नमामि गंगे

AQUATIC FAUNA OF THE GANGA RIVER

STATUS AND CONSERVATION

राष्ट्रीय स्वच्छ गंगा मिशन
National Mission for Clean Ganga
भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Cover Photo Credit:
Ganesh Choudhury, *Ganga Prahari* West Bengal

Citation:
WII-GACMC (2017). Aquatic Fauna of Ganga River: Status and Conservation. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehradun. Pp ……

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Message from the Minister, Ministry of Water Resources, River Development and Ganga Rejuvenation.

I am pleased to know that the Wildlife Institute of India, Dehradun has been fruitful in its efforts in the 'Biodiversity conservation and Ganga rejuvenation' project entrusted by the National Mission for Clean Ganga, Ministry of Water Resources, River Development and Ganga Rejuvenation, and is releasing this book on the Status and Conservation of the aqualife of the Ganga River.

The Ganga River, right from its source to the mouth, nurtures a diverse assembly of life forms, along with supporting a dense human population of almost 500 million. This mighty river system and its aquatic wildlife are under severe threat due to the unsustainable use of its resources, reduced flow, water pollution and conversion of riparian areas and river islands. The rising human population and resulting urbanisation and economic growth will further intensify these threats. Therefore, rejuvenation of the river ecosystem is critical to restore its ecological integrity and to ensure the survival of its aquatic species such as the iconic Gangetic river dolphin.

I congratulate the Wildlife Institute of India for this book and I heartily acknowledge the efforts made by the team in its preparation. I am sure that the effective execution of the recommendations envisioned in it will help restore the river and its biodiversity. I wish the Wildlife Institute of India all the success for its activities under the project.

(Nitin Gadkari)
Minister of Water Resources,
River Development & Ganga Rejuvenation

Message from Secretary, Ministry of Water Resources, River Development & Ganga Rejuvenation

I am pleased to know that the Wildlife Institute of India, Dehradun is successfully carrying out various tasks under the project 'Biodiversity Conservation and Ganga Rejuvenation' entrusted by the National Mission for Clean Ganga (NMCG), Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR,RD&GR), Government of India.

Rivers are the lifelines of an ecosystem, providing direct services such as water and food to indirect services such as groundwater recharge. Human civilizations has always centered on river systems. The Ganga River is one of the largest river systems in the world. It harbours important aquatic fauna such as the Gangetic river dolphin, gharial, otters, turtles and several aquatic and terrestrial birds. The aquatic wildlife of the Ganga and their habitats are in peril due to reduction in water flow, pollution and over exploitation of riverine resources.

The restoration of the Ganga River and its key biodiversity, therefore, is one of the most important national agendas of the Government of India. This book on the Status and Conservation of Ganga's aqualife provides in-depth information on the biodiversity of the Ganga River. The book is a repository of knowledge on the priority species of the Ganga River, and if the recommendations provided herein for the conservation of the river and its priority aquatic species are implemented thoroughly, it will aid in achieving NMCG's mandate of restoring the biodiversity of the Ganga River. This will also facilitate in accomplishing *Namami Gange's* objectives of *Aviral Dhara* and *Nirmal Dhara*.

I congratulate the Director, Wildlife Institute of India and his team for the tremendous amount of effort they have made in bringing out this book. I sincerely believe that this will make a significant contribution towards aquatic wildlife conservation in India and assist in making informed decisions for policy making for the conservation of the Ganga River and its aqualife.

(Upendra Prasad Singh)
Secretary
Ministry of Water Resources,
River Development & Ganga Rejuvenation

MESSAGE FROM THE DIRECTOR GENERAL, NATIONAL MISSION FOR CLEAN GANGA (NMCG)

It gives me immense pleasure to know that the Wildlife Institute of India, Dehradun has successfully prepared this book on the status and conservation of the Ganga River and its aqualife, under the tenets of its NMCG funded Biodiversity Conservation and Ganga Rejuvenation project.

The holy Ganga is enshrined in our culture and tradition, providing livelihoods to more than a third of the country's population. It is also home to a wide variety of aquatic fauna, a significant proportion of which is of global conservation significance.

However, the increasing human population and the resulting development activities has led to the severe degradation of the river ecosystem, and therefore, the diverse fauna that it supports. The reduced water availability due to diversion and unregulated abstraction is playing a major role in the declining population of the aquatic biodiversity of the Ganga River. Restoring this is a challenging task and calls for novel innovations and understanding of science as well as society. In view of this, NMCG has entrusted the Wildlife Institute of India with the project 'Biodiversity Conservation and Ganga Rejuvenation' under the *Namami Gange* programme of the Ministry of Water Resources, River Development and Ganga Rejuvenation. The project aims for a science-based aquatic species restoration plan for the Ganga River and to ensure that a significant reduction of threats to the biodiversity of the Ganga River is achieved by 2020.

The faunal diversity of the Ganga River has captivated the attention of many scholars and thus a pool of literature is available. This information is however, scattered and not easily accessible. This book is an attempt to consolidate this information, and provide the status of priority aquatic species. It is a collation and synthesis based on an extensive literature review and biodiversity assessment of the Ganga River by the Wildlife Institute of India. I envisage that the information contained therein will aid in bringing together a strategic conservation plan for these species and would provide direction for the biological restoration process of the Ganga River.

(Rajiv Ranjan Mishra)
Director General
National Mission for Clean Ganga

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ACKNOWLEDGEMENTS

The Wildlife Institute of India would like to acknowledge the support provided by the National Mission for Clean Ganga (NMCG) and the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR,RD&GR) for the implementation of the 'Biodiversity conservation and Ganga rejuvenation' project. We acknowledge the support provided by the forest departments of the five Ganga River states for carrying out a rapid biodiversity assessment along the river. We would also like to acknowledge the support provided by the Nuclear Power Corporation of India Limited (NPCIL) and Narora Atomic Power Station (NAPS) for the establishment of a rescue and rehabilitation centre for distressed aqualife. We acknowledge the support provided by the field staff and the local people for carrying out the rapid biodiversity assessment.

EXECUTIVE SUMMARY

Freshwater ecosystems harbour a rich diversity of species and provide suitable habitats for at least 9.5% of all animal species. However, freshwater diversity is declining at an alarming rate due to a multitude of factors, most of which can be attributed to human-induced habitat loss or degradation and alteration. It is being realized globally that losses of aquatic ecosystems often have repercussions on economic and social well-being. Thus, conservation planners are turning to solutions for ecological restoration of rivers and the processes therein.

The Ganga River is one of the largest and most diverse river systems of Asia with one of the highest human densities in the world. Varied geomorphological features along the Ganga River, coupled with climatic variations, results in a continuous gradient of habitats for various life forms, right from the headwaters to the mouth. Encompassing three ecologically diverse biogeographic zones, the river also harbours important aquatic faunal species such as the Gangetic river dolphin, gharial, otters, turtles and several aquatic and terrestrial birds. However, the aquatic diversity of the Ganga River and its habitats is in peril due to a multitude of factors arising from unsustainable resource use practices.

The restoration of the Ganga River and its key biodiversity, therefore, is one of the most important items on the national agenda of the Government of India. Science-based aquatic species restoration of the Ganga River by involving multiple stakeholders is thus planned through the National Mission for Clean Ganga-funded project 'Biodiversity conservation and Ganga rejuvenation'. This synthesis is an attempt to gather the available information on Ganga's aqualife, to consolidate the baseline data on the historical and present distribution of the aquatic species of the Ganga River, to identify areas with high biodiversity values and to identify threats to the ecological integrity of the Ganga River. The species that are most vulnerable to habitat alterations, endemic species and species listed as Critically Endangered, Endangered, Threatened or Vulnerable in the IUCN Red List or listed in the schedules of CITES or IWPA (1972) were selected as priority species for conservation action.

An extensive literature review and the rapid biodiversity assessment revealed that the distribution ranges of priority aquatic species such as the Gangetic river dolphin, gharial and mugger have reduced significantly. Loss of longitudinal and lateral connectivity and restricted availability of suitable habitat conditions have restricted the populations of these species to smaller stretches of the river. A reduced availability of pools deeper than 4 m was

found to be the most limiting factor, hampering the movements and distribution of priority species, namely the Gangetic river dolphin and gharial. Only 38.7% of the river had a depth of 4 m or more during the summer season. Structural changes in the river morphology due to dams, barrages, bank alteration, agriculture and sand mining are some of the factors that have impacted the distribution of priority aquatic species and threaten their survival. The rapid biodiversity assessment revealed that the populations of the priority aquatic species were mostly restricted to the relatively undisturbed areas, including the Protected Areas (PAs). These PAs account for around 15.5% of the total length of the Ganga River, and the priority species were found to be distributed along about 50% of the surveyed stretch of the Ganga River. Therefore, restoration attempts must focus on these high-biodiversity areas, and conservation planning should be initiated in consultation with the stakeholder groups.

Diverse uses of resources in different stretches of the Ganga River have given rise to different threats, and hence measures to address these threats should be stretch-specific. The upper stretch of the Ganga River has undergone structural changes, and any further changes would undermine the ecological integrity, affecting the religious and recreational values of the Ganga River. Intensive agriculture along the banks of the river and on the river islands and sand mining in the middle stretch of the Ganga River have altered the habitats of island-nesting birds and turtles. The lower stretch of the Ganga River is also highly modified by the Farakka Barrage that has led to flow alterations and changes in salinity regimes in the estuarine areas, resulting in changes in the species assemblages.

The water quality in the middle and lower stretches of the Ganga River has been altered due to wastewater from domestic and industrial sources and agricultural run-off. The altered water quality is aggravated by the low flow conditions in the Ganga River. Indiscriminate use of synthetic chemicals in agriculture and healthcare releases persistent pollutants such as heavy metals and other endocrine-disrupting chemicals, which interfere with the hormonal and immune systems of the aquatic species through bioaccumulation and biomagnification along the food chain.

In the middle stretch of the Ganga River, the sections from Farrukabad to Kanpur and from Allahabad to Varanasi had higher levels of all the threats to aquatic diversity. In the lower stretch of the Ganga River, the sections from Sitab Diara to Ajimganj/Jiaganj and from Barrackpore to Falta were the critical areas with high levels of threats. .

Evidence of bioaccumulation and biomagnification has been documented along the food chain and food web of the Gangetic river dolphin. Impacts of climate change are exacerbating the threats of the Ganga River in the form of an unpredictable flow regime and changes in both the upstream and downstream distribution ranges of species.

It is evident that planning restoration is not only a river conservation issue but also a social one owing to the high dependence of the densely populated local communities living along the banks of the Ganga River. The PA network should be strengthened by including biodiversity-rich stretches of the river through strategic planning, with the involvement and support of local communities in the conservation process. In this regard, efforts should be made to raising awareness among stakeholders and to garner societal support for conservation. Site-specific strategies need to be developed by aligning the local people's livelihoods with conservation priorities. Stakeholders, including the local communties and policy makers, need to be made aware of the role of an ecologically intact Ganga River in enhancing the quality of life. To maintain a balance between societal and ecological needs, sustainable and efficient water use practices in norms with modern abstraction techniques should be incorporated in the water policy and allocation guidelines.

1. INTRODUCTION

Freshwater ecosystems harbour a rich diversity of species and habitats, and although these ecosystems still remain incompletely surveyed, it is conservatively estimated that freshwater ecosystems provide suitable habitats for at least 9.5% of all animal species (Balian et al., 2008; Collen et al., 2014), nearly 6% of all described species (Dudgeon et al., 2006) and one-third of all vertebrate species (Strayer, 2010). The patterns and processes of interactions amongst these species and between species and their habitats account for numerous ecosystem services that are critical to the survival of all life forms, including humans (Carrizo et al., 2013). However, freshwater diversity is declining at an alarming rate due to a multitude of factors (Revenga et al., 2005; Collen et al., 2009; Strayer & Dudgeon, 2010; Darwall et al., 2011). On an average freshwater populations declined by 81% between 1970 and 2012 with an average annual decline of 3.9% (WWF, 2016), most of which can be attributed to human-induced habitat loss or degradation (Collen et al., 2014).

Ecological studies have proved that there is a correlation between species diversity and ecosystem stability as well as productivity (Odum, 1953; MacArthur, 1955; Elton, 1958; Gardner & Ashby, 1970; May, 1973). In effect, ecosystem stability depends on the ability of communities to contain species, or functional groups, that are capable of differential response, and the greater the species diversity of a biological community, the less the risk of ecological collapse (Palmer et al., 2010; Mellin et al., 2014). Additionally, ecoregional species richness and riverine productivity have also been found to be positively correlated (Duffy et al., 2007; McIntyre et al., 2016). Unless appropriate actions are taken to maintain this diversity, ecosystem processes will be disrupted (Pressey et al., 2007). Therefore, declines in species diversity will lead to reduced ecological stability and productivity and, ultimately, to ecological collapse (Mellin et al., 2014), severely affecting human well-being (Feld et al., 2011).

With increasing evidences for the ecological, economic and social losses associated with loss of aquatic systems, especially rivers (Vorosmarty et al., 2010), conservation planners are turning to solutions for ecological restoration of rivers (Lake et al., 2007; Palmer et al., 2004). There are many theories and physical measures (single species focus, channel re-configuration and in-stream habitat improvement) related to restoration. However, the concept of the restoration of an entire stream or river ecosystem by restoring its biodiversity is widely accepted (Lake et al., 2007; Palmer et al., 2010).

The aim of ecological restoration is to enhance the biodiversity and the resultant ecosystem services (Palmer et al., 2007). Maintenance of habitat connectivity, seasonal flow variability, augmenting habitat suitability and addressing issues related to unsustainable resource use are some of the parameters for successful ecological restoration of a river or a stream and are seldom seen in the restoration process (Lake et al., 2007).

The Aichi targets of the Convention on Biodiversity have set priorities for threatened freshwater taxa occurring outside the present global PA network (Raghavan et al., 2016). However, success would rely on science-based systematic conservation efforts at the national, state and local levels. Systematic planning requires prioritization of selected stretches of a river on the basis of their biodiversity and habitat suitability through participatory planning and collaborative implementation of strategies, decisions and actions that secure the long-term survival and favourable conservation status of biodiversity (Kukkala & Moilanen, 2013). However, owing to the incomplete biological information available for any riverscape, setting conservation priorities is a challenging task (Scott et al., 1993; Noss et al., 1997). Nevertheless, the fragmented state of a riverscape and high degree of habitat loss and fragmentation aggravates the urgency to conserve remaining habitats, the refuges that can act as repositories of source populations.

To address these problems, conservation planners have developed alternative methods to identify and prioritize conservation areas. A common approach used to prioritize conservation areas involves identification of umbrella species and their habitat requirements. Conservation areas are selected on the basis of the existing and potential habitat of the umbrella species and the connectivity among those habitat patches; which in turn would provide sufficient habitat variability to confer protection to a large number of naturally co-occurring species of conserveation interest (Launer & Murphy, 1994; Berger, 1997; Martikainen et al., 1998).

Most of the freshwater conservation literature available focuses on systematic, strategic and landscape-level planning through the declaration of freshwater PAs (Saunders et al., 2002; Kingsford et al., 2005; Abell et al., 2007), which in principle should take into account the catchment characteristics of the river basin (Abell et al., 2007). This approach, although coherent, is not practical for river basins with high human densities where social and economic constraints exist, and it is not feasible to protect all areas (Nel et al., 2009).

Therefore, the question arises as, how to conserve the freshwater ecosystems for these densely populated areas, where the majority of the population lives in perpetual poverty and is highly dependent on the resources of the river.

In view of the foregoing discussion, this synthesis on the status and conservation of the aqualife of the Ganga River was carried out. A comprehensive review was carried out to know the probable species of the Ganga River, which is provided in Annexures I to VI. This synthesis critically examines the historical and current status of the priority aquatic species and the factors threatening their survival. It aims to identify the most strategic and feasible approach to conserve human-dominated river basins in the wake of the expanding population of the country and the increasing threats to rivers and their biodiversity. It comprises a comprehensive strategy to restore the biodiversity value of the Ganga River and is a result of extensive primary and secondary studies carried out under the project 'Biodiversity conservation and Ganga rejuvenation', funded by the National Mission for Clean Ganga (NMCG). The project aims to prepare a science-based aquatic species restoration plan for the Ganga River by involving multiple stakeholders. The Ganga Aqualife Conservation Monitoring Centre (GACMC), established under the mandate of the project, intends to build a scientific knowledge base on the Ganga River, to develop national guidelines for consideration of aquatic fauna in planning and execution of water infrastructure development and to disseminate this knowledge to the general public as well as the scientific community. The species most vulnerable to habitat alterations, endemic species and species listed as Critically Endangered, Endangered, Threatened or Vulnerable in the IUCN Red List or listed in the schedules of CITES or IWPA (1972) were selected as priority species for the synthesis.

