized as threatened (CR, EN, and VU assessments) while 46 (8.8%) have been assessed as Near Threatened. Fifteen (2.9%) are Endangered and five (1.0%) are Critically Endangered. Among the 15 Endangered species, ten are endemic in the Ganga-Brahmaputra and four to the Chindwin. One species, *Clarias magur* is common to both the Ganga-Brahmaputra and the Chindwin. The five Critically Endangered species are either endemic to hill streams located within the Ganga-Brahmaputra and Chindwin drainages, are restricted to a single lake or to a single cave system within the Ganga-Brahmaputra drainage.

Eight species were omitted from the assessment in error, mainly from the Ayeyarwaddy catchment, whilst a further twelve species have been described since the assessment project began and have not been assessed (Table 3.2), illustrating the need for an increased effort to undertake further taxonomic study and fieldwork within the region.

**Table 3.1 The number of fish species and percentages of Eastern Himalayan fishes under each IUCN Red List category.**

| | Global Red List Category | Number of species |
|---|---|---|
| Threatened categories | Extinct | 0 |
| | Extinct in the Wild | 0 |
| | Critically Endangered | 5 |
| | Endangered | 15 |
| | Vulnerable | 50 |
| | Near Threatened | 46 |
| | Least Concern | 263 |
| | Data Deficient | 141 |
| | **Total** | **520** |

## 3.3 Patterns of species richness

### 3.3.1 All fish species

Portions of the Brahmaputra drainage located in Arunachal Pradesh, Meghalaya, and northern Bengal, together with parts of Assam and the Himalayan foothills between Nepal and Bihar exhibit the most diverse fish fauna (Figure 3.2). Species richness is highest in the Tista, Kameng, Dikrong, Subansiri and Siang basins. The richness in these areas is due to the diversity of habitats and environments existing between the plains of the Brahmaputra at a low altitude (120–200 m) to the upland coldwater regions (1,500–3,500 m) in the hill ranges in Arunachal Pradesh and also in Meghalaya and Assam within a short aerial distance of 200–500 km.

**Table 3.2 Fish species omitted from the assessment in error and recently described.**

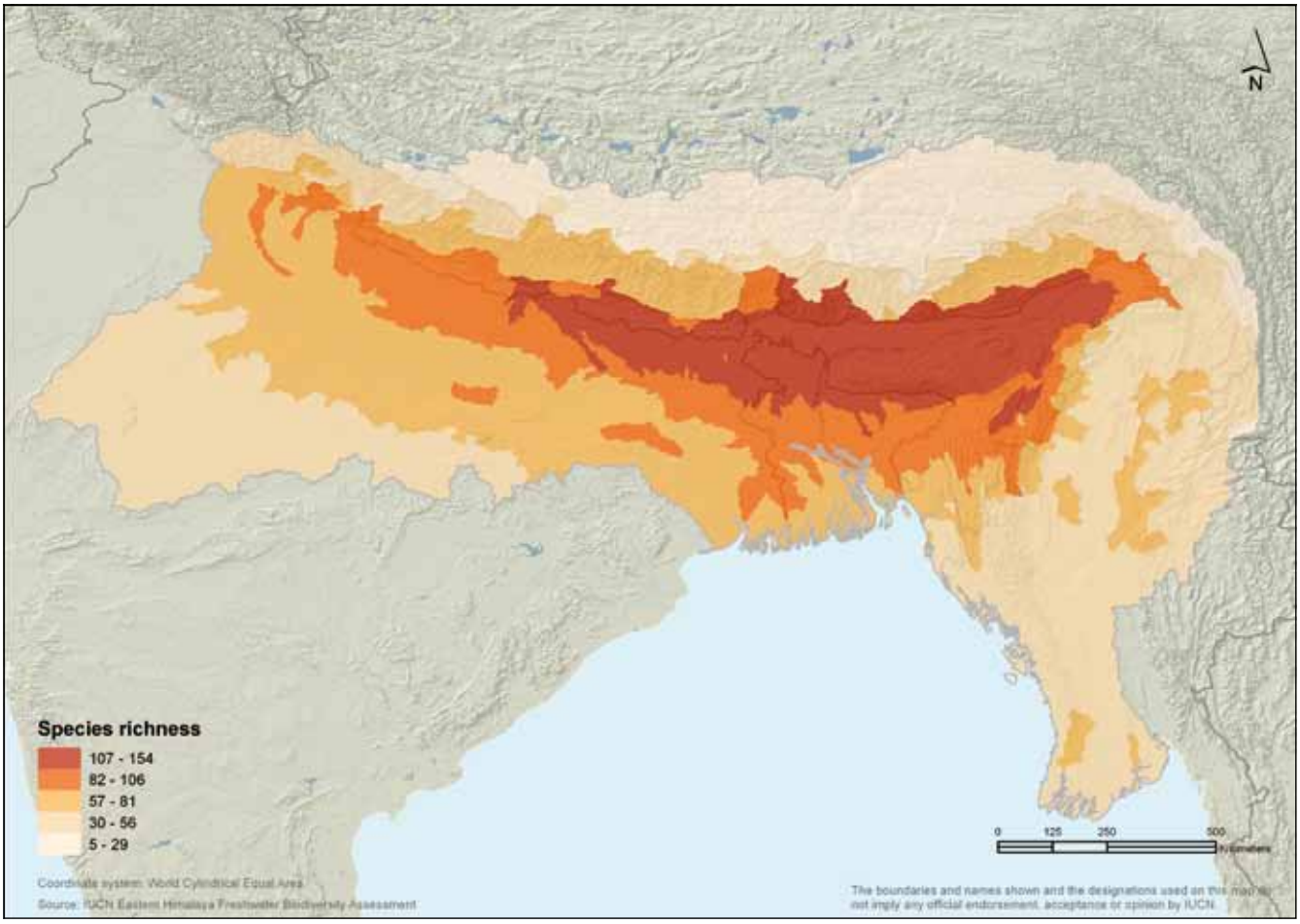
| **Omitted species** | | |
|---|---|---|
| *Badis pyema* | Kullander and Britz, 2002 | Upper Ayeyarwaddy River |
| *Badis kyar* | Kullander and Britz, 2002 | Upper Ayeyarwaddy River |
| *Danio nigrofasciatus* | (Day, 1870) | Ayeyarwaddy River |
| *Danio quagga* | Kullander, Liao and Fang, 2009 | Chindwin River |
| *Pangio signicauda* | Britz and Maclaine, 2007 | Upper Ayeyarwaddy |
| *Parasphaerichthys lineatus* | Britz and Kottelat, 2002 | Lower Ayeyarwaddy |
| *Microdevario nana* | (Kottelat and Witte, 1999) | Lower Ayeyarwaddy and Sittaung |
| *Chaca burmensis* | Brown and Ferraris, 1988 | Lower Ayeyarwaddy and Sittaung |
| **Recently described species** | | |
| **India** | | |
| *Amblyceps cerinum* | Ng and Wright, 2010 | Brahmaputra |
| *Pseudolaguvia spicula* | Ng and Lalramliana, 2010 | Barak system |
| *Pseudecheneis koladynae* | Anganthoibi and Vishwanath, 2010 | Kaladan (Kolodyne) River |
| *Glyptothorax chimtuipuiensis* | Anganthoibi and Vishwanath, 2010 | Kaladan (Kolodyne) River |
| **Myanmar** | | |
| *Lepidocephalichthys alkaia* | Havird and Page, 2010 | Upper Ayeyarwaddy |
| *Macrognathus aureus* | Britz, 2010 | Upper Ayeyarwaddy |
| *Psilorhynchus melitta* | Conway and Kottelat, 2010 | Ann Chaung, Rakhine Yoma |
| *Psilorhynchus brachyrhynchus* | Conway and Britz, 2010 | Upper Ayeyarwaddy |
| *Psilorhynchus piperatus* | Conway and Britz, 2010 | Lower Ayeyarwaddy |
| *Psilorhynchus gokkyi* | Conway and Britz, 2010 | Lower Ayeyarwaddy |
| *Psilorhynchus parvimentatus* | Conway and Kottelat, 2010 | Ann Chaung, Rakhine Yoma |
| *Chaudhuria ritvae* | Britz, 2010 | Lower Ayeyarwaddy |

Similar levels of richness are expected in other basins, i.e. the Lohit and Dibang basins and those in Bhutan flowing to the Brahmaputra drainage and headwaters of the Barak and Chindwin basins and the Kaladan (Kolodyne) drainage. The Kaladan River is a drainage that flows between the Ganga-Brahmaputra and the Chindwin-Irrawaddy drainages. The river is separated from the Ganga-Brahmaputra drainage by the Chittagong hill tract in the west and from the Chindwin-Irrawaddy by the Rakhine Yoma hill range in the east. The ichthyofauna of the Kaladan is poorly explored (Anganthoibi and Vishwanath 2010b), and inaccessibility and differences in sampling intensities may in part explain why the Kaladan basins do not feature more strongly in Figure 3.2. The drainage is in the *Chin Hills-Arakan* ecoregion. Although Kar and Sen (2007) listed 42 species of fishes from Kaladan, they neither gave descriptions of the species nor mentioned where the collections were eventually deposited. Recent collections from the Kaladan drainage were made by Anganthoibi and Vishwanath (2009, 2010a) who remarked that the area may be under considerable anthropogenic pressure. Further habitat modification and (most likely) degradation is to be expected in this river drainage with the proposal for the Kaladan Multipurpose Project. This involves the creation of inland waterways along the course of the river to enable navigation from the port of Sittwe in Myanmar to the state of Mizoram in northeastern India through for supply of essential commodities from mainland India.

We acknowledge that the areas of highest diversity indicated here may reflect bias in research and sampling, since the ichthyofauna of the areas with the highest densities have been the subject of numerous recent studies (e.g. Ng 2006; Vishwanath and Linthoingambi 2007). It is likely that the diversity of the ichthyofauna of the Gangetic Plains may be higher than currently recognized. However, given the paucity of hill stream taxa in the plains, this diversity is not likely to be particularly high. The northern parts of the region under study are occupied by the Himalaya where the fish species diversity is lower due to the higher altitude and colder temperature.

Kaladan River in the southern part of Mizoram, India. © Waikhom Vishwanath

**Figure 3.2 Map showing overall freshwater fish species richness in the Eastern Himalaya region.**



### 3.3.2 Threatened species

The majority of threatened fishes are in the Chindwin basin in Manipur (Figure 3.3), particularly the Imphal River and its tributaries draining the surrounding hills and the central plain of Manipur and the adjoining areas in Myanmar, i.e. the eastern parts of the Chin Hills and the Kabaw valley. The Barak basin in Manipur is also under threat. The other areas holding high numbers of threatened species are the Brahmaputra basin in Arunachal Pradesh, Upper Assam, and Meghalaya, the Tista basin in Sikkim and parts of northern Bengal, and areas of western Nepal. The Brahmaputra drainage is widespread with many smaller tributaries, and species may find alternative basins in the drainage for their survival. In contrast, the Imphal River basin with restricted boundaries is more isolated and threats may therefore have a greater impact on fish populations. With the construction of the barrage, the upstream and downstream sections of the Imphal River, the main drainage of the Manipur Valley are fragmented.

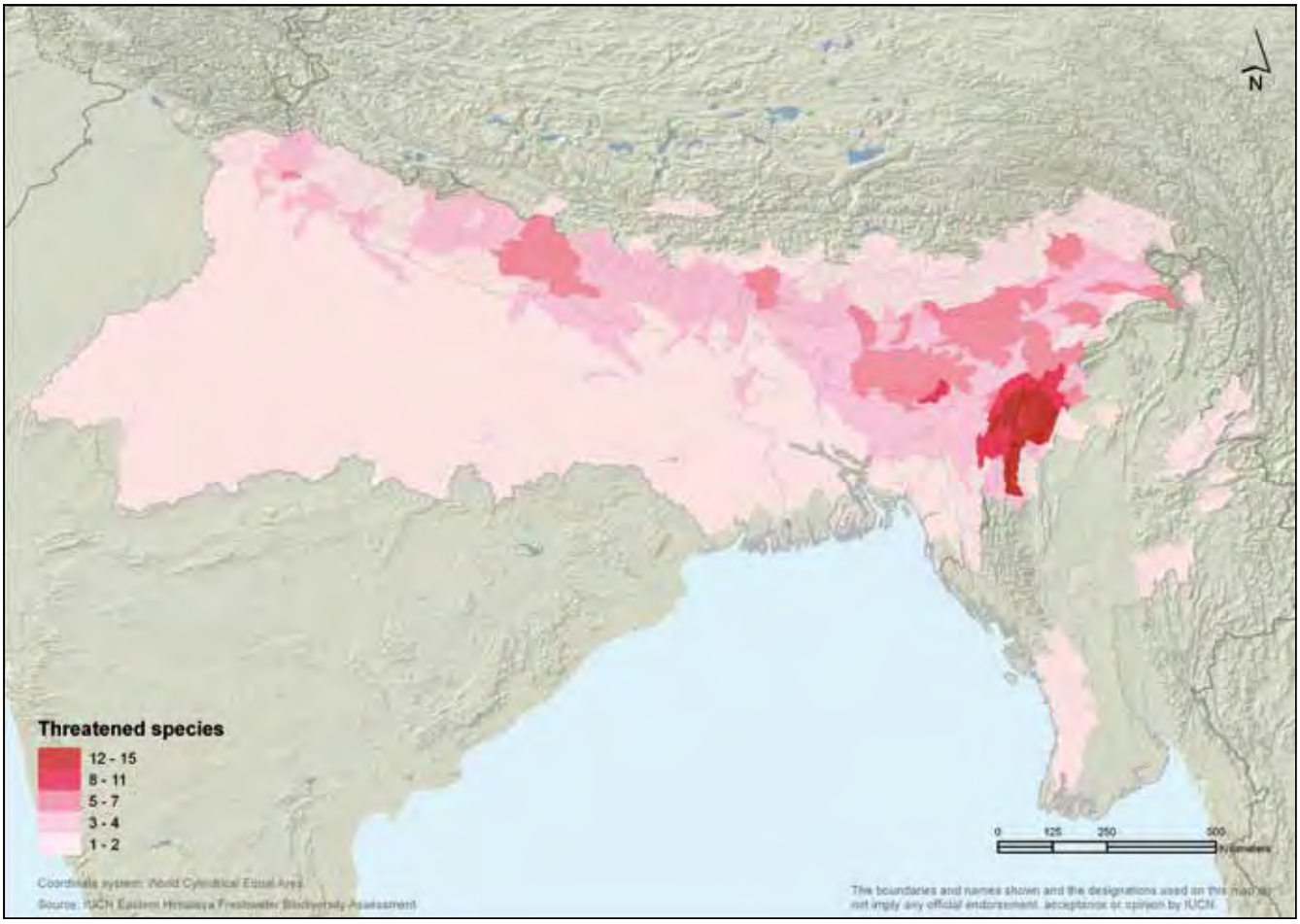
Siltation has caused the drying of many swamps whilst others have been reclaimed either for paddy cultivation or encroachment of land for expansion of residential areas. The commissioning of the Loktak hydro-electric project in 1983 caused drastic change in the aquatic environment in the basin. Loktak Lake (about 40,000 ha), the largest freshwater lake in northeastern India, is fed by several streams. The lake is connected with the Imphal River by the Ungamel and Kordak channels. To supply water required for the hydro-electric project from the lake, a barrage has been constructed across the Imphal River slightly below the point where these channels join the Imphal River. Thus water brought by the Imphal River is fed into the lake by reversing the flow in the channels.

In addition, there are threats to the fishes in hill streams due to destructive fishing, including blast, poison and electric fishing, as well as the use of fish barrages. With the development of Moreh (Manipur, India) and Tamu (Myanmar) townships for Indo-Myanmar trade, there is great increase in human population and in development activities. This has impacted on the aquatic environment, particularly in the Lokchao River in Manipur and Yu River basin in Myanmar.

Of the 15 Endangered species, *Puntius manipurensis*; *Schistura kanjupkhulensis* and *Psilorhynchus microphthalmus* are endemic to Manipur Valley while *Schistura reticulata*, is endemic to the eastern hill streams of Manipur draining into the Yu River.

The Barak basin in Manipur is also identified as an area with a high number of threatened species. The western hills of Manipur

**Figure 3.3 Map showing threatened (IUCN Red List categories VU, EN, and CR) freshwater fish species richness in the Eastern Himalaya assessment region.**



are drained by the Barak and its tributaries. The river flows southwards on the eastern side of the Vangai range and then makes a 'U'-turn at Tipaimukh where it is joined by the Tuivai River, flowing westward between Manipur and Myanmar. The Barak then flows northward on the western side of the Vangai range and then enters the Cachhar district of Assam to finally enter Bangladesh and join the Surma-Meghana basin. With the development of the Tipaimukh High Dam hydro-electric project there will be flow modification and flooding of the Barak basin in the western part of Manipur. Habitats of several hill stream fishes will be disturbed and upstream and downstream parts of the river will be fragmented.

Many of the species endemic to the Barak basin of Manipur (e.g. *Badis tuivaiei*; *Pterocryptis barakensis*; *Schistura minutus* and *S. tigrinum*) are assessed as Endangered or as Vulnerable (e.g. *Sisor barakensis*).

Critically Endangered species constitute only one percent of the assessed species. Of the five CR species one sisorid catfish, *Glyptothorax kashmirensis*, although most likely restricted to the Kashmir valley, is included here due to a record from the Ganga drainage in Nepal which requires confirmation. Three schizothoracines (*Schizothorax integrilabiatus, S. nepalensis* and *S. rarensis*) are restricted to high altitude lakes, the first one to the Xixong Lake, Tibet, China, and the later two to Rara Lake in Nepal. One nemacheiline loach, *Schistura papulifera* is endemic in the Krem Synrang Pamiang cave system, in the Jaintia Hills, eastern Meghalaya, India. Considering the extent and number of threats occurring in this area, it might be expected that some Data Deficient species will be re-assessed into this (or another threatened category) when further information on distributions and population trends becomes available. Further expert surveys are required to assess the population and threat status of such fishes. This is required to solve taxonomic ambiguities of many nominal species. Such ambiguities arise through a worrying decrease in research focussed on taxonomy in recent years, where attention has shifted instead to research for the production of high yielding fish varieties to meet the ever increasing demands for food.

*Schistura papulifera* (CR) a loach endemic in the Krem Synrang Pamiang cave system in the Jaintia Hills, eastern Meghalaya, India. © Maurice Kottelat

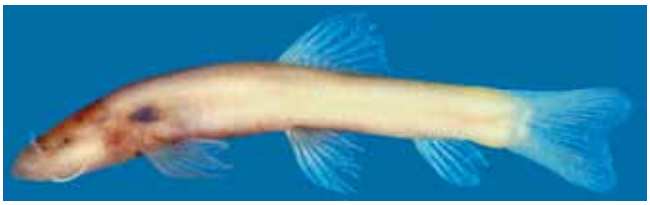


**Table 3.3 Vulnerable freshwater fish species and their distributions in the Eastern Himalaya assessment region.**

| Species | Drainage | Species | Drainage |
|---|---|---|---|
| *Aborichthys garoensis* | Brahmaputra | *Gymnocypris scleracanthus* | Brahmaputra |
| *Aborichthys tikaderi* | Brahmaputra | *Laubuca khujairokensis* | Chindwin |
| *Bangana almorae* | Brahmaputra | *Myersglanis jayarami* | Chindwin |
| *Barilius chatricensis* | Brahmaputra | *Nemacheilus pavonaceus* | Brahmaputra |
| *Barilius dimorphicus* | Brahmaputra | *Physoschistura elongata* | Brahmaputra |
| *Barilius dogarsinghi* | Chindwin | *Pseudecheneis sirenica* | Brahmaputra |
| *Barilius ngawa* | Chindwin | *Pseudecheneis ukhrulensis* | Chindwin |
| *Botia rostrata* | Brahmaputra | *Puntius ater* | Chindwin |
| *Cirrhinus cirrhosus* | Brahmaputra | *Puntius chelynoides* | Ganga |
| *Danio jaintianensis* | Brahmaputra | *Puntius jayarami* | Chindwin |
| *Devario acuticephala* | Chindwin | *Puntius khugae* | Chindwin |
| *Devario anomalus* | Brahmaputra | *Puntius ornatus* | Chindwin |
| *Devario assamensis* | Brahmaputra | *Puntius shalynius* | Brahmaputra |
| *Devario browni* | Chindwin | *Puntius yuensis* | Chindwin |
| *Devario naganensis* | Chindwin | *Rasbora ornatus* | Chindwin |
| *Devario yuensis* | Chindwin | *Semiplotus semiplotus* | Ganga-Brahmaputra |
| *Garra bispinosa* | Chindwin | *Schistura chindwinica* | Brahmaputra |
| *Garra compressus* | Chindwin | *Schistura inglisi* | Brahmaputra |
| *Garra flavatra* | Rakhine Yoma | *Schistura khugae* | Chindwin |
| *Garra litanensis* | Chindwin | *Schistura nagaensis* | Chindwin |
| *Garra manipurensis* | Chindwin | *Schistura prashadi* | Chindwin |
| *Garra nambulica* | Chindwin | *Schistura reticulofasciata* | Brahmaputra |
| *Garra paralissorhynchus* | Chindwin | *Schistura singhi* | Brahmaputra |
| *Glyptothorax manipurensis* | Chindwin | *Schizothorax richardsonii* | Ganga |
| *Gymnocypris dobula* | Brahmaputra | *Sisor barakensis* | Brahmaputra |

The proposed Tipaimukh dam across the Barak River in Manipur has the potential to result in the loss of habitat and impact on migratory species, as well as other downstream impacts. The distribution of *B. tuivaiei* which is known from the Barak and one of its tributaries, the Tuivai, will be fragmented by this dam and its storage reservoir. *Schistura reticulata, S. kanjupkhulensis* and *Psilorhynchus microphthalmus* of the Chindwin headwaters of Manipur are suffering habitat loss due to sand and gravel mining for construction and urban development near their habitats. It is not certain if these species also occur in other tributaries of the Chindwin on the Myanmar side. *Schistura sijuensis* is a cave fish restricted to the Siju cave in Meghalaya. *Puntius manipurensis* is endemic to Loktak Lake, the largest freshwater lake in northeastern India and a Ramsar recognized site. The Ithai Barrage constructed across the Manipur River to divert water to the lake for the Loktak Hydroelectric Project and eutrophication has caused extensive damage to the ecology of the lake. The species listed by Hora (1921) are no longer present. Many weed and introduced fishes, such as Chinese carps and *Oreochromis mossambicus* appear to have replaced the endemic species.

The generic status of *Lepidocephalichthys arunachalensis*, a species originally described under the genus *Noemacheilus,* requires confirmation. Kottelat (1990) doubted the inclusion of the species in *Noemacheilus* and suggested that it instead be placed within *Lepidocephalichthys* based on the author's illustrations. The species is presently assessed as Endangered. More surveys are required to confirm the present distributions of *Devario horai,* and *Pillaia indica*. *Clarias magur* has been resurrected from synonymy with *C. batrachus* by Ng and Kottelat (2008). All available literature shows the collections of the fish from Eastern Himalaya region as *C. batrachus*, and more detailed surveys are required to provide a more accurate picture of the distribution of the species.

*Myersglanis jayarami* (VU), endemic to the Chindwin basin in Manipur. © Waikhom Vishwanath

Of the species assessed as Vulnerable, two (*Semiplotus semiplotus* of the Ganga-Brahmaputra and *Semiplotus modestus* of Kaladan basins) deserve special attention. *Semiplotus* has a unique oral morphology consisting of an inferior, broad mouth with an exposed cornified mandibular cutting edge and a dentary with a broad deflected labial surface used to scrape algae off the bottom rocks. The fishes migrate upstream in shoals at night feeding on the algae on bottom rocks. Destruction of the habitat and feeding grounds of the species will be a great pressure on their existence.

### 3.3.3 Restricted range and endemic species

The Eastern Himalaya is an area of considerable freshwater ichthyofauna endemicity. This high level of endemism stems from the presence of large number of hillstream species with highly localized distributions from a number of different families, including the Balitoridae, Psilorhynchidae, Cyprinidae and Sisoridae. For example, all known species of the genus *Aborichthys* (Balitoridae) are endemic to the Brahmaputra drainage in northern Bengal, Meghalaya and Arunachal Pradesh. Several species of amblycipitidid and sisorid catfishes, danionins and badids are also endemic to the Brahmaputra drainage. This degree of endemicity in the region may be the result of Miocene tectonic activity (He *et al.* 2001; Rüber *et al.* 2004). The uplift of

**Table 3.4 Endangered freshwater fish species and their distributions in the Eastern Himalaya assessment region.**

| Species | Drainage |
|---|---|
| *Amblyceps arunchalensis* | Brahmaputra |
| *Badis tuivaiei* | Brahmaputra |
| *Clarias magur* | Ganga-Brahmaputra |
| *Devario horai* | Brahmaputra |
| *Lepidocephalichthys arunachalensis* | Brahmaputra |
| *Pillaia indica* | Brahmaputra |
| *Psilorhynchus microphthalmus* | Chindwin |
| *Pterocryptis barakensis* | Brahmaputra |
| *Puntius manipurensis* | Chindwin |
| *Schistura kangjupkhulensis* | Chindwin |
| *Schistura minutus* | Brahmaputra |
| *Schistura reticulata* | Chindwin |
| *Schistura sijuensis* | Brahmaputra |
| *Schistura tigrinum* | Brahmaputra |
| *Tor putitora* | Ganga-Brahmaputra |

**Table 3.5 Critically Endangered freshwater fishes and their distributions in the Eastern Himalaya assessment region.**

| Species | Drainage |
|---|---|
| *Glyptothorax kashmirensis* | Kashmir valley |
| *Schizothorax integrilabiatus* | Xixong lake, Tibet, China |
| *Schizothorax nepalensis* | Rara Lake, Nepal |
| *Schizothorax raraensis* | Rara Lake, Nepal |
| *Schistura papulifera* | Meghalaya, India |

*Schistura inglisi*, a Vulnerable fish from rivers below Darjeeling and Sikkim, Eastern Himalaya. It has a restricted range, and is threatened by sedimentation. © Antti Vuorela

the Indo-Burman mountain range not only separated the Upper Brahmaputra from the Ayeyarwaddy and led to the formation of a number of sister species in these two major rivers, it also led to the formation of a large number of mountain and hill streams, each of which evolved its own fish fauna.

### Endemic fishes of Manipur

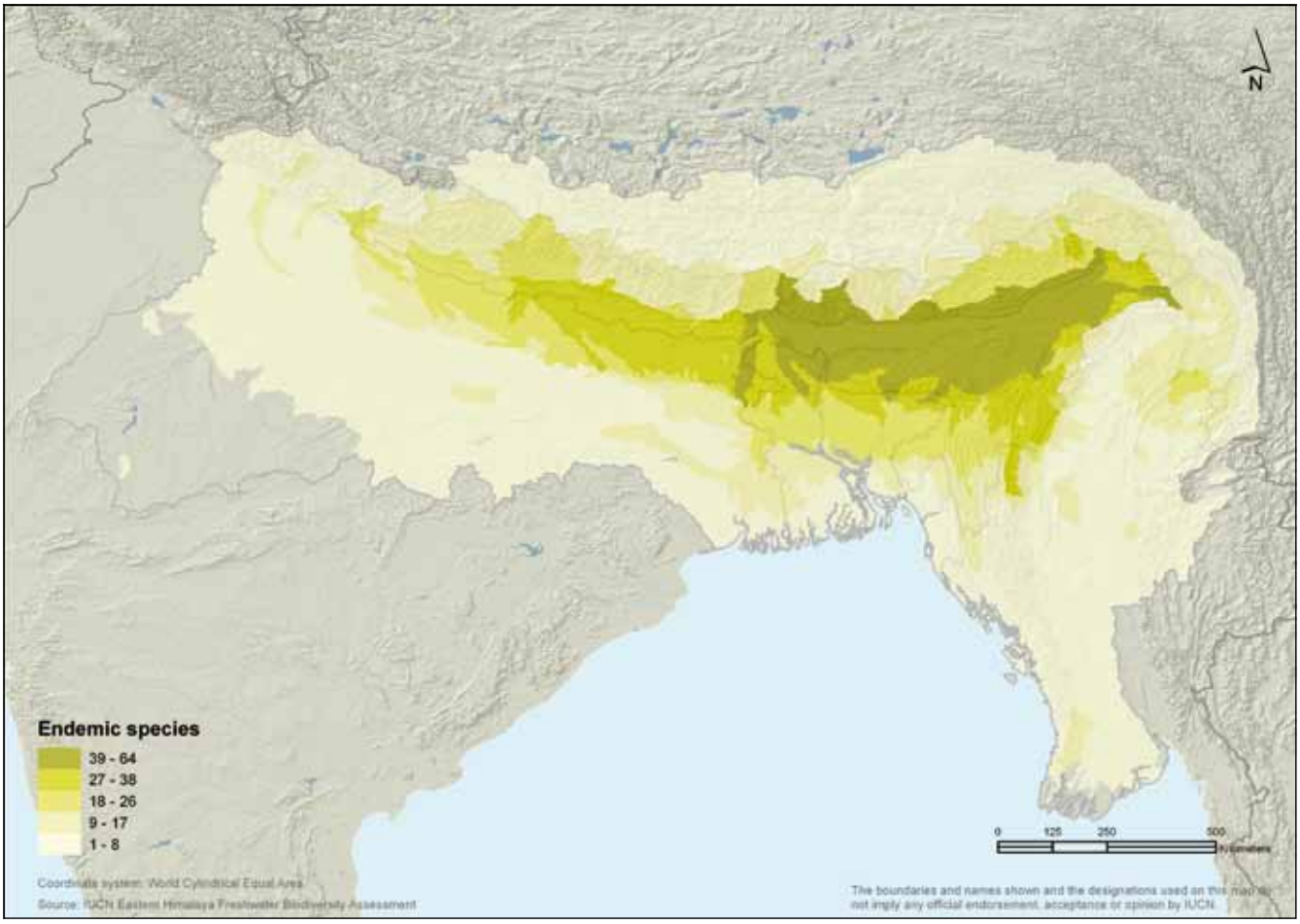
The collections of fishes from Manipur by Hora (1921) can be placed in two categories: (i) those from the northern watershed (Brahmaputra) and (ii) those from the southern watershed (Chindwin). Hora (1921) remarked that the southern watershed fauna consists of Burmese and endemic Manipur elements. Hora and Mukerji (1935) also reported that the fish fauna of Naga (the Naga Hills of British India consisted of parts of present Nagaland and Manipur) contain both Assamese (Brahmaputra) and Burmese (Chindwin) elements in equal proportions.