2. GANGA RIVER

The Ganga River is among the largest rivers in Asia. It flows through India and Bangladesh and has been a cradle of human civilization since time immemorial (Trivedi, 2010; Kumar, 2017). It is considered one of the most sacred rivers in the world. In Hindu mythology it is worshipped as "Goddess Ganga" and is believed to have been bought to earth from heaven by King Bhagirath (Kumar, 2017). Historically, several provincial or imperial capitals were located along its banks, and the Ganga basin was the centre of power from the Mauryan period to the Mughal era (Wink, 2002; Kumar, 2017). The Ganga River was declared the "National River" on 4 November 2008 (Sanghi & Kaushal, 2014). The Ganga River basin is spread across 11 states and covers 26.3% of India's total geographical area (Sanghi & Kaushal, 2014). The main stem of the Ganga River flows through the five states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. The remaining six states in which the basin lies are Delhi, Haryana, Himachal Pradesh, Madhya Pradesh, Chattisgarh and Rajasthan (NGRBA, 2011).

2.1. Course of the Ganga River

The main stem of the Ganga River (Goumukh to the Bay of Bengal) is roughly 2525 km in length (Tandon & Sinha, 2018), with 1450 km falling in Uttarakhand and Uttar Pradesh, 445 km in Bihar and Jharkhand and 520 km in West Bengal (Sanghi & Kaushal, 2014). The Bhagirathi River is considered the source stream of the Ganga River. It originates from the Gangotri glacier at Goumukh, in the Western Himalaya, and merges with the Alaknanda River at Devprayag, where the "Ganga River" is formally formed. After this, the Ganga River flows through narrow Himalayan valleys and reaches the plains at Haridwar (NRCD, 2009). At Haridwar, the Bhimgoda Barrage diverts water to the Upper Ganga Canal for irrigation. Further down, two barrages at Bijnor and Narora divert the water into the Madhya Ganga Canal (only during the monsoon) and Lower Ganga Canal, respectively. Thereafter the river is joined by the Ramganga River at Kannauj and the Yamuna River at Allahabad (NGRBA, 2011). Downstream of Allahabad, the river is met by the Tons, Son, Punpun, Gomti, Ghagra, Gandak and Kosi rivers, flowing through Varanasi, Patna and Bhagalpur (Tandon & Sinha, 2018). At Pakur, the Farakka Barrage regulates the flow of the Ganga River by diverting water into a feeder canal linking the Hooghly River. Downstream of this barrage, the Ganga River bifurcates to form the Hooghly River, which flows through West Bengal before merging into the Bay of Bengal, and the main branch, which enters Bangladesh as the Padma River (NRCD, 2009).

The main stem of the Ganga River may be divided into three stretches: the upper stretch (from Goumukh to Haridwar), the middle stretch (from Haridwar to Varanasi) and the lower stretch (from Varanasi to Ganga Sagar). These divisions reflect variations in geology, geomorphology, soil type, climate, flora and fauna and social and economic issues.

2.2. Geology and Geomorphology

Structurally, the Ganga River basin is made of three large divisions of the Indian subcontinent, namely the Himalayan Fold Mountains and the Central Indian highlands; the peninsular shield; and the Gangetic Plain (NRCD, 2009).

The Ganga River basin occupies the Himalayan foredeep in a northeast–southwest-oriented elongate depression (Tandon & Sinha, 2018), formed in response to the uplift of the Himalaya after the collision of the Indian and Asian plates (Singh et al., 1990; Sinha et al., 2005). The average gradient of the basin is 20 m/km (Valdiya, 2016). The Gangetic Plain is made of two discrete hinterlands–the Himalaya in the north and the cratons to the south (Tandon & Sinha, 2018). It evolved as a result of the filling up of the foredeep basin with a thick deposition of sediments derived chiefly from the Himalaya and partly from the hills of northern peninsular India (Das, 2014; Valdiya, 2016). The terrain along the Ganga River is divided into two parts, the northern part, composed of alluvial terrain of Quaternary age, and the southern part, composed of consolidated crystalline and sedimentary formations of Archaean-to-Palaeozoic age (Wadia, 1961). Two distinct physiographic and chronological units are recognized in this plain: the Older Alluvium, comprising coarser sedimentary units of the Banda, Varanasi and Bhangar, and the Newer Alluvium, consisting of the Khadar, Bhur and Bhabhar (Valdiya, 2016).

The Ganga River, in its upper stretch, from Gangotri to Haridwar, flows through steep, mountainous valleys of the Himalaya, consisting of a partly confined floodplain and braided channels (Sinha et al., 2017; Tandon & Sinha, 2018).The middle stretch, from Haridwar to Varanasi, winds through the Gangetic Plain region and consists of the piedmont, craton margin and valley interfluve type of landscape settings; a partly confined floodplain; and braided and sinuous channels (Sinha et al., 2017).

The lower stretch of the Ganga River, from Varanasi downstream, passes through the Ganegetic Plain and before merging with the Bay of Bengal forms the distributary-delta

system south and east of Farakka (Tandon & Sinha, 2018). It is made of craton margin and valley interfluve landscape settings; a partly confined and confined floodplain; and sinuous, braided channels and anabranches (Sinha et al., 2017). The Sundarban delta was formed in the Tertiary period as a result of tectonic movements in northwestern Punjab and a southeastern flow of the Ganga River, resulting in the deposition of sediments in the Bengal basin (Gopal & Chauhan, 2006; Wadia, 1961). The delta complex formed as a result of combined contributions of the Ganga and the Brahmaputra rivers is the world's largest delta, covering an area of 60,000 km^2 (Valdiya, 2016).

2.3. Soil Types

The Ganga River basin is characterized by a wide variety of soils. The upper stretch of the basin consists of mountain and sub-montane soils covering around 1.59% and 4.28% of the area, respectively, and are highly erodibile. The middle and lower stretches of the Ganga River basin are made of mainly alluvial soil (covering 52.44% of the area), with very high erodibility. Red soil covers 12% of the area, and is also highly erodible. Red and yellow soils and mixed red-and-black soils cover 8% of the area, and they are moderately erodible. Deep black soils and medium black soils cover 14% of the area, and have low erodibility. The remaining 6% of the area has shallow black soils and lateritic soils. The erodibility of these soils is very low (NGRBA, 2011; NRCD, 2009). It can be concluded that the Ganga River basin is highly erodible (NRCD, 2009; Sanghi & Kaushal, 2014), as a result of which the floodplains and banks are vulnerable to erosion through run-off.

2.4. Climate

Due to significant variations in the geographical extent of the Ganga River, including altitudinal variations, specifically at the source the temperature along the river basin varies between 5°C and 45°C (Misra, 2011; Jain et al., 2016). The climate is positively influenced by the southwest monsoon (Ghosh, 1991), which extends from June to October. During the monsoon, the basin receives almost 85% of the total annual rainfall. The annual average rainfall varies between 39 cm and 200 cm, with an average of 110 cm (NRCD, 2009). The average annual temperatures are high throughout the basin except the high-elevation areas of the upper Ganga River basin (Jain et al., 2016). They rise sharply from March to May (summer season), from 30°C to 45°C. The average temperature of the Ganga River basin during winter season (from November to February) is between 5°C and 30°C (Misra, 2011).

The upper stretch of the Ganga River, close to the snow line, receives snowfall, and 100–250 cm of annual rainfall (number of rainy days being 100–150). The annual average temperature varies from <10°C to 20°C (Nautiyal, 2010).

The middle stretch and most of the lower stretch of the Ganga River flow through the Gangetic Plain. The average annual rainfall in the Gangetic Plain varies between 60 cm and 160 cm, with the western parts receiving less rainfall (from 60 cm to 140 cm) in comparison with the eastern parts (from 90 cm to >160 cm). The northern part of the plains receives higher rainfall compared with the southern part. The temperature varies from 5°C to 25°C in winter and from 20°C to more than 40°C during summer in the Gangetic Plain (Sinha et al., 2005).

The climate of the Sundarban delta region of the lower stretch of the Ganga River is characterized by relatively high temperatures and humidity (>80%) all throughout the year. The average annual rainfall is 166.1 cm and decreases from 180.5 cm near Sagar Islands, in the south, towards Kolkata, in the north. The daily minimum temperature during winter varies between 2°C and 4°C, and rises to a maximum of about 43°C in March and may exceed 32°C during the monsoon. Thunderstorms in the afternoon are common during summer and are known as *Kalbaisakhi* (disastrous winds of Baisakh) (Gopal & Chauhan, 2006).

2.5. Biogeography, Flora and Fauna

The Ganga River harbours a unique assemblage of biodiversity due to its passage through three distinct biogeographic zones, namely the Himalaya, the Gangetic Plain and the Coastal Zone (Rodgers & Panwar, 1988).

The upper stretch of the Ganga River falls under the Himalayan biogeographic zone and is one of the richest areas in terms of habitat and species diversity (Rodgers & Panwar, 1988). The Ganga River falls under the West Himalaya province (2B) and comprises five forest types, *viz*., Alpine scrub (*Juniperus* sp., *Rhododendron campanulatum*); Sub-alpine forest (*Betula utilis, Abies spectabilis, Abies pindrow*); Himalayan Dry temperate forest (*Pinus gerardiana, Cedrus deodara*); Himalayan Moist temperate forest (*Quercus floribunda, Quercus leucotricophora*); and Sub-tropical pine forest (*Pinus roxburghii*) (Champion & Seth, 1968; Bahuguna et al., 2016). The snow leopard (*Panthera uncia*), Himalayan tahr (*Hemitragus jemlahicus*), musk deer (*Moschus* sp.), Himalayan black bear (*Ursus thibetanus*

laniger) and Himalayan monal (*Lophophorus impejanus*) (Rodgers & Panwar, 1988) are some representative terrestrial species of this stretch. Representative aquatic faunal species of this biogeographic zone include the golden mahaseer (*Tor putitora*), snow trout (*Schizothorax richardsonii*), mahaseer (*Tor tor*) (Bilgrami, 1991; Rao, 2001), Eurasian otter (*Lutra lutra*) and smooth-coated otter (*Lutrogale perspicillata*) (Hussain, 2002; Nawab & Hussain, 2012).

The middle stretch and most of the lower stretch of the Ganga River wind through the Gangetic Plain, which is one of the largest biogeographic zones in India, extending from the Yamuna River eastward across Uttar Pradesh, Bihar, Jharkhand and West Bengal (Sharma, 2005). It is considered one of the most fertile areas in the world, and most of the original vegetation has been converted into cropland. This biogeographic zone is divided into the Upper Gangetic Plain (7A) and the Lower Gangetic Plain (7B) provinces (Rodgers et al., 2000). The region harbours two major forest types, Tropical Dry deciduous forest (*Dalbergia sissoo*, *Acacia nilotica*, *Madhuca indica*) and Tropical Moist deciduous forest (*Shorea robusta*, *Tectona grandis*, *Terminalia arjuna*) (Champion & Seth, 1968). Representative terrestrial species of this zone include the chital (*Axis axis*) and sambar (*Rusa unicolor*) (Rodgers & Panwar, 1988), and among the representative aquatic species are the Gangetic river dolphin (*Platanista gangetica*), smooth-coated otter (*Lutrogale perspicillata*), gharial (*Gavialis gangeticus*) and marsh crocodile (*Crocodylus palustris*) (Rodgers & Panwar, 1988). Examples of birds from these stretches of the Ganga River are Sarus crane (*Grus antigone*) and Indian skimmer (*Rynchops albicollis*) (Sundar et al., 2000; Sundar, 2004).

Before merging with the Bay of Bengal, the Ganga River flows through the Coastal Zone, mostly the Sundarbans delta (Rodgers & Panwar, 1988). The vegetation of this area falls under the swamp-and-littoral-forest type (Champion & Seth, 1968; Bahuguna et al., 2016) and is represented by species such as the sundari (*Heritiera fomes*), mangrove palm (*Nypa fruticans*), and tall-stilt mangrove (*Rhizophora apiculata*) (Champion & Seth, 1968; Gopal & Chauhan, 2006). The royal Bengal tiger (*Panthera tigris tigris*), barking deer (*Muntiacus muntjak*), leopard cat (*Felis benghalensis*), fishing cat (*Felis viverrina*) and lesser adjutant stork (*Leptotilos duius*) are the representative terrestrial fauna. Representative aquatic faunal species include the northern river terrapin (*Batagur baska*), saltwater crocodile (*Crocodylus porosus*), Indian flapshelled turtle (*Lissemys punctata*) and Indian softshelled turtle (*Trionyx gangeticus*) (Gopal & Chauhan, 2006).

2.6. Demography

The Ganga basin is one of the most densely populated river basins in the world, with a population of more than 500 million people (Misra, 2011). It supports around 43% of the Indian population, with the average population density being over 700 individuals/km^2 and the density near the deltaic zone being over 1000 individuals/km^2 (Table 2.1) (GOI, 2011; Sanghi & Kaushal, 2014). There are 30 cities, 70 towns and thousands of villages located along the banks of the Ganga River (Behera et al., 2013). The major cities along the upper stretch of the Ganga River are Srinagar, Rishikesh and Haridwar (Uttarakhand). Major cities along the middle stretch within the state of Uttar Pradesh are Bijnor, Narora, Kanauj, Kanpur, Allahabad, and Varanasi. Mirzapur, Patna, Bhagalpur (Bihar), Sahibganj (Jharkhand), Farakka, Bahrampur, Serampore, Howrah and Kolkata (West Bengal) are major cities along the lower stretch (CPCB, 2013).

Table 2.1 Human density along the Ganga River (Source: GOI, 2011)

Stretch	State	Persons	Density (persons/km^2)
Upper	Uttarakhand	10,116,752	189
Middle	Uttar Pradesh	199,581,477	829
Lower	Bihar	103,804,637	1102
	Jharkhand	1,150,038	414
	West Bengal	91,347,736	1029
	Total	**437,816,840**	712.6

3. STATUS OF AQUALIFE IN THE GANGA RIVER

A multistage approach was used to assess the status of the priority/umbrella species (Table 3.1) in the Ganga River. The first stage consisted of a comprehensive literature review on the distribution, abundance and threats to the priority species. Information was collected and compiled using Google Scholar, 'Harzing's Publish or Perish and other online search engines. Mimeo reports, *Fauna of British India*, *Fauna of India* and other available literature from the British era were consulted. In the second stage, historical and current occurrence, abundance and distribution of the selected species were studied from the literature gathered. In the third stage, the results of the rapid biodiversity assessment of the main stem of the Ganga River, carried out during the pre-monsoon (April to June 2017) and post-monsoon (October and November 2017) periods, covering a distance of 2200 km, from Devprayag, in Uttarakhand, to Nurpur, in West Bengal, were incorporated in this synthesis. The rapid biodiversity assessment generated biological and depth profiles of the Ganga River. This information on the aquatic diversity distribution pattern, threats, areas of concentration of threats and depth profile was collated and areas of higher conservation significance were identified by integrating these with the spatial data.

Table 3.1 Representative aquatic fauna from three biogeographic zones of the Ganga River

Class	Representative species	IUCN status	CITES	IWPA status
The Himalaya				
Mammal	Asian small-clawed otter	Vulnerable	Appendix II	Schedule I
Reptile	Gharial	Critically Endangered	Appendix I	Schedule I
Fish	Golden mahaseer	Endangered	Not listed	Not listed
The Gangetic Plain				
Mammal	Gangetic river dolphin	Endangered	Appendix I	Schedule I
	Smooth-coated otter	Vulnerable	Appendix II	Schedule II
Reptile	Gharial	Critically Endangered	Appendix I	Schedule I
Bird	Sarus crane	Vulnerable	Appendix II	Schedule IV
Fish	Bata fish	Least Concern	Not listed	Not listed
The Coasts				
Mammal	Gangetic river dolphin	Endangered	Appendix I	Schedule I
Bird	Lesser adjutant stork	Vulnerable	Not listed	Not listed
Reptile	Northern river	Critically	Appendix II	Schedule I

	terrapin	Endangered		
	Saltwater crocodile	Least Concern	Appendix I	Schedule I
Fish	Hilsa	Least Concern	Not listed	Not listed

The earliest historical records of the species of the Ganga River can be found in the fifth pillar edict of Emperor Asoka (Annandale, 1923; Dhammika, 1993), which prohibits killing or hunting of animal species, including the Gangetic river dolphin, turtles (possibly *Kachuga dhongoka*) and bird species found in the rice fields in the Ganga River basin. The endangered Gangetic stingray was first described by Hamilton (1822) and thereafter by Annandale (1909), Bilgrami (1991) and Lakra et al. (2010a). Annexure I to VI provides an account of the probable species of the Ganga River on the basis of previous studies and the present study. Gangetic river dolphins, birds, crocodilians and fishes are some of the most studied taxa of the Ganga River. The following sections describe the historical and present-day status of these and other priority aquatic species in the Ganga River.

3.1. Mammals

The major aquatic and semi-aquatic mammalian species found in the Ganga River include the Gangetic river dolphin and three species of otter, *viz.* smooth-coated otter, Asian small-clawed otter and Eurasian otter (Annexure I). These species are habitat specialists and have special adaptive features for living in aquatic systems. Being at the top of the food chain, they rapidly move between habitats, transport nutrients and energy between systems and stabilize the ecosystem. They also exert different top-down regulations upon trophic interactions and the coupling of ecosystems and habitats.