### Endemic fishes of the Ganga Basin

Though undoubtedly the largest basin of the region, the Ganga has fewer endemic freshwater fishes than any of the other major drainages of the Eastern Himalaya. The paucity of Gangetic endemics may be an artefact of our poor knowledge of the Gangetic ichthyofauna in general, which was, rather ironically, one of the first of the Eastern Himalayan drainages to be surveyed by ichthyologists. Of the species of freshwater fishes recorded from the Ganga, less than 10% are considered to be endemic. As is the case for other Eastern Himalayan drainages, the majority of gangetic endemics are hillstream inhabitants, restricted to higher elevations within the northern Indian states of Uttarakhand and Uttar Pradesh, and Nepal. Three species of *Schizothorax* are endemic to Lake Rara, an isolated lake in Western Nepal (Terashima 1984). Gangetic endemics belong to relatively few families, all of which belong to the Otophysi, including the cypriniform families Balitoridae (four species), Cyprinidae (five) and Psilorhynchidae (two), and the siluriform families Bagridae (one), Erethistidae (four), and Sisoridae (three). Surprisingly, most Gangetic endemics have been described only relatively recently, most within the last 30 years (e.g. *Schizothorax raraensis* Terashima 1984, *S. macropthalmus* Terashima 1984, *S. nepalensis* Terashima 1984, *Erethistoides ascita* Ng and Edds 2005, *E. cavatura* Ng and Edds 2005, *Pseudecheneis crassicauda* Ng and Edds 2005, *P. serracula* Ng and Edds 2005, *P. eddsi* Ng 2006, *Psilorhynchus nepalensis* Conway and Mayden 2008 and *Balitora eddsi* Conway and Mayden 2010).

A species of *Aborichthys* collected from the Dikrong River, Arunachal Pradesh, India. © Waikhom Vishwanath

**Figure 3.4 Map showing endemic freshwater fish species richness in the Eastern Himalaya region.**



Most Gangetic endemics are currently categorized as Data Deficient or of Least Concern. Two species (*Schizothoraz richardsonii* and *Puntius chelynoides*) are categorized as Vulnerable, due to threats from non-native species and pressures from local fisheries, and two (*S. nepalensis* and *S. raraensis*) are categorized as Critically Endangered due to restricted distributions (Lake Rara, northwestern Nepal; Terashima, 1984).

#### Endemic fishes of Brahmaputra basin

The number of endemic species in the lower reaches of the Brahmaputra basin is comparatively small and the labyrinth fish *Ctenops nobilis* is a characteristic example. The level of endemism is strikingly higher in the mountain tributaries of the Brahmaputra and typical species are those of the genus *Aborichthys*, a number of catfish species of the families Amblycipitidae and Sisoridae, of the cyprinid genera *Danio* and *Devario*, or of the percomorph family Badidae. *Pillaia indica*, listed above as Endangered, is a typical hillstream species with a possibly localized distribution. A number of species in these mountain areas are currently categorized as Data Deficient and may contain additional endemics. Further studies involving the collection of new material from mountain streams in the Brahmaputra basin are needed and would without doubt result in the discovery of additional new freshwater fish species with localized distributions.

#### Endemic fishes of the Ayeyarwaddy basin

Abell *et al.* (2008) noted that there are more endemic species in the Sittaung-Irrawaddy region than in any of the Ganga-Brahmaputra sub regions. There also seem to be few species shared by the two drainage systems and the catfish *Pangasius pangasius* may serve as an example here. As with the Ganga and Brahmaputra drainages, the highest level of endemism in the Ayeyarwaddy is encountered in its mountain tributaries along the Rakhine Yoma and Chin Hills, the Bago Yoma and its northernmost tributaries along the Chinese border. Large areas of Myanmar are still poorly known and have not been sampled, with the Upper Chindwin and the mountain region around Lake Indawgyi being a prime example. The few specimens from the Chindwin area in museum collections indicate that a substantial number of new and endemic species can be expected from here. The few recent collections from the mountains around Indawgyi Lake yielded a number of interesting new species, including the spectacular *Danionella dracula* (see Britz *et al.* 2009), and *Danio tinwini* (see Kullander and Fang 2009), a popular aquarium fish. An area with a large number of endemic species compared to its size is the Rakhine Yoma with a total of at least 15 species restricted to the western slopes of the mountain range, a hand full of undescribed species, and another five possible endemics from the eastern slopes (Kullander and Fang 2009; Fang and Kullander 2009; Conway and Britz 2010; Ng 2004; Ng and Kottelat 2007).

### 3.3.4 Data Deficient species

About 27% of the 520 included species of fishes are assessed as Data Deficient. Given this relatively high percentage of species assessed as such, it is necessary to examine the underlying reasons for the lack of information in greater detail. Approximately half (74 out of 142) of the species assessed as Data Deficient have been described recently (within the last ten years). These species were described either from older material that had been misidentified, or from recent collections made (mostly) in poorly sampled areas. In many cases, the descriptions are based on only one or a handful of specimens. Given the (usually) small numbers of type specimens and the fact that the type series of these species are typically obtained from only a single locality, adequate information on the biology and distribution of these species for an accurate assessment is lacking. The incomplete knowledge

A scanning electron microscope view of *Danionella dracula*, the miniature cyprinid from northern Myanmar that shows fang-like jaw projections resembling true teeth. © Ralf Britz

*Channa pulchra* (DD), one of the species endemic to the western slopes of the Rakhine Yoma (Arakan mountain range), and is typical of the recently described Data Deficient species from this part of Myanmar. © Ralf Britz

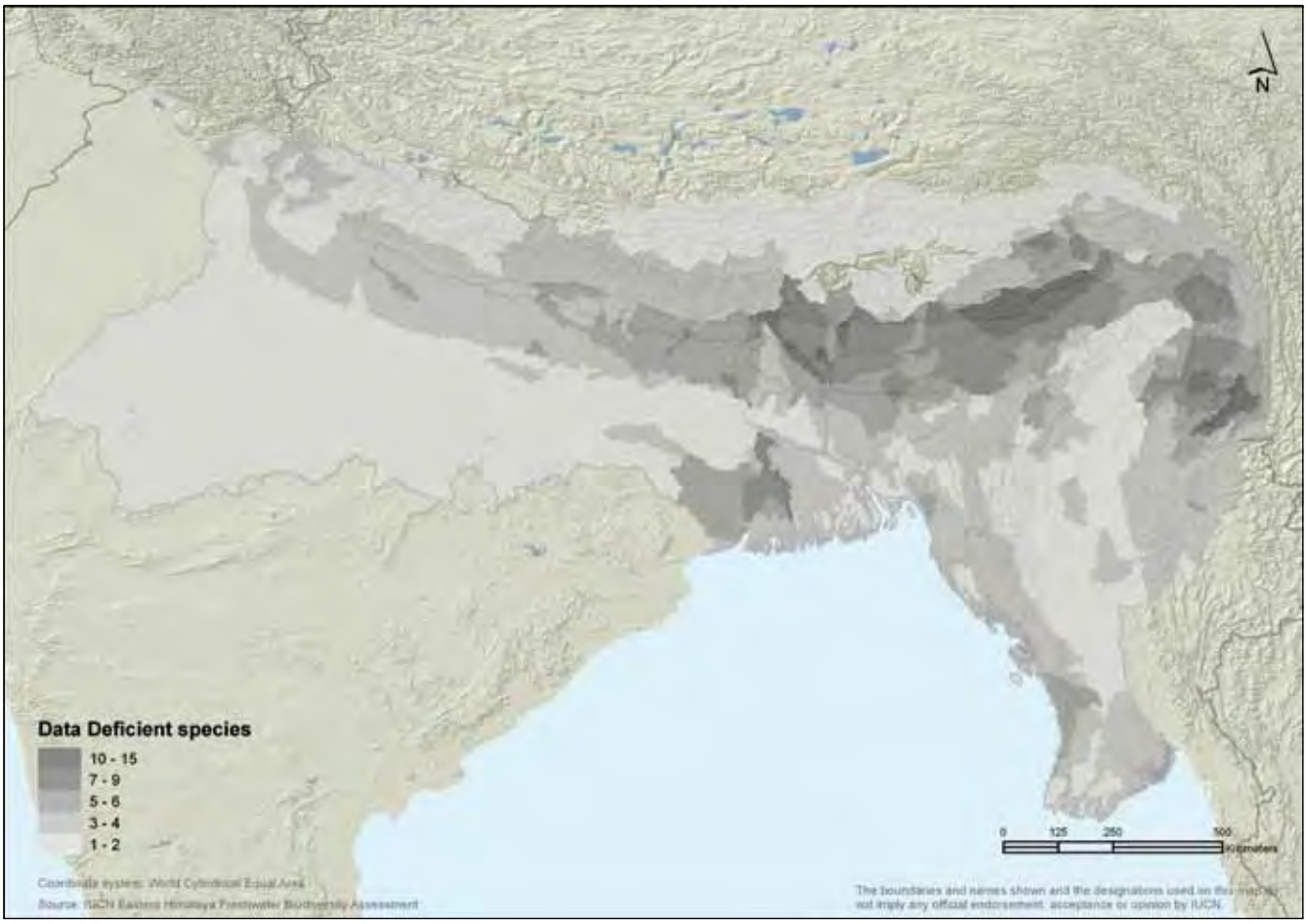
of the freshwater fish fauna of Myanmar and its distribution in the country are reasons for the large number of Data Deficient species in this country.

Of the remaining species assessed as Data Deficient, three of them (*Anabas cobojius*, *A. testudineus*, and *Gobiopterus chuno*) are widely distributed taxa that most likely consist of several morphologically similar species. Until the taxonomic identity of material from throughout their entire distributions can be adequately resolved, it is not possible to accurately assess the conservation status of these species because current information on their distribution and biology is deficient.

The remaining 65 species are assessed as Data Deficient primarily due to the uncertainty surrounding their taxonomic status, or because of the paucity of collection records in museum collections worldwide. These are species that are typically only known from the type series (e.g. *Balitora eddsi,* Conway and Mayden 2010). In some cases, the type specimens are no longer extant, making the identification of these species more difficult, especially if the original description and the accompanying figures (if any) are inadequate. Where specimens are available, these are usually collected from one or only a handful of localities and almost always without any information on the biology of the species, making an accurate assessment of their conservation status impossible at the moment.

The high percentage of species assessed as Data Deficient highlights the need for a much greater understanding of the freshwater ichthyofauna of the Eastern Himalaya. Given that discoveries of new species of fishes from this area are likely to continue at an accelerated pace, the disparity between our knowledge of the diversity and the biology threatens to grow wider. This is especially true for the small-sized species of freshwater fishes (for which we expect a much greater diversity to exist in the Eastern Himalaya than is currently recognized), that

**Figure 3.5 Data Deficient freshwater fish species richness in the Eastern Himalaya assessment region.**



are generally the last to be discovered in any surveys of freshwater fish fauna (Lundberg *et al.* 2000). In addition to the need for resolving the taxonomy of the freshwater ichthyofauna of the region, more quantitative data on yields and process-oriented investigations are also needed for a better understanding of the population of fish species in the Eastern Himalaya, as well as to provide ample information for the sustainable management of the freshwater fishery resources.

### 3.3.5 Extinct species

No species has been categorized as globally Extinct (EX) or Extinct in the Wild (EW) in the Eastern Himalaya assessment region or Hotspot. Molur and Walker (1998) reported *Osteobrama belangeri* (Valenciennes 1844), to be regionally Extinct in the Wild from India (Manipur). This minor carp is highly prized for its food value in Manipur. The species is presently known to be distributed in the Ayeyarwaddy basin in Myanmar only. Hora (1921) reported the species from Manipur Valley. Menon (1989) referred to the species as the Loktak fish of Manipur and reported the fish to be disappearing fast due to the introduction of common carp (*Cyprinus carpio)* in Loktak Lake. The species is known to migrate from the Ayeyarwaddy to Manipur Valley where they breed and grow. With the construction of the Ithai barrage across the Manipur River for the Loktak hydro-electric project in the early 1980s, the route of the species to the valley has been disrupted. The fish has been successfully induced to breed in captivity and is cultured in the state and has been declared as the 'State Fish of Manipur' by the government.

The Tanguar *haor* wetlands, a nationally and internationally important wetland in Bangladesh. © IUCN Bangladesh

## 3.4 Major threats to fishes

Anthropogenic modification of the riverine ecosystems of the Eastern Himalayan region have likely been going on for thousands of years. Given the fact that sustained and pervasive human impacts are typical of the rivers in the region, accurate

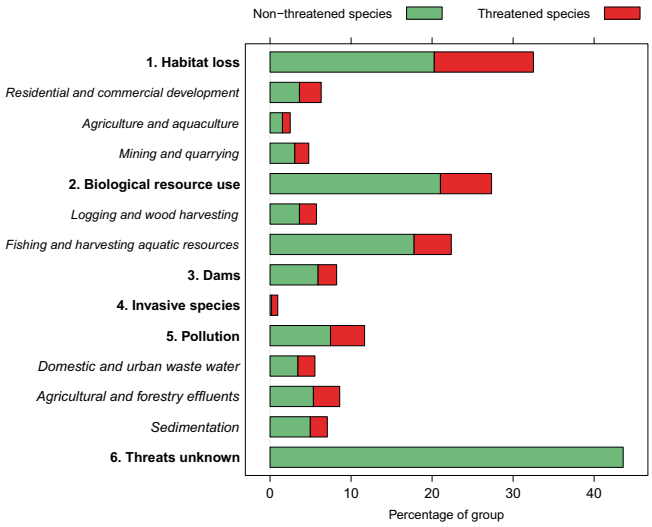
*Pangasius myanmar*, an important foodfish in the Ayeyarwaddy and lower Chindwin rivers. It is assessed as Data Deficient as further information is required on its distribution and population trends. © Ritva Roesler

assessment of the extent of human impacts on riverine biodiversity is impossible (Dudgeon 2000). The threats to freshwater biodiversity can be divided into five major categories (flow modification, habitat degradation, over-exploitation, species invasion and water pollution; after Dudgeon *et al.* (2006)). With the possible exception of species invasion, the other four threat categories are amply represented in the Eastern Himalaya, and should be regarded as the major threats to the freshwater ichthyofauna of the region. Major threats identified for species included in this assessment are shown in Figure 3.6.

### 3.4.1 Hydropower and irrigation dams

The Eastern Himalaya is a region criss-crossed with numerous river systems; given the strong human presence in this region, flow modification schemes such as dams and canals have a ubiquitous presence. Hundreds of multi-purpose reservoirs for water supply, irrigation, hydropower and fisheries have been constructed, as well as numerous barrages for water diversion (Smakhtin and Anputhas 2006). Such alterations of natural flow regimes have a negative effect on the freshwater ichthyofauna of the region, such as the obstruction of fish breeding migrations (Dudgeon 2005). Some of these dams (e.g. the Farakka barrage in the Ganga River) have been around for some time, and their negative impact on the fish populations has been documented, particularly for fish species undertaking spawning migrations such as *Tenualosa ilisha* (briefly reviewed in Rahman (2006)). Although an ecological catastrophe was narrowly averted with the cancellation of the Inter-Linking of Rivers Plan (a massive project that envisaged the linking of many of the major river drainages in India to divert water from the Ganga-Brahmaputra system to the drier areas in the southern and western parts of the country), flow modification of the river systems in the Eastern Himalaya has become an irrevocable part of the landscape (given the pressing need for water resources in the region) and the termination of this scheme is likely to be only temporary.

**Figure 3.6 Percentage of freshwater fishes impacted by selected major threats in the Eastern Himalaya assessment region. Note that many species have more than one threat listed.**




### 3.4.2 Habitat degradation

In addition to flow modification, the freshwater ichthyofauna of the region is also threatened by habitat degradation. Many floodplains have been cut out from rivers by embankments and remaining riparian lands are under intensive agriculture and grazing pressure. Human settlements, shifting agriculture, deforestation, mining and other activities have also degraded the river catchments and increased the sediment loads of all rivers (Smakhtin and Anputhas 2006). Although the effects of increased turbidity on fishes in general are well documented (Bruton 1985), very little is known about its direct impacts on the freshwater ichthyofauna of the Eastern Himalaya.

### 3.4.3 Exploitation

The over-exploitation of fishes, chiefly for food, is a major concern within the Eastern Himalaya. Overfishing in inland fisheries can have severe consequences, not only for freshwater ecosystems, but also for the human inhabitants of the area (Allen *et al.* 2005). Given that the area encompasses some of the most densely inhabited areas of the Indian subcontinent, the pressure to fish populations from capture fisheries is undoubtedly very high. The fact that the inland fisheries in the Indian subcontinent are largely unregulated is a major cause for concern. Another major obstacle to the sustainable management of the freshwater fisheries resources is the paucity of empirical data regarding levels of exploitation and their effects on the fish populations. The little available data paints a sobering picture, with steep declines in catches of common food fish species over the last few decades strongly implying that current levels of exploitation are clearly unsustainable (Mishra *et al.* 2009; Patra *et al.* 2005).

### 3.4.4 Introduced species

The impacts of alien invasive fish species on the freshwater ichthyofauna of the Eastern Himalaya has received little attention. There have been few published inventories mapping the distributions of invasive species. Although they have been listed in more general faunistic works of the region (e.g. Vishwanath *et al.* 2007) the few studies on invasive fishes available are frequently geographically restricted (e.g. Bhakta and Bandyopadhyay 2007). It is indicative of the state of research on alien invasive fishes of the

A female of *Danionella translucida* (LC), the smallest freshwater fish in the Eastern Himalaya region. © Ralf Britz

Loktak Lake, the largest freshwater lake in northeastern India. © Waikhom Vishwanath

**Box 1. Threats in the Manipur Valley and Loktak Lake. Waikhom Vishwanath**

Unlike Inle Lake in Myanmar, fish species in Loktak Lake are not specialized and restricted to the lake (Hora 1921), being also found in the nearby streams of the valley. Manipur Valley was very rich in its native species and Hora (1921) listed 56 species from the state and described six new species. However, many species have been lost from Loktak Lake as a result of the introduction since the 1980s by the state government of Indian and Chinese carps for aquaculture, and by over-exploitation. The major traditional fishery in the lake was for *Osteobrama belangeri* and *Wallago attu* using traditional *phoom namba* fishing methods. Menon (1989) observed that *O. belangeri*, was nearing extinction due to the introduction of Common carp. Other once common lake and valley species such as *Crossocheilus burmanicus Syncrossus berdmorei, Ompok bimaculatus, Puntius conchonius* and *Labeo pangusia* are now missing, replaced by Grass carp, Common carp, *Notopterus notopterus*, and *Oreochromis* spp. The lake has become a reservoir facilitating the spread of introduced species.

Construction of the Ithai Barrage has disrupted migration of fishes from the lake, and some species have lost their spawning habitats. Species such as *Syncrossus berdmorei* and *Raiamas guttatus* that were widely found in swamps, streams and irrigation canals have been lost from these habitats around the lake. Singh and Shyamananda (1994) reported that the Loktak Lake ecosystem had changed considerably since the commissioning of the Loktak multipurpose project. The natural wetlands with fluctuating water level had been converted into a reservoir with almost constant water level. During heavy rainfall and floods, siltation has resulted from soil erosion. Wetlands have also been impounded for agriculture.

Below the lake, the flows in many of the rivers in the plain have declined, especially in the winter, with water held back in the reservoir, and available water abstracted for irrigation and water supply.

Sand and pebble mining occurs widely for use as construction materials. As a result, populations of species such as *Lepidocephalichthys guntea, L. berdmorei, L. irrorata* and *Pangio pangia* have drastically declined.

region that the highly invasive loricariid catfish *Pterygoplichthys* has only been reported from the Eastern Himalaya relatively recently (Hossain *et al.* 2008; Sinha *et al.* 2010), despite the fact that it was most likely been introduced to the region much earlier. In a similar vein, the negative impact of the alien invasive common carp (*Cyprinus carpio*) on native cyprinids in the Ganga River drainage has only recently been documented (Singh and Lakra 2006; Singh *et al.* 2010) even though this species is likely to have been established decades ago (having been introduced in India as an aquaculture species about 50 years ago). This mirrors the situation in southern India, where the potential impacts of alien invasive fishes on the native freshwater ichthyofauna are only now beginning to be studied in greater detail (e.g. Khan and Panikkar 2009; Knight 2010). We can thus consider the state of our knowledge on invasive fish species and their impacts on the native ichthyofauna in the Eastern Himalaya to be early in the learning curve.

Concern over some introduced species is such that in 1997, the Indian Ministry of Agriculture wrote to all states and union territories of India calling for the destruction of all stocks of *Clarias gariepinus* and Bighead carp (*Hypopthalmichthys nobilis*) which have been introduced into the country without official sanction. However, the species are widely available in the markets in parts of India, illustrating the difficulty of controlling introduced species.

### 3.4.5 Pollution

The major rivers in the Eastern Himalaya, particularly the Ganga and the lower reaches of the Brahmaputra suffer from considerable pollution as a consequence of the high human density in the region, urban and transport development, industrial and agricultural activities, and a number of other activities. Untreated sewage, industrial effluents, pesticides and partially cremated human bodies are routinely discharged into the Ganga (Ahmad *et al.* 1996; Ajmal *et al.* 1984; Pimentel *et al.* 1999). The effects of pollution in the major river systems of the Eastern Himalaya have been well documented (Edds *et al.* 2002; Gopal and Agarwal 2003).

## 3.5 Conservation recommendations

Freshwater fishes of the Eastern Himalaya region are under anthropogenic pressures and a total of 70 species (13.9%) are considered threatened, while 46 (8.8%) are Near Threatened. The deteriorating ecological situation of aquatic water bodies and their catchments due to various human activities are causing critical problems for many fish populations and aquatic biodiversity in general. Fishes also underpin the livelihoods of many, especially rural, households and communities. There is a need therefore to take necessary steps to conserve fish genetic resources and their habitats on the one hand, and to develop rational and efficient utilization and management of fish stocks on the other. There is an urgent need for the conservation of fish species across the region for both economic and ecological reasons (e.g. Menon 2004). Since the region harbours many threatened or endemic species, the measures below are suggested. Clearly, any conservation measures require both funding and the political will of regional governments to implement and enforce the suggestions.

### 3.5.1 Deforestation

Programmes to reduce the rate and extent of forest loss and degradation and to promote forest restoration in river catchments are urgently needed. An integrated approach is required to address such issues as land rights and resource access, livelihood security, and agricultural development (e.g. to reduce dependence on shifting agriculture).

Afforestation is a practical means of reducing soil erosion in catchments. An extensive social forestry programme would effectively reduce degradation and loss of forest cover, and the practice of *jhum* (shifting) cultivation might be controlled. This would ultimately help to retain vegetation cover and reduce silt burdens in rivers.

### 3.5.2 Pollution

Water quality needs to be greatly improved across much of the region, especially in the lower parts of rivers, including the Ganga and Brahmaputra, and measures taken to maintain water quality in rivers that are as yet less impacted by pollution from sedimentation, agriculture, industrial and urban sources. While reporting on the pollution status of the Moirang River, a small river draining into the Loktak Lake in Manipur, Kosygin *et al.* (2007) remarked the water quality of the river needs to be improved if it is to be used for fisheries purposes. Further, they suggest that the discharge of untreated municipal sewages and the use of agrochemicals in river catchments should be controlled and reduced.

This requires training in the development and implementation of water quality monitoring, assessment and control, as well as investment in pollution reduction technologies and the effective enforcement of legislation.

### 3.5.3 Dams

The extensive development across much of the region, both current and planned, of hydropower and irrigation dams should be informed by appropriate environmental impact assessments that take into account impacts on migratory and commercially valuable fish species, and the environmental flow requirements of all species.

The restoration of natural flow regimes should be adopted by dam and river management authorities, and technologies to mitigate the impact of barrages to migratory species implemented.

The Tista barrage, an irrigation dam on the Tista River in West Bengal. A series of dams are planned on the river in India, with an estimated total capacity of 50,000 MW. © Heok Hee Ng

### 3.5.4 Invasive species

The control of introduced species of fish, as well as other species that impact upon fishes and their habitats (e.g. invasive aquatic plants) is urgently needed. Research is required into effective control methods. Action, including the effective implementation of existing legislation, is needed to minimize the movement and introduction of invasive alien species to systems where they are not yet present.

### 3.5.5 Education and community engagement

Local communities should be encouraged to participate in the conservation of fishes and their habitats, including awareness programmes on the status and importance of fishes and their habitats. The concept of *Social Fencing* has been developed, where local communities themselves protect fish stocks and their habitats. Such initiatives depend on the development of trust between communities and regulatory authorities.

A key component of education programmes should include the production of information and identification materials in local languages and using local names where relevant, especially for threatened species. The distribution of clear photo-identification cards to fishing communities would allow them to start managing fish stocks.

### 3.5.6 Fish and habitat sanctuaries

Fish sanctuaries for the protection of threatened species or vulnerable habitats should be established in suitable areas. The upper portion of the Ganga-Brahmaputra drainages in northeastern India and Nepal and parts of Myanmar (e.g. the

Electrofishing at Rishi Khola, on the border between West Bengal and eastern Sikkim, India. © Antti Vuorela

**Box 2. The ornamental fish trade in the Eastern Himalaya region: northeastern India**

**Heok Hee Ng**

The export of wild-caught ornamental fishes from India accounts for less than one percent of the global market (Mahapatra *et al.* 2007), however the Eastern Himalaya (encompassing northeastern India) is a key area where a substantial industry in wild-caught ornamental fishes exists (the other being southwestern India). Approximately two hundred species of freshwater fishes from this region have been caught and exported as ornamental fishes (Mahapatra *et al.* 2007), although less than half are exported regularly (H.H. Ng per. obs.). This is said to account for about 85% of all exports of ornamental fishes from India (Mahapatra *et al.* 2005). Unlike the case in southwestern India, where collection for the ornamental fish trade can be a major threat to the populations of some freshwater fishes (Raghavan *et al.* 2007, 2009), there are no current indications that collection for the ornamental fish trade is substantial enough in the Eastern Himalaya to pose a major threat to the fish populations there. However, empirical data in the form of capture statistics are badly needed to support this inference.

Rakhine Yoma region) would seem to be suitable areas for protection of species such as *Tor putitora, Semiplotus semiplotus*, *Schizothorax nepalensis*, *Amplyceps arunachalensis*, *Botia rostrata*, *Devario horai, Garra flavatra,* and *Lepidocephalichthys arunachalensis*. Similarly, the upstream areas of the Chindwin drainage in Myanmar and India (Manipur) could be protected for *Psilorhynchus microphthalmus*, *Barilius dogarsinghi*, *Garra compressus*, *Schistura kangjupkhulensis*, *S. nagaensis*, *S. prashadi*, and *Yunnanilus brevis*.

### 3.5.7 Implementation of domestic and international legislation

Legislation currently exists across most if not all of the region to effectively conserve aquatic biodiversity and habitats, however such legislation is not always effectively implemented.

Destructive fish harvesting techniques such as dynamiting, poisoning and electric fishing should be prevented, and laws on catching brooders formulated at the national and trans-boundary level.