3.1.1. Gangetic river dolphin (*Platanista gangetica*)

The Gangetic river dolphin is one of the four exclusive freshwater dolphins in the world, whose distribution is restricted to the Indian subcontinent. It is an indicator of a healthy river ecosystem.

Historical Distribution

Prior to the initiation of water resource development activities in the Ganga River during the 19th century, the Gangetic river dolphin was distributed between 77°E and 88°E, throughout the Ganga, Brahmaputra/Meghna and Karnaphuli rivers and their tributaries in India, Nepal and Bangladesh (Sinha et al., 2000). In the Ganga River, their distribution ranged from

Haridwar to the Sundarbans, and in the Yamuna River, the species was reported up to Delhi in the month of May (Anderson, 1878; Sinha et al., 2010) (Figure 3.1). During the late 19th century, about 10,000 Gangetic river dolphins were estimated to be thriving in the Ganga River and its tributaries (Anderson, 1878); however, Sinha and Kannan (2014) estimated their population to be 3526 individuals during the early 2000s (Box 1).

Gangetic river dolphins are now restricted to the mainstem Ganga River and its large tributaries *viz*. the Ramganga, Yamuna, Gomti, Ghaghara, Rapti, Son, Gandak and Kosi (Sinha et al., 2000). They have disappeared from the Haridwar stretch of the Ganga River, and the Bijnor Barrage, 100 km downstream of Haridwar, now restricts their population (Sinha et al., 2000). The population in the Yamuna River is now only restricted to the confluence of the Chambal and Yamuna rivers, near Etawah, almost 490 km downstream from Delhi (Sinha & Sharma, 2003) (Figure 3.1). It has also become locally extinct in most of the small tributaries or is sighted only during the rainy season (Sinha & Sharma, 2003). During the past 20 years, many scholars have studied the Gangetic river dolphin, but most of the information is in patches and at different timescales. Table 3.2 provides information on the encounter rate of the Gangetic river dolphin on the basis of earlier studies. In the Ganga River, the encounter rate was highest at Vikramshila Gangetic Dolphin Sanctuary (1.8/km) and lowest between Bijnor and Narora (0.36/km). The abundance of the Gangetic river dolphin was noted to be 179 and 270 in the mid and peak dry seasons, respectively (Kelkar et al., 2010), in the Vikramshila Gangetic Dolphin Sanctuary. The loss of habitat connectivity, hydrology alteration, overexploitation of the prey-base and hunting moved the species from the Vulnerable category to the Endangered category of the IUCN Red List in 2004 (IUCN, 2016). A comparative account of the historical and current distribution of the dolphin in its range in the Ganga River basin (Figure 3.1) shows that the dolphins have been extirpated from Haridwar to the Bijnor Barrage (approximately 100 km) in the mainstem of the Ganga River and from Delhi to Etawah (approximately 490 km) in the Yamuna River.

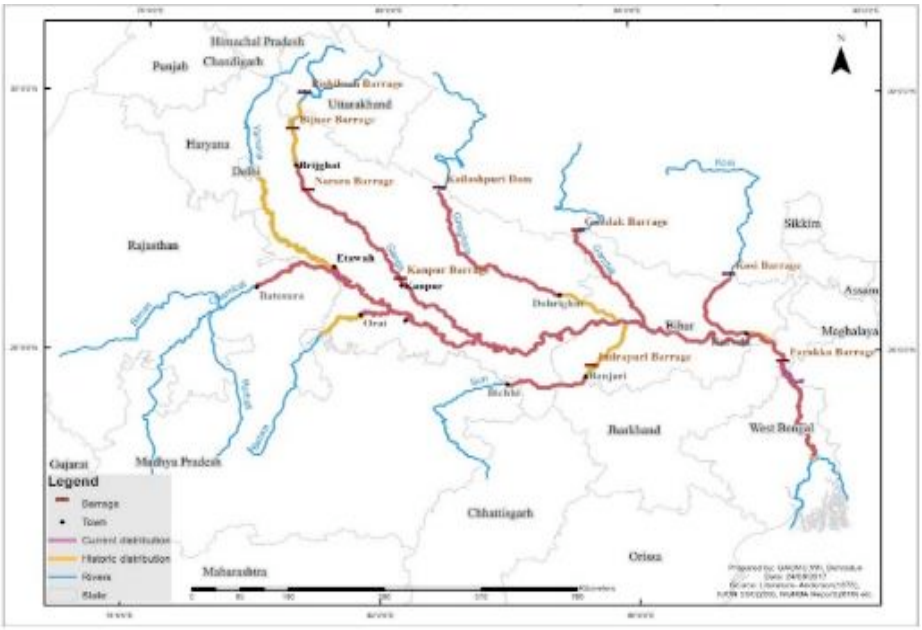


Figure 3.1. Historic and current distribution of Gangetic river dolphin in the Ganga River

Table 3.2. Encounter rate of Gangetic river dolphin in the main stem of the Ganga River

River stretch	Encounter rate (individuals/km)		
	Previous studies		Present study (2017)
Bijnor and Narora	0.36	Behera (1995)	0.21
Narora and Kanpur	0	Sinha (1999)	0.03
Kanpur and Allahabad	0.49	IIT (2012)	0.24
Allahabad to Buxar	0.48	Sinha (1999)	0.77
Buxar to Manigharighat	1.62	Sinha et al. (2010)	0.36
Vikramshila Gangetic Dolphin Sanctuary	1.8	Choudhary et al. (2006)	0.65
Manigharighat to Farraka	1.64	Sinha (1999)	0.22
Farakka Feeder Canal	0.55	Sinha et al. (2000)	0.10

Present Distribution

During the rapid biodiversity assessment, a total of 648 individuals of the Gangetic river dolphins were encountered from Bijnor (Uttar Pradesh) to Nurpur (West Bengal). Gangetic river dolphins were most abundant from Brijghat to Narora, upstream of Kanpur, from Bhitura to Ghazipur and between Chappra and Kahalgaon. Smaller and scattered groups were observed between Sahibganj and Rajmahal and from Baharampur to Barrackpore (Figure

3.2). Groups of Gangetic river dolphin mostly congregated at pools with a depth of >3 m and at meanders with steep clayey banks.

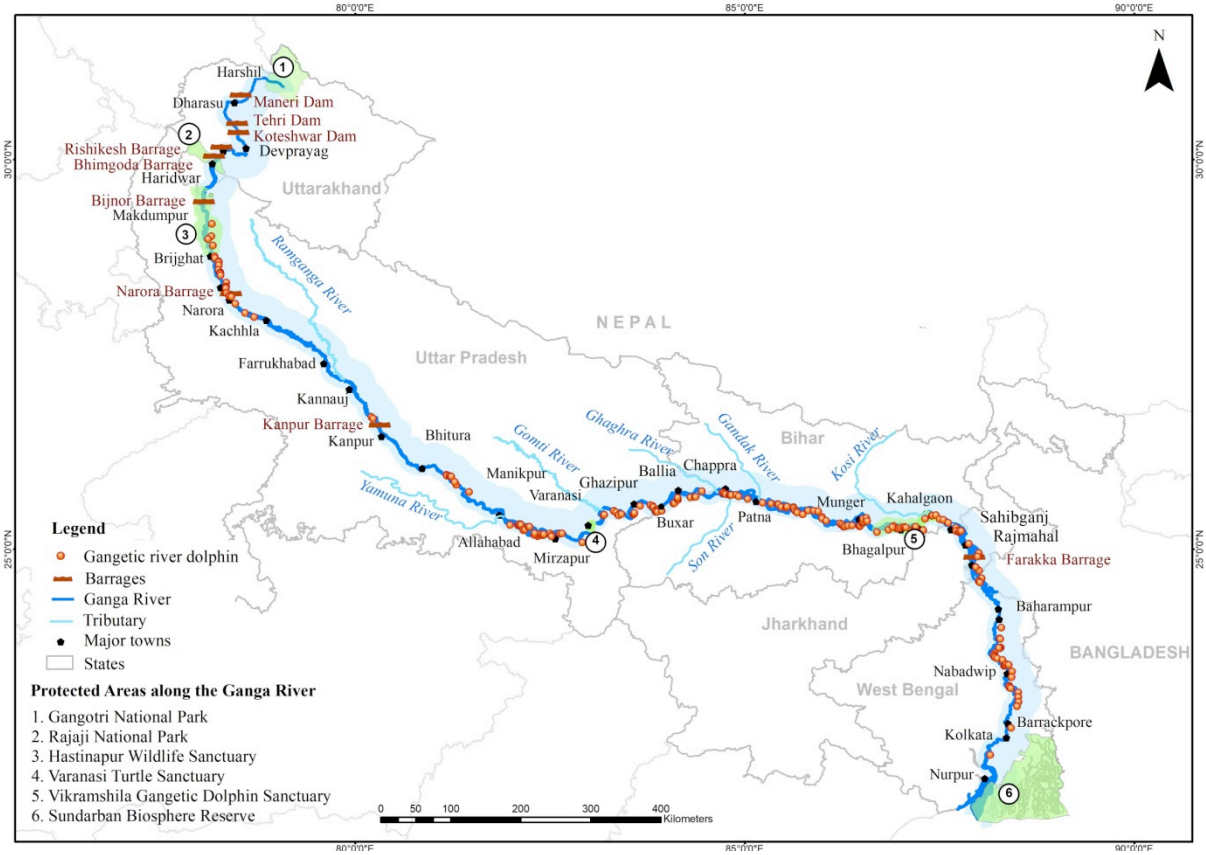


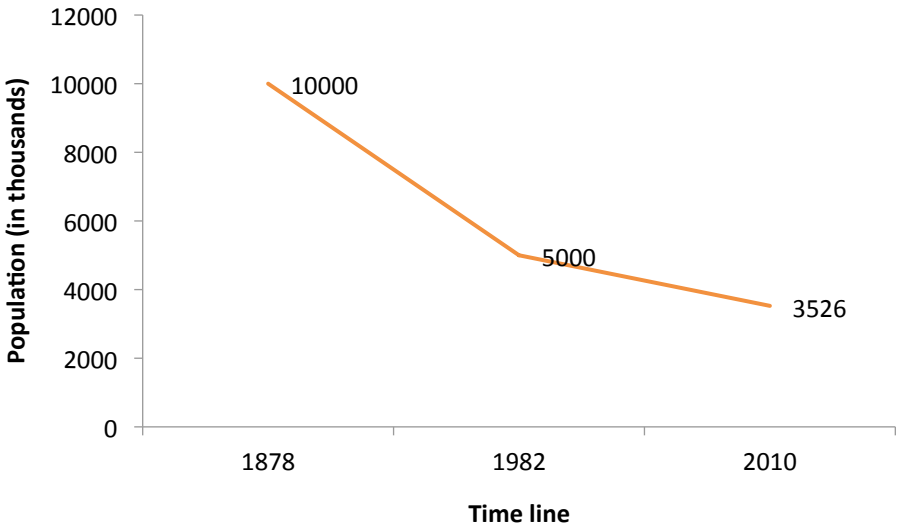
Figure 3.2. Distribution of Gangetic river dolphin in the Ganga River, on the basis of the rapid biodiversity assessment

Loss of habitat connectivity, reduced flow regime, reduced prey base and water pollution restricts homogeneous distribution of the species and, as a result, this species is now restricted to deep pools, particularly from downstream of Kanpur. Optimal habitats are present in stretches from Brijghat to Narora, downstream of Kanpur from Allahabad to Bhagalpur, from Gopal Ghat to Palasi, from Ram Nagar to Nabadwip and downstream of Nabadwip to Howrah-Kolkata. It was observed that fishing using gill nets, overfishing and a reduced flow regime are major threats to the species.

From the literature review and rapid biodiversity assessment, it was inferred that the populations of the Gangetic river dolphin in the Ganga River are highly fragmented and therefore undergoing loss of genetic diversity. The population is concentrated in the middle

stretch of the river, where dispersal constraints such as dams and barrages as well as shallow areas are not present.

BOX 1



Decline in the population of the Gangetic river dolphin from 1878 to 2010 on the basis of estimates provided by Anderson (1878); Jones (1982); and Sinha and Kannan (2014)

BOX 2

River	River stretch	Encounter rate (individuals/km)	Reference
Chambal	Batesura and the confluence of the Yamuna River	0.15	Singh and Sharma (1985)
Son	Between Bicchi, in Madhya Pradesh, and Banjari	0.076	Sinha et al. (2000)
Kosi	Between Kosi Barrage and Kursela	0.42	Sinha and Sharma (2003)
Gandak	Gandak Barrage to Gandak-Ganges confluence at Patna	0.8	Choudhary et al. (2012)
Ken	Confluence with Yamuna to Sindhan Kalan village	0.26	Sinha et al. (2000)
Betwa	Confluence with Yamuna to Orai	0.07	Sinha et al. (2000)
Sind	Confluence with Yamuna	0.045	Sinha et al. (2000)

Encounter rates of the Gangetic river dolphin in the tributaries of the Ganga River

3.1.2. Otters

Otters form a well-marked group, representing the family Mustelidae. They are mammals adapted for a semi-aquatic life. They are the principal predators of aquatic environments and indicators of the health of wetland or riverine ecosystems as they are sensitive to degradation along the food chain and habitat (Erlinge, 1972; Kruuk et al., 1993; Mason & MacDonald, 1987). Of the 13 species of otters worldwide, five species occur in Asia, and three of them are found in India. Otters usually live in low densities, are elusive and are largely nocturnal, thus making direct sightings difficult (Hussain, 2002). Hence, most of the studies on otter distributions are based on occasional sightings supplemented by indirect evidence of presence. Three species of otter have historically been found in the Ganga River and its tributaries.

Historical Distribution

The earliest authentic reports of the occurrence of otters in the tributaries of the Ganga River in the Terai, Garhwal and Kumaun areas (lower Himalaya) were given by Atkinson (1882), Blanford (1881) and Hinton and Fry (1923). Historically, the smooth-coated otter (*Lutrogale perspicillata*) was distributed from the Himalaya southward to Karnataka and eastward to Burma (Pocock, 1941). It was also reported from the Terai region during the late 19th century; from the Yamuna River; and from Salt Lake and the Sundarbans, in West Bengal (Atkinson, 1882, 1974) (Table 3.3) (Figure 3.3).

In the last decade the smooth-coated otter has been reported from the Upper Ganga (Alaknanda), Ramganga, Mandal, Sonanadi and Palain rivers in the Upper Gangetic Plain (Nawab & Hussain, 2012); Hastinapur Wildlife Sanctuary (Khan et al., 2014); the Bijnor–Narora stretch of the Ganga River (Bashir et al., 2012); and Vikramshila Gangetic Dolphin Sanctuary (Choudhary et al., 2006).

The Eurasian otter (*Lutra lutra*) was historically distributed north of the Ganga River, extending throughout the Himalaya and in the Upper and Lower Gangetic plains up to Kolkata (Sclater, 1891). It was also distributed in the eastern coastal region of India up to Sri Lanka (Figure 3.4). Atkinson (1882) reported that the species was present throughout the Terai and in all the larger streams along the foothills of the Himalaya, ascending 30 miles or more. He also noted groups of 5 to 12 individuals in the Ramganga River in the Patli Dun and

around 20 individuals in the Suswa in Dehradun. In the recent past, Hussain (2002) reported signs of *L. lutra* from the Ramganga River, in the upper Gangetic basin.

Historically, the distribution of the third species of otter, *viz.* the Asian small-clawed otter (*Aonyx cinereus*), has been discontinuous (Blanford, 1881). It was reported from the lower elevations of the Himalaya and lower Bengal, being common near Kolkata, in Assam and in Burma. The species was observed in the Sarda River at Barmdeo, above the junction of the Alkananda and Pindar rivers near Karnaparayag; in the Nandakini, above Nandprayag; and in Bhilang and at Salt Lake, Kolkata (Jerdon, 1874) (Figure 3.5). These otters are diurnal animals. They are found in remote areas free of human disturbance.

A survey conducted during 1993–1995 from Rishikesh to Kanpur found no otters in the Ganga River (Rao, 2001). In more recent studies, their presence has only been reported from the lower Himalayan and Terai regions at smaller tributaries of the Ganga River in the Alaknanda valley, in PAs (Hussain, 2002). It is evident from the literature that otters are present throughout the length of the Ganga River. These studies also provided insights into the habitat and behaviour of the otters. However, these studies were conducted at different timescales and were limited in their geographical extent and were not specific to the Ganga River. Hence the population trends of otter species cannot be deduced from these studies. Extensive studies are therefore needed to assess the population trends of otter species in the Ganga River and its basin.

Table 3.3. Historical and current distribution of otters in the Ganga River states

Species	Scientific name	IUCN status	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	W. Bengal
Smooth-coated otter	*Lutrogale perspicillata*	VU	H + P	H + P	H + P	H + P	H + P
Eurasian otter	*Lutra lutra*	NT	H + P	-	-	-	-
Small-clawed otter	*Aonyx cinereus*	VU	H + P	-	-	-	H

H, historically distributed; P, present distribution.

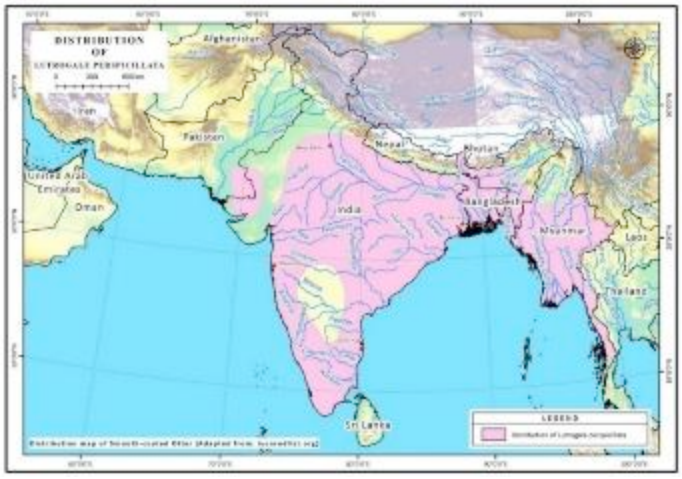


Figure 3.3. Distribution of smooth-coated otter (*Lutrogale perspicillata*), adapted from IUCN

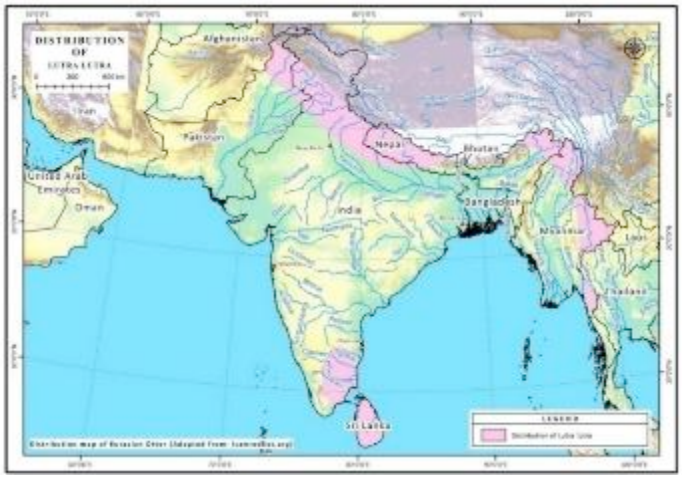


Figure 3.4. Distribution of Eurasian otter (*Lutra lutra*), adapted from IUCN

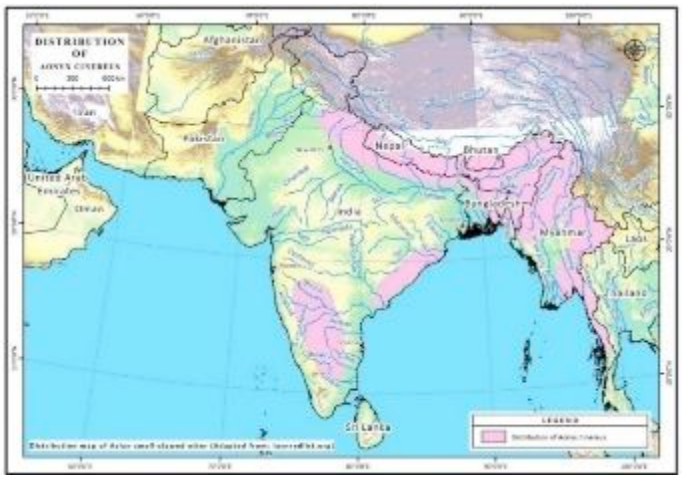


Figure 3.5. Distribution of Asian small-clawed otter (*Aonyx cinereus*), adapted from IUCN

Present Distribution

During the rapid biodiversity assessment, the presence of otters was confirmed on the basis of direct sightings and indirect evidence such as footprints and spraints. In the upper stretch of the Ganga River, indirect evidence, downstream of Devprayag, and direct sighting of groups of smooth-coated otters in Rajaji National Park downstream of the Bhimgoda Barrage confirmed the presence of the smooth-coated otter. Groups of smooth-coated otters were also sighted at Munger and at Kahalgaon in the Vikramshila Gangetic Dolphin Sanctuary (Figure 3.6). Throughout the length of the river, habitats suitable for the smooth-coated otter were mostly found in the undisturbed stretches, including the PAs, with good vegetation cover and high fish diversity. The three otter species in the Ganga River are patchily distributed, with declining population. .

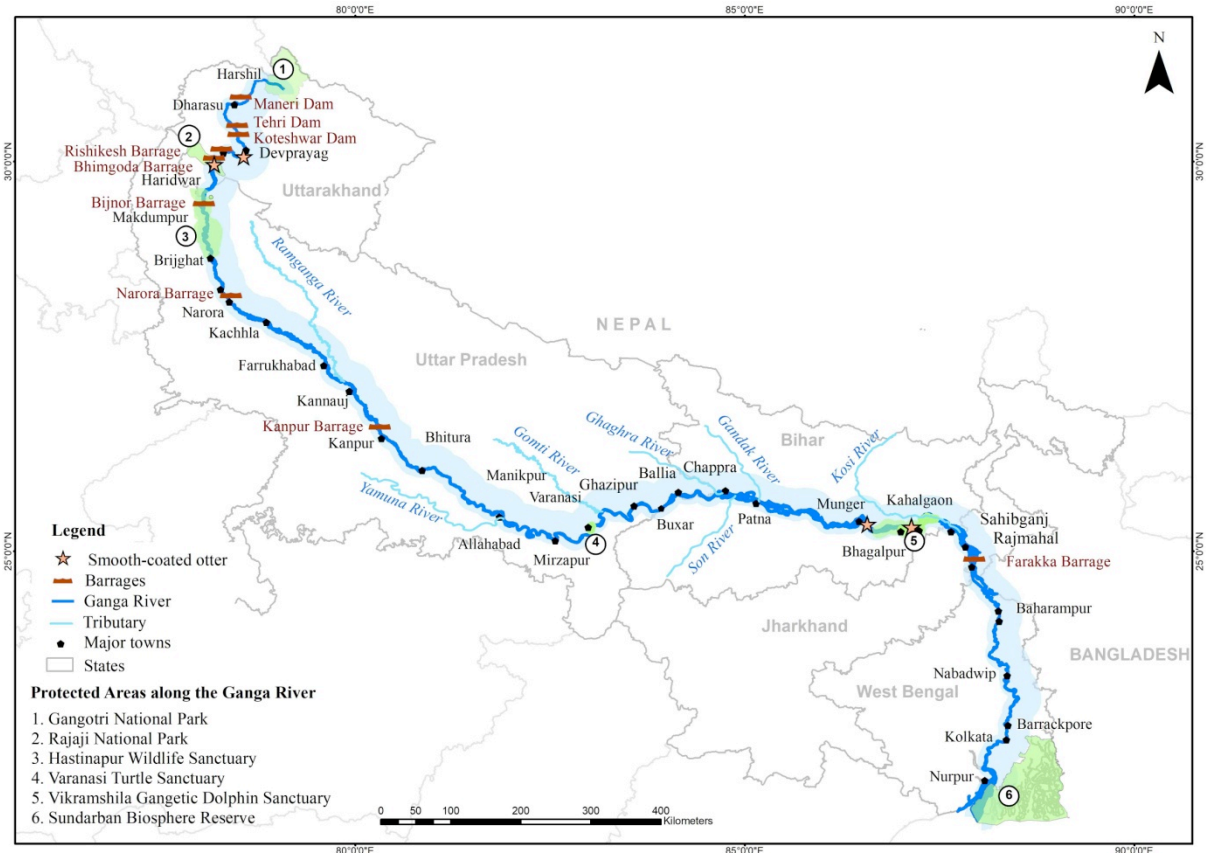


Figure 3.6. Distribution of smooth-coated otter in the Ganga River, on the basis of the rapid biodiversity assessment

3.2. Avifauna

India is one of the global hotspots for birds, with over 1340 bird species (13% of the world's species) recorded from the country (Manakadan & Pittie, 2001). Falling within the Central Asian Flyway, the area is utilized by 307 species of migratory waterbirds, most of them coming from Central and North Asia, at the beginning of the winter season. Of the 307 migratory species, two are Critically Endangered, five are Endangered and 13 species are Vulnerable. Out of the remaining 287 species, 10 species are Near Threatened and 277 species are Least Concern as per the IUCN Red List. Of the 1340 bird species.

The Ganga River basin has several seasonally flooded wetlands, permanent lakes and marshes, which serve as major migratory waterbird habitats. Some of these have been declared as PAs, for e.g., Jhilmil Conservation Reserve in Uttarakhand, Surhataal Wildlife Sanctuary in Uttar Pradesh, Kusheshwar Asthan Bird Sanctuary in Bihar and Udhwa Bird Sanctuary in Jharkhand. The Ganga River, with its mosaic of habitats, supports 128 waterbirds and obligate bird species (Annexure II). Apart from resident and migratory species, some iconic and globally threatened birds such as the black-bellied tern (*Sterna acuticauda*), Indian skimmer (*Rynchops albicollis*), sarus crane (*Antigone antigone*) and river lapwing (*Vanellus duvaucelii*) also breed on the islands, sandbars and banks of the Ganga River. The literature suggests that the greatest species richness of the Ganga River is in Uttar Pradesh (Figure 3.7), which has 135 bird species. The least number of species is reported from Jharkhand, in the lower stretch. Very few systematic studies have been carried out on the distribution of waterbirds along the Ganga River. For example, Rao (2001) reported 46 species from Rishikesh to Kanpur, covering the upper and middle stretches. In the middle stretch, Rahmani (1981) recorded 120 species at the Narora Barrage and Bashir et al. (2012) recorded 55 species from Bijnor to Narora. In the lower stretch, Bilgrami (1991) recorded 23 bird species from Munger, in Bihar, to Farakka, in West Bengal. Annexure II provides details of the probable birds of the Ganga River.

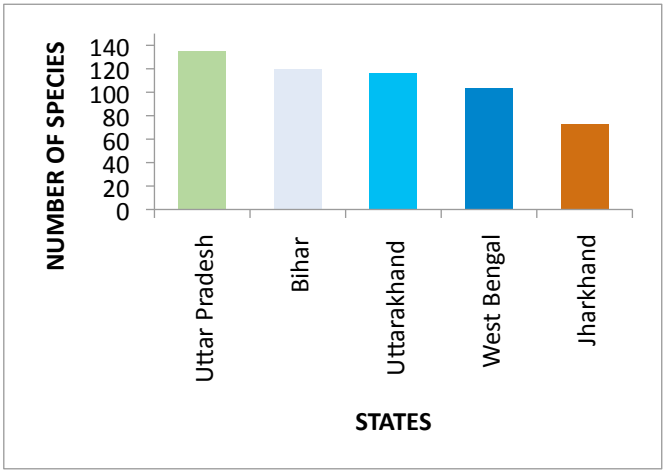


Figure 3.7. Riverine and wetland avifauna richness in the Ganga River states

During the rapid assessment of waterbird diversity, 87 species of waterbirds and five obligate species belonging to 22 families were recorded from six reservoirs along the Ganga River (Figure 3.8). Among these six reservoirs, 65 bird species were recorded from Bijnor barrage followed by 62 species from Narora, 41 species from Rishikesh, 37 species from Kanpur, 30 species from Farakka and 27 species from Bhimgoda barrage in Haridwar (Figure 3.9). Of the total species observed in the reservoirs, the members of the Family Anatidae (ducks and geese) dominated (18 species) followed by Scolopacidae (waders) and Ardeidae (egrets and herons) (Figure 3.10). Of the total 92 species recorded during the assessment along the reservoirs, 17 species belonged to Rare, Endangered and Threatened (RET) categories of IUCN, of which one species each were Critically Endangered and Endangered, six were Vulnerable and 10 species were Near Threatened.

Figure 3.8. Migratory birds monitoring sites

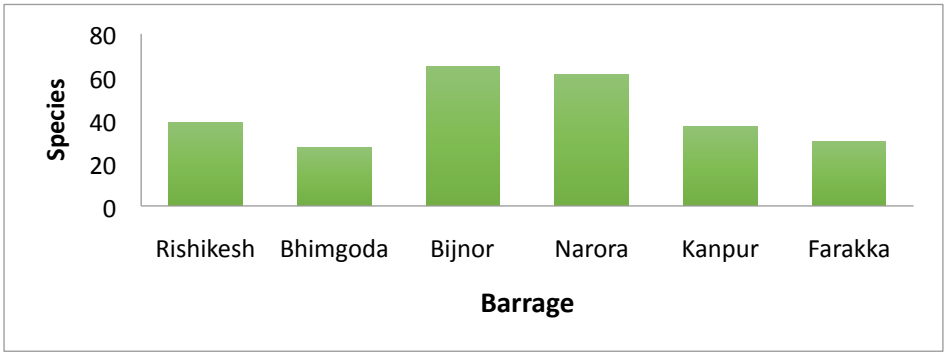


Figure 3.9. Number of waterbird species observed at six reservoirs along the Ganga River

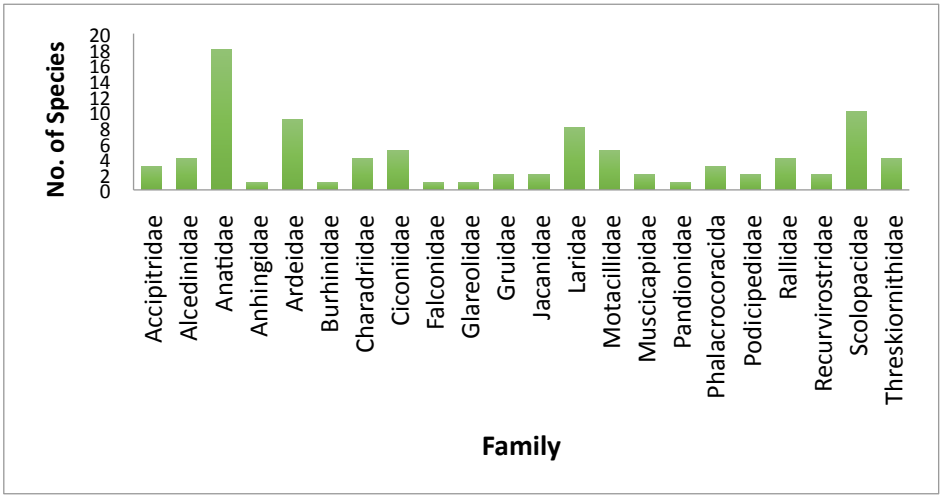


Figure 3.10. Number of species belonging to different Families of birds seen at six reservoirs along the Ganga River

The migratory waterbirds used sandy islands and sand banks of the Ganga River for roosting and the resident water birds such as Indian skimmer, little pratincole and river terns for breeding. Focused studies were also carried out in selected stretches of the Ganga River as a part of the rapid biodiversity assessment to supplement the available information on the distribution and abundance of waterbirds along the Ganga River. For example, Ankit (2017) carried out an intensive study in the middle stretch of the Ganga River near Allahabad, covering 25 km upstream and downstream, and encountered 7153 waterbirds belonging to 41 species in 12 families. Among them, the river lapwing (*Vanellus duvaucelii*), ruddy shelduck (*Tadorna ferruginea*), Temminck's stint (*Calidris temminckii*), black-headed gull (*Larus ridibundus*), brown-headed gull (*Larus brunnicephalus*), pied avocet (*Recurvirostra avosetta*) and spotted redshank (*Tringa erythropus*) were the most abundant species due to the habitat characteristics of the Ganga River in the study area. In another study conducted by Vasudeva (2017) at Narora, a Ramsar site, 83 bird species were encountered, which represented 43 families. Passeriformes was the dominant order, with 15 families, followed by Charadriformes (six families) and Coraciiformes (five families). During the rapid biodiversity assessment, 107 species of water and water-associated bird belonging to 22 families and 10 orders were recorded from Tehri, in Uttarakhand, to Nurpur, in West Bengal. Of these, 85 were waterbirds and 22 were obligate species.

The increasing instances of reclamation and conversion of floodplain wetlands and river islands for agriculture, shifts in flow pattern, water pollution and poaching of waterbirds

affect their occurrence as well as abundance. Resident island-nesting birds such as the black-bellied tern, Indian skimmer, river lapwing and river tern are most vulnerable to natural flow regime alterations and disruptions in water chemistry and are already in the globally threatened category in the IUCN Red List. The threats to the migratory and resident birds of global concern need to be addressed by taking site-specific measures and policy level decisions to maintain adequate flow and the extent of conversion of the floodplain wetlands and river islands.

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3.2.1. Black-bellied tern (*Sterna acuticauda*)

The black-bellied tern is a small, riverine, colonial island-nesting species of the family Laridae and is a resident breeder of the Middle and Lower Gangetic plains (7A and &7B). This species has been recorded from India, Pakistan, Nepal, Bangladesh, Myanmar, Thailand, Laos, Cambodia Vietnam and southern China (Figure 3.11). It is listed as Endangered in the IUCN Red List, as it is almost extinct or rapidly declining all across its range owing to destruction of its breeding habitat, collection of eggs for food, overfishing and the flooding of nests, often caused by dams.