### 3.5.8 Research and training

Regular monitoring of habitat condition and population trends of fishes should be undertaken. Maintenance of ecological

**Box 3. The ornamental fish trade in the Eastern Himalaya region: Myanmar**

**Ralf Britz**

Since the early 2000s the ornamental fish business in Myanmar has greatly increased its international significance and has been responsible for the export internationally of some extremely popular aquarium fishes. These are mostly small and colourful fishes, like *Danio choprae*, *D. margaritatus*, *D. tinwini*, *D. kyathit* or *Puntius padamya*. Due to considerable logistical problems in the country and the small number of exporting companies, the number of individuals removed from the wild and exported does not affect the natural populations in any significant negative way. Very localized species or populations could potentially come under threat, but this has not happened so far. The purported threat to *D. margaritatus* (the Galaxy or Celestial Pearl Danio) through overfishing and habitat destruction by ornamental fish collectors, was demonstrated to be without substance, as the species was found to be much more widely distributed and not restricted to the small pool where it was first discovered. The threat posed by habitat alterations, the most significant of which in Myanmar is possibly the building of dams, is expected to be much more severe.

In recent years, a number of newly discovered species with potential ornamental value, like *Channa ornatipinnis* or *Garra flavatra*, have appeared in the trade just weeks after their description and some of the new species have been known from the ornamental fish trade before they were collected and scientifically described, like *Danio tinwini*. Many of the 'big surprises' and spectacular imports in the ornamental fish market in recent years have come from Myanmar. This country has certainly the potential to expand its ornamental fish export business considerably.

*Garra flavatra*, a very popular aquarium fish, endemic to drainages on the western slope of the Rakhine Yoma in Myanmar. © Ralf Britz

processes and functions of water bodies in the region is essential for the successful conservation of fishes and their habitats.

Detailed knowledge of the habitat ecology and biology of fishes is essential for the conservation and sustainable use of threatened fishes especially.

Research and training in fish taxonomy should be promoted, and resources made available to ensure that workers have access to current international taxonomic research.

### 3.5.9 Sustainable utilization of fish resources

Fish resources should be wisely utilized. The challenge therefore is to conserve fish, while providing sustained benefits to the local communities, who are dependent upon these resources.

## 3.6 References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# Chapter 4. The status and distribution of freshwater molluscs of the Eastern Himalaya

Prem B. Budha[1], N.A. Aravind[2] and B.A. Daniel[3]



## 4.1 Overview of freshwater molluscs of the Eastern Himalaya: Geomorphological factors affecting distribution

The Eastern Himalayas rise abruptly from 500 m to over 8,000 m and include some of the world's deepest river gorges as well as the world's highest mountain. This complex landscape contains ecosystems that range from alluvial grasslands and subtropical broadleaf forests amongst the foothills to temperate broadleaf forests in the mid-hills, mixed conifer and conifer forests in the higher hills, and alpine meadows above the tree line. The region constitutes one of the most diverse alpine botanic zones on earth, and amongst the most ecologically diverse assemblages of vertebrates. This diversity is threatened by habitat loss, fragmentation, and degradation making the region a priority for conservation investment. Although invertebrates are protected by international, national, and local legislation, lists of protected species under-represent invertebrates on which to base conservation actions, and often include only the largest, most conspicuous species (Strayer 2001).

[1] Centre for Biological Conservation, P.O. Box 1935, Kathmandu, Nepal. prembudha@yahoo.com
[2] Suri Sehgal Centre for Biodiversity and Conservation, and Academy for Conservation Science and Sustainability Studies, Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Srirampura, Jakkur PO, Bangalore 560064, India. aravind@atree.org
[3] Zoo Outreach Organisation, Box 1683, 9A, Lal Bahadur Colony, Peelamedu, Coimbatore 641 004, India. badaniel@zooreach.org

To address this gap in our knowledge, the current study assessed the distribution and conservation status of molluscs in the Eastern Himalaya. It should be recognized that many taxonomic problems persist in the current literature and that the regional taxonomy requires further work to resolve these issues. Inconsistencies between available data clearly indicate that the taxonomic situation is still a major problem in establishing a database for species conservation planning in the region. However, we would like to emphasis that the assessment is based on the best available data for this region in the published literature and available in the public domain.

Among aquatic invertebrates, molluscs are among the most important species for monitoring the presence and effects of toxic substances in aquatic ecosystems (Salanki *et al.* 2003), and form an important component of most biological monitoring programmes that rate water quality and status of aquatic systems based on invertebrate assemblages (Ponder 1994; Seddon 1998; Strong *et al.* 2008).

The freshwater gastropod fauna belongs to the clades Neritimorpha, Caenogastropoda and Heterobranchia (including the Pulmonata) (Strong *et al.* 2008). They are distributed in a wide range of habitats including rivers, lakes, streams, swamps, springs, temporary ponds, drainage ditches and other ephemeral and seasonal waters. Highest diversity occurs in the tropics with decreasing species richness and endemicity at higher latitudes (Strong *et al.* 2008) and altitudes.

There are 206 recognized genera of freshwater bivalves, most families represented by only one to five genera (Bogan 2008). Two main areas of diversity and endemism in freshwater bivalves are the southeastern United States and the Oriental zoogeographic regions (Bogan 2008). The freshwater bivalve fauna of the Oriental Region is represented by eight families, 47 genera and 150 species. Gargominy and Bouchet (1998) identified 27 areas of special importance for freshwater mollusc diversity as key hotspots of diversity with high rates of endemism among freshwater gastropods. The present assessment includes a total of 186 species including 112 gastropods and 74 bivalves, however, systematic status of many species is still unclear and biology of most of the species is poorly understood.

### 4.1.1 Secondary freshwater species (brackish water species)

The Neritidae, Assimineidae and Iravadiidae are brackish water marine families. In the assessment region, seven species from Assimineidae and two species from Iravadiidae are represented and they are exclusively brackish water species.

### 4.1.2 Biogeography of Eastern Himalayan freshwater molluscs

Biogeographically, most families of freshwater mollusc of the Eastern Himalayan region are cosmopolitan. The families Thiaridae, Planorbidae, Lymnaeidae, Viviparidae, Bithyniidae, Unionidae, and Corbiculidae have global distributions; whereas the Ampullariidae and Pachychilidae are more tropical, found in South America, Africa and Asia. The genus *Brotia* is predominantly found in Southeast Asia, and is represented by only one species (*Brotia costula*) within the current assessment region. Some species such as *Sulcospira huegeli* show a disjunct

Women from a community in Kailali District, southwestern Nepal, collecting gastropods for consumption. © Prem B. Budha

distribution, being found in the central and southern Western Ghats and in northeastern Indian states (Subba Rao 1989).

### 4.1.3 Earlier studies and taxonomic problems of Eastern Himalayan freshwater molluscs

Studies of freshwater molluscs of the Eastern Himalaya hotspot region were at their peak during the late 19th and early 20th centuries. Prashad (1928) and Preston (1915) contributed much to our knowledge on the taxonomy and distribution of molluscs in the region. Later, the Zoological Survey of India (ZSI) surveyed northeastern Indian states and published checklists of species occurring in different states in (e.g. Fauna of West Bengal, Fauna of Meghalaya, and the Fauna of Tripura). Recently, Nesseman *et al.* (2007) contributed to our knowledge of the freshwater molluscs of the Ganga River basin in India and Nepal. However, there are some taxonomic issues that need to be addressed urgently (for example, the species recently described by Nesseman *et al.*, needs further clarification). The taxonomic status of several species, including *Lymnaea shanensis* and *Parreysia olivacea*, collected from lakes in Myanmar need to be verified as these species have not been collected again since they were described. There has been little recent study of molluscs across large parts of the region, including Bhutan, parts of Nepal, and Myanmar, as well as several states in India.

## 4.2 Conservation status

The summary presented here is based on an assessment of 186 species of freshwater molluscs following application of the IUCN Red List Categories and Criteria (IUCN 2001) (Table 4.1). This assessment includes 112 (60%) species of Gastropoda and 74 (40%) species of Bivalvia. Of these, only two species were assessed as Threatened; *Lymnaea ovalior* and *Tricula mahadevensis*, both assessed as Vulnerable (VU). One species (*Sphaerium austeni*) was assessed as Near Threatened (NT) (Table 4.2). Most species were assessed as either Least Concern (66.1%) or Data Deficient (32.3%) (see Table 4.1 and Figure 4.1). The high number of Data Deficient species indicates that the information on population status, habitat, distribution and threats at species level is absent or deficient for these species. Our knowledge of freshwater molluscs from parts of the region is especially limited, mainly due to the lack of scientists working in that region due to political instability (e.g. in Myanmar). Data for many DD species are known only from 19th or 20th century descriptions. They have often not been collected since they were first collected, and further expert survey across the region is required to determine to conservation status of these species.

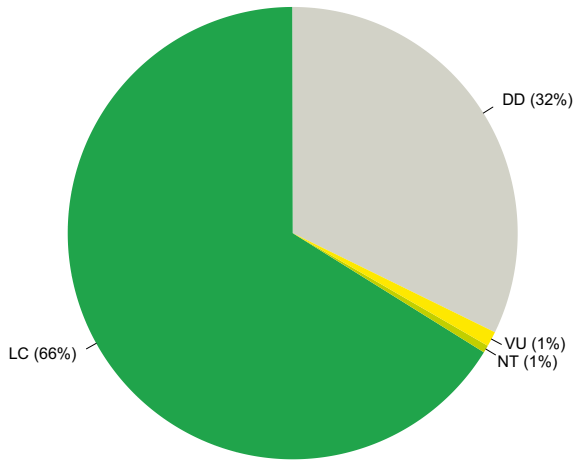
**Table 4.1 Number of species of freshwater mollusc in each Red List category.**

| | Global Red List Category | Number of species |
|---|---|---|
| Threatened categories | Extinct | 0 |
| | Extinct in the Wild | 0 |
| | Critically Endangered | 0 |
| | Endangered | 0 |
| | Vulnerable | 2 |
| | Near Threatened | 1 |
| | Least Concern | 123 |
| | Data Deficient | 60 |
| | **Total** | **186** |

**Table 4.2 Threatened and Near Threatened freshwater molluscs of the Eastern Himalayan Hotspot.**

| Order | Family | Species | Category |
|---|---|---|---|
| Gastropoda | Lymnaeidae | *Lymnaea ovalior* | VU |
| Gastropoda | Pomatiopsidae | *Tricula mahadevensis* | VU |
| Bivalvia | Sphaeriidae | *Sphaerium austeni* | NT |

**Figure 4.1 Percent freshwater mollusc species in each global Red List category.**




### 4.2.1 Gastropoda

Thirteen gastropod families in 33 genera comprising 112 species (Table 4.3) from the Caenogastropoda and Pulmonata. The Thiaridae is the most dominant family representing 19% of species within the region followed by Planorbidae (17%) and Lymnaeidae (9%). In terms of genera representation, the Planorbidae has highest number of genera with 19%, followed by Neritidae (13%) and Bithyniidae (13%). Two species of gastropods (*Lymnaea ovalior* and *Tricula mahadevensis*) out of 112 are threatened and the remainder are either DD or LC.

**Table 4.3 Gastropods of the Eastern Himalaya.**

| Family | Genus | Species | Data Deficient | Least Concern | Near Threatened | Vulnerable |
|---|---|---|---|---|---|---|
| Ampullariidae | 1 | 3 | - | 3 | - | - |
| Assimineidae | 1 | 7 | 1 | 6 | - | - |
| Bithyniidae | 4 | 7 | 3 | 4 | - | - |
| Bullinidae | 1 | 1 | - | 1 | - | - |
| Iravadiidae | 1 | 2 | 1 | 1 | - | - |
| Lymnaeidae | 3 | 15 | 4 | 10 | - | 1 |
| Neritidae | 5 | 9 | 1 | 8 | - | - |
| Pachychilidae | 2 | 2 | - | 2 | - | - |
| Planorbidae | 5 | 18 | 7 | 11 | - | - |
| Pomatiopsidae | 2 | 8 | 6 | 1 | - | 1 |
| Stenothyridae | 2 | 10 | 4 | 6 | - | - |
| Thiaridae | 3 | 22 | 8 | 14 | - | - |
| Viviparidae | 3 | 8 | 2 | 6 | - | - |
| **Total** | **33** | **112** | **37** | **73** | **-** | **2** |

**Table 4.4 Freshwater bivalves of Eastern Himalaya region.**

| Family | Genus | Species | Data Deficient | Least Concern | Near Threatened | Vulnerable |
|---|---|---|---|---|---|---|
| Arcidae | 1 | 2 | - | 2 | - | - |
| Corbiculidae | 2 | 8 | 2 | 6 | - | - |
| Solecurtidae | 1 | 1 | - | 1 | - | - |
| Sphaeriidae | 4 | 14 | 4 | 9 | 1 | - |
| Unionidae | 8 | 49 | 17 | 32 | - | - |
| **Total** | **16** | **74** | **23** | **50** | **1** | **-** |

### 4.2.2 Bivalvia

Freshwater bivalves of the Eastern Himalayan region belong to five families (16 genera and 74 species). Family Unionidae is the dominant group, containing 66% of species found in the region, followed by Sphaeriidae (21%) and Corbiculidae (10%) (Table 4.4). Family Solecurtidae is represented by only one species, *Novaculina gangetica*, endemic to coastal areas of West Bengal. Among the 74 species of bivalves assessed only *Sphaerium austeni* is classified as Near Threatened.

## 4.3 Patterns of species richness

### 4.3.1 All molluscs

A total of 186 species of freshwater molluscs composed of 112 species of gastropods and 74 species of bivalves have been assessed for this region (Table 4.5, Figure 4.2). Areas of high species richness are seen in the Ganga delta and basins of the Ayeyarwaddy River in Myanmar. The species richness of freshwater molluscs in the Eastern Himalayan hotspot region decreases from east to west. The farthest western region of the hotspot has fewer than 40 species, compared to eastern region, where nearly 130 species occur. This variation can be attributed in part to a lack of survey data from the western region however the principle factor is likely to be the richer landscape to the east where high mountains, deep valleys, rivers, streams and many lentic habitats such as large lakes, coastal estuaries and manmade habitats provide a broad range of different habitats for mollusc species. The area with the highest species richness coincides with area with the highest levels of Data Deficient species. This shows that for an exceedingly high proportion of species we lack detailed information.

It is interesting to note that a very large proportion of gastropods are found in lentic habitats (56% of species) compared to bivalves (8%). On the other hand, a very significant proportion of bivalves are confined to lotic habitats (72%) as against gastropods (38%). A total of 21 species (six gastropods and 15 bivalves) are found to inhabit both lentic and lotic habitats. Families Lymnaeidae, Assimineidae, Bulinidae and Pomatiopsidae are exclusively lentic habitat specialists. Families Arcidae, Corbiculidae, Solecurtidae, Iravadiidae, Neritidae and Pachychilidae are exclusively lentic habitat specialists (Table 4.6). Species such as *Lymnaea luteola, L. acuminata, Indoplanorbis exutus*, and *Gyraulus convexiusculus* are common, even in polluted waters.

**Table 4.5 Species diversity of freshwater molluscs in the Eastern Himalaya region.**

| Class | Number of Families | Number of genera | Number of species |
|---|---|---|---|
| Gastropoda | 13 | 33 | 112 |
| Bivalvia | 5 | 16 | 74 |
| **Total** | **18** | **49** | **186** |

**Table 4.6 Habitat associations of freshwater molluscs in the Eastern Himalaya region.**

| Class | Number of species | Lentic | Lotic | Both |
|---|---|---|---|---|
| Gastropoda | 112 | 63 | 43 | 6 |
| Bivalvia | 74 | 6 | 53 | 15 |
| **Total** | **186** | **69** | **96** | **21** |

Note that a number of mollusc species were mapped based on country (in the case of Nepal, Bhutan, Myanmar and Bangladesh) or sub-country (China and India) units due the absence of detailed distribution knowledge for many species, and the analysis maps shown here should interpreted with some caution.

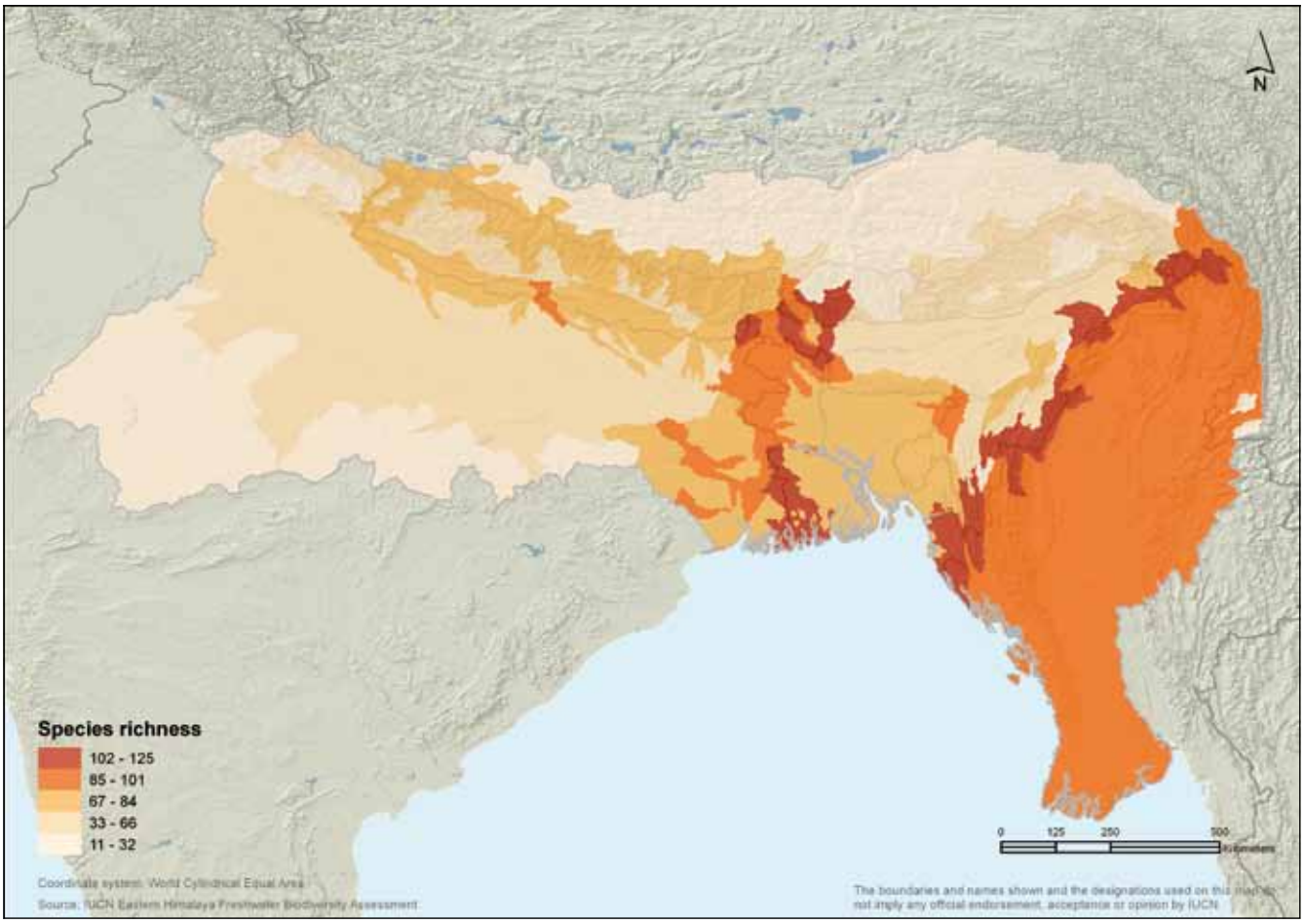
### 4.3.2 Threatened species

The Eastern Himalaya assessment, based on available literature and personal observation, reported only two threatened species (*Lymnaea ovalior* and *Tricula mahadevensis*), both assessed as Vulnerable due to restricted distributions, and one Near Threatened species (*Sphaerium austeni*).

*Lymnaea ovalior* (VU) is currently only known from Loktak Lake, in Manipur, which is the largest freshwater lake in northeastern India. The lake is impacted by settlements around the edge of the lake, especially sedimentation and siltation caused by the loss of vegetation cover from the surrounding catchment, and from the effects of the nearby Loktak Hydropower Project on the Manipur River that feeds the lake. Further survey work is required to confirm the current distribution of the species.

The other threatened species, *Tricula mahadevensis*, has been recently described from the mid-hill streams of central Nepal (Nesemann *et al.* 2007). Specimens were collected from Mahadev Khola (a forest stream) in the upper reaches of Nagarkot, Bhaktapur District, within the Kathmandu valley, Nepal. Although further research is required to confirm its taxonomic status and distribution, it has been assessed as Vulnerable due to a suspected restricted distribution, with threats to its unpolluted forest hill streams habitat from tourist developments and water pollution in the vicinity. The Near Threatened species, *Sphaerium austeni*, occurs only in montane pools of Nagaland (Naga Hills) and Manipur in India (Subba Rao 1989).

**Figure 4.2 Species richness of freshwater molluscs in the Eastern Himalaya region.**



### 4.3.3 Endemic species

Within the Eastern Himalaya region, the number of endemic species is highest in northeastern India and western Myanmar (see Figure 4.3). The Brahmaputra River basin is particularly diverse compared to the Ganga River basin. This can be attributed to high habitat heterogeneity and a varied microclimate existing in the former region. The northeastern region of the hotspot harbours some unique and endemic freshwater mollusc such as *Solenaia soleniformis*, several species of *Parreysia* and *Pseudodon* that are known only from the Myanmar drainages.

### 4.3.4 Data Deficient species

One third (32.6%) of the Eastern Himalayan freshwater molluscs have been assessed as Data Deficient (Table 4.7, Figure 4.4) either because they have not been collected since they were described during colonial periods, or because of a lack of information on their current status. As is the case with some African freshwater molluscs (see, for example, Darwall *et al.* 2005; 2009), a lack of anatomical studies of the original material of Eastern Himalayan specimens makes it impossible to determine if specimens collected later are in fact the same as species described earlier. This is especially true for several bivalves and some gastropods collected and described from the Myanmar region. In the region, Data Deficient species occur across 14 families and 25 genera. Many species collected from several parts of the region during early 20th century have not been collected since and no information on their ecology, population structure, and threats is available. Hence, there has been lot of ambiguity about the identity of these species.

Many of these Data Deficient species are known to occur or have been reported from highly polluted or highly disturbed rivers or lakes such as the middle and lower parts of the Ganga and Brahmaputra rivers and delta. These DD species might be Critically Endangered or even be Extinct given the level of disturbance to the habitat in which they occur and detailed studies are urgently needed to assess the status of these species.

The Kathmandu valley, showing habitat similar to the type locality of *Tricula mahadevensis* (VU). © David Allen

**Figure 4.3 Endemic mollusc species richness in the Eastern Himalaya region.**

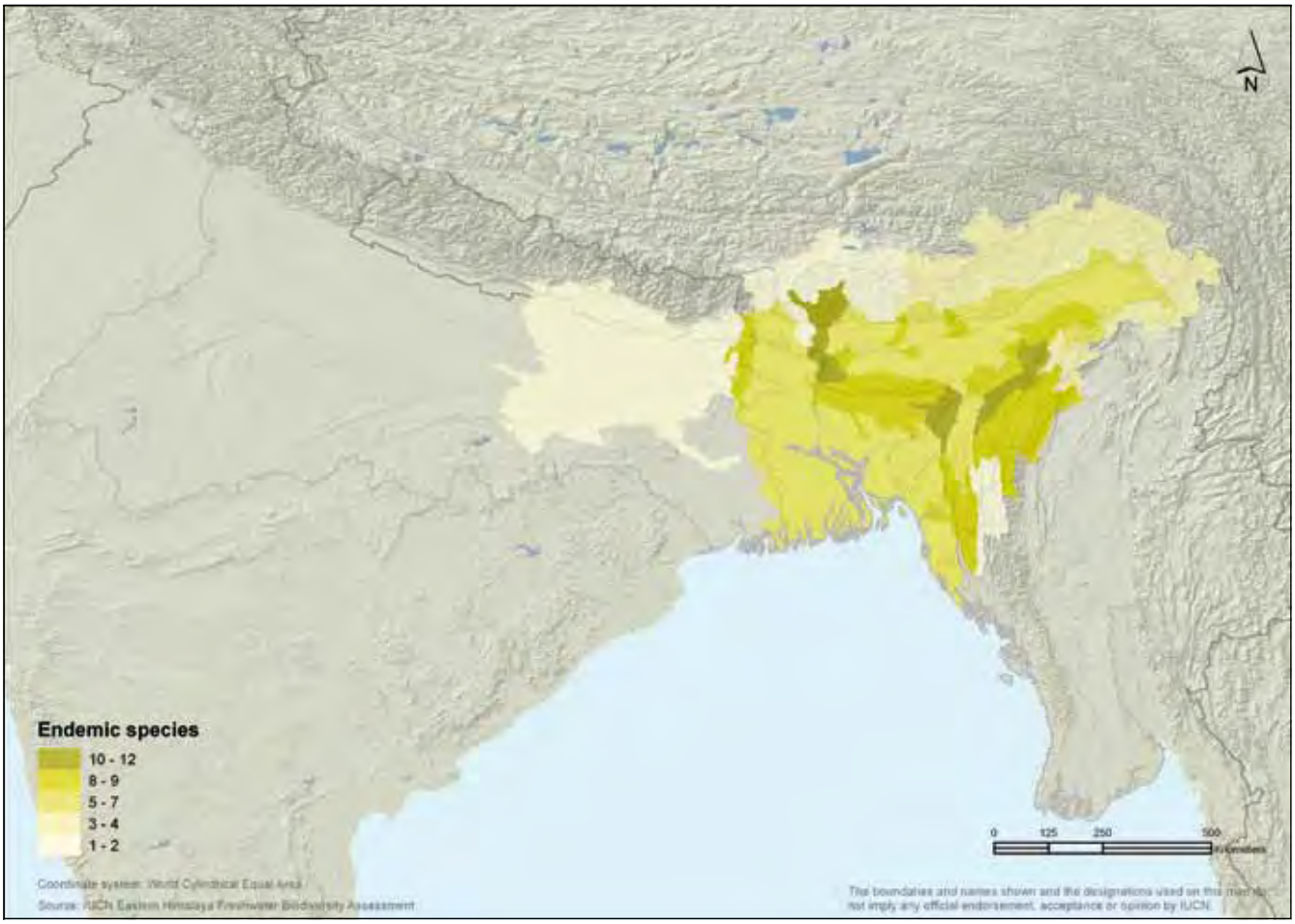



**Table 4.7 Data Deficient species of the Eastern Himalaya region.**

| Class | Number of families | Number of genera | No. of species |
|---|---|---|---|
| Gastropoda | 11 | 17 | 38 |
| Bivalvia | 3 | 8 | 23 |
| **Total** | **14** | **25** | **61** |

## 4.4 Major threats to freshwater molluscs

Many aquatic species in lakes and streams have limited distributions making them particularly vulnerable to extinction (Primack 2001). Terrestrial and freshwater molluscs represent the most threatened group of animals (Lydeard *et al.* 2004). Of the 2,306 species of freshwater molluscs assessed globally, 45% of species are threatened (CR = 291; EN = 245; VU = 500, total 1,036), 25% species are Data Deficient and 13% species are already extinct (IUCN 2009). This decline is well documented for the very diverse freshwater molluscan fauna of the southeastern United States and highlights the need to assess freshwater species globally (Bogan 1993; Lydeard *et al.* 2004; Neves *et al.* 1998) to provide guidance for conservation action and establish a baseline on which to assess its effectiveness. The consensus is that the most dramatic cause of the declines and extinctions of freshwater bivalves are associated with habitat modification and destruction arising from the effects of dams, canalization, changes in water depth, flow regime changes, and siltation. These modifications affect not only the freshwater mussels, but also the fish that some unionoid mussels depend on during their parasitic life stage.

Additional threats to aquatic molluscs in the Eastern Himalayan hotspot include water abstraction for industry and irrigation, pollution, agricultural intensification, impacts resulting from the use of poisons and other damaging fishing practices, and urban runoff. Among these, pollution, agriculture and urban runoff are the major factors (Figure 4.5). However, it is clear that a great deal more information is required on the scope, scale and impact of threats across the region, as shown by the large number of species for which threats are unknown.