Historical records of the species (1990–2016) are presented in Table 3.4. Behera (1995) reported the presence of the species from Bijnor to Narora during 1995 in Uttar Pradesh. A continuous survey conducted by Dey et al. (2014) during 1999–2014 found the species regularly at Vikramshila Gangetic Dolphin Sanctuary, in Bihar. The species has not been reported from Uttarakhand and Jharkhand. In 1994, the species was reported from the Farakka Barrage (Jha, 2006). Extensive studies are needed to assess the population trend of this species in the Ganga River and its basin.

During the rapid biodiversity assessment, a total of 198 individuals were recorded from Bijnor to Farakka at 65 locations. The greatest abundance was found between Narora and Kannauj, followed by the stretch from Sahibganj to Rajmahal and upstream of Ghazipur (Figure 3.19).

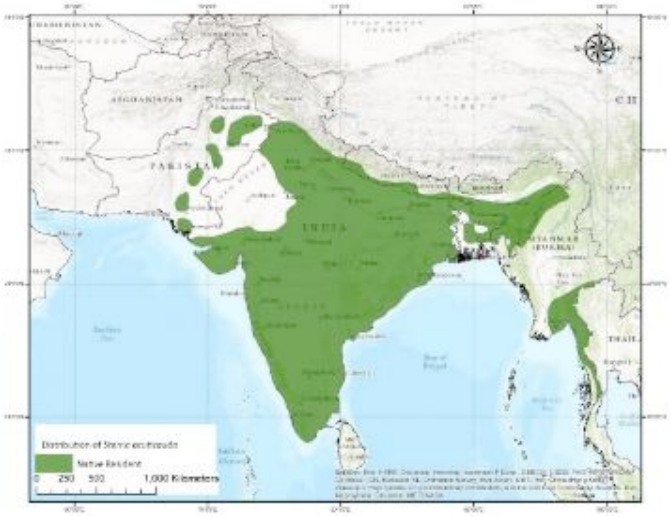

Figure 3.11. Distribution of black-bellied tern (*Sterna acuticauda*)

3.2.2. Indian sarus crane (*Antigone antigone*)

The largest crane in the Indian subcontinent, the sarus is a resident breeder of the Gangetic floodplains. It inhabits the natural wetlands, small seasonal marshes, floodplains, fallow and cultivated lands and paddy fields. The global population of the species is showing a decreasing trend as is listed as Vulnerable in the IUCN Red List. The Indian population is also suspected to have decreased owing to the loss and degradation of wetlands and ingestion of pesticides used in agricultural fields (Sundar et al., 2000; BirdLife International, 2016).

Historically this species inhabited northern central and eastern India, including West Bengal, Nepal and Pakistan (Figure 3.12). The number of individuals in India, Nepal and Pakistan is estimated to be 8000–10,000. In India, the species was distributed from Jammu and Kashmir, in the north, to Chandrapur, in Maharashtra, in the south, and from Gujarat, in the west, to West Bengal and Assam, in the east (Choudhury, 1998; Kaur et al., 2002).

More recent studies reveal that Uttar Pradesh still remains the stronghold of the species, with a population estimated at over 6000 individuals (Sundar, 2008). Bashir et al. (2012) reported encounter rates of 0.285 ± 0.065 during boat surveys and 0.192 ± 0.076 during bank searches in 2007 along the Bijnor–Narora stretch of the Ganga River. Forty-five individuals of the species were reported (2006–2007) from Farrukhabad, Shahjahanpur and Hardoi districts, of Uttar Pradesh, along the Ganga River (Maheswaran et al., 2010). A state-wide survey conducted in Uttar Pradesh during 2010 (Jha & McKinley, 2014) found 6927 individuals in the districts along the Gangetic Plain.

The sarus does not seem to be a common bird in the Lower Gangetic Plain of West Bengal any more, and its population in West Bengal and Bihar remains unknown (Sundar et al., 2000). The species has not been reported from Uttarakhand. Extensive studies are needed to assess the population trend of this species in the Ganga River and its basin. During the rapid biodiversity assessment, 1362 sarus cranes were observed between Brijghat and Farakka, with the greatest abundance near Bhitura, followed by Kanpur, Kannauj and Farukhabad (Figure 3.16). In the site-focused study conducted by Vasudeva (2017), 12 individuals of the species were encountered from Karnwas to Seensai, near Narora, during January–May 2017.

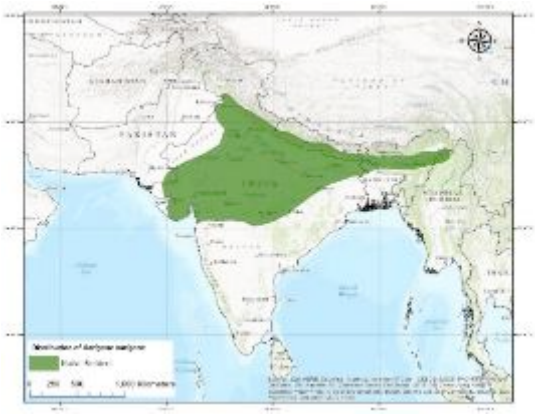

Figure 3.12. Distribution of Indian sarus crane (*Antigone antigone*)

3.2.3. Indian skimmer (*Rynchops albicollis*)

The Indian skimmer is one of the three skimmer species of the world and the only one that is found in the Indian subcontinent. This predatory fish-eating bird has a unique adaptive feature: uneven bills. The lower mandible is longer than the upper mandible.

This species has been reported from India, Pakistan, Bangladesh and Myanmar and is a rare visitor to Nepal (Figure 3.13). It is a globally threatened bird listed as Vulnerable in the IUCN Red List, with an estimated Indian population of 2500 individuals (BirdLife International, 2017). Its range has become increasingly fragmented in recent decades. It is found in Uttar Pradesh, Bihar, Jharkhand and West Bengal along the Ganga River basin and in the Indus River in Kashmir. The species has a widespread distribution in winter and is found in Karwar, on the western coast, and in Chennai and Pondicherry, on the eastern coast. Breeding colonies are known from the Chambal River. Historical records of the species (1990–2016) are presented in Table 3.5. The species has not been reported from Uttarakhand

and Jharkhand. Early observations from 1991 were obtained from the Lower Gangetic Plain of West Bengal (Jha, 2006), and recent sightings from Uttar Pradesh have been reported by Mishra et al. (2016).

During the rapid biodiversity assessment, 411 individuals of Indian skimmers were recorded. The Indian skimmer were most frequently encountered between Bijnor and Ghazipur. Seven nesting colonies of the Indian skimmer were recorded between Kachhla and Varanasi. Maximum number of nesting colonies were encountered between Allahabad and Varanasi. The species was most abundant near Varanasi, followed by Allahabad, Mirzapur and Narora. (Figure 3.16). In earlier site-specific studies, Ankit (2017) encountered 83 birds at a nesting island near Allahabad and Seventy-six individuals of the species were encountered from Karnwas to Seensai, near Narora, during January–May 2017 (Vasudeva, 2017).

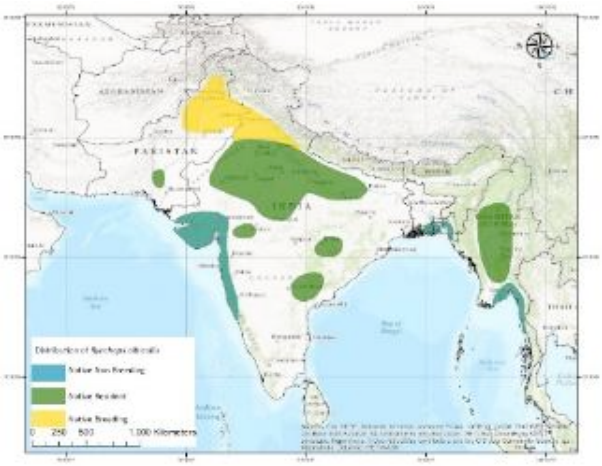

Figure 3.13. Distribution of Indian skimmer (*Rynchops albicollis*)

3.2.4. River tern (*Sterna aurantia*)

A resident breeder in India, the river tern is a common riverine species and an island-nesting bird. This species occurs across a wide range in southern Asia and Southeast Asia, including Pakistan, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam and southern China (del Hoyo et al., 1996) (Figure 3.14). Globally, the species id showing a decreasing trend in its population and is listed as Near Threatened in the IUCN Red List. The population in India is estimated to be >50,000 individuals (Delany & Scott, 2006). The nesting areas are vulnerable to flooding, predation and disturbance (del Hoyo et al., 1996), and abrupt declines have occurred in parts of Southeast Asia.

Bashir et al. (2012) reported an encounter rate of 0.272 ± 0.059 for the species during a boat survey conducted in 2007, along the Bijnor–Narora stretch of the Ganga River. In a continuous survey conducted by Dey et al. (2014) from 1999 to 2014, 10–20 individuals were regularly sighted at Vikramshila Gangetic Dolphin Sanctuary. The species is reported occasionally from the Lower Gangetic Plain and the Coastal Zone of West Bengal. No literature pertaining to the species is available for Uttarakhand and Jharkhand.

During the rapid biodiversity assessment, 197 individuals of the species were encountered between Bijnor and Farakka. Major congregations were observed near Farukhabad and Bijnor and at Brijghat (Figure 3.19). In a site-focused study conducted by Vasudeva (2017), 72 individuals of the species were encountered from Karnwas to Seensai, near Narora, during January–May 2017.

Figure 3.14. Distribution of river tern (*Sterna aurantia*)

3.2.5. River lapwing (*Vanellus duvaucelii*)

The river lapwing is a resident breeding riverine species in India. The species occurs in parts of the Indian subcontinent, including Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Cambodia, Laos and Vietnam; southern China; and Southeast Asia (Chandler, 2009) (Figure 3.15). Listed as Near Threatened in the IUCN Red List, it is showing moderately rapid overall population decline owing to the impacts of human pressures on riverine ecosystems and multiple dam construction projects (BirdLife International, 2016).

Few systematic surveys have been conducted to assess the population of the species in the Gangetic Plain of Uttar Pradesh, Jharkhand and West Bengal in the past decades, and the species is only mentioned in checklists from these areas (State Fauna Series, Zoological

Survey of India). During a continuous survey conducted by Dey et al. (2014) from 1999 to 2014, the species was found at Vikramshila Gangetic Dolphin Sanctuary. Ankit (2017) encountered 568 individuals of the species along a 50 km stretch near Allahabad from December 2016 to January 2017.

River lapwings were very common and widely distributed throughout the stretch of the Ganga River that was surveyed. A total of 2923 individuals of this species were observed during the assessment. The greatest abundance was found near Kanpur, followed by Bhitura, Farukhabad, Kannauj, Manikpur, Ghazipur, Kachla, Mirzapur and Bijnor (Figure 3.19). In a site-focused study conducted by Vasudeva (2017), 210 individuals of the species were encountered from Karnwas to Seensai, near Narora, during January–May 2017.

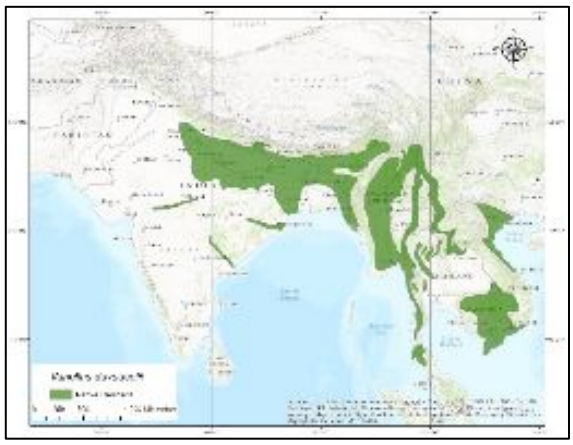

Figure 3.15. Distribution of river lapwing (*Vanellus duvaucelii*)

3.2.6. Painted stork (*Mycteria leucocephala*)

This threatened species occurs widely in the Indian subcontinent; however, it has become rare in Myanmar, Thailand, Laos and Vietnam and is possibly extinct in China (Figure 3.16). There are an estimated 15,000–25000 individuals in South Asia (Wetlands International, 2012) and fewer than 10,000 in Southeast Asia (Perennou et al., 1994), with populations declining throughout the range owing to hunting, wetland drainage and pollution. Therefore, the species is listed as Near Threatened in the IUCN Red List.

The species has been recorded in the Himalayan zone of Pauri-Garhwal District and Rajaji National Park, in Uttarakhand (Islam & Rahmani, 2008). During a continuous survey conducted by Dey et al. (2014) from 1999 to 2014, the species was found at Vikramshila

Gangetic Dolphin Sanctuary (Table 3.6). Bashir et al. (2012) recorded the species from the Bijnor–Narora stretch of the Ganga River. A large flock was observed by Mishra et al. (2016) at Rae Bareilly, Uttar Pradesh. The species is occasionally reported from the Lower Gangetic Plain of West Bengal. However, apart from a few checklists, there is no literature on the abundance and distribution of the species.

Figure 3.16. Distribution of painted stork (*Mycteria leucocephala*)

3.2.7. Great thick-knee (*Esacus recurvirostris*)

The species is distributed across India, Pakistan, Sri Lanka, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Iran, Laos, Cambodia, Vietnam and southern China (Figure 3.17). Precipitous declines have occurred in parts of Southeast Asia. India probably holds the bulk of the population now. Increasing numbers of dams and impoundments on large rivers in the range of the species threaten to alter flow regimes and inundate nesting habitats downstream. This has resulted in declines in the population of the species and therefore is listed as Near Threatened in the IUCN Red List.

According to checklists, the species is present in Uttar Pradesh, Bihar and West Bengal. Seven individuals of this species were reported from mud flats and sandbanks of the Sundarbans (Zöckler et al., 2005). During the rapid biodiversity assessment, 197 individuals were recorded. Maximum sightings were from Kachhla – Farrukhabad stretch, followed by Brijghat – Narora, and Narora – Kachhla stretches (Figure 3.19).

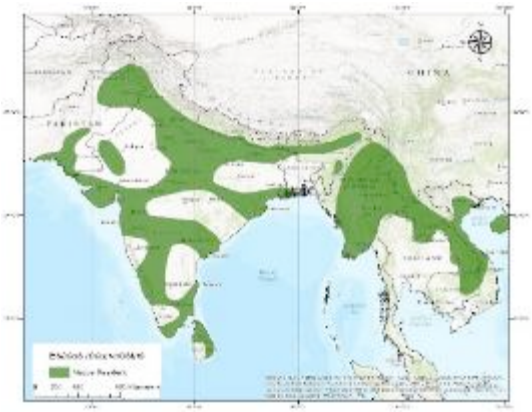

Figure 3.17. Distribution of great thick-knee (*Esacus recurvirostris*)

3.2.8. Little pratincole (*Glareola lactea*)

This species has an extremely large range, distributed in India, Afghanistan, Bangladesh, Bhutan, Cambodia, China, India, Laos, Myanmar, Nepal, Oman, Pakistan, Sri Lanka and Thailand (Figure 3.18). The global population size and trend are currently unknown (BirdLife International, 2016) but the species is listed as Least concern in the IUCN Red List. According to checklists, the species is present in Uttar Pradesh, Bihar and West Bengal**.** Apart from this, there is very little in the literature on the abundance and distribution of this species with respect to the Ganga River and its floodplain.

A total of 3339 individuals of this species were encountered from Makdumpur to Nabadwip during the rapid biodiversity assessment. The species was most abundant between Narora and Kanpur, followed by the stretch upstream of Bhagalpur and from Bhitura to Ghazipur (Figure 3.19). In site specific studies, Ankit (2017) encountered 440 individuals of this species along a 50 km stretch near Allahabad District from December 2016 to January 2017 anda total of 166 individuals were encountered from Karnwas to Seensai, near Narora, during January–May 2017 (Vasudeva, 2017).

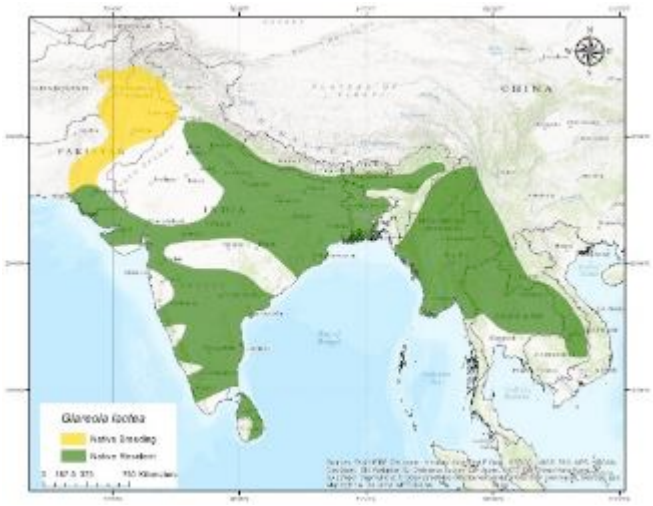

Figure 3.18. Distribution of little pratincole (*Glareola lactea*)

Table 3.4. Records of black-bellied tern in the Ganga River and its floodplain

Year	Ganga River state								
	Uttar Pradesh			Bihar			West Bengal		
	No.	Region	Reference	No.	Region	Reference	No.	Region	Reference
1994	No literature available			No literature available			23	Farakka Barrage	Jha (2006)
1995	NA	Bijnor–Narora	Behera (1995)				No literature available		
1999 to 2013	No literature available			15–20	50–65 km of Vikramshila Gangetic Dolphin Sanctuary	Dey et al. (2014)			
2014				30–40					

Table 3.5. Records of Indian skimmer in the Ganga River and its floodplain

Year	Uttar Pradesh			Bihar			West Bengal		
	No.	Region	Reference	No.	Region	Reference	No.	Region	Reference
1991	No literature available			No literature available			7	Manikchak Ghat	
1995							4	Near Gopalpur	
1997							9		
1998							23	Near Farakka Barrage	
1999							20		Jha (2006)
2004				Breeding	Barari, Bhagalpur	Dey et al. (2014)	No literature available		
2005									
2007								Chittaranjan Bara Dam, Burdwan	Sharma (2008)
				No literature available			9	District	

2008				Bhagalpur	Dey et al. (2014)	
2011				Frequently observed	6	Nidoya and Rajar Char, Purbasthali-Ganges Islets, Burdwan District
2015	148	Gegaso, Dalmau, Unchahar, Raebareilly District	Mishra et al. (2016)	2	No literature available	
2016				No literature available		

Table 3.6. Records of painted stork in the Ganga River and its floodplain

Year	Ganga River States					
	Uttar Pradesh			Bihar		
	No.	Region	Reference	No.	Region	Reference
1999–2006	No literature available			40–50	Lodipur and Bhagalpur	Dey et al. (2014)
2007	0.063±0.011, boat; 0.041±0.014 bank	Bijnor–Narora	Bashir et al. (2012)			
2008–2013	No literature available					
2014	No literature available			14	Bhagalpur	
2015	187	Rae Bareilly	Mishra et al. (2016)	No literature available		
2016						

A total of 107 bird species, belonging to 36 families and 16 orders, were sighted during the rapid biodiversity assessment. The greatest number of species was from the order Charadriformes (26 species), followed by Passeriformes (16 species), Anseriformes (13 species) and Pelecaniformes (11 species). The Indian skimmer, sarus crane, black-bellied tern, river tern, river lapwing, great thick-knee and small pratincole are some of the resident breeding birds of the Ganga River that were most frequently encountered during the rapid biodiversity assessment (Figure 3.19). Indian skimmers were most frequently encountered between Bijnor and Ghazipur. Nesting colonies of the Indian skimmer were recorded between Kachhla and Farrukhabad, at Bithura Ghat, at Allahabad and from Mirzapur to Varanasi. The species was most abundant near Varanasi, followed by Allahabad, Mirzapur and Narora. Sarus cranes were observed between Brijghat and Mirzapur, with maximum abundance near Bhitura, followed by Kanpur, Kannauj and Farukhabad. River terns were

recorded between Bijnor and Varanasi. Major congregations were observed near Farukhabad and Bijnor, followed by Brijghat. River lapwings were very common and widely distributed throughout the stretch of the Ganga River that was surveyed. The greatest abundance was found near Kanpur, followed by Bhitura, Farukhabad, Kannauj, Manikpur, Ghazipur, Kachla, Mirzapur and Bijnor. The great thick-knee was encountered from Bijnor to Kannauj. The greatest abundance was recorded near Farukhabad, followed by Kachla, Kannauj, Narora and Brijghat. Black-bellied terns were sighted from Bijnor to Kannauj. The greatest abundance was found between Narora and Kannauj, followed by the stretch from Sahibganj to Rajmahal and upstream of Ghazipur.Small pratincoles were encountered from Makdumpur to Nabadwip. The species was most abundant between Narora and Kanpur, followed by the stretch upstream of Bhagalpur and Bhitura to Ghazipur.

However, the population trends of these birds cannot be estimated due to the lack of temporal-scale information. More extensive studies on the distribution and ecology of these birds are essential for planning their conservation.

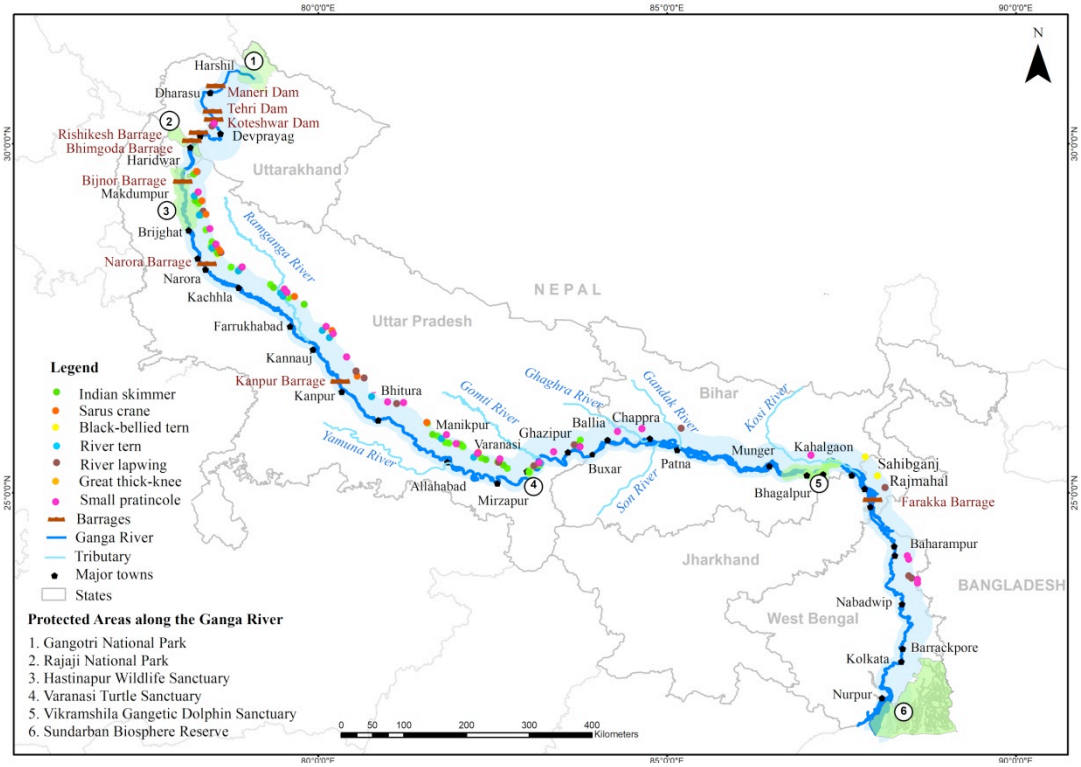

Figure 3.19. Distribution of resident breeding birds, along the Ganga River, on the basis of the rapid biodiversity assessment

3.3. Reptiles

3.3.1. Crocodilians

Crocodilians are represented by 24 living species (Martin, 2008). In India, *Crocodylus palustris* (mugger or marsh crocodile) and *C. porosus* (saltwater crocodile) represent the family Crocodylidae, and *Gavialis gangeticus* (gharial) represents the family Gavialidae. These species are distributed in the Ganga River and its major tributaries (Annexure III).

Historical Distribution

Historically, gharials were largely restricted to the perennial Himalayan river systems in the northern part of the Indian subcontinent (Boulenger, 1890; Smith, 1931; Wright, 1982). Indian rivers that formerly supported large populations of the gharial include the Ramganga, Ghagra, Gandak, Kosi and Girwa (Whitaker, 1979). The species were on the verge of extinction in India by the mid-1970s, and the population had plummeted to fewer than 200 individuals. Project Crocodile was initiated in 1975 and included an intensive captive rearing and breeding programme intended to restock depleted gharial habitats, especially in the Chambal River, at National Chambal Sanctuary, and in the Girwa River, at Katerniaghat Wildlife Sanctuary. The restocking programme, along with legal protection, increased the breeding population in the Chambal River in the Ganga River basin.

Recently, gharials have been reported from the main stem Ganga River between Bhagalpur and Sultanganj (Nawab et al., 2016) and from its tributaries *viz*., Ramganga, at Corbett Tiger Reserve (Chowfin & Leslie, 2013); Son River, at Son Gharial Sanctuary; Girwa River, at Katerniaghat Wildlife Sanctuary; and Chambal River, at National Chambal Sanctuary (Figure 3.20). The Chambal River has the largest subpopulation of breeding gharials in the wild, with around 48% of the total population (IUCN, 2009).

The mugger is one of the most widely distributed species owing to its highly adaptable nature. Throughout India, this species survives in stagnant water, jheels, reservoirs, tanks and rivers with placid currents (Boulenger, 1890). In India, it is present in 15 states including much of the Ganga River drainage. Significant populations occur in the middle Ganga (Bihar and Jharkhand), Chambal River (Rajasthan and Madhya Pradesh) (Sharma & Singh, 2015) and Gujarat (Figure 3.21). In Uttarakhand, the species has been reported from the Ramganga River and the reservoir area in Corbett Tiger Reserve (Nawab, 2007), from Rajaji National Park and from parts of Haridwar and Lansdowne forest divisions (Joshi, 2013).

In the Ganga River basin, this species has been reported from Hastinapur Wildlife Sanctuary and the Ramsar site between Garhmukteshwar and Narora (Nawab et al., 2016), from the Banas and Tapti rivers (McCann, 1940) and from the states of Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal (Whitaker and Daniel, 1980). Table 3.7 provides a comparative account of the gharial and mugger populations in the Ganga River and its tributaries on the basis of the literature.It is evident that these species have been studied mostly in the tributaries of the Ganga River.

Historically, the saltwater crocodile *Crocodylus porosus* was distributed along the coast of South Asia (Figure 3.22). The rarity of the species in India was apparent by the late 1960s (Daniel, 1970) as the population became extinct in the states of Kerala, Tamil Nadu and Andhra Pradesh (de Vos, 1984; FAO, 1974). A small population remained in the Brahmani-Baitarani Delta, in Odisha, the Gangetic Delta of the Sundarbans, in West Bengal, and Andaman Islands (FAO, 1974). The species has become locally extinct over large parts of its range, with viable populations only occurring in PAs (Santiapillai & Silva, 2001).

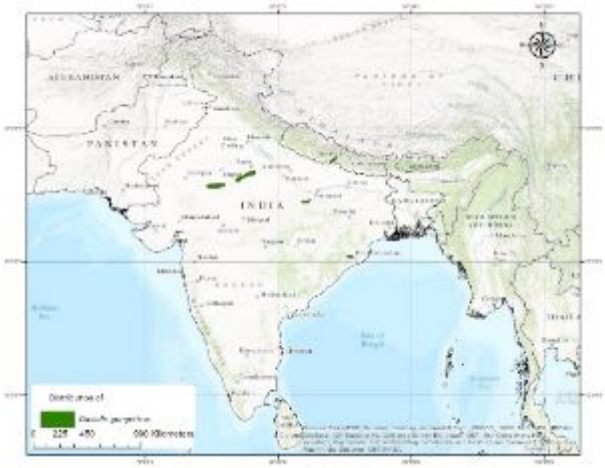

Figure 3.20. Distribution of gharials (*Gavialis gangeticus*)

Figure 3.21. Distribution of mugger (*Crocodylus palustris*)

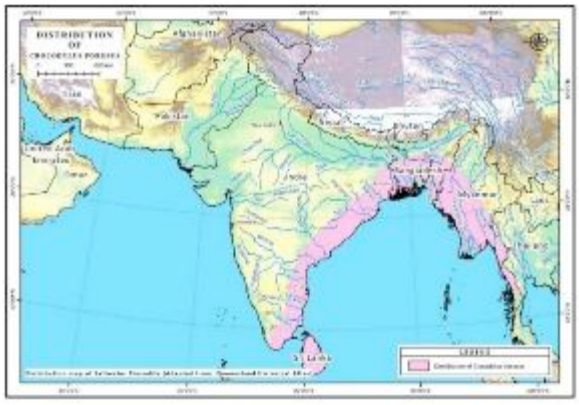

Figure 3.22. Distribution of saltwater crocodile (*Crocodylus porosus*)

As part of the Crocodile Conservation Project (GOI, 1975), *C. porosus* were released in Bhitarkanika Wildlife Sanctuary in 1975 and in the Sundarbans until 1982 to rejuvenate the existing population. Bustard and Choudhury (1981) and, later, Kar and Bustard (1986) reported a decline in the population of the Sundarbans. During 1998, the total Indian population of *C. porosus* was 170–330 (Sharma, 1998). More recently, Saha et al. (2011) reported the presence of a good population of *C. porosus* in the Sundarban estuary. Extensive studies are needed to assess the population trend of this species in the Ganga River and its basin.

Present Distribution

During the rapid biodiversity assessment, individual gharials were sighted in Rajaji National Park downstream of the Bhimgoda Barrage, and groups of gharials were sighted between Bijnor and Brijghat. Individual muggers were sighted near Bijnor and at Malda, upstream of the Farakka Barrage (Figure 3.23). The gharials sighted between Bijnor and Brijghat were

part of the released population restocked in Hastinapur Wildlife Sanctuary. Suitable habitats in terms of deep-water stretches, lateral connectivity and nesting sandbars and islands were found at certain locations in the Ganga River, *viz*. from Bijnor to Narora and from Farrukhabad to Varanasi.

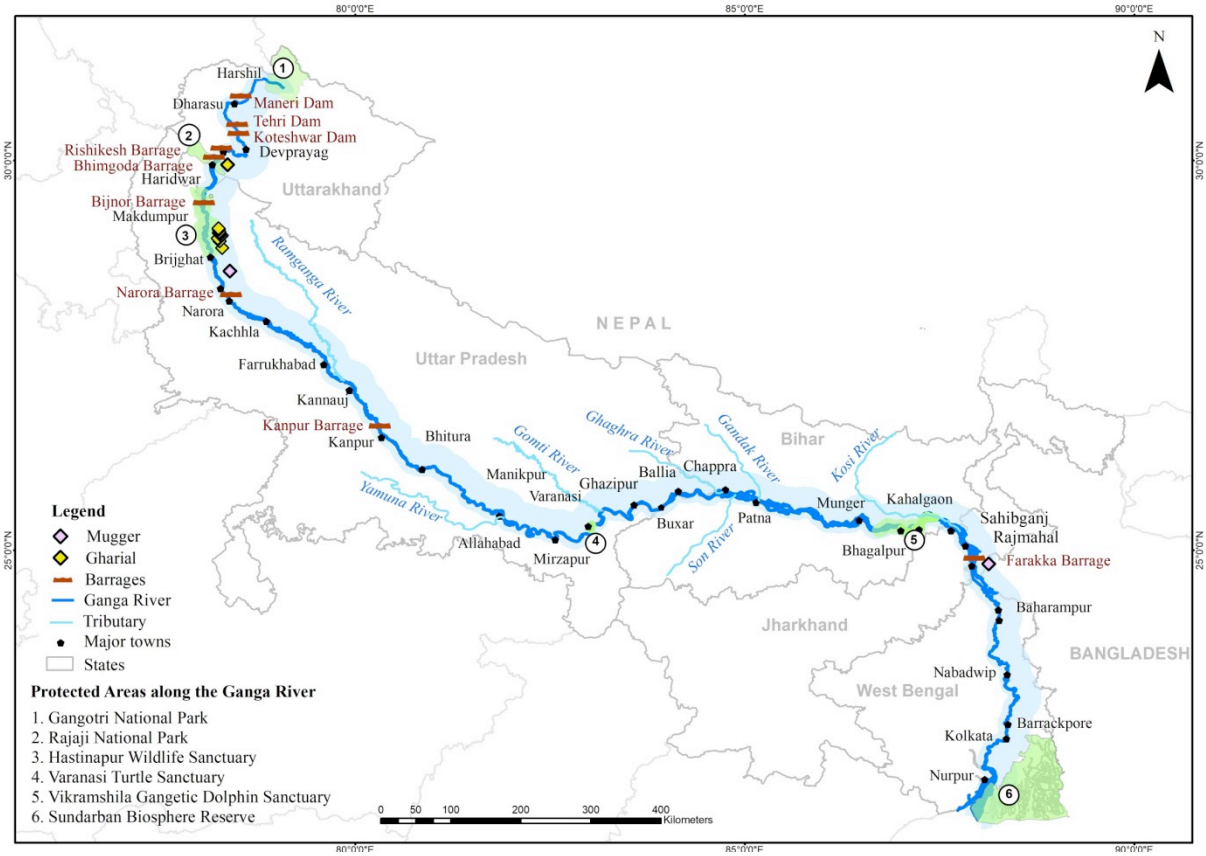

Figure 3.23. Distribution of gharials and muggers in the Ganga River, on the basis of the rapid biodiversity assessment

Crocodilians are highly vulnerable to anthropogenic habitat alteration and are therefore conservation-dependent species. However, most of the crocodilian habitats along the Ganga River are not protected. The absence of habitat features such as deep waters, a good prey-base and basking and nesting beaches hinders the survival of gharials and muggers. The population trend of these species in the Ganga River cannot be inferred from a literature review due to a lack of consolidated information.