### 4.4.1 Harvesting

Freshwater mussels are in great demand because of their use in lime manufacturing industry (for construction materials for example), shell button production, jewellery (both shell and pearls) souvenirs and handicrafts. In Bihar, artisan communities depend on the natural supply of *Parreysia* species for making souvenirs, artefacts, jewels etc. The extent of collection from wild populations is in the region of several tonnes each year in Bihar (A. Dey, pers. comm.). The use of freshwater molluscs as protein-rich food is important in all parts of the region, especially

**Figure 4.4 Species richness of Data Deficient species in the Eastern Himalaya region.**

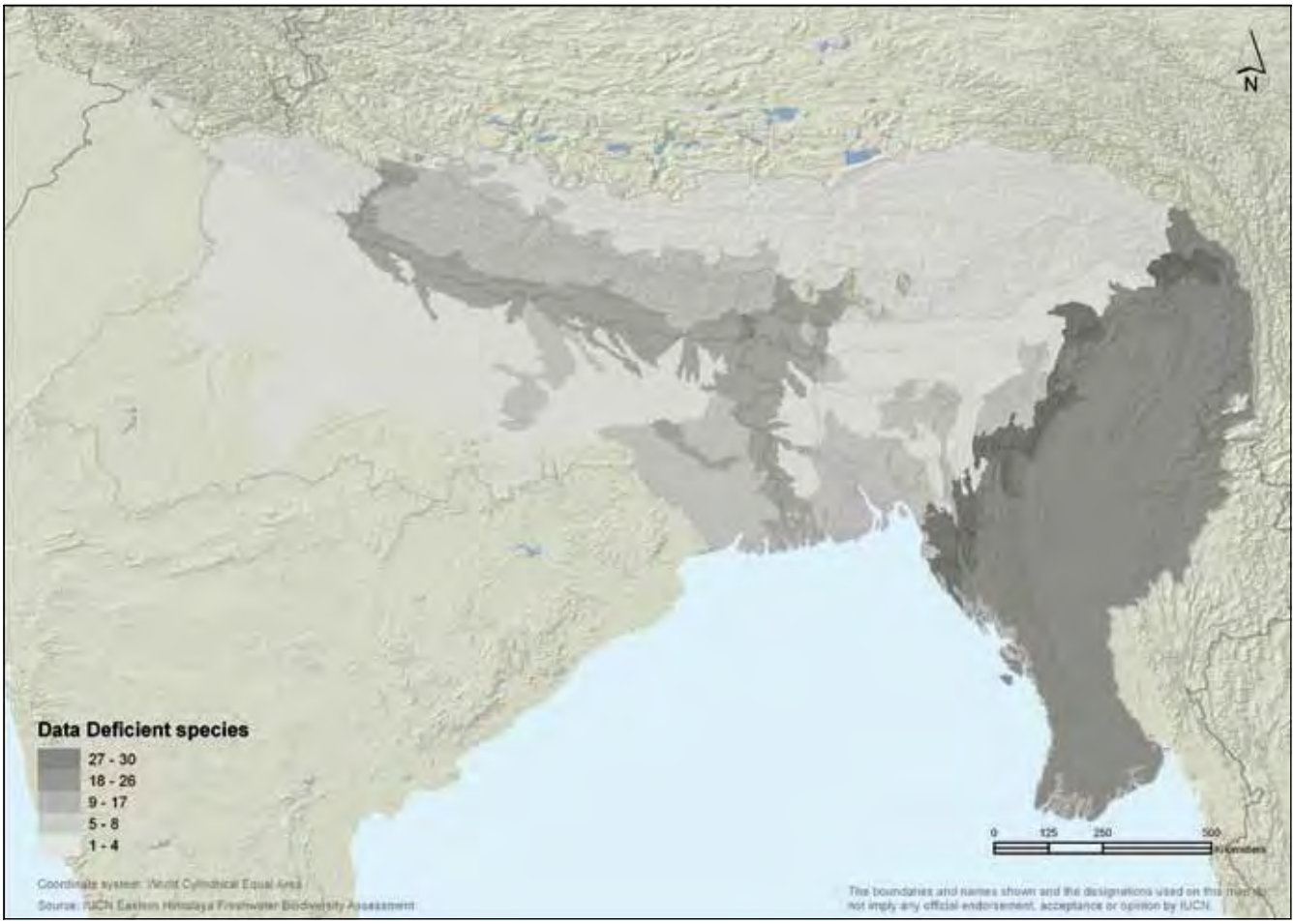
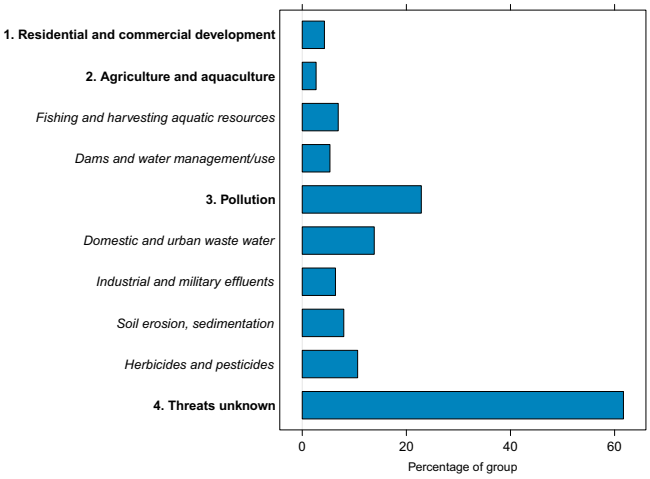



**Figure 4.5 Threats to molluscs within the Eastern Himalaya assessment region.**




for lower income social groups. In India, freshwater molluscs are eaten by some tribal communities, in West Bengal, Bihar, Orissa, and other northeastern states. In West Bengal, freshwater molluscs play a critical role in the economy and tradition of 80% of families belonging to more than 30 groups of scheduled castes and tribes (Baby *et al*. 2010). Freshwater molluscs are also extensively used as feed in shrimp farms, fish hatcheries and for poultry production (Misra and Mukhapadhyay 2008). In Bangladesh, tribal groups including the Bawm, Chakma, Garo, Hajong, Marma, Monipuri, Murang, Rajbangshi, Santal and Tanchanga (Baby *et al*. 2010; Shaha *et al*. 2003) are known to eat freshwater molluscs. The species most commonly consumed by people for subsistence and also for medicine belong to the genera *Brotia*, *Thiara*, *Parreysia*, *Lamellidens, Bellamya*. However, whilst there is heavy utilisation of freshwater molluscs across the region the extent to which this utilisation impacts wild populations needs to be studied to understand in what circumstances such utilisation becomes a threat to a species' populations.

### 4.4.2 Pollution

Water pollution is one of the major conservation issues for freshwater mollusc in the region. The Ganga, one of the largest rivers in the world, is also one of the most highly polluted rivers. Below Haridwar the river is polluted mainly because of agricultural run-off (siltation and agro-chemicals), urban run-off, impacts from large-scale pilgrimage, and industrial sources. It has been estimated that about 1.15 million tonnes of chemical fertilizer and about 2,600 tons of pesticides are drained into the Ganga each year (Reyes 1991; Subramaian *et al.* 1999). Industrial effluents are also a source of increasing pollution in Nepal (Reyes 1991; Subramanian *et al.* 1999). Pollutants can have a considerable negative impact on freshwater mollusc fauna, especially on bivalve populations, as they prefer clear and unpolluted waters. Siltation in the Brahmaputra River due

The Pin Tauk waterfalls, Eastern Shan State, in Myanmar. © Ralf Britz

to large scale deforestation in the northeastern Indian states might have great impact on freshwater molluscs, with bivalves being most significantly affected. Sedimentation reduces habitat heterogeneity by filling the gaps between gravels, thus affecting their population (USGS 2010). However, some species such as *Lymnaea luteola, L. acuminata, Indoplanorbis exutus*, and *Gyraulus convexiusculus* are highly tolerant and can be found in large numbers in organically polluted lentic habitats (Rajan and Murugan 2001).

### 4.4.3 Water abstraction and construction of dams

Water abstraction and damming are one of the major threats to freshwater biodiversity including freshwater molluscs across the region, with very large numbers of dams in place or planned in the near future on all major rivers and their tributaries. In India alone, state governments in the northeastern region have very ambitious plans for dam construction, including more than 300 planned in Arunachal Pradesh alone. Similar plans exist in neighbouring countries such as Myanmar, and upstream in China. If these projects are implemented they have the potential to seriously impact the aquatic fauna across the region.

At present there are hardly any data on the impact of dams and water abstraction on freshwater mollusc populations in this region, however drawing on a range of case studies McAllister *et al.* (2001) presented a range of upstream and downstream impacts of large dams that include variation of flow regimes, increased sedimentation, loss of fish-hosts, and habitat degradation. These impacts are likely to be applicable to the Eastern Himalaya making an assessment of the likely impacts and identification of options for mitigation an urgent priority,

## 4.5 Conservation recommendations

Strong *et al.* (2008) advised a conservation approach, with research and inventories of freshwater molluscs, including their systematics, ecology, life history, physiology, morphology, genetics, distribution, population size and biogeography to enhance database infrastructures of the museums. Without documenting these aspects at species level, it is hard to design effective conservation plans. Only 2% of all mollusc species have had their conservation status rigorously assessed (Seddon 1998; Lydeard *et al.* 2004).

### 4.5.1 Species-specific conservation programmes

There are no species-specific programmes in place for freshwater mollusc in the region. This is mainly because of lack of data on species distributions, population trends and threats, and this first assessment will certainly guide further research. Only two species have been assessed as Threatened, and it is likely that a number of further species, especially those in the highly-polluted lower parts of the Ganga. Conservation actions for these Threatened species should consider the conservation of habitats, restricting construction of dams, and preventing forest loss and degradation (for example, through reducing the impacts of *jhum* shifting agriculture) in upper parts of catchments. The establishment of protected areas, where they encompass aquatic habitats and their watersheds, such as Ramsar sites and other protected areas, can help conserve freshwater molluscs.

### 4.5.2 Research action required

Research into the distribution, population status, specific threats and taxonomy of freshwater molluscs in the Eastern Himalaya is urgently required. Many type localities need to be resurveyed to confirm if described range-restricted freshwater molluscs are still present or have already become extinct, and to confirm the taxonomic status of previously described species. The lack of trained malacologists, funding and the socio-political situation in the region has greatly hampered research on freshwater molluscs. Except for a few commonly occurring species, information on ecology, population structure and dynamics, distribution, and habitat preference is not known. A greater degree of taxonomic research and training is also required to ensure that widely accepted taxonomic concepts are adopted.

### 4.5.3 Taxonomic issues

Taxonomic research is central to ecological studies and conservation, but it is one of the most neglected disciplines (Stuart *et al.* 2010), especially in counties rich in biodiversity but poor in resources. Training in taxonomic expertise and enhanced communication and outreach are basic requirements of biodiversity conservation. Taxonomic knowledge of freshwater molluscs in the Eastern Himalaya is severely lacking and Budha (2005) highlighted the urgent need to develop taxonomic expertise. Preston's *Fauna of British India* written in 1915 is still the fundamental book comprising the taxonomic account of freshwater gastropod and bivalves of the Indian subcontinent, though Subba Rao (1989) updated the taxonomic

Tharu women, from the Nepalese terai, processing locally harvested snails (*Bellamya bengalensis* and *Parreysia* spp.) for consumption.
© Prem B. Budha

Children in the Nepalese *terai*, harvesting snails (*Bellamya bengalensis* and *Parreysia* spp.) for consumption. © Prem B. Budha

knowledge of the region. Since then the taxonomic knowledge has not been developed among regional taxonomists. There are many under- and unexplored areas that can be expected to contain both undescribed species and new populations of currently known species, but there are hardly any new descriptions of molluscs in the region in the decades that have passed since Subba Rao (1989) with few exceptions; e.g. Nesemann *et al.* 2007, which itself is also not free from taxonomic questions. Ramakrishna and Dey's *Handbook* (2007) followed the same taxonomic practices, which are not in use for the contemporary science of taxonomy.

It is possible that many of the Data Deficient species, and especially those that have not been re-collected since description, may be synonyms of common or widespread species when fresh material is collected for study.

There is an urgent need to undertake a thorough taxonomic review of the regions molluscs, combined with the collection of fresh study material and research into species distributions. Collaboration is required with international workers to ensure that contemporary taxonomic trends are followed.

### 4.5.4 Conservation education and awareness

As in much of the world, and perhaps especially in less developed and emerging countries, awareness about the conservation of lesser-known taxa such as molluscs is practically unheard off with national governments focussing conservation investment on large and charismatic animals such as tigers, rhino and so on. An effort has to be made to create awareness among the public, forest managers and policy makers on the importance of lesser-known groups such as molluscs and how these species can be conserved. Until now, no such attempts have been made in this region. One of the reasons for lack of awareness is that no popular, easy to use illustrated guide on freshwater molluscs exists.

### 4.5.5 Policy

For efficient and successful implementation of any conservation plans, there should be strong policy in place. It is unfortunate that there are no policies for conservation of mollusc in any of the countries in the assessment region. In India, the Wildlife (Protection) Act, 1972 which lists most of the groups, fails to include freshwater mollusc.

### 4.5.6 Use and livelihoods

Some molluscs, such as *Bellamya, Pila, Lamellidens,* and *Parreysia,* are extensively used in the production of traditional medicines, as food and for sale by low-income groups, for whom freshwater resources are often of vital importance in sustaining livelihoods and food security, as well as in the production of jewellery and lime for construction materials. Conservation actions should consider livelihood issues of the communities who are dependent on these resources for their subsistence and basic health care, and the design of conservation measures should ensure that an inclusive approach is taken.

## 4.6 Conclusions

One hundred and eighty-six species of freshwater molluscs were recorded in the Eastern Himalaya assessment region and assessed according to the global IUCN Red List Categories and Criteria. Only two (1%) were found to be Threatened, whilst 66% were Least Concern, and a further 32% Data Deficient. Whilst the best available information was used to inform the conservation assessments, the very high level of Data Deficient species shows that there is a great need for further research into (i) the taxonomy of the regions' mollusc fauna; (ii) the ecology, distribution, and population trends of freshwater molluscs across the region; (iii) the impact and distribution of key threats (including pollution from urban, agricultural, and industrial sources, as well as climate change and sedimentation). Evidence from other regional assessments of freshwater mollusc conservation status (e.g. Darwall *et al.* 2005, 2009) suggests that the overall level of threat found in this assessment is remarkably low. It is recommended that the conservation assessments of the Eastern Himalaya freshwater mollusc fauna are repeated if the above information becomes available.

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# Chapter 5. The status and distribution of dragonflies and damselflies (Odonata) of the Eastern Himalaya

Amit Mitra[1], Rory Dow[2], K.A. Subramanian[3], and Gaurav Sharma[4]



## 5.1 Overview of the regional fauna

Extending between the Koshi Valley in Nepal and northwest Yunnan in China, the Eastern Himalaya Hotspot includes parts of the Nepalese and Indian *terai*, the Sikkim and Darjeeling hills in India, the whole of Bhutan, northern and northeastern India, southeast Tibet (Xizang) in China and western Myanmar. The region contains diverse ecosystems including temperate and tropical forests, mountain peaks, including the highest peak of Mount Everest, grasslands, savannas, and alpine meadows. The region is also the meeting point for the Indo-Malayan, Palaearctic, and Sino-Japanese biogeographical realms, with diverse ecological and altitudinal gradients and an associated diversity of flora and fauna (CEPF 2005, 2007). The Eastern Himalaya project area extends beyond the Hotspot to include the entirety of six freshwater ecoregions (WWF/TNC 2008): (i) the *Ganga Delta and Plain* freshwater ecoregion, (ii) *Ganga Himalayan Foothills*, (iii) the *Upper Brahmaputra* ecoregion, (iv) the *Middle Brahmaputra* ecoregion, (v) the *Chin Hills-Arakan Coast* ecoregion, and (vi) the *Sittaung-Irrawaddy* ecoregion. Freshwater ecoregions present within the project area are shown in Figure 2.3.

The diversity of Odonata is influenced by the diversity of habitats and large altitudinal range in the region. The diversity includes exclusively stream (lotic) or stagnant (lentic) water breeding species, as well as species that utilize both these habitats at different altitudes. Apart from perennial aquatic habitats such as rivers, torrential streams and tiny steep trickles in hilly terrain, slow running marshy streams in flatter areas in valleys, forested swamps, open marshes freshwater lakes, freshwater ponds and ditches at lower altitudes, the region also has seasonal ponds during the monsoon. Agricultural fields and irrigation channels also offer seasonal habitats for some of the dragonflies of this region. Species richness declines with increasing altitude, and is negligible in the alpine zone.

Mitra, T.R. (2002) reported 960 species and subspecies of Odonata from continental Southeast Asia. The Eastern Himalaya biodiversity hotspot alone supports 38.2% Odonata fauna of continental Southeast Asia. During the present assessment using the IUCN Red List Categories and Criteria, a total of 367 Odonata species belonging to 135 genera under 21 families of all three suborders have been assessed at the global scale; of these, 140 had been assessed since 2006 (i.e. assessments less than five

[1] Department of Zoology, Sherubtse College, Royal University of Bhutan, Kanglung, Bhutan. amitodonata@yahoo.com
[2] National Museum of Natural History *Naturalis*, P.O. Box 9517, 2300 RA Leiden, The Netherlands. rory.dow230@yahoo.co.uk
[3] Western Regional Centre, Zoological Survey of India, Akurdi, Pune-410 044, India. subbuka.zsi@gmail.com
[4] Desert Regional Centre, Zoological Survey of India, Pali Road, Jodhpur-342 005, India. drgaurav.zsi.india@gmail.com

years old and not requiring re-assessment) and the remaining 228 were assessed by this project. The species list was based on literature records from the region. A few species whose range just extends into the project region were omitted because it was more appropriate to assess them under different projects.

For much of the region the majority of Odonata records either date from before 1940 or can be considered as somewhat unreliable. For many parts of the region there are very few records of Odonata. Both of these problems are especially pronounced in Myanmar and the adjacent parts of the project region. In India, the majority of good quality fieldwork that has been conducted in the project region since the end of the colonial era has been concentrated in just a few areas, e.g. Dehra Dun and the Khasi Hills in Meghalaya, and even for the later example, most of the records date from the 1960s and 1970s, so that there is a severe lack of up-to-date data. There was a spurt of activity in Nepal in the 1980s and 1990s, but again this was concentrated in a few areas, with much of the country essentially unsurveyed for Odonata, as is the case for large parts of Bhutan and all of Tibet. There is also little reliable data from Bangladesh. There are numerous taxonomic problems with the regions Odonata awaiting resolution, and quite a number of the poorly known species are of doubtful status. The lack of recent, good quality, data from much of the region presents an extremely serious


Different Odonata habitat types within the assessment region: (a) Cascade waterfalls; and (b) a freshwater high altitude lake at 2,900 m, both at Yonphula, Trashigang, in Bhutan. © Amit Mitra

barrier to reliably assessing the threats faced by the regions Odonata.

### 5.1.1 The Ganga Basin

The basin includes the *Ganga Delta and Plains* freshwater ecoregion, spreading over the tropical and subtropical floodplain rivers and wetlands surrounding the Ganga basin of southernmost Nepal, northern and northeastern India and Bangladesh, and the *Ganga Himalayan Foothills* freshwater ecoregion comprising montane freshwater ecosystems of the southern tip of Himachal Pradesh and whole of Uttarakhand in India, south to Manasarawar Lake and parts of the southern border of China just touching northern Nepal and the whole of Nepal except the southernmost part (WWF/TNC 2008). Odonate endemicity is high in this area.

#### Ganga Delta and Plains ecoregion

This freshwater ecoregion includes southern Nepal, southwest Rajasthan, northern Madhya Pradesh, Uttar Pradesh, Bihar, most of West Bengal except the upper hills, parts of Assam, Tripura and whole of Bangladesh except the eastern half of Chittagong division. The endemic Odonata of the ecoregion are *Lestes nigriceps*, *Coeliccia rossi*, *Coeliccia dorothea*, *Gynacantha rammohani*, *Gynacantha odoneli*, *Gynacantha albistyla*, *Gynacantha biharica*, *Ictinogomphus distinctus*, *Gomphidia leonorae*, *Gomphidia williamsoni*, *Onychogomphus grammicus*, *Burmagomphus hasimaricus*, *Asiagomphus odoneli*, *Platygomphus dolabratus*, *Megalogomphus flavicolor* and *Macromia pallida*. Interestingly both the species of *Gomphidia* within the assessment region are confined to this ecoregion. *Lestes nigriceps*, *Gynacantha odoneli*, *Gynacantha biharica*, *Gomphidia williamsoni*, *Asiagomphus odoneli*, *Burmagomphus hasimaricus*, *Megalogomphus flavicolor* and *Macromia pallida* were not reported from India since their description before 1948 (Lahiri 1989). However, *Burmagomphus hasimaricus* has been recorded from Nepal in 1985 (Vick 1985). Unfortunately, except for *Platygomphus dolabratus,* all the above species are Data Deficient.

#### Ganga Himalayan Foothills ecoregion

The Odonata biotopes in this ecoregion varies from perennial fast to medium flowing streams, slow running marshy streams, water falls, lakes, seasonal agricultural fields and irrigation channels and small water-bodies. The endemic species of the ecoregion include *Chlorogomphus olympicus*, *Davidius kumaonensis*, *Onychogomphus cerastis*, *Ictinogomphus kishori, Macromia sombui*, *Agriocnemis corbeti*, *Himalagrion pithoragarhicus*, *Calicnemia doonensis* (LC) and *Calicnemia nipalica* (VU). Except the last two, all of the endemic species for the region are Data Deficient. *Davidius kumaonensis* and *Chlorogomphus olympicus* were not recorded from India since 1948 (Lahiri 1989). However, *Chlorogomphus olympicus* has been reported in 1970 from Nepal (St Quentin 1970). The greatest number of dragonflies (both in terms of individuals and species) occur in the tropical and temperate parts and above 3,000 m the fauna is markedly reduced, consisting of some species of the Himalayan endemic genus *Neallogaster* such as *Neallogaster latifrons* at 4,100 m (Vick 1985); there is also an isolated record of *Pantala flavescens* at 6,300 m in eastern Nepal (Jackson 1955).

The Indian part of the Sunderbans, in the Ganga-Brahmaputra delta. © Amit Mitra

### 5.1.2 The Brahmaputra Basin

The Brahmaputra basin is subdivided into the *Upper Brahmaputra* freshwater ecoregion, covering the Alpine meadows and tropical upland rivers of southern Tibet and northernmost tips of Bhutan and Arunachal Pradesh in India and the *Middle Brahmaputra* freshwater ecoregion encompassing the tropical and subtropical upland rivers of Sikkim, Darjeeling, Arunachal Pradesh and parts of Assam and Meghalaya of India, Bhutan and parts of southeast Tibet. The basin represents second highest endemism within the assessment region.

#### Upper Brahmaputra ecoregion

Dominated by alpine meadows, the diversity and the endemism of dragonfly fauna is lower in the Upper Brahmaputra. The only endemic species known for this region is *Macrogomphus robustus* which has been assessed as Data Deficient.

#### Middle Brahmaputra ecoregion

Diverse ecosystems ranging from Alpine meadows to tropical and subtropical rivers, fast flowing hill streams, slow running marshy streams, freshwater lakes and waterfalls are the characteristics of this ecoregion. This complete ecoregion is the part of Eastern Himalaya Biodiversity Hotspot. Diversity and endemism both are quite high. Endemicity is high in the Odonata of this region. Among the endemics of Middle Brahmaputra are *Anisopleura lieftincki*, *Orolestes durga*, *Megalestes lieftincki*, *Indolestes assamicus*, *Burmargiolestes laidlawi*, *Coeliccia bimaculata*, *Coeliccia prakritii*, *Coeliccia fraseri*, *Coeliccia sarbottama*, *Phaenandrogomphus aureus*, *Davidius baronii*, *Dubitogomphus bidentatus*, *Megalogomphus bicornutus*, *Nihonogomphus indicus*, *Onychogomphus meghalayanus*, *Oligoaeschna martini*, *Periaeschna lebasi*, *Chlorogomphus fraseri*, *Macromia flavovittata* and *Sympetrum himalayanum*. Except *Coeliccia fraseri* (VU), all of the endemic species for the region are Data Deficient. *Indolestes assamicus*, *Dubitogomphus bidentatus*, *Megalogomphus bicornutus*, *Macromia flavovittata* and *Sympetrum himalayanum* have not been reported from India since 1948 (Lahiri 1989). The evolutionary relict species *Epiophlebia laidlawi,* first reported from the Darjeeling area, has recently also been reported from Bhutan within this ecoregion (Brockhaus and Hartmann 2009).

### 5.1.3 The Chin Hills-Aracan Coast ecoregion

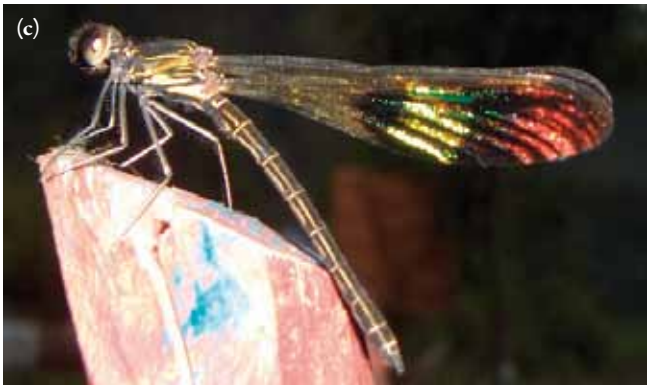
The ecoregion spreads over southern Meghalaya, parts of lower Assam, western Manipur, parts of southern and eastern Tripura in India, the eastern half of Chittagong division of Bangladesh and Rakhine State and western and southern Chin State in Myanmar. Endemicity is high in this region. The endemics of the ecoregion are *Rhinocypha trimaculata*, *Rhinocypha vitrinella*, *Calicnemia sudhaae*, *Calicnemia mukherjeei*, *Elattoneura atkinsoni*, *Anisopleura vallei*, *Bayadera kali*, *Indolestes indicus*, *Megalestes raychoudhurii*, *Lestes garoensis*, *Protosticta fraseri*, *Davidius malloryi*, *Heliogomphus spirillus*, *Chlorogomphus schmidti*, *Idionyx imbricata*, *Idionyx intricata*, *Somatochlora daviesi*, *Anotogaster gigantica* and *Oligoaeschna khasiana*. The only species of *Somatochlora* (known from lower Meghalaya) and *Planaeschna* known from the assessment region occur here. Except *Elattoneura atkinsoni*, *Indolestes indicus* and *Idionyx intricata*, all endemics for the region are Data Deficient. *Anisopleura vallei*,

*Pantala flavescens* (LC), the Global Skimmer or Monsoon Migrator, a globally widespread species. © Amit Mitra

*Ictinogomphus rapax* (LC) , pictured here in the Dehradun Valley, India. © Amit Mitra

Some unique Odonata from Bhutan in the Middle Brahmaputra ecoregion: a) a copulatory wheel of *Aeschna petalura* at a freshwater lake in Yonphula (2,900 m); b) *Anotogaster nipalensis* from Kanglung; c) *Rhinocypha unimaculata* from Yadhi, Mongar. © Amit Mitra






*Protosticta fraseri*, *Davidius malloryi* and *Idionyx imbricata* have not been recorded in India since 1948 (Lahiri 1989).

### 5.1.4 The Sittaung-Irrawaddy freshwater ecoregion

Encircling the Ayeyarwaddy River, this ecoregion spreads along the central and eastern Manipur, parts of Nagaland in India, parts of western Yunnan in China and most of the Myanmar except the westernmost part of Shan State, the easternmost part of Chin state and lower Myanmar including Mon state, Tanintharyi State and the lower half of Kayin State. With a diverse ecosystem, this ecoregion supports a rich diversity of Odonata fauna. Species thought to be endemic to the region include *Dysphaea walli*, *Leptogomphus inclitus*, *Microgomphus loogali*, *Orientogomphus earnshawi* and *Rhipidolestes malaisei*; the occurrence of these five genera within the overall Eastern Himalaya assessment region is limited to this ecoregion. The other endemic species of the region include *Coeliccia schmidti*, *Coeliccia rotundata*, *Protosticta uncata*, *Lestes malaisei*, *Indolestes inflatus*, *Gynacantha burmana*, *Chlorogomphus speciosus*, *Idionyx unguiculata*, *Burmagomphus v-flavum*, *Onychogomphus annularis*, *Onychogomphus maclachlani*, *Onychogomphus maculivertex*, *Paragomphus frontalis*, *Paragomphus risi* and *Platygomphus feae*. All species endemic to the region are Data Deficient.