Table 3.7. Past and present population status of gharials and muggers along the Ganga River and its tributaries

Species	River	Past		Present		Change	Reference
		No.	Year	No.	Year		

	Ganga	—	—	<200	2006	—	Andrews (2006); Whitaker (2007)
	Chambal	107	1979	1065	1992	895% increase	Hussain (1999)
		226	1997	78	2006	65% decrease	Andrews (2006); Sharma and Basu (2004); Whitaker (2007)
	Chambal (Tasod to Chakar)	311–368	2004–2008	720	2015	95% increase	Sharma (2004, 2005, 2006, 2007); Anon (2015)
	Chambal (stretch between Pali and Khirkan)			122	2009	10% increase	Katdare et al. (2011)
Gharial	Girwa (Katerniaghat)	30	1997	26 (20 F/6 M)	2006	13% decrease	Andrews (2006); Sharma and Basu (2004); Whitaker (2007)
	Son	10	1997	3	2006	70 % decrease	
	Corbett Tiger Reserve (confluence of Ramganga River and Kalagarh Reservoir)	18	2008	32	2013	77% increase	Chowfin and Leslie (2013)
	Bhagalpur and Sultanganj			Sighted			Bharati et al. (2016)
	Gandak			25	2012		
	Patna			4	2007		
	Corbett Tiger Reserve (Ramganga)			129	2007		Nawab (2007)
	Chambal	15	1998				Nair (2009)
Mugger	Chambal (Pali–Rajghat–Ch. Nagar)	33	1984–1985	356	2014	Increase	Sharma and Singh (2015)
	Pali–Rajghat	23	1984–1985	147	2014	Increase	
	Rajghat–Ch. Nagar	10	1984–1985	209	2014	Increase	

3.3.2. Turtles

India has one of the most diverse turtle fauna, with 24 species of freshwater turtle and four species of tortoise, and ranks among the top five countries in terms of importance for turtle conservation in Asia (Stuart & Thorbiarnarson, 2003) and the world (Rhodin, 2006). Freshwater turtles were first described by Gunther (1864) in *The Reptiles of British India*. The Ganga River provides habitats for 14 testudines (13 turtle and 1 tortoise species) in the

middle and lower stretches up to the deltaic region (ZSI, 1991). The turtles in Ganga are represented by nine hardshell species, *viz. Batagur kachuga*, *B. dhongoka*, *B. baska*, *Hardella thurjii*, *Pangshura tecta*, *P. smithii*, *Geoclemys hamiltonii, Melanochelys trijuga* and *P. tentoria* (two subspecies, *P. t. tentoria* and *P. t. circumdata*) and four softshell species, *viz*. *Nilssonia gangetica*, *N. hurum*, *Chitra indica*, and *Lissemys punctata* (two subspecies, *L. p. punctata* and *L. p. andersoni*) (Annexure IV).

Turtles play a critical ecological role by controlling aquatic vegetation, serve as scavengers and help maintain rivers and lakes in a healthy condition. Unfortunately, these remarkable reptiles are now facing extinction due to habitat degradation and poaching. Ample literature is available on the turtles of the Indian subcontitnent; however, extensive ecological studies are needed to assess the population trend of the turtle species in the Ganga River and its basin.

3.3.2.1. Red-crowned roofed turtle (*Batagur kachuga*)

The turtles belonging to the genus *Batagur* are herbivorous and aquatic and grow to a large size. With the males exhibiting striking seasonal breeding colours, they are also some of the most attractive and rarest turtles in the world. The red-crowned roofed turtle (*Batagur kachuga*) is endemic to South Asia. This rare turtle, previously categorized as Endangered in the IUCN Red list, was updated to Critically Endangered in 2000 owing to its alarming disappearance from its range (IUCN, 2016).

Little is known about the historic distribution of the red-crowned roofed turtle. Anderson (1871) observed the species in the Yamuna River in Agra. Native to South Asia, it had an extensive historic range in northern India, Nepal and Bangladesh (IUCN, 2016; Gray, 2017) (Figure 3.24). It was historically reported from the Ganga, Brahmaputra and Chambal river systems, of northern India (IUCN, 2016).

The last known stronghold of this large river turtle is the Chambal River, in central India. However, small isolated populations still exist in the Ganges and Brahmaputra river basins (IUCN, 2016). The species has been decimated by extensive hunting and intense habitat degradation, including pollution and large-scale water extraction projects for agriculture and drinking purposes. The main anthropogenic threats to the remaining population are accidental

drowning of adults in illegal fishing nets, sand-mining, agricultural cultivation on sandbanks and sandbars, water diversion and irregular flows from upstream dams.

Figure 3.24. Distribution of red-crowned roofed turtle (*Batagur kachuga*)

3.3.2.2. Northern river terrapin (*Batagur baska*)

The northern river terrapin (*Batagur baska*) is a Critically Endangered turtle species owing to its small and declining wild population and regional extinctions in most of its range (IUCN, 2016).

Historically, the species was distributed throughout South Asia from the Brahmani-Baitarini Delta (Odisha) and the Sundarban region through the mouth of the Irrawaddy River in Myanmar and the Malay Peninsula (southern Thailand, Malaysia) to Sumatra, Cambodia and southern Vietnam (Praschag et al., 2008; Moll et al., 2009) (Figure 3.25). Museum specimens of the species from Salt Lake, in Kolkata, and the Indus Delta, of southern Pakistan, suggest that this species was distributed in these areas during the mid-19th century (Moll et al., 2009). Das (1987) reported that the species was found in tidal rivers, channels and estuaries and along the coasts of Odisha and the Sundarbans, of West Bengal.

Recent studies indicate that a huge population of *B. baska* was extirpated from the river deltas and estuaries of Odisha and West Bengal, in India, and the Ayeyarwady Delta, in Myanmar, during the 19th and early 20th centuries (Moll et al., 2009; Sinha et al., 2014). No viable population and wild nesting sites of this species are currently known (Hudson, 2016). During 2015–2016, a few remnant individuals were recorded from village ponds in the Sundarbans,

where the local fishermen maintain the turtles as source of eggs, as there are no longer any known nesting areas (unpublished data). The species was extirpated from the Hooghly River due to overharvesting of both adults and eggs for human consumption.

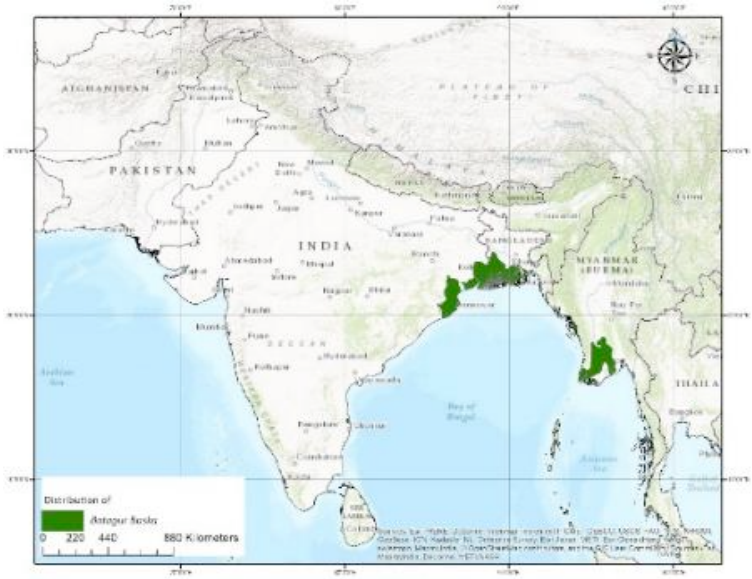

Figure 3.25. Distribution of northern river terrapin (*Batagur baska*)

3.3.2.3. Three-striped roofed turtle (*Batagur dhongoka*)

The three-striped roofed turtle is endemic to the rivers of Bangladesh and India (Gunther, 1864). The status of the species was updated from Lower Risk/Near Threatened in 1996 to Endangered in 2000 in the IUCN Red List, and it is listed in Schedule I (Part II) of the IWPA (1972). Historically the species was distributed in the Gangetic Plain, in Uttar Pradesh, Uttarakhand, Madhya Pradesh, West Bengal and Bihar (Gunther, 1864; Theobald, 1876). The species was recorded from Corbett National Park, in Uttarakhand (Moll, 1986; Hanfee, 1999), Dudhwa Tiger Reserve, in Uttar Pradesh, and National Chambal Sanctuary, in Madhya Pradesh (Hanfee, 1999) (Figure 3.26). The species is currently distributed in the drainages of North India in the Ganga and Chambal rivers (Devaprakash, 2015). This species is among the most exploited turtles of southern Asia due to its predictable nesting habits and site fidelity.

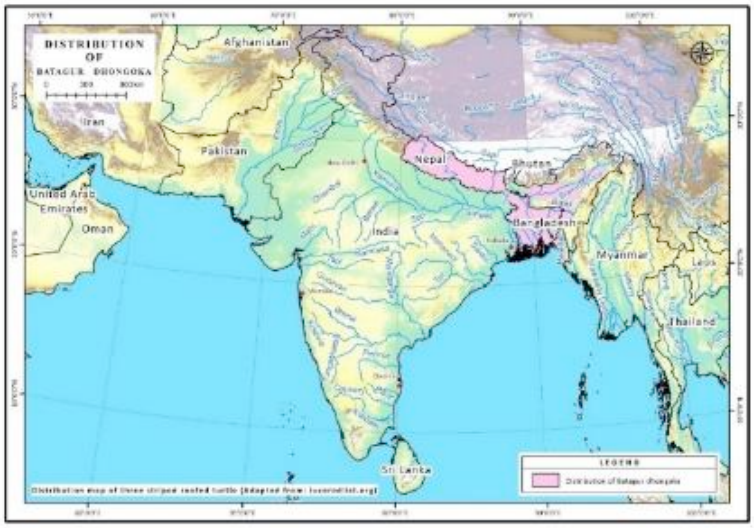

Figure 3.26. Distribution of three-striped roofed turtle (*Batagur dhongoka*)

3.3.2.4. Spotted pond turtle (*Geoclemys hamiltonii*)

The spotted pond turtle, also known as the black spotted turtle or the black pond turtle (*Geoclemys hamiltonii*), is endemic to South Asia. It is classified as Vulnerable (VU) according to the IUCN Red List, and it is listed in Schedule I of the IWPA (1972). The species is carnivorous.

The spotted pond turtle is a relatively rare species, found only in the Indus and Ganga river drainages in Pakistan, northern India, Bangladesh and Nepal. Historically, the turtle was abundant in the Lower Ganga and was reported from the Gandak Dam, of Bihar, and its vicinity (Gunther, 1864; Moll & Vijaya, 1986; Theobald, 1876). In the 19th century, this turtle was widely distributed in the deep water systems of the northern and northeastern parts of the Indian subcontinent (Smith, 1931; Vijaya, 1983) (Figure 3.27). Bhaduria et al. (1995) reported the occurrence of the species in the Gomti and Girwa rivers, of Uttar Pradesh. More recent studies indicate the presence of the species in PAs along the Ganga River and its tributaries and in West Bengal (Daniel, 2002; Sinha et al., 2014). The most significant threat to the black pond turtle is the largely uncontrolled trade of freshwater turtles in Asia.

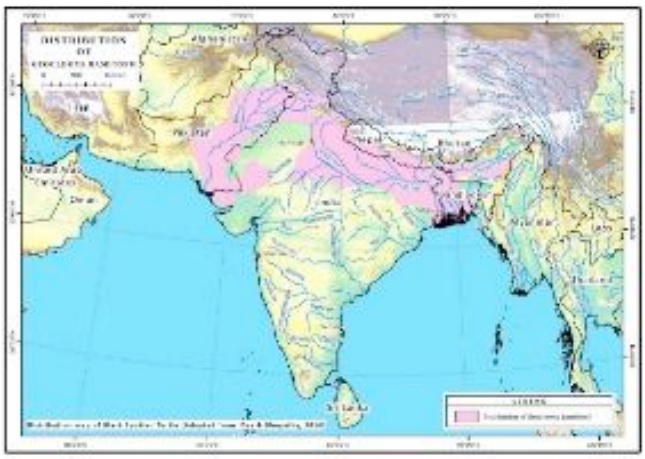

Figure 3.27. Distribution of spotted pond turtle (*Geoclemys hamiltonii*)

3.3.2.5. Indian tent turtle (*Pangshura tentoria*)

The Indian tent turtle is similar to the Indian roofed turtle. The species is listed under the Least Concern category in the IUCN Red List and Schedule I (Part II) of the IWPA (1972). It is mainly omnivorous and consumes a wide variety of aquatic plants and animals in the wild.

The Indian tent turtle (*Pangshura tentoria*) is found in central and northern India and Bangladesh (Theobald, 1876). In the recent past, the species has been reported from Kolkata, Bihar (Moll, 1987) and Katerniaghat Wildlife Sanctuary and Dudhwa Tiger Reserve, in Uttar Pradesh (Hanfee, 1999). The Indian tent turtle is restricted to the upper and central rivers of India, *i.e.,* the rivers flowing into the Bay of Bengal (Moll, 1987) (Figure 3.28). Rao (1993) reported the species from the Chambal River. Baruah et al. (2016) mentioned the presence of the species in the Yamuna River and at the Kalindri–Ganga confluence, in Uttar Pradesh, and at Farrukhabad (Uttar Pradesh), Deogarh (Madhya Pradesh), Katarniaghat, Gorakhpur (Madhya Pradesh) and West Bengal.

During the rapid biodiversity assessment, evidence of the presence of *Pangshura* was found all along the mainstem of the river, especially in the middle stretches, such as at Bijnor.

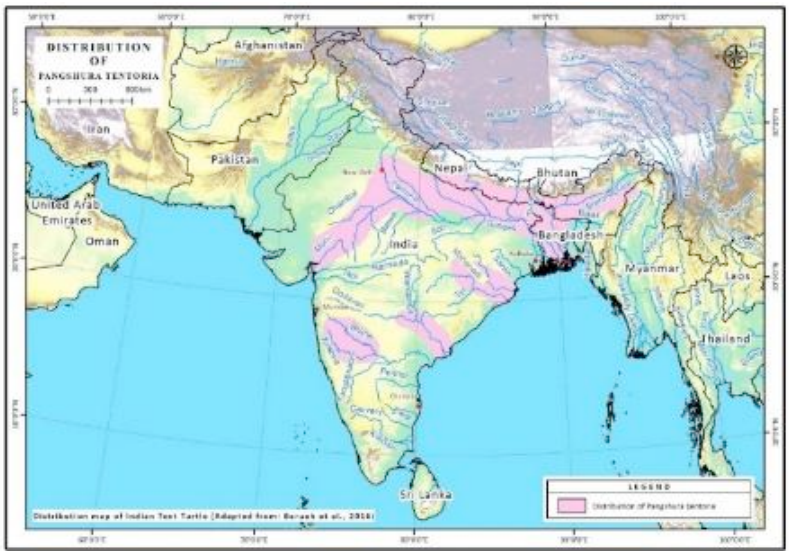

Figure 3.28. Distribution of Indian tent turtle (*Pangshura tentoria*)

3.3.2.6. Brown roofed turtle (*Pangshura smithii*)

The species is listed as Near Threatened (NT) in the IUCN Red List and is listed in Schedule IV of the IWPA (1972). It is a rapid swimmer and is omnivorous in nature (Das, 1991; Sial et al., 2016).

The species inhabits medium to large rivers with vegetation. It is distributed in the Upper and Middle Ganga (Moll, 1987; Hanfee, 1999) and in West Bengal in the Lower Ganga (Daniel, 1970). The main anthropogenic factors affecting the species include habitat degradation by the construction of dams and barrages, cultivation along river banks and pollution of aquatic habitats (Bista & Shah, 2010).

3.3.2.7. Indian roofed turtle (*Pangshura tecta*)

This unique crawling reptile is listed as Least Concern (LC) in the IUCN Red List and in Schedule I (Part II) of the IWPA (1972). The Indian roofed turtle has an omnivorous diet.

The Indian roofed turtle has been recorded from lentic habitats of the Ganga River and is commonly seen basking on logs or river banks (Moll, 1987). Historically, *P. tecta* was distributed in northern and peninsular India (Smith, 1931; Edds, 1998). The single greatest threat to *P. tecta* is commercial collection of the species for the pet trade. The species has been observed in food markets in south China (Lau & Shi, 2000).

3.3.2.8. Crowned river turtle (*Hardella thurjii*)

This large freshwater turtle is classified as Vulnerable (VU) in the IUCN Red List and is listed in Schedule IV of the IWPA (1972). The crowned river turtle has an omnivorous diet.