### 5.1.5 The Eastern Himalaya Biodiversity Hotspot

The freshwater ecoregions of the Eastern Himalaya Biodiversity Hotspot include (1) part of the Ganga delta and plains, (2) the middle and eastern part of the *Ganga Himalayan* ecoregion, (3) *Middle Brahmaputra* ecoregion, (4) the Indian portion of *Chin Hills-Arakan Coast* ecoregion, and (5) part of the *Sittaung-Irrawaddy* ecoregion. The diverse ecosystems of the hotspot and the endemic Odonata of each have already been discussed under the different freshwater ecoregions it encompasses. However, there are number of Odonata species which are present in more than one ecoregion, but that are confined to the Eastern Himalayan Hotspot. These species are: *Echo margarita*, *Rhinocypha ignipennis*, *Rhinocypha cuneata* (DD), *Rhinocypha immaculata*, *Calicnemia miniata*, *Calicnemia mortoni*, *Stylogomphus inglisi*, *Macrogomphus montanus* (DD), *Macrogomphus seductus* (DD), *Anotogaster nipalensis*, *Anotogaster basalis* (DD), *Chlorogomphus preciosus* (DD), *Chlorogomphus selysi*, *Chlorogomphus mortoni* (DD), *Sympetrum hypomelas*, *Sympetrum orientale* (DD), *Bayadera longicauda* (DD), *Anisopleura lestoides*, *Schmidtiphaea schmidi* (DD), *Philoganga montana*, *Megalestes irma* (DD), *Elattoneura campioni* (DD), *Coeliccia svihleri* (DD), *Coeliccia vacca* (DD), *Himalagrion exclamationis* (DD), *Epiophlebia laidlawi*, possibly *Onychogomphus saundersii* (DD) for which the type locality is

in India, but its exact wherabouts is unknown, *Onychogomphus cacharicus* (DD), *Nepogomphus modestus*, *Paragomphus lindgreni* (DD), *Paragomphus echinoccipitalis* (DD), *Anisogomphus orites* (DD), *Merogomphus martini*, *Perissogomphus stevensi*, *Periaeschna unifasciata* (DD), *Cephalaeschna acutifrons* (DD), *Cephalaeschna orbifrons*, *Cephalaeschna viridifrons*, *Petaliaeschna fletcheri* (DD), *Aeshna petalura*, *Neallogaster hermionae*, *Neallogaster latifrons*, *Lyriothemis acigastra* (DD), *Idionyx stevensi*, *Aciagrion olympicum*, *Aciagrion approximans*, *Protosticta himalaica* (DD) and *Copera superplatypes* (DD). It is interesting to note that 24 out of 48 endemics for the Eastern Himalaya Hotspot are Data Deficient. *Bayadera longicauda*, *Megalestes irma*, *Himalagrion exclamationis*, *Chlorogomphus mortoni*, *Onychogomphus cacharicus*, *Paragomphus lindgreni*, *Paragomphus echinoccipitalis*, *Cephalaeschna acutifrons*, and *Copera superplatypes* have not been reported from India since 1948 (Lahiri 1989). However *Chlorogomphus mortoni* and *Himalagrion exclamationis* have been reported from Nepal by Mahato (1988), *Cephalaeschna acutifrons* and *Bayadera longicauda* have been reported by Asahina (1981, 1985), *Paragomphus lindgreni* has been reported by Vick (1987) and *Pseudotramea prateri* has been reported by (St Quentin 1970) from different regions in Nepal.

### 5.1.6 Endemism in the Eastern Himalaya Assessment Region

Apart from the above discussed species endemic to the different ecoregions or the Eastern Himalayan Hotspot, there are species common to more than one ecoregion, and whose range extends beyond the Eastern Himalayan Hotspot, but that are confined within the entire assessment region. These endemics for the whole Eastern Himalaya Assessment Region are *Anisopleura comes*, *Bayadera indica*, *Coeliccia loringae*, *Rhinocypha quadrimaculata*, *Rhinocypha unimaculata*, *Rhinocypha hilaryae*, *Onychogomphus duaricus*, *Anisogomphus occipitalis*, *Megalogomphus smithii*, *Asiagomphus personatus*, *Ictinogomphus angulosus*, *Gynacantha bainbriggei* and *Amphithemis vacillans*. Among the above endemic species, *Coeliccia loringae*, *Rhinocypha hilaryae*, *Nihonogomphus pulcherrimus*, *Megalogomphus smithii*, *Gynacantha bainbriggei* and *Amphithemis vacillans* are Data Deficient.

## 5.2 Conservation status

The results presented below are based on an assessment of species global conservation status using the IUCN Red List Categories and Criteria: Version 3.1 (IUCN 2001) of (i) species known to be present in the Eastern Himalaya project region (see Figure 2.2 for a map of the river catchments included in the project), and (ii) species considered to be present in the Eastern Himalaya Biodiversity Hotspot, based on a GIS overlay of the species distribution maps and the Hotspot boundary. The list of species considered to be present within the project area was produced by Dr S.A. Subramanian and Dr Rory Dow in consultation with other experts participating in the project.


a) *Bayadera longicauda* from Kathmandu, Nepal; b) above, Male *Paragomphus lineatus* from the Dehradun valley, India. © Amit Mitra

A total of 367 Odonata taxa of the region were considered to be present within the project area, of which four taxa are considered Threatened, which constitutes 1.1% of the faunal assemblage of Eastern Himalayan Odonata. *Epiophlebia laidlawi*, the Himalayan relict that was considered threatened in India by Mitra, T.R. (2002) was assessed as Near Threatened globally in 2006, is in need of reassessment. Eleven taxa (3% of total assessed species) are assessed as Near Threatened. A total of 216 taxa (58.9% of total assessed species) are Least Concern.

The main difficulty faced in assessing the regional Odonata is the lack of data, especially recent data, not just on distribution and population sizes, but also on habitat requirements, so that threats cannot be assessed reliably. Some of the species have not been seen since their discovery. In the absence of reliable recent data, 135 species have been considered Data Deficient, which constitutes more than one-third (36.8%) of the total Odonata taxa of the region. The majority of the Data Deficient species are from families whose members typically breed in forest streams, although habitat information is entirely lacking for many of these species. Due to rapid deforestation, leading to extensive habitat degradation in some areas throughout the region, a good number of these Data Deficient and Near Threatened species might move into higher threat categories with after extensive expert sampling in the region and the information on their habitat requirements and the threats that they face that such sampling would produce. On the other hand, with more fieldwork many of the Data Deficient species are likely to be shown to be Least Concern, and others are likely to be shown to be junior synonyms of more widespread species.

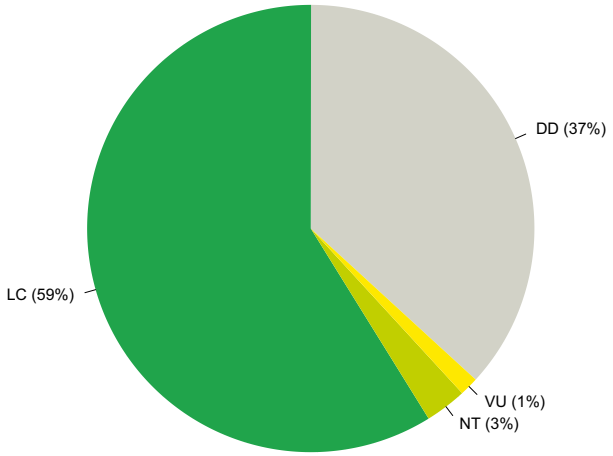
The level of Data Deficient species (36.8% of species considered present within the project area) is very high compared to other assessment projects (e.g. 18% in southern Africa (Darwall *et al.* 2009); 13.9% in western Africa (Darwall *et al.* 2005), 4% in the Mediterranean Basin (Riservato *et al.* 2009). This reflects the problems with lack of data already mentioned.

Overall, the number of threatened species is very low, with only four species (1.1%) meeting the criteria for threatened status. These species (*Bayadera hyalina*, *Calicnemia nipalica*, *Chlorogomphus selysi*, and *Coeliccia fraseri*) were all assessed as Vulnerable on the basis of arestricted range. A further eleven species were assessed as Near Threatened, again primarily on the basis of restricted distribution. This does not necessarily imply that there is only a low level of threat to Odonata in the region, it is a result of the lack of basic data for a high percentage of species; where the true distribution of a species can only be guessed at and little or nothing is known about its habitat requirements, any threats that it might face cannot be assessed reliably and it must remain Data Deficient until the necessary information becomes available.

**Table 5.1 The number of Odonata species in each Red List Category in the Eastern Himalaya project area.**

| | Global Red List Category | Number of species |
|---|---|---|
| Threatened categories | Extinct | 0 |
| | Extinct in the Wild | 0 |
| | Critically Endangered | 0 |
| | Endangered | 0 |
| | Vulnerable | 4 |
| | Near Threatened | 11 |
| | Least Concern | 218 |
| | Data Deficient | 135 |
| | **Total** | **367** |

**Figure 5.1 The percentage of Odonata species in each global Red List category in the Eastern Himalaya project region. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LC = Least Concern, and DD = Data Deficient.**




## 5.3 Patterns of species richness

### 5.3.1 Overall species richness and endemism

The Eastern Himalaya region, as defined by this project (encompassing the Gang-Brahmaputra, Kaladan and Ayeyarwaddy basins), has a total of 367 species recorded as present. Some species, e.g. *Pseudagrion hypermelas*, *Pseudagrion malabaricum* and *Burmagomphus pyramidalis*, were omitted due to marginal or doubtful presence within the region. However the two *Pseudagrion* species should have been included, but both would be Least Concern if assessed. *Burmagomphus pyramidalis* has been recorded once from the project area, but this record is regarded as in need of confirmation, so the species was omitted.

Within the assessment region, levels of species diversity and endemism are not distributed uniformly. Sub-catchments in the *Gang Himalayan Foothills* and the *Middle Brahmaputra* freshwater ecoregions have high species richness, whilst western parts of Ganga plain and upper Brahmaputra have the lowest species richness. The *Chin Hills-Arakan* coast and *Sittaung-Irrawaddy* freshwater ecoregions have intermediate levels of species richness (Figure 5.2).

Within the *Ganga Himalayan Foothills* and *Middle Brahmaputra* freshwater ecoregions, species richness is highest

in lower and middle Sikkim, north Bengal (Darjeeling region), eastern Assam and Meghalaya (Khasi Hills) states in India, eastern Nepal and southern Bhutan. Between 126–167 species of odonates have been recorded from this region. Endemism in this species rich area is concentrated in the Khasi Hills, with between 8–42 recorded endemics (Figure 5.3). Patterns of distribution of range restricted and Data Deficient species are very similar to species richness and endemism, suggesting the paucity of extensive surveys and recent data.

The highest species richness and endemicity within assessment region and hotspot are at the junction of the *Ganga Himalayan Foothills*, *Middle Brahmaputra* and *Ganga Delta and Plains* freshwater ecoregions. This region has high altitudinal, rainfall, temperature and bioclimatic gradients, and supports diverse terrestrial and freshwater ecosystems within a restricted area, and the high habitat diversity of freshwater and terrestrial ecosystems of the region is likely one of the reasons for the high species diversity. Conversely, highly species rich and endemic areas are also extensively explored regions by naturalists and entomologists from the second half of the 19th century and since current analysis largely relies on literature records, the distribution patterns of species richness and endemism reflect levels of field surveys across the region, and further work is clearly need to ensure that species distributions are accurately understood.

### 5.3.2 Threatened species

Threatened species are restricted to subcatchments in central Nepal and the Khasi Hills. Four species from the project region have been assessed as Vulnerable, all as Vulnerable under category D2 (restricted range and with current threats or with threats in the near future (Table 5.2).

*Chlorogomphus selysi* was assessed in 2007 and placed in Vulnerable under criterion D2 because fewer than five locations were known, however data from Nepal suggests that the species is not uncommon there, but under-recorded because of difficulty of capture; possibly this species should be reassessed as Near Threatened or Least Concern. *Bayadera hyalina* was also placed in Vulnerable under criterion D2; it has a disjointed distribution, with records only from the Khasi Hills in Meghalaya and Doi Inthanon in Thailand, with more sampling in the intervening region it is likely that this species could be reassessed as Near Threatened or Least Concern. *Calicnemia nipalica* is only known from three locations in a small area of Nepal; the assessment is based on this restricted range. *Coeliccia fraseri* is only known from the Khasi Hills of Meghalaya, an area known to have suffered heavily from deforestation and other threats; again the assessment was based on the restricted range and known threats.

**Figure 5.2 Species richness of dragonflies and damselflies in the Eastern Himalaya region.**

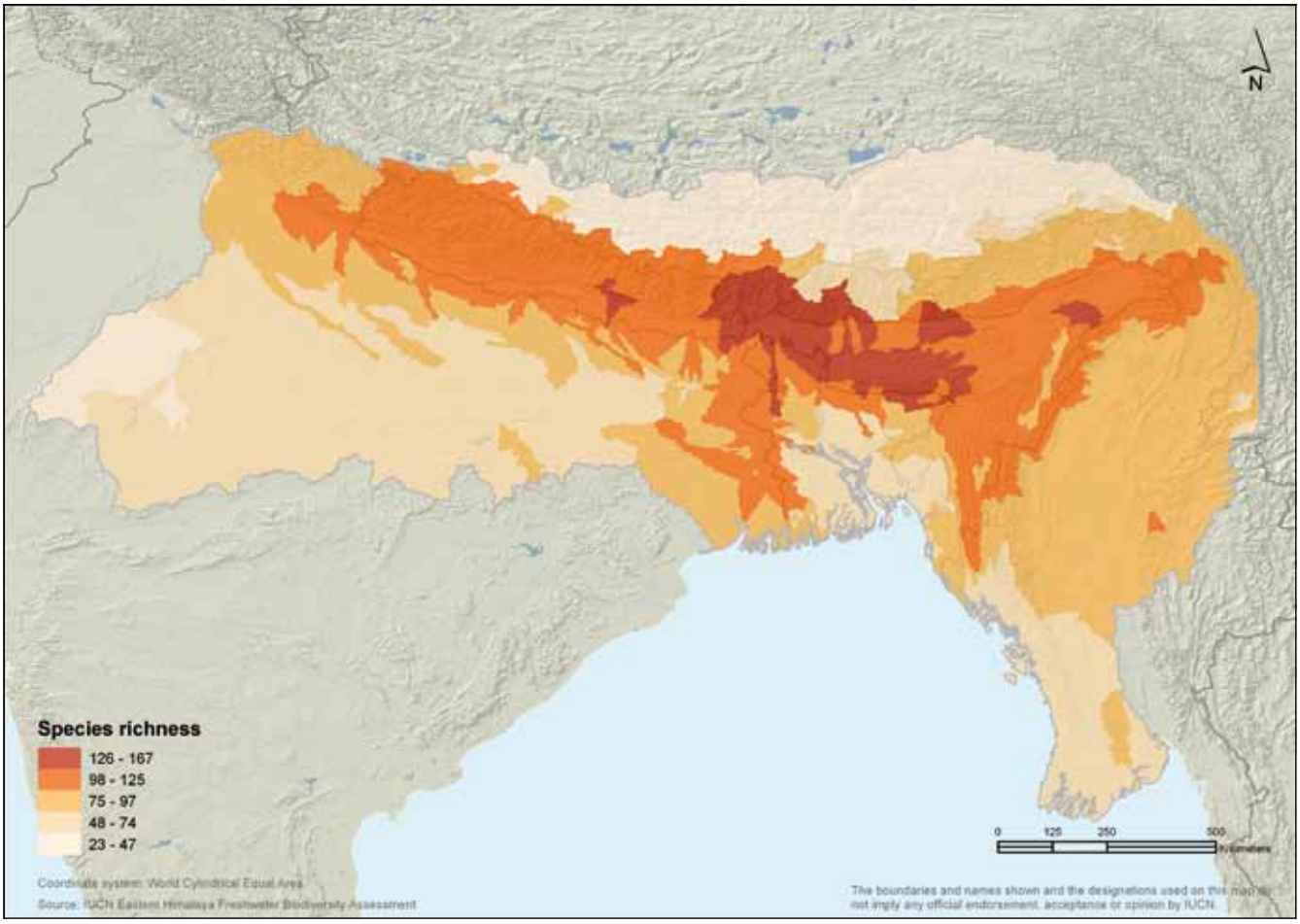


**Table 5.2 Threatened (VU) and Near Threatened NT) species of dragonflies and damselflies within the Eastern Himalaya region.**

| Family | Binomial | Category |
|---|---|---|
| EUPHAEIDAE | *Bayadera hyalina* | VU |
| PLATYCNEMIDIDAE | *Calicnemia nipalica* | VU |
| CHLOROGOMPHIDAE | *Chlorogomphus selysi* | VU |
| PLATYCNEMIDIDAE | *Coeliccia fraseri* | VU |
| GOMPHIDAE | *Anormogomphus kiritshenkoi* | NT |
| GOMPHIDAE | *Asiagomphus personatus* | NT |
| PROTONEURIDAE | *Elattoneura atkinsoni* | NT |
| EPIOPHLEBIIDAE | *Epiophlebia laidlawi* | NT |
| CORDULIIDAE | *Idionyx optata* | NT |
| CHLOROCYPHIDAE | *Indocypha vittata* | NT |
| LESTIDAE | *Indolestes indicus* | NT |
| LIBELLULIDAE | *Indothemis carnatica* | NT |
| GOMPHIDAE | *Merogomphus martini* | NT |
| CORDULEGASTRIDAE | *Neallogaster ornata* | NT |
| AESHNIDAE | *Planaeschna intersedens* | NT |

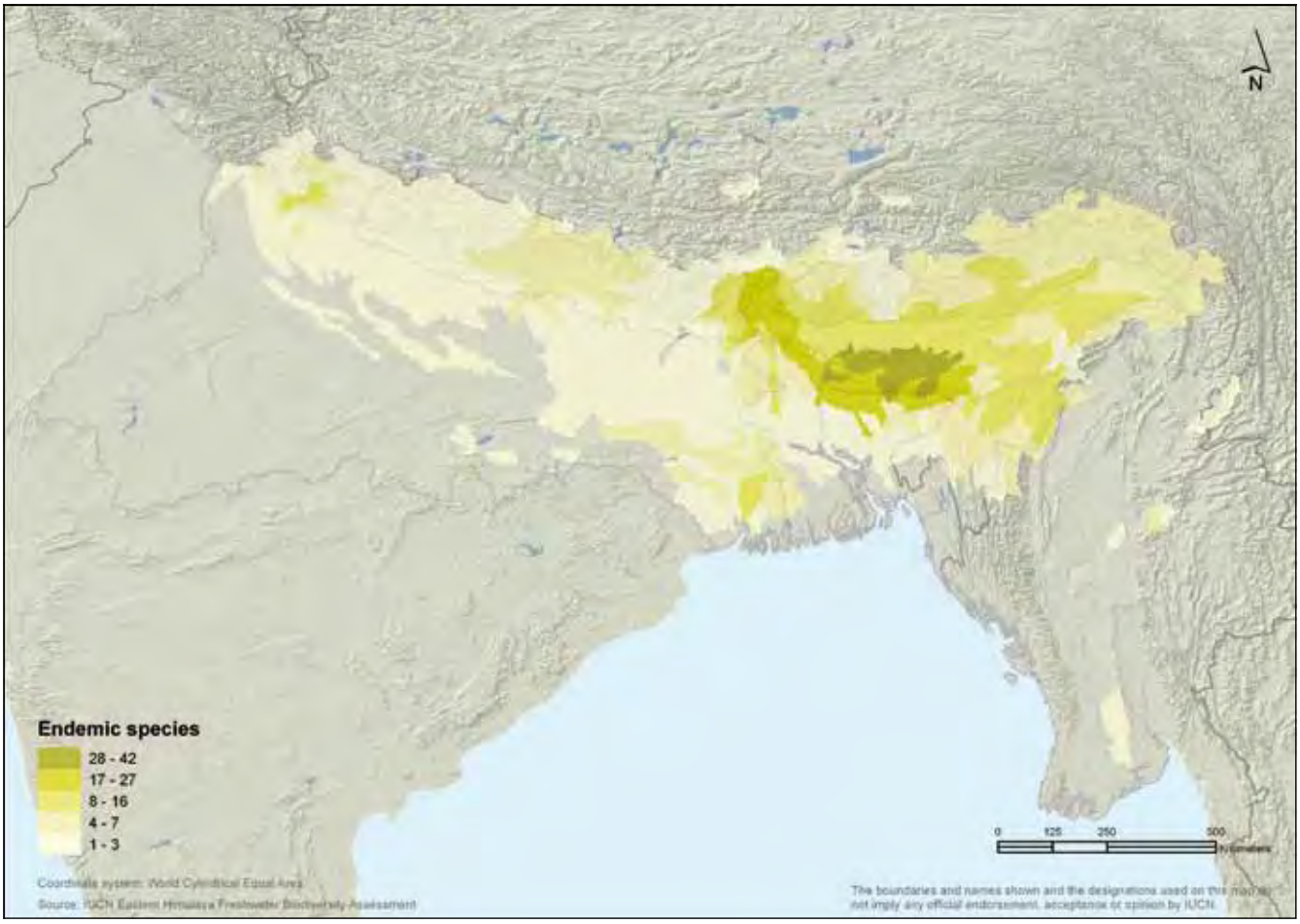
Most of the Near Threatened species have relatively wide ranges, but only a few known locations; it is to be hoped that, with more fieldwork in the region, most of these species can be reassessed as Least Concern. The exception is *Indolestes indicus*, which is only known from the Khasi Hills in Meghalaya, and is close to qualifying for Vulnerable status.

### 5.3.3 Data Deficient species

A very high level (nearly 37%) of species have been found to be Data Deficient in this region. Whilst most DD species have been mapped, many have only been mapped to country level (Myanmar, Bangladesh, Bhutan and Nepal) or to sub-country unit (state boundaries in India, and provinces in China), with the result that the analysis maps (overall species richness, endemic species, and Data Deficient species richness maps) should be interpreted with caution.

It is clear that the areas of high data deficiency are closely related to the areas of high species richness, and extensive survey is required in order to determine species distributions and thereby allow assessment of their conservation status. In addition, much better information is needed on the scale, scope, and impact of

**Figure 5.3 Species richness of endemic dragonflies and damselflies in the Eastern Himalaya region. Note that this map has been produced by selecting river sub-basins within the Eastern Himalaya assessment area boundary (containing the Ganga, Brahmaputra, Ayeyarwaddy and Kaladan river basins).**



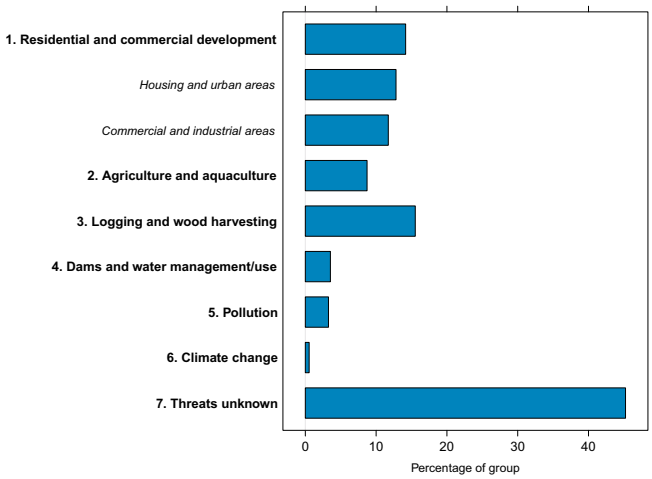
threats to Odonata and their terrestrial and aquatic habitats. At present nearly 45% of species included in this assessment have no information available on threats (see Figure 5.5).

## 5.4 Major threats to Odonata

As already discussed above, for many of the regions Odonata, we cannot assess the threats that they face as we do not know their habitat requirements; however general threats likely to impact Odonata can be discussed. The Himalayan region, including the Tibetan Plateau, has shown consistent warming trends during the past 100 years (Yao *et al.* 2006). Threats to general biodiversity from climate change could be acute in the Eastern Himalayan region, which is rich in endemic species that have restricted ranges of distribution (Root *et al.* 2003). Land-use change from forest to other usages in the Eastern Himalaya region has been conspicuous in the last few decades, causing depletion of natural resources in the Himalaya (Singh and Singh 1992). The quest for rapid economic development and expanding agricultural activities have increased the exploitative pressures on forests leading to habitat alteration and fragmentation (Pandit *et al.* 2007). In India, estimates of forest loss vary widely, but recent estimates (e.g. Puyravaud *et al.* 2010) show native forest cover declining by between 0.8% to 3.5% per year over the period 2000–2005. Fresh water wetlands, riparian habitats and ephemeral streams are also under pressure. In the floodplains sedimentation, eutrophication, natural succession and drying off are the main threats to the wetlands. Riparian habitats are suffering from floods caused by the outburst or melting of glacial lakes, sedimentation in the river beds, erosion of the banks etc. Ephemeral streams are also disappearing or becoming degraded by the habitat alteration. Thus the reproductive habitats of dragonflies are being impacted across the whole assessment region. In parts of the region, such as Sahastradhara in Dehradun, tourism and tourist developments impact upon habitats through uncontrolled activities including throwing plastic waste away indiscriminately, bathing in streams, damaging river banks by parking vehicles, and cutting trees and vegetation along streams to build shops and stalls (Kumar and Mitra 1998).

However, during the present assessment threats are defined for only 135 species that constitutes 36.8% of the total 367 assessed species for Eastern Himalaya region due to poor documentation of the existing threats for the species of the region and lack of data on the habitat requirements on many species. It was found that the rapid deforestation leading to extensive habitat degradation is the major threat prevailing for the assessment region. Logging and wood harvesting rates highest in the existing threat category affecting 15.5% of the total assessed species. This is also likely to be the major threat to many of the species currently assessed as Data Deficient. Other major existing threats such as the development of residential and commercial areas (affecting 14.2% of the total assessed species), housing and urban areas (impacting 12.8% of the total assessed species) and commercial and industrial areas (impacting 11.7% of the total assessed species) are directly or indirectly associated with logging, particularly in Bhutan and areas in northeastern India, where most of the houses are built with wooden materials. The need for more agricultural land is also posing threats to the forest resources of the region, and altering the habitats of forest dwelling species of Odonata. Commercial aquaculture is altering the ecological balances in freshwater lakes and ponds, affecting the immature stages of certain species of odonate. Of the assessed species, 8.72% are facing existing threats from agricultural and aquacultural practices. Damming of large rivers for hydroelectricity projects throughout the region is having adverse impacts on the Odonata diversity, especially in the *Middle Brahmaputra* ecoregion which is affecting 3.5% of assessed species presently; the true impact of such projects might be shown to be more severe when more data on the distribution

**Figure 5.5 Percentage of dragonflies and damselflies in the Eastern Himalaya region affected by selected major threats. Note that for a significant number of species, reflecting the high level of Data Deficient species, there was insufficient information available to confirm the presence or absence of threats.**




A fast flowing hill stream near Rangjung, Bhutan. © Amit Mitra

of species assessed as Data Deficient at present becomes available. Pollution in the lentic or lotic water bodies by effluents of growing number of industries contributes to the existing threats (3.3% of assessed species) for Odonata fauna of the region, however we have little data on the tolerance of Odonata to pollution, none at all for any of the possibly threatened species, so that it is not possible to gauge how much of a threat is posed by pollution. It is interesting to note that equal percentages of threatened species (25%) are affected by all the above said existing threats except agriculture and aquaculture practices (nil).

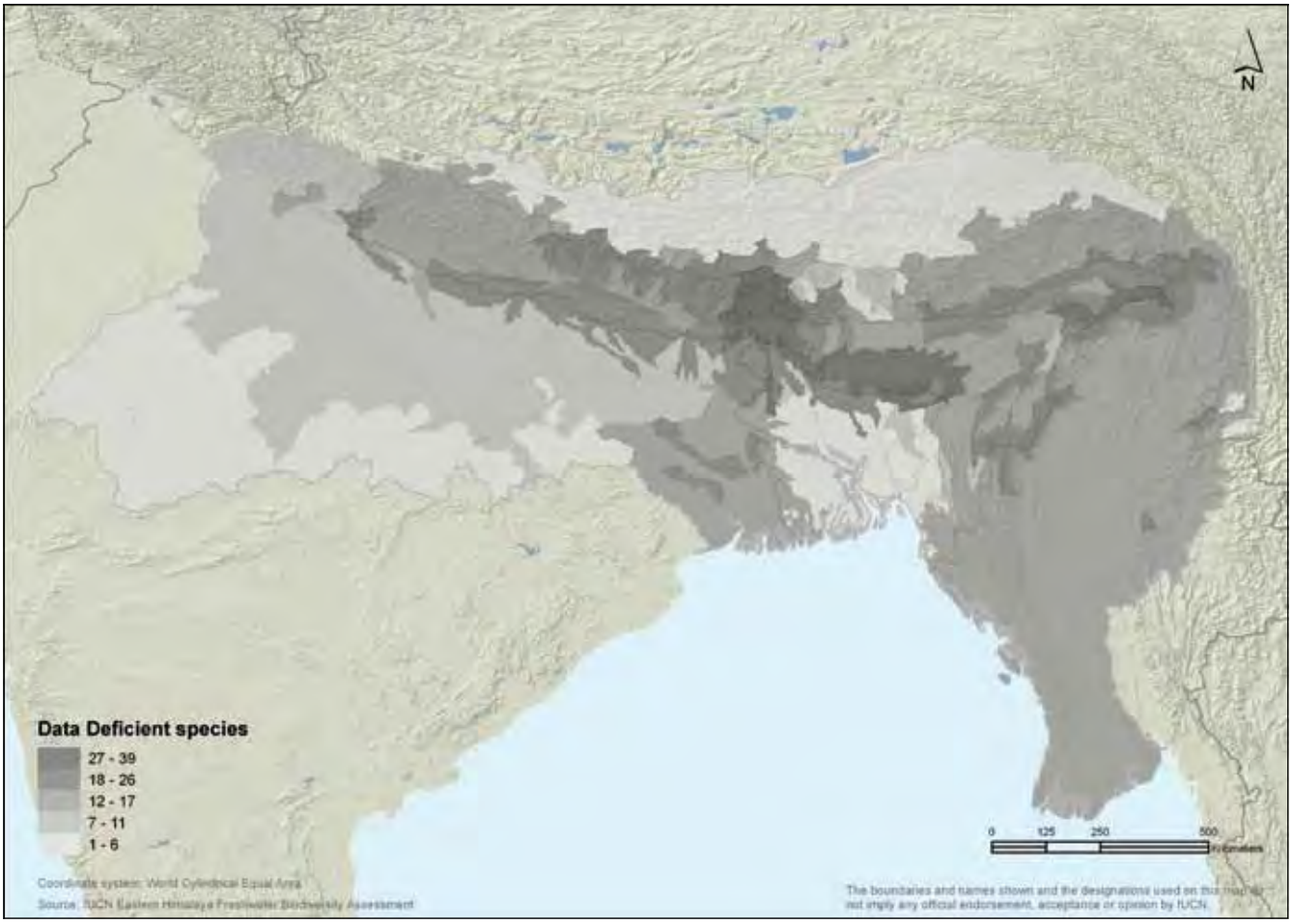
## 5.5 Conclusions and conservation recommendations

Of the 367 species of Odonata considered present within the Eastern Himalayan assessment region, more than one third (135) are Data Deficient. This shows that there is lack of good quality research and recent data from the region. Lahiri (1989) has published a list of 78 Odonata species and subspecies that have not been reported from India since 1948 and 49 of these are part of present assessment. Thirty-eight of these 49 species are in the Data Deficient list of the present assessment. A further 13 of these 49 species were recorded from Nepal from the mid-1960s to late 1980s (Vick 1989), making the records around 30 years old, and records for many other species are of a similar age. Only 50 species of dragonflies have been reported from parts of eastern and southern Bhutan (Mitra 2008), much of Bhutan is still unexplored, a situation that is repeated across much of the assessment region, for example in Arunachal Pradesh in India, and in Myanmar.

There is an urgent need for extensive, expert survey across the region. However fresh survey efforts are hampered by existing legislation in some regional countries which make it difficult to obtain permits for collection and loan of invertebrate specimens for scientific research; this is entirely counter productive for conservation efforts. Additional serious constraints include a lack of funding for fieldwork, and the need to train experts in taxonomy and field research methodologies. Moreover, large parts of the assessment region are affected by insurgency and political instability which has discouraged extensive fieldwork in these areas; the mountainous and forested terrain in many parts of the region itself makes access difficult.

Most species considered endemic to the region have been assessed as Data Deficient which raises doubts over their status as endemic to the region. Fieldwork in the unexplored areas within and outside the assessment region, and fresh fieldwork even in the relatively well known areas, might reveal that of some of these species are not actually endemic to the project region, but have wider ranges. Similarly, fieldwork is needed to determine the

**Figure 5.4 Species richness of dragonflies and damselflies in the Eastern Himalaya region.**



habitat requirements etc. for the Data Deficient species. Without extensive fieldwork the status of the Data Deficient species cannot change. Indeed, the lack of data can be considered to be a major threat to the Odonata of the region, as until this lack is remedied, proper conservation planning is not possible.

The fundamental need is for extensive, good quality, fieldwork over the entire region. There is also a pressing need for high quality taxonomic work on the Odonata of the region. Revisions in many groups would likely result in the discovery that many of the currently Data Deficient species are in fact junior synonyms of better known species on the one hand, and in the discovery of new species in the region on the other. However such taxonomic work is made almost impossible by the lack of material for those groups where the taxonomical problems are most severe, by legislation that hampers international scientific collaboration in some countries, and by difficulties in locating and gaining access to type material for a number of species, as well as by poor maintenance of insect collections in many regional institutions.

As far as the conservation of the Odonata fauna of the region is concerned, the only measures that are effective in protecting invertebrate populations are habitat protection measures, which need to be planned using the kind of data that we mostly lack for the region. Lahiri (1989) pointed out that most of the type localities of rare and endemic Odonata of eastern India concentrate in and around northern Bengal and Sikkim and Khasi Hills; however there has been insufficient sampling in other eastern Indian states such as Manipur, Arunachal Pradesh, and Nagaland. With their diverse ecosystems, these areas also sustain the majority of known Indian species. Identifying such pockets in other countries within the assessment region and giving at least parts of such pockets protected status would safeguard a high percentage of species and their habitats. For Odonata, if areas to be protected are chosen carefully, they do not have to be large, in practice more good might be done by protecting many small areas including examples of all habitat types in a particular region, than by protecting one or two large, but homogenous in terms of habitat, areas.

*Echo margarita* (LC) breeds in clear montane streams in northeastern India and may be present in Myanmar. © Krushnamegh Kunte

To summarize, the following actions are recommended:

1. Funding should be made available for extensive expert sampling of Odonata across the project region, and for relevant training.
2. Priority should be given to taxonomic research.
3. Regional governments should review their existing legislation that affects scientific collection of invertebrates, and loan and exchange of material with researchers in other countries, and remove or revise the ill-advised barriers to these activities that are currently in place.
4. When fresh data becomes available, and any taxonomic studies that are needed become available, Odonata experts should reassess the Odonata of the region currently placed in any category other than Least Concern, and, where necessary make recommendations on the protection of suitable habitat.
5. Standards of curation and storage of regional insect collections should be raised to prevent loss of type and other scientifically valuable material.

The actions recommended above are mostly concerned with research, but until this research has taken place, actual conservation measures cannot be planned affectively.

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Boat on Indawgyi River, Kachin State, Myanmar. © Jack Tordoff/CEPF

# Chapter 6. Regional synthesis for all taxa

David Allen[1], Yichuan Shi[1], Robert Holland[1] and Kevin Smith[1]



The combined data sets for all species assessed through this project (freshwater fishes, molluscs, and odonates) are analysed here to present a synthesis of the status and distribution of some key components of freshwater biodiversity throughout the Eastern Himalaya Hotspot and the wider Eastern Himalaya assessment region (encompassing the Ganga, Brahmaputra, Ayeyarwaddy and Kaladan river basins). The objective is to provide outputs to help inform conservation and development planning for wetland ecosystems and species at the regional, national, and site scales.

## 6.1 Patterns of species richness

The Eastern Himalaya region supports significant numbers of species dependent upon freshwater habitats (Table 6.1). Several groups, including odonates, mammals, and waterbirds are especially well represented within the region.

Of the 1,073 species assessed through this project, 77 species (7.2%) are globally threatened (Table 6.2; Figure 6.1), and none are considered to have become Extinct (EX) or Extinct in the Wild (EW). When compared with the level of global threat for selected taxonomic groups that have been comprehensively assessed (e.g. amphibians, 32% threatened; mammals, 22% threatened; birds, 12.4% threatened) (IUCN 2010), this figure is relatively low. However, the level of Data Deficient species within the Eastern Himalaya project region is very high at nearly one third (32.8%) of all species assessed, compared with; amphibians (25.3% DD); mammals (15.2% DD), and birds (0.6% DD) (IUCN 2010). It is likely that the overall level of threatened species will be found to be higher when further information becomes available on levels and patterns of threat to wetland species and their habitats in the region, as well as species distributions and population trends. In addition, whilst some areas are heavily impacted by development such as the lower Ganga and Brahmaputra rivers which are highly threatened by agricultural, industrial, and urban development, large parts of the region are less developed, including many upland areas, and this may also be reflected in the low levels of threatened species. However, there are extensive plans for water resource development within the region (e.g. hydropower and irrigation dams (including mainstream dams on the Ayeyarwaddy and Brahmaputra), and transport infrastructure development (the Kaladan Multi-Modal Transit Transport Project between India and Myanmar) and therefore the level of threat could dramatically increase in the near future. Systematic studies on impacts of introduced taxa, impacts of overharvesting through systematic market surveys and more comprehensive surveys in the region could lead to better assessments than are presently possible. In addition, determining the ecological niche of species and preparing niche models could help improve information on species distributions within sub-basins as currently species are assumed to be present throughout the whole sub-basin where they are known or thought to occur.

[1] IUCN Species Programme, 219c Huntingdon Road, Cambridge CB3 0DL, UK. david.allen@iucn.org; yichuan.shi@iucn.org; robert.holland@iucn.org; kevin.smith@iucn.org

### 6.1.1 Centres of species richness

Species richness is presented as the number of species contained within river sub-catchments, derived from HydroSHEDS hydrographic data (Lehner *et al.* 2006) and has been mapped for each of the three species groups assessed directly by the project. A number of Data Deficient species, especially those where the type locality is not known, were mapped to country (Nepal, Bangladesh, Bhutan and Myanmar) or sub-country unit (India and China) level.

As with many species richness maps, they have the potential to be biased by sampling intensity and mapping methodology. Some parts of the region have benefited from much more intense survey and taxonomic study either historically (i.e. the colonial era) or by more recent workers, or because they happen to be close to research centres. An example, in the case of fish, would be Manipur in India, where Waikhom Vishwanath has been active in undertaking both survey and taxonomic research. Conversely, some areas are likely to have higher species richness than is shown in this report as they have been historically under-surveyed, often because of political instability or actual difficulty of access, for example parts of Myanmar.

The higher levels of species richness can be seen (with the exception of parts of Bhutan, Sikkim and Darjeeling in India, and parts of eastern Nepal) to be restricted to below 2,000 m altitude in parts of the *Ganga Delta and Plain* ecoregion.

The sub-catchments with the highest species richness (containing between 275–411 species) are mostly within a band of between 250 and 2,000 m elevation from the northern tributaries of the Ganga along the Ganga plain and the Himalayan foothills along the Indian and Nepal border and across to the Brahmaputra plain in Assam and its tributaries from the Himalaya and from the south in Meghalaya and Nagaland. Other areas of high species richness include the tributaries of the Chindwin River (itself a tributary of the Ayeyarwaddy) in Manipur across to

**Table 6.1 Estimated numbers of extant inland water-dependent species by major taxonomic groups.**

| Taxon | Global number of described species | Number of species in Eastern Himalaya assessment region | % of species found in Eastern Himalaya assessment region |
|---|---|---|---|
| Fish | >15,000 | 540[1] | 3.6 |
| Molluscs | >5,000 | 186 | 3.7 |
| Odonates | 5,680 | 369[2] | 6.5 |
| Crabs | c.1,863 | 57[3] | 3.1 |
| Amphibians | 4,294 | 43[4] | 1.0 |
| Mammals | 142 | 12[4] | 8.5 |
| Waterbirds | 567 | 115[4] | 13.2 |
| Turtles | 260 | 20[4] | 7.7 |

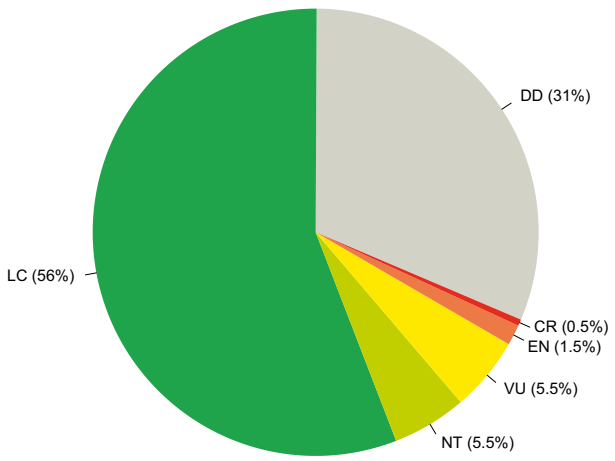
Data sources: Balien *et al.* 2008; [1] Includes 12 species omitted from the assessment in error (mainly from the Ayeyarwaddy basin). [2] Includes two species present in the region but not assessed by this project. [3] Assessed in 2008 through the Sampled Red List Index; [4] Estimates from IUCN Red List, 2009 data, based on query by country and sub-country units (species level only; sub-species not included).

**Table 6.2 Summary of Red List Category classifications at the global scale by taxonomic group.**

| Category | Odonata | Fish | Molluscs | Overall |
|---|---|---|---|---|
| EX | 0 | 0 | 0 | 0 |
| EW | 0 | 0 | 0 | 0 |
| CR | 0 | 5 | 0 | 5 |
| EN | 0 | 15 | 0 | 15 |
| VU | 5 | 50 | 2 | 57 |
| NT | 11 | 46 | 1 | 58 |
| LC | 216 | 263 | 123 | 602 |
| DD | 135 | 141 | 60 | 336 |
| **Total** | **367** | **520** | **186** | **1,073** |

IUCN Red List Categories: EX – Extinct, EW – Extinct in the Wild, CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern, DD – Data Deficient.

**Figure 6.1 The proportion (%) of species in each global Red List Category in the Eastern Himalaya region.**



Myanmar, the upper Kaladan in western Myanmar and Mizoram, the upper Tuichang River in Mizoram, the Karnaphuli River in southeastern Bangladesh and the Ganga through West Bengal and eastern Bangladesh.

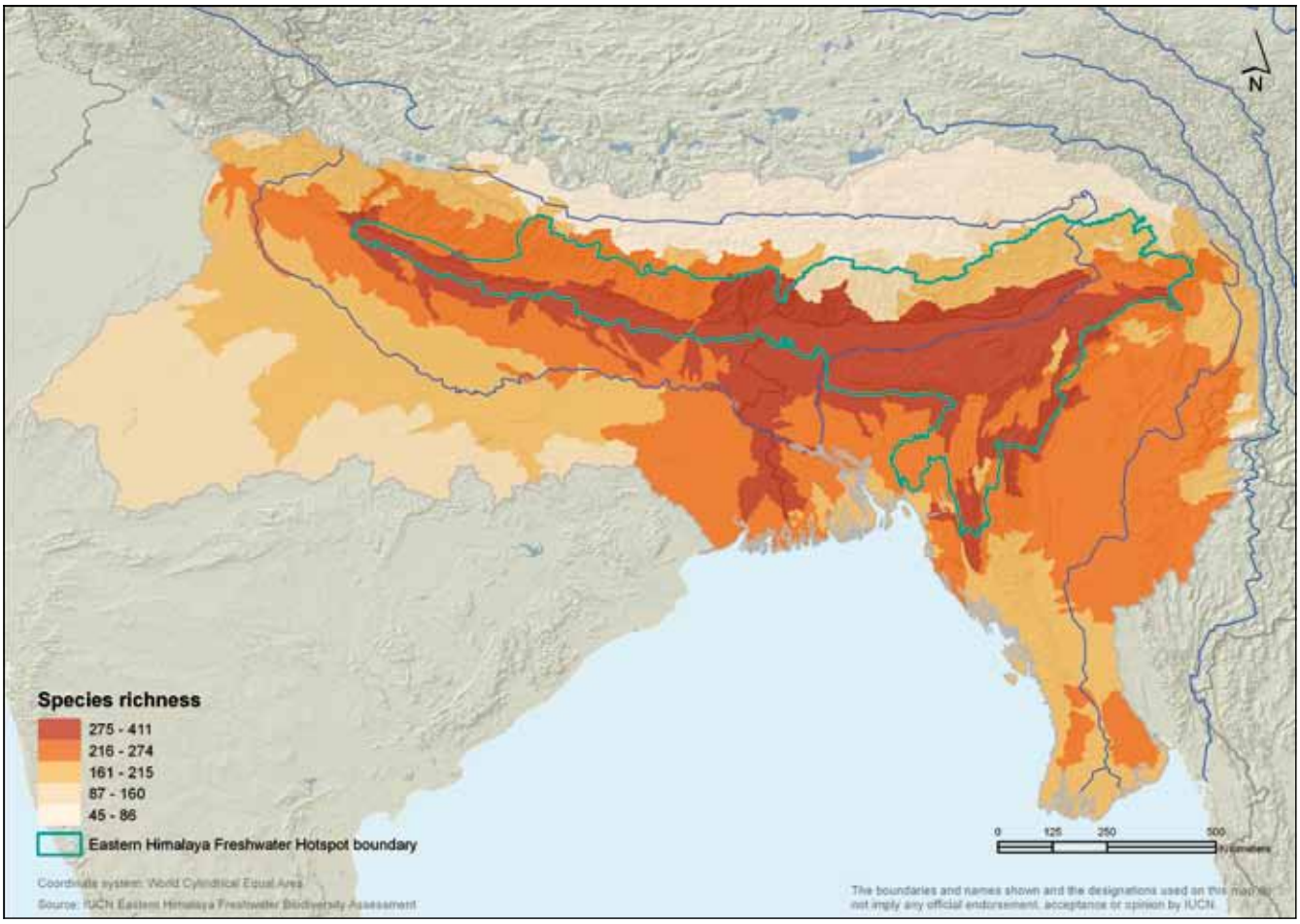
The catchments containing the most species (more than 350 species – not highlighted Figure 6.2) are all found within the Eastern Himalaya Hotspot itself. These exceptionally speciose catchments include the tributaries of the Brahmaputra flowing from Sikkim, Darjeeling and southwestern Bhutan (from the Sankosh River to the Tista River), the Atrai River, which originates in northwestern Bangladesh, and the upper Mahananda River in the very southeast of Nepal and Darjeeling. The high numbers of species found in areas such as the Himalayan foothills and parts of the Indian and Nepalese *terai* may be a product of the high degree of habitat and altitudinal variation in these places.

Some areas, such as Myanmar and Bhutan, have an apparent species richness that is conspicuously low, this is, however, likely an artefact stemming from a lack of data and survey work in these areas. An example of the potential to find new species, and need for intensive field survey and taxonomic studies, is shown by the number of new species, especially the smaller, less conspicuous species of fish in the Rhakine Yoma, in southwestern Myanmar (e.g. Britz 2008; Britz *et al.* 2009; Conway and Britz 2010; Vishwanath *et al.* 2007). The Himalayan foothills and parts of the Indian and Nepalese *terai* also have high levels of species richness, again likely a product of the high degree of habitat and altitudinal variation.

### 6.1.2 Distribution of threatened species

The greatest numbers of threatened species within a sub-catchment (between 13–16 species) are found in Manipur State, India within the Barak River, which flows west into the Meghna in Bangladesh, and the Manipur and Yu rivers, which flow south to the Chindwin River and eventually to the Ayeyarwaddy (Figure 6.3). These areas straddle the *Sittaung-Irrawaddy* and *Chin Hills-Arakan Coast* ecoregions. Areas with relatively high numbers of threatened species (between 8–12 species) are found in the upper catchments of the Meghana River in Meghalaya State, India within the *Chin Hills* and *Ganga Delta and Plain* ecoregions, the upper Gandaki River in central Nepal in the *Ganga Himalayan Foothills* ecoregion and in the wider catchments of the Barak River in Manipur in the *Chin Hills* ecoregion.

**Figure 6.2 Distribution of dragonflies and damselflies, freshwater fish, and aquatic molluscs in the Eastern Himalaya project area, based on known and inferred species presence, mapped to river sub-catchments. The boundary of the Eastern Himalaya Hotspot region is shown in green.**



The highest concentrations of threatened species are all found within the Eastern Himalaya Biodiversity Hotspot itself.

### 6.1.3 Distribution of Data Deficient species

The map of Data Deficient species is probably the most influenced by mapping methods as some of the species of molluscs and odonates were mapped to sub-country units (e.g. to Nagaland State) as detailed distribution at the sub-catchment scale was often lacking. As a result species numbers within some sub-catchments crossing political borders may be artificially high as they 'double count' the species on either side of the political border. This is seen in the upper catchments along the India-Myanmar border including the Patkai mountain range to China, Manipur and the upper Kaladan in Mizoram. Areas with high numbers of DD species (44–67 species) include the Brahmaputra tributaries draining from Sikkim and Darjeeling, and the Daying River (which crosses to China) and a section of the Ayeyarwaddy River in northeastern Myanmar. High numbers of DD species (between 33–47 species) are recorded throughout Myanmar and across the Indian states of Meghalaya and Sikkim, southern Nepal (from the Gandaki to the Kosi Rivers), eastern Nepal, and the Sarda River in Uttar Pradesh and western Nepal and western Bhutan.

### 6.1.4 Distribution of endemic species

Areas of high endemic species richness (between 65–97 species per sub-catchment) are found within the Eastern Himalaya biodiversity hotspot along the Brahmaputra plain and its tributaries in Darjeeling, Meghalaya, Assam and Arunachal Pradesh, and in the upper Meghna River in Meghalaya. These areas cover the eastern part of the *Ganga Delta and Plain* ecoregion and the *Middle Brahmaputra* ecoregion. The Sittaung River was excluded from the Eastern Himalaya assessment region (it is instead included in a parallel Indo-Burma freshwater biodiversity assessment); this in part explains the apparent low density of endemic species in Myanmar in the Ayeyarwaddy basin, as the Sittaung was once part of the Ayeyarwaddy drainage and shares much of the ichthyofauna.

**Figure 6.3 The distribution of threatened (CR, EN, and VU Categories) species dragonflies and damselflies, freshwater fish, and aquatic molluscs in the Eastern Himalaya project area, based on known and inferred species presence, mapped to river sub-catchments. The boundary of the Eastern Himalaya Hotspot region is shown in green.**

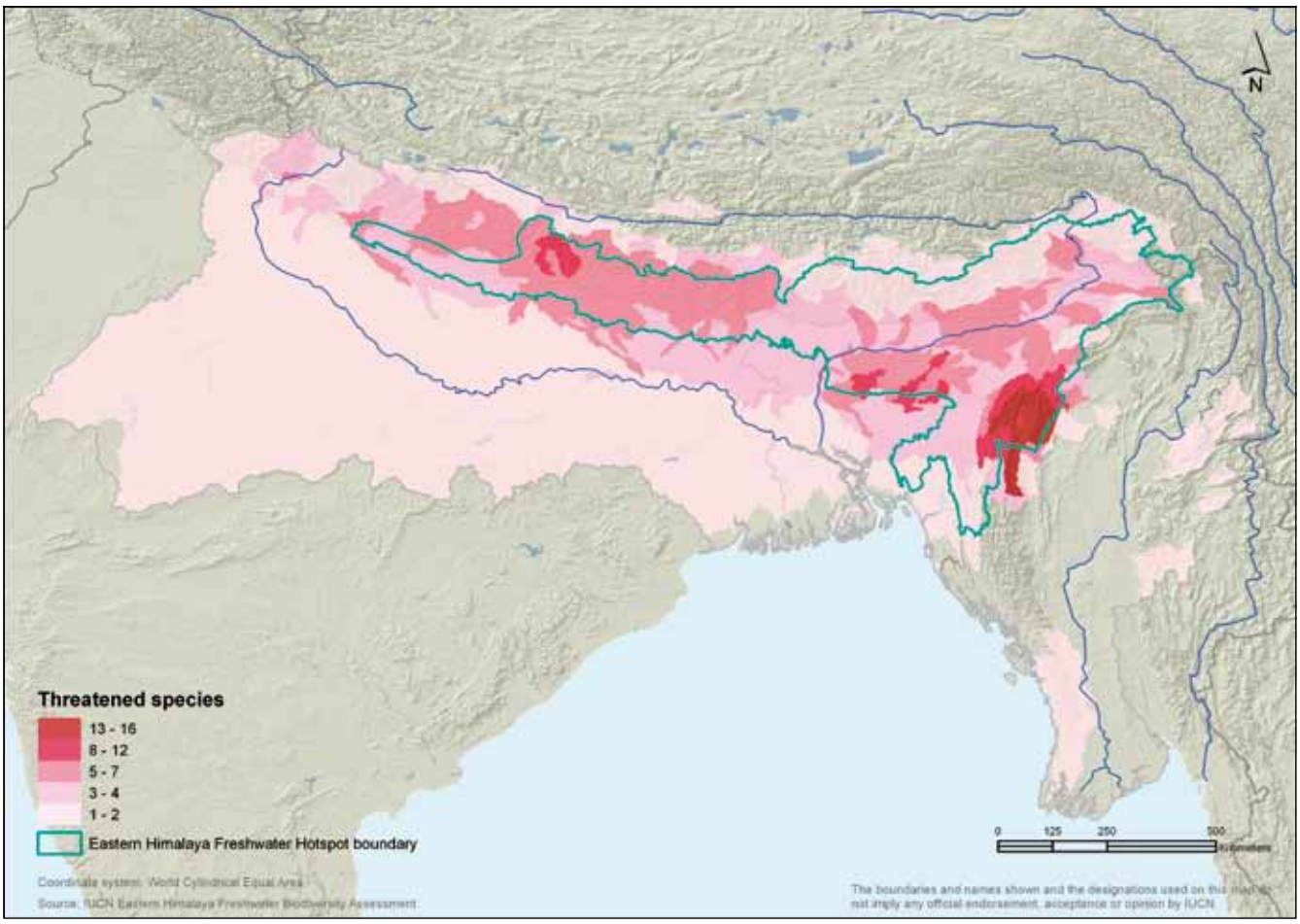
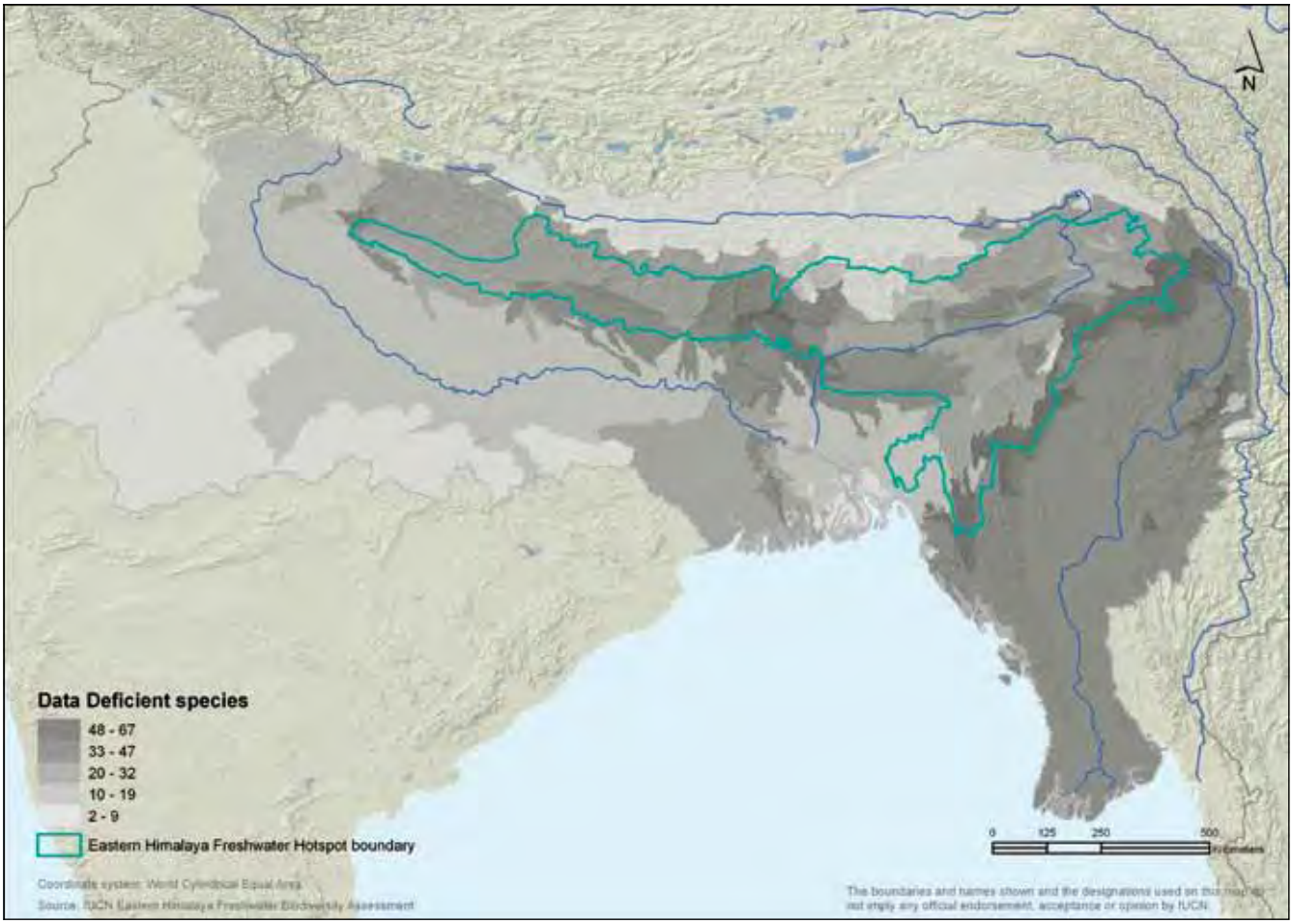


**Figure 6.4 The distribution of Data Deficient (DD) species dragonflies and damselflies, freshwater fish, and aquatic molluscs in the Eastern Himalaya project area, based on known and inferred species presence, mapped to river sub-catchments and in some cases sub-country units. The boundary of the Eastern Himalaya Hotspot region is shown in green.**




## 6.2 Key threats within the Eastern Himalaya

Biological resource use has been identified as the threat impacting most species within the Eastern Himalaya, affecting around 20% of all species and nearly 5% of threatened species (Figure 6.6). Within this, fishing and harvesting of aquatic resources (primarily fishes and some molluscs) is identified as threatening the greatest proportion of species, impacting over 30% of all threatened species and 12% of all species, whilst logging and wood harvesting impacts around 12% overall (4% of threatened species) (Figure 6.6). Pollution from agricultural sources threatens almost 26% of threatened species, and sedimentation, residential and commercial development and dams and deforestation all impact between 15 and 10% of threatened species (Figure 6.6).

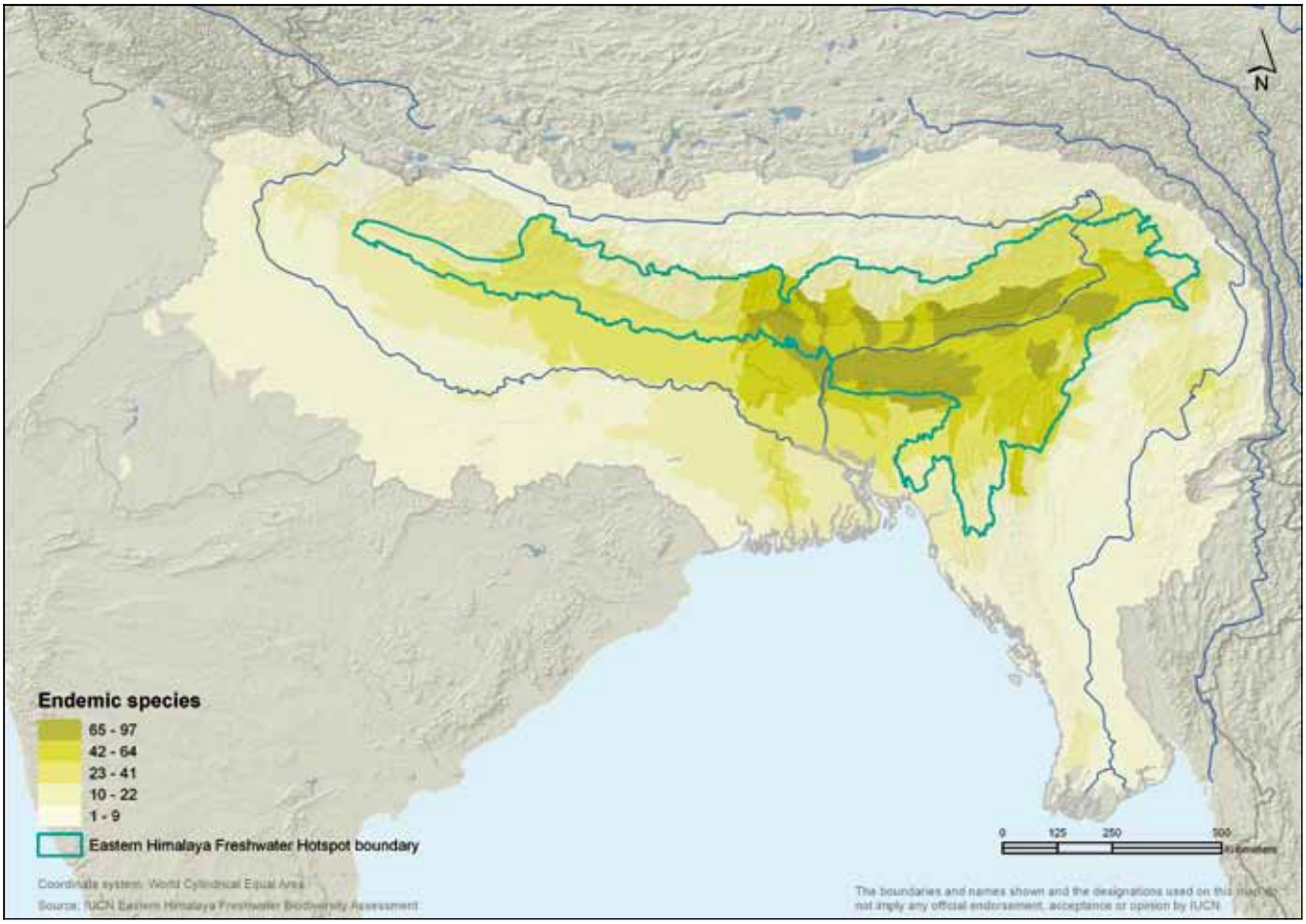
### 6.2.1 Participative threat mapping

Experts from within the region undertook a participative threat mapping exercise prior to data compilation and the subsequent assessments of species conservation status. The maps assisted experts to be consistent in their assessments of species conservation status by providing a standard reference map of threats across the region. Each expert drew, on paper maps, known threats within their geographic area of knowledge. The resulting maps, grouped by threat type, are presented in Figures 6.7–6.10. This exercise revealed (i) clear gaps in knowledge of threats across some parts of the region, in particular Myanmar, Bangladesh, parts of China, and north-central India; and (ii) that taxonomists, selected as species experts, do not necessarily have detailed knowledge of the types and distributions of threats, especially at the scale of the Eastern Himalaya project area. In future assessments additional expertise on regional threats will be incorporated.

### 6.2.2 Hydropower and irrigation dams

There are numerous dams within the assessment area, especially within the southern tributaries of the Ganga, and in the Ayeyarwaddy basin (Figure 6.11). The data used to produce this figure, which was generated through a review of GoogleEarth images (Mulligan *et al.* 2010), can not be used to distinguish between hydropower and irrigation dams, nor can it provide information on the impact of individual dams, however, the extent of current dams within the region is clear. Information on planned and potential dams within the region is difficult to

**Figure 6.5 The distribution of dragonflies and damselflies, freshwater fish, and aquatic molluscs species endemic to the Eastern Himalaya region, based on known and inferred species presence, mapped to river sub-catchments. The boundary of the Eastern Himalaya Hotspot region is shown in green.**



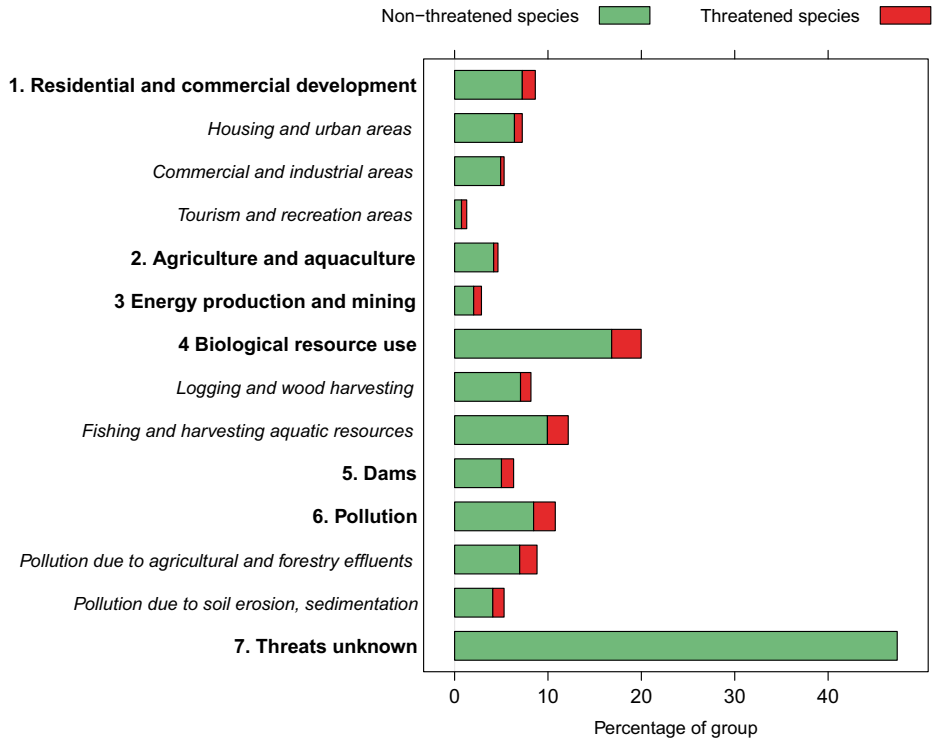




**Figure 6.6 Major threats to freshwater species in the Eastern Himalaya.**

Figure 6.7 Distribution of selected threats related to water use, dams, water abstraction, and sedimentation throughout the Eastern Himalaya assessment region.

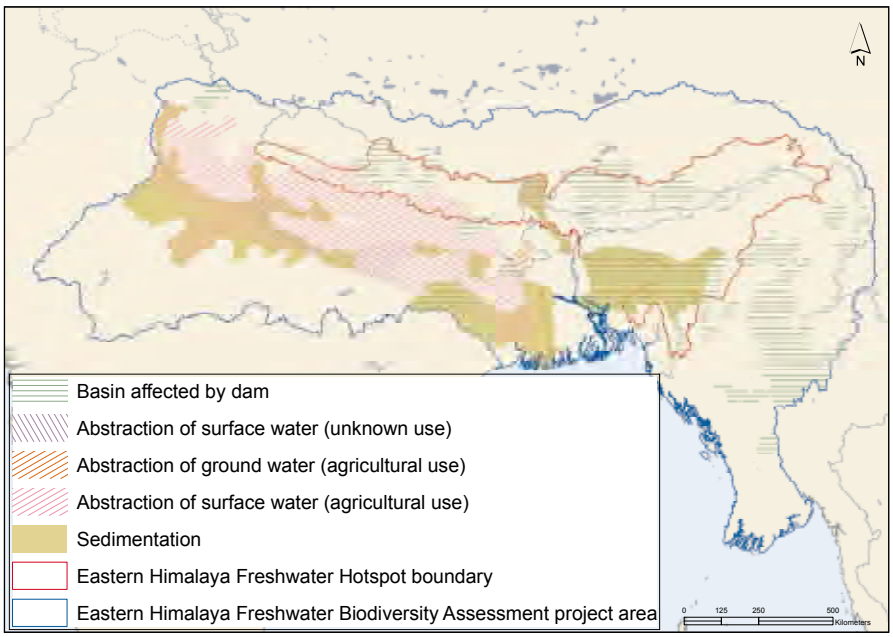



Figure 6.8 Distribution of selected threats related to fishing, logging and deforestation, and major weather events throughout the Eastern Himalaya assessment region.

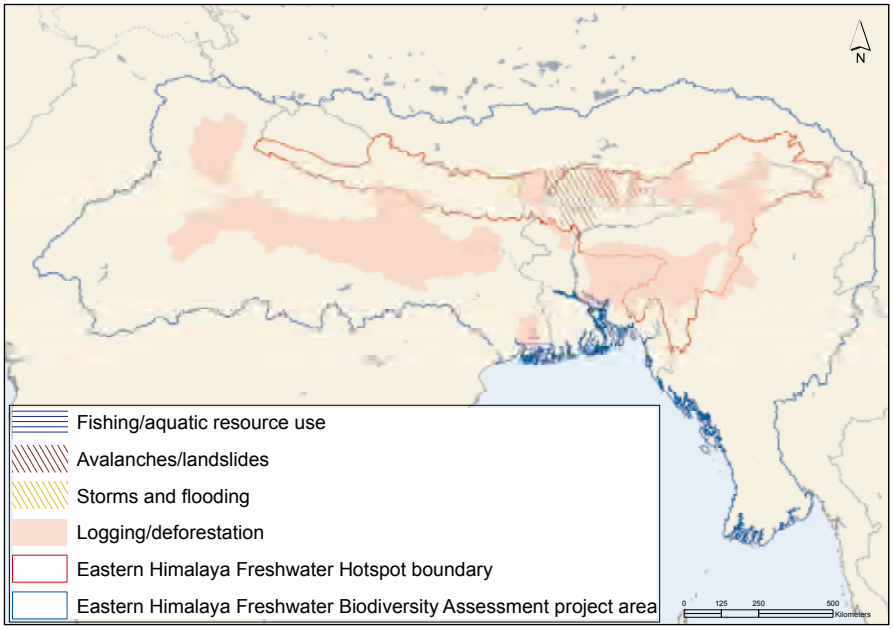
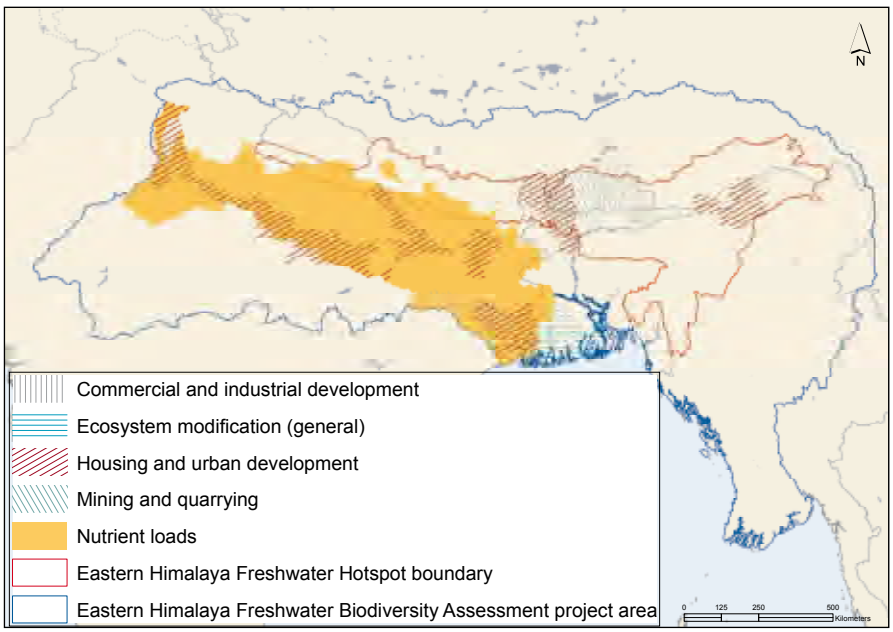



Figure 6.9 Distribution of selected threats related to urban, commercial and industrial development, mining, and aquatic nutrient loads throughout the Eastern Himalaya assessment region.



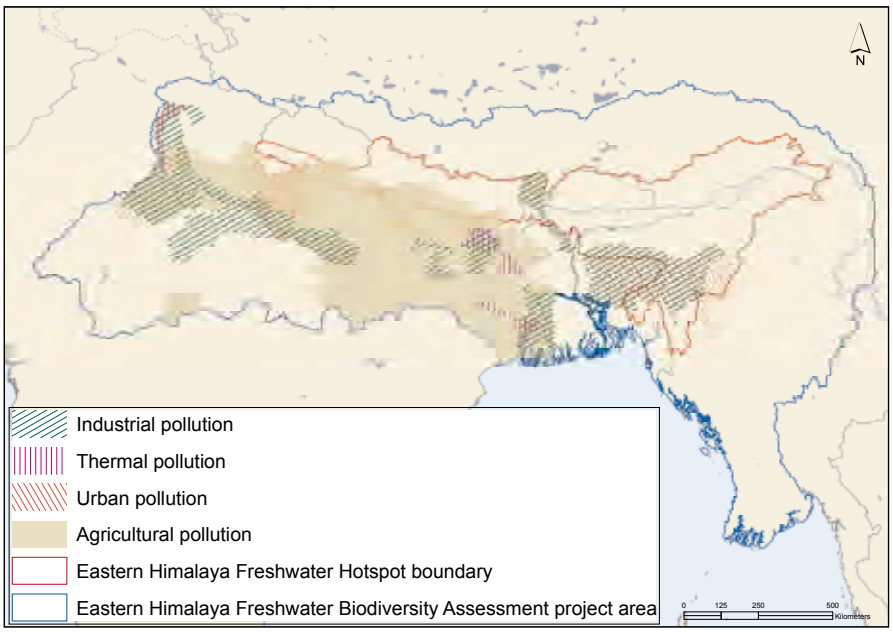



**Figure 6.10 Distribution of selected threats related to industrial, urban, and agricultural pollution throughout the Eastern Himalaya assessment region.**

obtain, but it is clear that there are large scale plans in some parts of the region to develop hydropower resources for electricity generation. There are plans to build several hundred dams across the Himalaya to increase power production to 150,000 megawatts in the next 20 years (Dharmadhikari 2008). At present there are no dams on the mainstreams of the major rivers. However, the first mainstream dam is now being built in China on the Brahmaputra at Zangmo (shown by the red dot in Figure 6.11), and more are being proposed for the Brahmaputra, Kaladan and Ayeyarwaddy Rivers.

Dams have been indicated as a threat in fewer than 10% of assessed species (and only around 2% of threatened species). The level of threat arising from dam development within the region is however, likely to greatly increase in coming years as more large dams are constructed to support the regions development. There is an urgent need to review the impacts of dams on aquatic biodiversity within the region, especially in the context of the high livelihood value fisheries.

### 6.2.3 Deforestation and siltation

Deforestation, the degradation of remaining forested areas, and shifting and intensive agricultural practices are thought to have resulted in increased sediment loads and have been cited as widespread threats in many parts of the region (e.g. Eckholm 1975; Blaikie 1985). This view is, however, not universally accepted as it is not clear that changes in upstream management practices would significantly reduce the sediment loads of rivers. The amount of sedimentation resulting from man-induced environmental degradation is thought by some to be insignificant relative to that resulting from natural erosion (Aylward *et al.* 2005).

With increasing populations and levels of development across the region, there is a need to balance the needs for agricultural food production with the ecosystem requirements of aquatic biodiversity which still forms the cornerstone of many rural livelihoods. Research into alternative agricultural practices that preserve soils and reduce sedimentation is required, along with programmes for education and support to communities in upland areas.

### 6.2.4 Species use and trade

Unsustainable use of biodiversity resources is a significant threat to aquatic species within the region. Direct use of freshwater species, such as through fisheries, impacts over 20% of the species assessed. Indirect forestry activities, such logging and other uses of forest resources, result in increased levels of sedimentation and other types of water pollution. These activities present an even higher level of overall threat to aquatic species through the subsequent loss and degradation of both aquatic and terrestrial (of importance to dragonflies and damselflies) habitats.

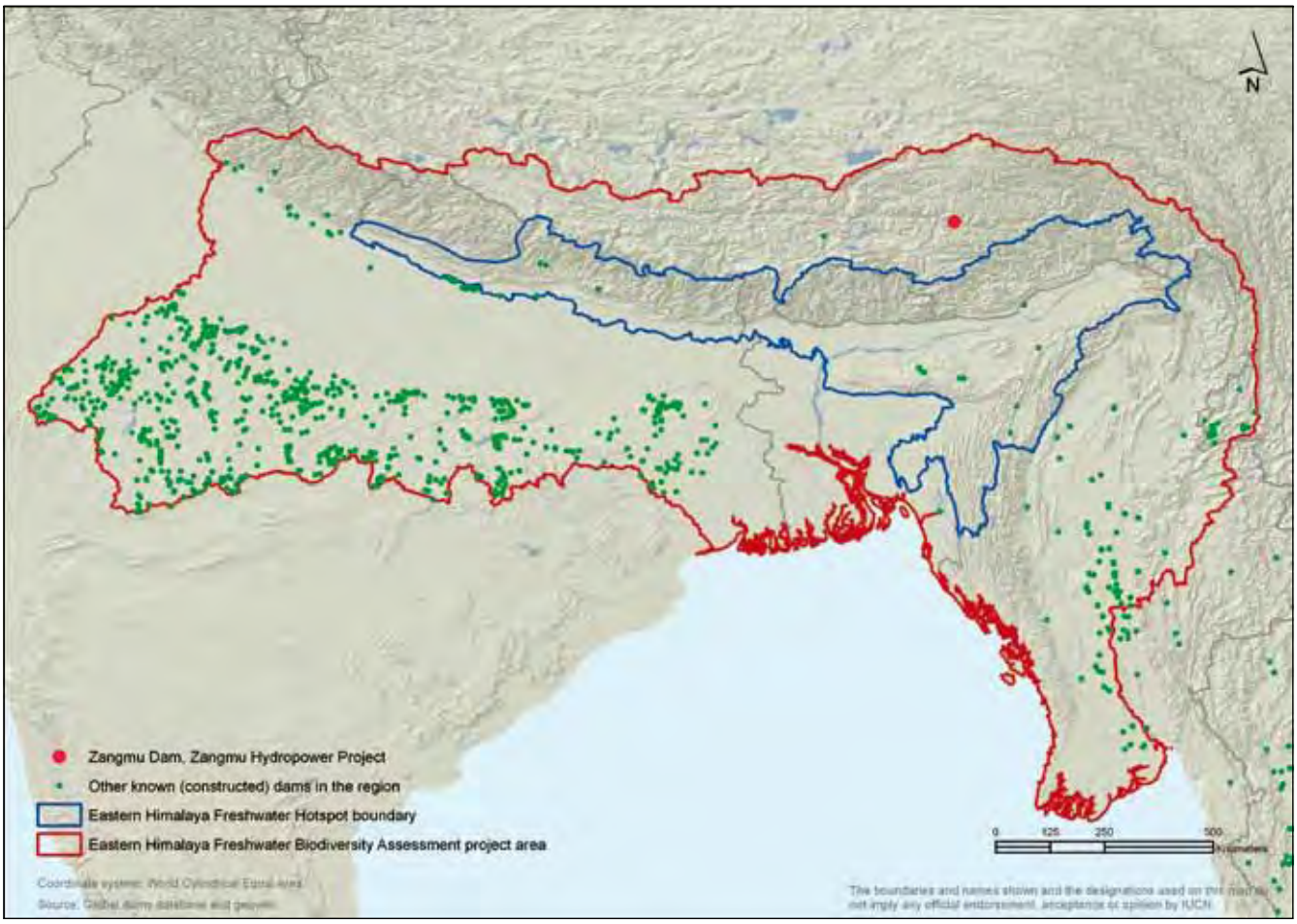
### 6.2.5 Pollution

Pollution from a range of sources is a significant threat across the region (Ghimire 1985; CEPF 2005; WWF 2010), and the scale of impacts is likely to have been underestimated. The lower parts of the Ganga are highly polluted from agricultural (sedimentation and agrochemicals), industrial and commercial, and urban (including sewage) sources, a situation that is likely to be repeated in other drainages. When compared to the other major rivers in India, the Brahmaputra is generally less polluted but petroleum refineries contribute most of the industrial pollution load into the basin along with other medium and small industries, as well as the high urban population in the lower parts of the catchment.

### 6.2.6 Unknown threats

For almost 50% of species their threats are unknown, as is reflected in the very high numbers of DD species recorded. This figure could have been reduced if better information on threats, species

**Figure 6.11 Location of currently known dams (green points) throughout the Eastern Himalaya region. Note the very large number of dams in the southern parts of the Ganga River catchment and parts of Myanmar. Also shown is the location (red point), at Zangmo in the Tibet Autonomous Region of China, of the first dam on the mainstream of the Brahmaputra (Yarlung Tsangpo) River. The dam is estimated to cost $1.2 billion, and has a generating capacity of 510 MW. With the exception of the Zangmo dam, the map only shows *current dams* visible on GoogleEarth, not those under construction or planned. Source: Global dams database and geowiki (Mulligan *et al.* 2010).**




distributions, and other aspects of species ecology and population trends had been available to inform the assessments. For several key threats, and especially hydropower dams, information on the scope and severity of threats and their impacts is unavailable, or is not in the public domain.

## 6.3 Identification of freshwater Key Biodiversity Areas

### 6.3.1 Proposed Key Biodiversity Areas (KBAs)

Key Biodiversity Areas (KBAs) are sites of global significance for species conservation that are identified using a set of transparent criteria and thresholds relating to the vulnerability and/or irreplaceability of species within the site (Langhammer *et al.* 2007). Vulnerability refers to the likelihood that a sites' biodiversity will be lost over time as indicated by the presence of species assessed as threatened. Irreplaceability refers to the spatial options for conservation of a species; in other words if a species is only found in a limited number of sites (sub-catchments in this case) there is a high risk the species will be lost globally and it is therefore considered irreplaceable. The IUCN Species Programme has developed a series of criteria to identify sub-catchments which qualify as Key Biodiversity Areas for freshwater species based on these definitions of vulnerability and irreplaceability (Darwall and Vié 2005; R. Holland, pers. comm.) (see Box 4).

Harvesting fish from a irrigation canal in the Ayeyarwaddy catchment, Myanmar. © Ralf Britz

**Box 4. Criteria for the identification of sub-catchments as proposed Key Biodiversity Areas**

**Criterion 1**
A site is known or thought to hold a significant number of one or more globally threatened (IUCN Red List Categories VU, EN, and CR) species or other species of conservation concern. This is the vulnerability based criterion as it identifies sub-catchments containing species with the highest risk of being lost in the future. To apply this criterion each species must be assessed using the IUCN Red List Categories and Criteria with those classified as Vulnerable, Endangered or Critically Endangered triggering KBA qualification.

**Criterion 2**
A site is known or thought to hold non-trivial numbers of one or more species (or infraspecific taxa as appropriate) of restricted range. Sites that contain vagrant species are not considered. This is the first of the irreplaceability criteria. Threshold values for restricted range differ between taxonomic groups. For fish and molluscs the threshold value was set as less than 20,000 $km^2$ and for odonates the threshold value was set at less than 50,000 $km^2$.

**Criterion 3**
A site is known or thought to hold a significant component of the group of species that are confined to an appropriate biogeographic unit or units. This is the second of the irreplaceability criteria. Here the *Freshwater Ecoregions of the World* (Abell *et al.* 2008) were utilized as the biogeographic units and for each sub-catchment the proportion of species that occur in just one ecoregion was calculated. A sub-catchment qualifies under Criterion 3 if 25% or more of the species within it are restricted to the ecoregion.

Deforestation in Nepal. © Nigel Hargreaves

For the three taxonomic groups (odonates, molluscs and fishes) assessed and mapped through this project, we initially identified 746 sub-catchments that qualify under at least one of the criteria. However, qualification of 249 sub-catchments was triggered purely through the presence of a few widely distributed but threatened fish species not best suited to site based conservation actions. We therefore excluded *Clarias magur* (EN), *Cyprinion semiplotum* (VU), *Puntius chelynoides* (VU), *Botia rostrata* (VU) and *Garra flavatra* (VU), all of which are wide ranging species, from consideration under Criterion 1. Although these species are excluded from the present analysis as part of the KBA process expert knowledge should still be used to identify key areas within these species ranges which might be suitable for site based conservation.

Following exclusion of these five species, 555 sub-catchments were still triggered as potential freshwater KBAs. Table 6.3 summarizes the number of sub-catchments that qualify for each group under each criterion. In total 299 fish species, 26 mollusc species and 237 odonate species triggered KBA qualification. Figure 6.12 illustrates the location of these sub-catchments. As can be seen a high proportion of the sub-catchments fall within the Eastern Himalaya Hotspot, emphasizing the importance of this region for freshwater biodiversity.

### 6.3.2 Next steps: formal designation of KBAs and gap analysis

Applying the KBA criteria represents the first step in the process towards formal designation of KBAs. The aim is not to minimize the area identified, but rather to identify all sub-catchment that qualify using a globally standardized set of criteria. Following this initial analysis expert knowledge and conservation planning tools are used to identify priority sub-catchments, within the identified network of all qualifying KBA sub-catchments, which can be proposed to the relevant national and international bodies for recognition as formal KBAs. This second, workshop based, process for the formal identification of KBAs has not yet been undertaken.

However, as can be seen in Figure 6.12, a number of sub-catchments contain a high proportion of species that meet the three KBA criteria. The concentration of qualifying taxa in these sub-catchments makes them strong candidates for formal recognition as freshwater KBAs.

In addition to highlighting areas of high conservation value, one of the important applications of KBAs is to enable assessment of the coverage of sub-catchments important for conservation of freshwater species by the current protected area network. The last few decades has seen a rapid expansion of the world's protected areas as one of the most effective tools for maintaining biodiversity (Naughton-Treves *et al.* 2005). However, designation of protected areas is often based on knowledge of a limited number of taxonomic groups (i.e. birds, mammals, selected plants and amphibians) and for practical reasons such as the cost of land in different regions of the world. The identification of KBAs for freshwater species is therefore an urgent priority so that gaps in the coverage of protected areas for these species can be identified.

**Table 6.3 Number of sub-catchments qualifying under each of the Key Biodiversity Area criteria.**

| | Fish | Molluscs | Odonates |
|---|---|---|---|
| Criterion 1 | 312 | 122 | 132 |
| Criterion 2 | 345 | 19 | 233 |
| Criterion 3 | 7 | 0 | 0 |

Figure 6.13 illustrates the sub-catchments identified as potential freshwater KBAs, and areas within the Eastern Himalayan Hotspot currently recognized or proposed as KBAs for other taxa or as protected areas (PAs). It is most notable that there is little congruence between those sub-catchments containing the highest numbers of freshwater species which meet the KBA criteria and those sites identified as priorities for conservation within the World Database of Protected Areas, as KBAs for other taxonomic groups, or as part of the Critical Ecosystem Partnership Fund (CEPF) ecoregion profile (CEPF 2005). Although the northern portion of the Kangchenjunga-Singalila region has been identified as a priority area by the CEPF, coverage of sub-catchments to the east, the regions around Meghalaya and Manipur, is very low.

Future work should ensure that conservation investment is inclusive of the needs of freshwater species and that the existing network of protected sites includes priority freshwater conservation sites as targeted conservation area in their own right.

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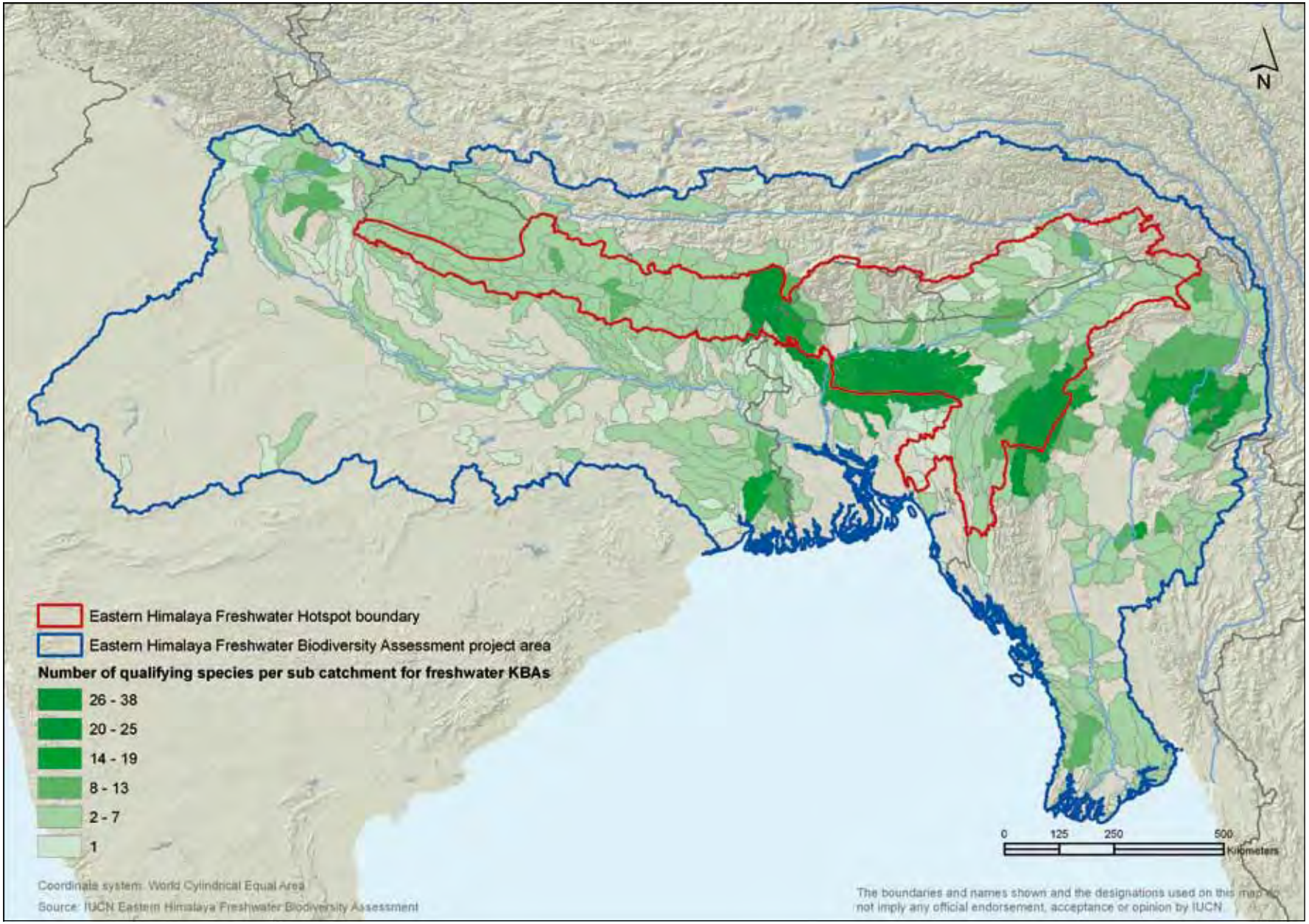


**Figure 6.12 Sub-catchments qualifying as potential freshwater Key Biodiversity Areas based on data for fish, molluscs and odonates. Sub-catchments in darker green indicate those areas with the highest number of qualifying species and so likely represent priorities areas for conservation of freshwater species.**

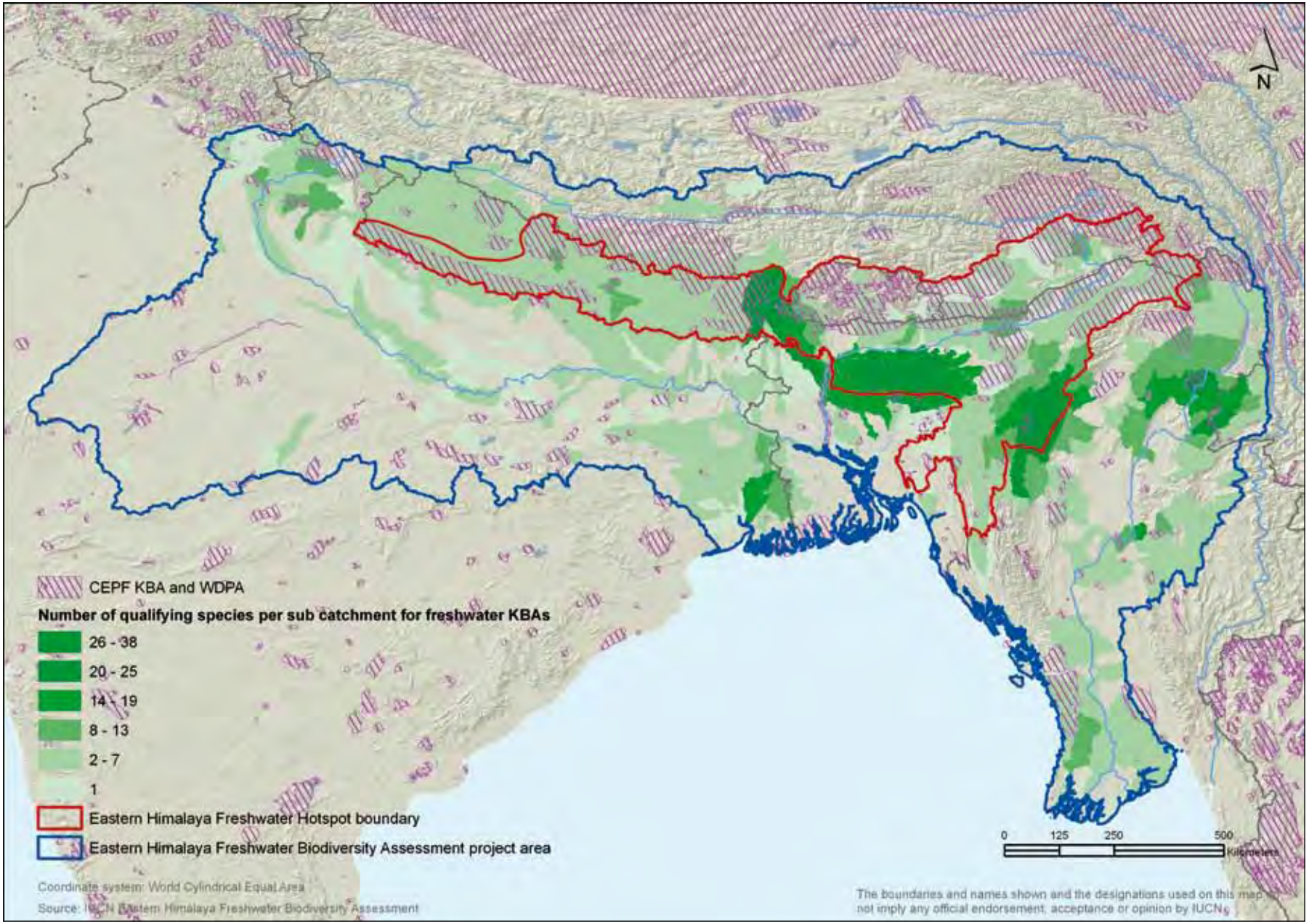


**Figure 6.13 Congruence between sub-catchments identified as potential freshwater Key Biodiversity Areas and areas identified as KBAs for other taxa, protected areas according to the World Database on Protected Areas, and CEPF priority conservation corridors.**

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# Chapter 7. Conclusions and Recommendations: Conservation priorities for the region

B.A. Daniel[1], Sanjay Molur[1] and David Allen[2]



## 7.1. Filling the information gaps: data deficiency, research, and training

Of the 1,073 species assessed in this project, 336 (31.3%) were assessed as Data Deficient, emphasizing the high degree of uncertainty regarding the status of the regions freshwater biodiversity. To ensure that conservation and development decisions across the region are informed by information on the habitat requirements, ecology and biology of freshwater species, it is essential to close this information gap. To do this, investment in research on the distributions, population trends, threats and taxonomy of freshwater species in the Eastern Himalaya is urgently required. Much of the information available for this region is 100 or more years old, notably for molluscs and odonates. A significant number of the Data Deficient species included in this assessment have not been re-collected since they were first described and therefore are only known from their type specimens and locality. Many type localities need to be resurveyed to determine if the many range-restricted freshwater taxa are still extant or have become extinct, the taxonomic status of many of these species also needs to be reviewed as some may be synonymous with other described species. This information can only be obtained through extensive and professional field surveys across the region.

Priority should also be given to taxonomic research for molluscs and odonates. There is an identified need to build the capacity amongst regional scientists to access and utilize current international research, standards and techniques in taxonomy. IUCN's Species Survival Commission and Specialist Groups could play a key role through providing expertise, training and access to literature.

Standards of curation and storage of museum collections need to be raised in some parts of the region to prevent the loss of type and other reference material. The regulatory framework should be modified so that it does not prevent the collection of specimens for research (with due regard to the conservation threat of collection), and so promotes international collaboration by facilitating sharing of material across the research community. This is supported by the World Conservation Congress Resolution CGR3.RES074, which emphasizes "... the importance of governments and research institutions encouraging research on species listed as threatened by IUCN to enhance understanding of the biology and conservation needs of these species..." (IUCN 2009).

Regular monitoring of habitat conditions and population trends of freshwater species, with particular reference to fishes, is recommended.

## 7.2 Pollution reduction and environmental impact assessment

Water quality improvement is a priority in the project area, particularly within the lower stretches of rivers, including the Ganga and Brahmaputra. The discharge of untreated sewage and industrial pollutants, and the use of agrochemicals in river catchments needs to be controlled and reduced, this requires

[1] Zoo Outreach Organization, Box 1683, 9A, Lal Bahadur Colony, Peelamedu, Coimbatore 641 004, India. [2] IUCN Species Programme, 219c Huntingdon Road, Cambridge CB3 0DL, UK.

training in the correct use of agrochemicals, in the development and implementation of water quality monitoring programmes, investment in pollution reduction technologies, and effective enforcement of legislation. Extensive awareness and education programmes are a priority for all stakeholders and related government and non-government agencies who promote hazardous practices.

All major projects that could impact freshwater systems should be subject to an independent and transparent environmental impact assessment (EIA). The information collated through the current project can be used as a starting place for EIAs, but all EIAs should include extensive and appropriate field surveys, an assessment of the livelihood value of freshwater species to communities likely to be impacted and the identification of environmental flow requirements essential for the maintenance of freshwater biodiversity (Dyson *et al.* 2008).

The operating conditions of existing dams should be reviewed to ensure that environmental flows are maintained or restored, and technologies adopted to mitigate the impact of barrages to migratory species.

## 7.3 Protected Areas: freshwater conservation and protected area connectivity

The existing protected area network and conservation zoning within the region demonstrate a low level of congruence with centres of high overall freshwater species richness and threatened freshwater species richness (see Figure 6.12), and efforts to address this should be made by conservation managers within the region. The role of communities in conservation needs to be recognized through the implementation of community conservation areas and resource management.

The analysis of candidate freshwater key biodiversity areas identified through this project should undergo a process of stakeholder review and refinement using detailed site-scale surveys and economic and social research. Finalized KBAs should be disseminated widely to stakeholders within the Eastern Himalaya region, and local policies developed for their management. The upper portion of the Ganga-Brahmaputra drainages in northeastern India, Nepal, and parts of Myanmar and upstream areas of the Chindwin drainage in Myanmar and India (Manipur) include a high proportion of the potential freshwater KBAs identified through this project.

The Balkila Watershed in the Uttarakhand Himlayas. © Ganesh Pangare/IUCN

## 7.4 Habitat and species conservation

There are high levels of forest loss and degradation across significant parts of the region resulting in the loss of terrestrial and aquatic habitats, both directly and through effects such as siltation. The rate of forest degradation must be reduced and action taken to promote forest restoration through social forestry, particularly in upper river catchments. To reduce dependence on shifting agriculture practices prevalent in some areas, an integrated approach is required to address issues such as land rights, resource access, livelihood security, and agricultural development.

Community involvement in species and habitat conservation efforts is vital if they are to be successful in addressing the threats facing freshwater habitats and species across the region. A good example of this is provided by community-based fisheries management that has been shown to be successful in the management of fishing stocks (see Box 5).

## 7.5 Legislation and enforcement

Though legislation to protect species and habitats exists across the region, implementation and enforcement is often not effective. Destructive harvesting of fishes (including the use of small mesh-size nets, dynamiting, poisoning and electric fishing) must be banned and existing legislation enforced. The large-scale collection of molluscs should be monitored and regulated.

Regional governments should review existing legislation that prevents the scientific collection of species for research, and the loan and exchange of materials with researchers in other countries (see Section 7.1, above). Policies for the conservation of lesser known invertebrate groups such as molluscs, dragonflies and damselflies are lacking in this region.

The introduction into the wild of species not native to the river or lake systems local to the area of introduction can have widespread impacts on the natural environment and biodiversity, including

### Box 5. Community based sustainable management in the Tanguar *haor* wetlands

**Md Shahad Mahabub Chowdhury (Programme Officer, IUCN Bangladesh)**

Tanguar *haor* is a unique wetland ecosystem in northeastern Bangladesh that is of both national and global significance. The wetlands were designated a Ramsar site (Wetland of International Importance) in 2000, and declared an Ecologically Critical Area in 1999 by the Bangladesh government.

Tanguar *haor* plays a critical ecological and economic role in Bangladesh. The wetland supports freshwater fish spawning grounds and directly sustains the livelihoods of over 56,000 people from 88 surrounding villages and contributes to national food production and security. Wetland resources were threatened by over-exploitation arising from the competitive fishery leasing system in operation, as well as from competing land uses such as cattle grazing and commercial duck farming. IUCN Bangladesh has worked in the wetlands since 2002 to establish an innovative comanagement system that allows the sustainable use of natural resources, applying the 'wise use' principles. The initiative has increased the capacity of local communities to effectively manage the wetland, and created alternative income generation options to reduce dependency on natural resources.

A historic milestone was achieved in the management and conservation of the Tanguar *haor* wetlands and its rich biodiversity when the traditional leasing system was abandoned by the Ministry of Environment and Forest (MoEF) in favour of a community-based management system. The Swiss Agency for Development and Cooperation supported the MoEF initiative, who then nominated IUCN Bangladesh to implement the project. The first phase of the project started in December 2006, with a second phase, due for completion in April 2012, commencing in May 2009.

The development objective of the current work is to establish a functional co-management system for conservation, stabilisation and sustainable use of the natural resources of the wetlands that generates opportunities for significant improvements in the livelihoods of rural communities and contributes to the costs (cost recovery processes) incurred by management.

http://iucnbd.org/tangua



to native fisheries of high food and economic value. New species, especially fish species for use in aquaculture, should be carefully evaluated for their level of risk before development for aquaculture or release into the wild. The cultivation and release of highly-invasive species should be restricted.

## 7.6 Raising awareness through biodiversity information

Freshwater ecosystems are vital to the livelihoods and economies of the Eastern Himalaya countries. However, their importance is often largely under-estimated, by local people as well as by decision makers, and they are often considered as "waste" areas where undeveloped tribal communities live. Awareness campaigns to promote the sustainable use and management of wetlands and rivers are crucial for the future of these vulnerable ecosystems. Effective educational programmes with special focus on children need to be implemented in order to raise awareness about the importance of freshwater species, their habitats' conservation and the threats that they face. Moreover, projects across all levels of society are needed to educate people about the value of water and the need of more efficient techniques for the utilization of it as a resource. Due to the rapid development of the region, it is fundamental to provide politicians, legislators and other relevant stakeholders with key biodiversity information about the status of freshwater ecosystems and the importance of integrating this information into the decision-making and planning process over both the short and longer term.

Local communities should be encouraged to participate in the conservation of freshwater species and their habitats (e.g. community-based resource management; Box 5). Developing trust between communities and regulatory authorities, and ensuring that communities have control over their local resources will help achieve the goals of freshwater species conservation and awareness building among the public, policy makers and managers.

## 7.7 References


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Ruddy Shelduck (*Tadorna ferruginea*) on Indawgyi River, Kachin State, Myanmar. © Jack Tordoff/CEPF

# Appendix 1. Example species summary and distribution map: *Psilorhynchus gracilis*

**Each species assessed through the Eastern Himalaya project has been submitted to the IUCN Red List (www.iucnredlist.org), and a species report and species distribution map can be downloaded from the Red List, and are included in the CD in Appendix 2. An example of a species report and map is shown here.**

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## Psilorhynchus gracilis

Summary | Classification Schemes | Images & External Links | Bibliography | Full Account

Taxonomy
Assessment Information
Geographic Range
Population
Habitat and Ecology
Threats
Conservation Actions
Bibliography

View Printer Friendly

### Taxonomy [top]

| Kingdom | Phylum | Class | Order | Family |
|---|---|---|---|---|
| ANIMALIA | CHORDATA | ACTINOPTERYGII | CYPRINIFORMES | PSILORHYNCHIDAE |

| | |
|---|---|
| **Scientific Name:** | *Psilorhynchus gracilis* |
| **Species Authority:** | Rainboth, 1983 |
| **Common Name/s:** English – Rainbow minnow | |
| **Taxonomic Notes:** | Original description based on specimens collected from multiple localities throughout Bangladesh (Rainboth 1983). Recognised as a valid species by Rahman (1989), Talwar and Jhingran (1991), Edds and Ng (2007), Kar and Sen (2007), Conway and Kottelat (2007) and Conway and Mayden (2008a,b). |

### Assessment Information [top]

| | |
|---|---|
| **Red List Category & Criteria:** | Least Concern ver 3.1 |
| **Year Assessed:** | 2010 |
| **Assessor/s** | Dahanukar, N. |
| **Reviewer/s:** | Allen, D., Conway, K.W. & Dey, S.C. |
| **Contributor/s:** | Molur, S. |
| **Justification:** *Psilorhynchus gracilis* is a widely distributed species with no evidence of extensive threats. Is is assessed as Least Concern. | |

### Geographic Range [top]

| | |
|---|---|
| **Range Description:** | *Psilorhynchus gracilis* was described from Bangladesh (Rainboth 1983) but recent studies have given the range extension of this species from Mizoram, India, (Kar and Sen 2007) and Nepal (Edds and Ng 2007). Rainboth (1983) predicted from the extent of the preferred habitat of the fish that the fish should be widely distributed throughout lower reaches of Ganges and Brahmaputra rivers, and more recent collections in Assam and West Bengal have confirmed this. |
| **Countries:** | **Native:** Bangladesh; India (Assam, Mizoram, West Bengal); Nepal |

### Population [top]

| | |
|---|---|
| **Population:** | There are no records on population trends. |
| **Population Trend:** | ? Unknown |

### Habitat and Ecology [top]

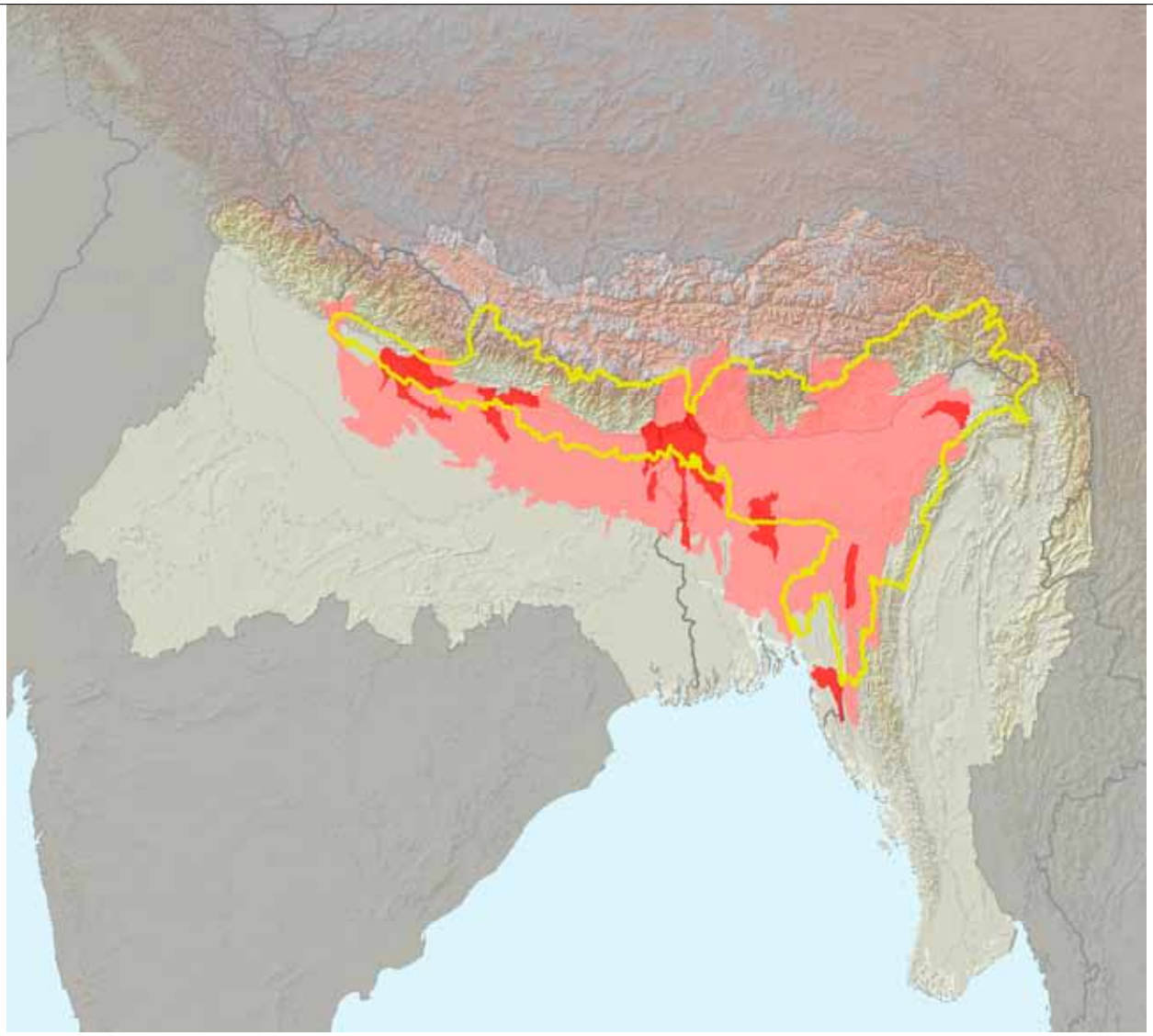
| | |
|---|---|
| **Habitat and Ecology:** | *Psilorhynchus gracilis* is found over small pebbles in shallow running waters where the bottom is primarily sandy (Rainboth 1983). |
| **Systems:** | Freshwater |
| **List of Habitats:** | 5 Wetlands (inland)<br>5.1 Wetlands (inland) - Permanent Rivers/Streams/Creeks (includes waterfalls)<br>5.2 Wetlands (inland) - Seasonal/Intermittent/Irregular Rivers/Streams/Creeks |

### Threats [top]

| | |
|---|---|
| **Major Threat(s):** | The threats to this species are not known. |

### Conservation Actions [top]

| | |
|---|---|
| **Conservation Actions:** | Further confirmation of the species range is required, and monitoring of the impacts of the ornamental trade collection. |



Note: Only the species distribution within the project region is shown

*Psilorhynchus gracilis*


gall stereographic central point: 0°, 0°

map created 12/02/2010

range type (native)

- Extant
- Probably extant

- national boundaries
- subnational boundaries
- lakes, rivers, canals
- salt pans, intermittent rivers
- Eastern Himalaya Hotspot

data source: (See spatial data for detailed source information)
IUCN

Mapped to river catchments and lake boundaries

0 640

kilometer

Eastern Himalaya Assessment

The boundaries and names shown and the designations used on this map do not imply any official endorsement, acceptance or opinion by IUCN.

The data used for the regional maps is the most up-to-date possible, which may be more recent than that used for the creation of the regional assessment text.

# Appendix 2. Data CD

(i) Executive Summary
(ii) Eastern Himalaya Assessment Report PDF
(iii) Species Summaries
(iv) Species Maps
(v) Species Shapefiles
(vi) Species Lists

**IUCN Red List of Threatened Species™ – Regional Assessment Projects**

**Africa**

*The Status and Distribution of Freshwater Biodiversity in Eastern Africa.* Compiled by William R.T. Darwall, Kevin G. Smith, Thomas Lowe, Jean-Christophe Vié, 2005.

*The Status and Distribution of Freshwater Biodiversity in Southern Africa.* Compiled by William R.T. Darwall, Kevin G. Smith, Denis Tweddle and Paul Skelton, 2009.

*The Status and Distribution of Freshwater Biodiversity in Western Africa.* Compiled by Smith, K.G., Diop, M.D., Niane, M. and Darwall, W.R.T. 2009.

*The Status and Distribution of Freshwater Biodiversity in Northern Africa.* Compiled by N. Garcia, A Cuttelod, and D. Abdul Malak. 2010.

*The Status and Distribution of Freshwater Biodiversity in Central Africa.* Compiled by Emma G.E. Brooks, David J. Allen and Darwall, W.T. 2010.

**Mediterranean**

*The Status and Distribution of Freshwater Fish Endemic to the Mediterranean Basin.* Compiled by Kevin G. Smith and William R.T. Darwall, 2006.

*The Status and Distribution of Reptiles and Amphibians of the Mediterranean Basin.* Compiled by Neil Cox, Janice Chanson and Simon Stuart, 2006.

*Overview of the Cartilaginous Fishes (Chondrichthyans) in the Mediterranean Sea.* Compiled by Rachel D. Cavanagh and Claudine Gibson, 2007.

*The Status and Distribution of Dragonflies of the Mediterranean Basin.* Compiled by Elisa Riservato, Jean-Pierre Boudot, Sonia Ferreira, Milos Jović, Vincent J. Kalkman, Wolfgang Schneider and Boudjema Samraoui, 2009.

*The Status and Distribution of Mediterranean Mammals.* Compiled by Helen J, Temple and Annabelle Cuttelod, 2009.

**Europe**

*The Status and Distribution of European Mammals.* Compiled by Helen J. Temple and Andrew Terry, 2007.

*European Red List of Amphibians.* Compiled by Helen J. Temple and Neil Cox, 2009.

*European Red List of Reptiles.* Compiled by Neil Cox and Helen J. Temple, 2009.

*European Red List of Saproxylic Beetles.* Compiled by Ana Nieto and Keith N.A. Alexander, 2010.

*European Red List of Butterflies.* Compiled by Chris van Swaay, Annabelle Cuttelod, Sue Collins, Dirk Maes, Miguel Lopez Munguira, Martina Šašić, Josef Settele, Rudi Verovnik, Theo Verstrael, Martin Warren, Martin Wiemers and Irma Wynhoff, 2010.

*European Red List of Dragonflies.* Compiled by Vincent J. Kalkman, Jean-Pierre Boudot, Rafał Bernard, Klaus-Jurgen Conze, Geert De Knijf, Elena Dyatlova, Sonia Ferreira, Miloš Jović, Jurgen Ott, Elisa Riservato and Goran Sahlen, 2010.

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OF THREATENED SPECIES™

**INTERNATIONAL UNION FOR CONSERVATION OF NATURE**

WORLD HEADQUARTERS
Rue Mauverney 28
1196 Gland
Switzerland
Tel: + 41 22 999 0000
Fax: + 41 22 999 0020
**www.iucn.org/species**
**www.iucnredlist.org**