Historically the species was distributed in the Middle Ganga and the Brahmaputra River (Chaudhuri, 1912). In recent studies, this species was found in the middle and lower reaches of the northern river systems, comprising the Indus, Ganga and Brahmaputra and their tributaries (Das & Bhupathy, 2009b). This species occurs in slow-moving rivers (Daniel, 1970). This hardshell species is commonly sold in eastern Indian markets because its body is large. Some studies indicate that hatchlings of the species are exported as pet (Rashid & Khan, 2000). The other threats to the species include pollution and conversion of wetlands.

3.3.2.9. Indian black turtle (*Melanochelys trijuga*)

This medium-sized turtle is listed as Near Threatened (NT) in the IUCN Red List and in Schedule IV of the IWPA (1972). The species is omnivorous.

M. trijuga is a relatively common species. It is the most widespread of Indian terrapins. Historically, the species was distributed in the hill ranges of the Western Ghats and south Gujarat (Daniel & Shull, 1964). The species has also been recorded from Uttarakhand, in the northern part of India, and Meghalaya, in northeastern India (Das, 1991). The species is exploited commercially for food in northeastern India (Das, 1991; Pawar & Choudhury, 2000), West Bengal and Kerala (Das & Bhupathy, 2009a).

3.3.2.10. Indian softshell turtle (*Nilssonia gangetica*)

The Indian softshell turtle inhabits deep rivers, streams, large canals, lakes and ponds with a bed of mud or sand and prefers areas with turbid waters (Ernst et al., 1997). This peculiar-looking freshwater reptile is listed as Vulnerable in the IUCN Red List and in Schedule I (Part II) of the IWPA (1972). It feeds mostly on fish, amphibians, carrion and other animal matter, but it also feeds on aquatic plants.

The species inhabits multiple river systems, including the Ganga, Indus and the Mahanadi systems. Historically, the Indian softshell turtle was distributed in the Ganga River and its tributaries. It was also recorded from Pakistan, Bangladesh and southern Nepal (Figure 3.29) (Annandale, 1912; Gunther, 1864). Annandale (1912) reported the species from different

places in the Gangetic Delta, especially from Khulna and markets of West Bengal. Das et al. (2010) reported nests of *N. gangetica* from the Chambal River.

The main threats to the Indian soft-shelled turtle is the trade in this species in East Asia for its meat and fishing as this river-dwelling turtle becomes trapped in fishermen's nets. Pollution is also a significant problem in the rivers inhabited by these turtles. Extensive studies are needed to assess the population trend of this species in the Ganga River and its basin. During the rapid biodiversity assessment, the species was abundant all along the main stem of the Ganga River.

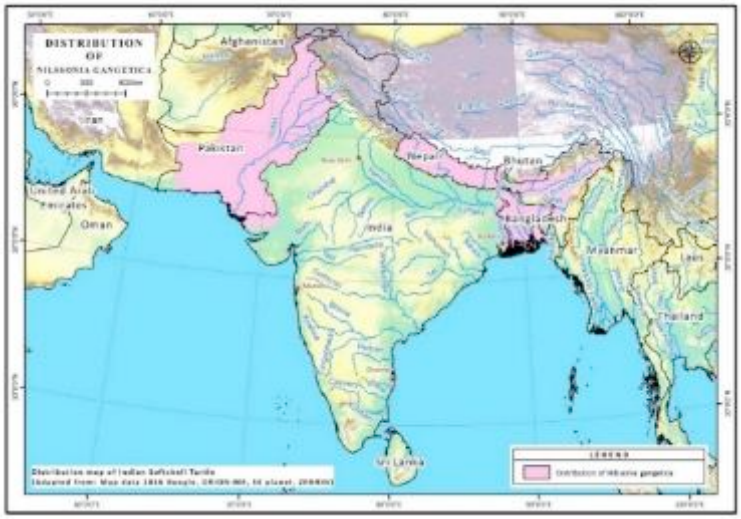

Figure 3.29. Distribution of Indian softshell turtle (*Nilssonia gangetica*)

3.3.2.11. Indian peacock softshell turtle (*Nilssonia hurum*)

The Indian peacock softshell turtle is similar to the Indian softshell turtle, but it is smaller in size. The species is listed as Vulnerable in the IUCN Red List and in Schedule I (Part II) of the IWPA (1972). The Indian peacock softshell turtle (*Nilssonia hurum*) is a relatively abundant, large riverine species and widespread in the northern and central parts of India, Pakistan, Bangladesh and Nepal.

Annandale (1912) reported the species from the lower reaches of the Ganga River. Later, Smith (1931) and Moll and Vijaya (1986) reported the species from the Ganga River as well as from its tributaries. Das (1988) reported the species from Bhopal and Madhya Pradesh. The species is widespread in the northern and central parts of the Indian subcontinent, but the

southern and eastern limits of its distribution remain unclear (Figure 3.30). Das et al. (2010) reported *N. hurum* nests from the Chambal River (these nests were less than 2% of *N. gangetica* nests) and reported the species from the Sarju, Kane and Rapti rivers and a few oxbow lakes in the area. Sinha et al. (2014) reported the species from Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh and West Bengal. *N. hurum* appears to be the most common large softshell turtle in the lower parts of the Ganga River system; however, information on the population sizes is still lacking (Das et al., 2010). The species is extensively hunted in all of northern and eastern India for its meat and calipee (Das et al., 2010).

Figure 3.30. Distribution of Indian peacock softshell turtle (*Nilssonia hurum*)

3.3.2.12. Indian narrow-headed softshell turtle (*Chitra indica*)

The Indian narrow-headed softshell turtle is an extremely large and aquatic species. The species is listed as Endangered in the IUCN Red List, and in Schedule II of the IWPA (1972). The Indian narrow-headed softshell turtle is widespread in South Asia, and its distribution in India includes the Indus, Ganga, Godavari, Coleroon and Mahanadi rivers (Das, 1991; Moll, 1986) (Figure 3.31). The distribution of the species is extensive but apparently localized and patchy. Gunther (1864) and Theobald (1876) reported the species from the Ganga River and its tributaries. Annandale (1912) reported that the species was common in the Gangetic Delta and that it was commercially exploited in West Bengal, where it was sold in local markets. Inglis et al. (1919) recorded *C. indica* in Jalpaiguri District, of West Bengal. Smith (1931) reported it from Fatehgarh, on the Ganga River. Iverson (1992) reported the species from Barrackpore, and Sharma (1998) reported it from Uttar Pradesh, Bihar and West Bengal. Hanfee (1999) and later Das and Singh (2009) found the species in the Ghagra and Chambal rivers. The species is now hunted intensively for its calipee. Moreover, the species is threatened by the modification of the riverine habitat (Das & Singh, 2009).

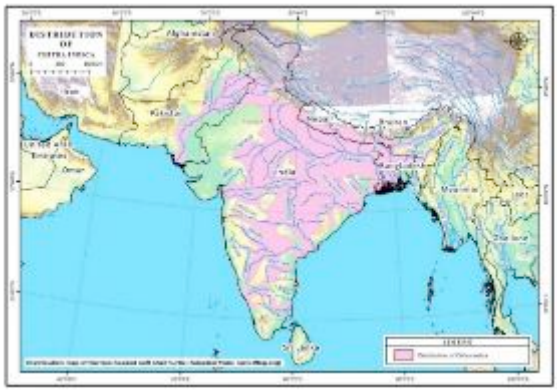

Figure 3.31. Distribution of Indian narrow-headed softshell turtle (*Chitra indica*)

3.3.2.13. Indian flapshell turtle (*Lissemys punctata*)

This relatively small softshell turtle is listed as Least Concern (LC) in the IUCN Red List and in Schedule I (Part II) of the IWPA (1972). The species is an opportunistic omnivore. Das (1995) noted a seasonal shift in the diet of this turtle in northern India. It is normally carnivorous.

Lissemys punctata is restricted to the Indian sub-region and has been found in the states of Assam, Bihar, Haryana, Jammu and Kashmir, Madhya Pradesh, Meghalaya, Rajasthan, Sikkim, Uttar Pradesh and West Bengal. It is also found in the southern part of peninsular India, in the states of Kerala and Tamil Nadu. *L. punctata* and its eggs are rather heavily exploited for food, and it is one of the species observed most frequently in markets (Whitaker, 1997).

During the rapid biodiversity assessment, a total of 2788 turtles were sighted. These were most frequently encountered between Makdumpur and Kanpur Barrage (Figure 3.32). Of these, 2693 were hardshell turtles, with *Pangshura* sp. being the most abundant, followed by *Batagur dhongoka* and a few individuals of *Geoclemys hamiltonii, Hardella thurjii*. Between the two species of softshell turtles sighted, *viz*., *Nilssonia gangetica* and *Lissemys punctata,* sightings of *N. gangetica* was more frequent.

Highest numbers of individuals were encountered between Farukhabad and Kanpur, where few individuals of *G. hamiltonii, H. thurjii* and *B. dhongoka* were recorded. This was followed by the stretch from Makdumpur to Narora, where *Pangshura* spp. was most abundant, and a few individuals of *B. dhongoka* and *N. gangetica* were also encountered. The

least number of individuals were recorded between Kachla and Farukhabad, where *Pangshura* spp. was the most abundant, followed by *L. punctata, N. gangetica, G. hamiltonii* and *B. dhongoka*. Scattered populations of *Pangshura* spp. and *N. gangetica* were sighted near Manikpur, Allahabad and Baharampur.

The river stretch with the highest numbers of turtle sightings is dynamic, with shallow water and numerous sandy islands, which are preferred by turtles for basking. The riverbanks between Bijnor and Narora were less disturbed as human habitations were far from the banks. Hardshell turtle species such as *Pangshura* spp. and *Batagur* sp. were observed basking on the loamy shore, which is characterized by soil bolus with little vegetation. Individuals of these species were also observed basking on submerged logs and bushes. Individuals of softshell turtle such as *N. gangetica* were mostly observed basking along the sandy islands.

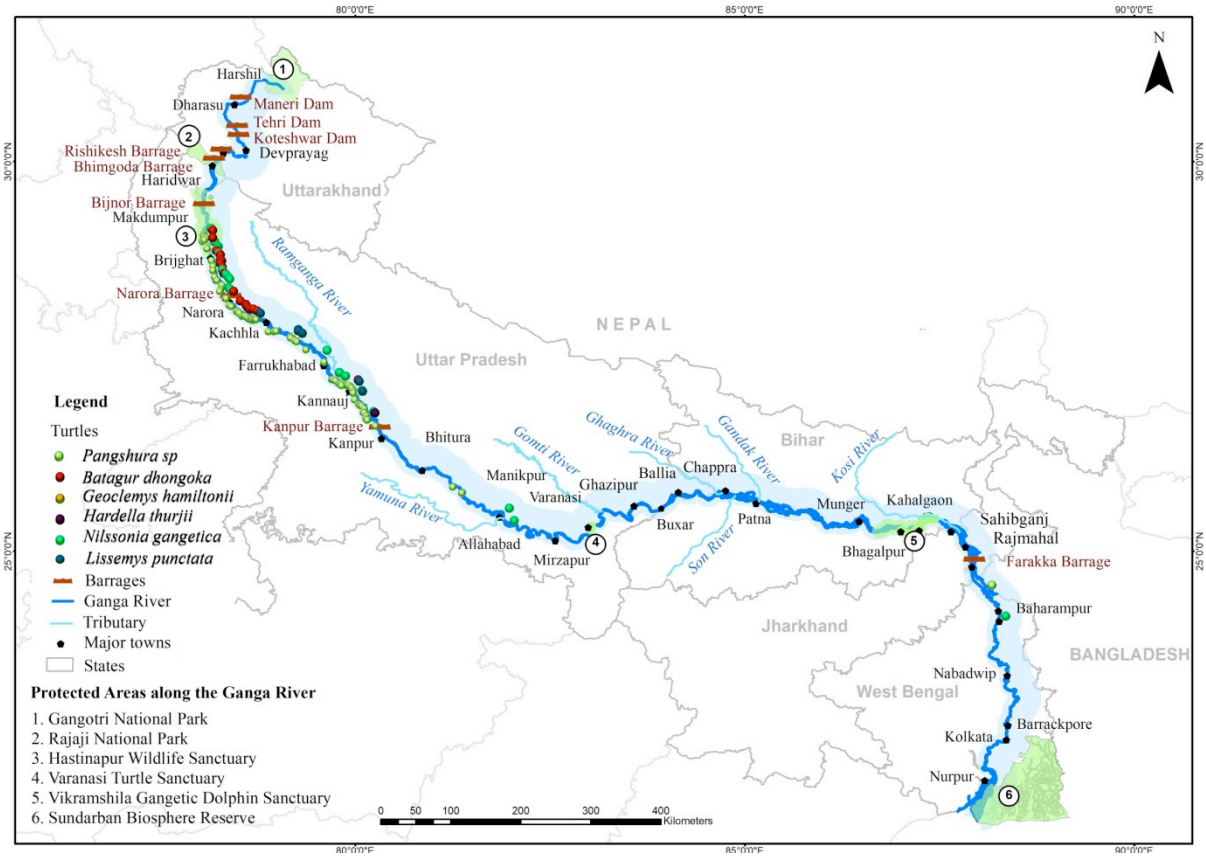

Figure 3.32. Distribution of turtles in the Ganga River on the basis of rapid biodiversity assessment

The population trends of these turtle species in the Ganga River cannot be inferred from a literature review due to a lack of information. Habitat destruction and poaching are the major

threats to the survival of these species. Species such as *Batagur baska* have been extirpated from the lower stretches due to poaching and overexploitation. Sightings of recruitment class (hatchlings and juveniles) between Bijnor and Narora indicates a recovering population.

3.4. Amphibians

Amphibians play a pivotal role in both aquatic and terrestrial ecosystems as secondary consumers in several food chains. From the ecological perspective, amphibians are regarded as good ecological indicators. Their responses have been used to indicate habitat fragmentation, ecosystem stress, impacts of pesticides, etc. Adult amphibians are one of the best biological pest controllers.

Amphibian populations are currently undergoing a rapid decline due to habitat loss, overutilization and fungal diseases. Amphibians are semi-aquatic vertebrates, and their life cycle is primarily dependent on freshwater resources. The eggs are laid in water or other moist habitats, and the larvae grow in water bodies, where they metamorphose into the adults. The characteristic feature of this group is the presence of semi-permeable skin, used for cutaneous gas exchange. This feature and the dependence of these animals on freshwater ecosystems make them acutely sensitive and susceptible to slight changes in temperature, humidity and air or water quality, thereby making them highly vulnerable to climate change.

The Ganga River nurtures about 90 species of amphibian in its basin, from as high as 3000 m asl through the plains to the delta. The endemic amphibian *Amolops chakrataensis* (Chakrata stream frog) is known only from the hill streams of the type locality, Chakrata, in Uttarakhand. Other frogs such as the Indian bullfrog (*Haplobatrachus tigrinus*), Himalayan torrent frog (*Nanorana vicina*) and Nepal paa frog (*Nanorana micina*) are reported from various stretches of the river. According to Bilgrami (1991), the genus *Rana* is distributed widely across the Ganga River. Bilgrami (1991) recorded *R. limnocharis, R. tigrina and R. cynophlyctes* from the middle and lower stretches of the Ganga River. Amphibians are the least studied group, and hence information pertaining to them is either unavailable or scanty. Annexure V provides a comprehensive list of probable amphibian species of the Ganga River. On the basis of the available literature, descriptions of a few species are provided in the following pages. The literature pertaining to amphibians is limited. Therefore, extensive studies are needed to assess the population trends of these species in the Ganga River and its

basin. The presence and distribution of these species along the Ganga River can only be defined after an extensive survey, which is currently being undertaken.

3.4.1. Himalaya paa frog (*Nanorana vicina*)

The species is a medium-sized frog (58 mm). Its body colour is olive or brown and, it is listed as Least Concern in the IUCN Red List. It is mainly reported from the upper stretches of the Ganga River, from elevations of 2000–3000 m asl.

The Himalayan paa frog is associated with high-altitude streams, springs, fountains and other running water within open forests and grassland habitats. The threats faced by this species are currently not known, but habitat destruction is presumed to be one of them.

3.4.2. Annandale's paa frog (*Nanorana annandalii*)

The species is listed as Near Threatened in the IUCN Red List. It is a medium-sized species (55 mm). It is olive coloured, with marbling and a white-coloured belly. It is distributed in the upper stretches of the Ganga River between 1500 and 2000 m asl. This frog is found in rocky streams and brooks in montane forests and in pools in forest clearings. Stream modification due to boulder collection and dams are major threats.

3.4.3. Nepal paa frog (*Nanorana minica*)

Listed as Vulnerable in the IUCN Red List, the species has a relatively small-sized body (28—41 mm). It is brownish in colour, with black spots and small warts at the back of the body. The distribution of the species is highly fragmented. This frog is found only in montane sub-tropical forests and streams. The species is restricted to western Nepal, and northern India. In the Ganga River, it is reported from the upper stretch, from 1000 to 2400 m asl. Habitat loss through dam construction and pollution are the major threats to the species.

3.4.4. Cascade frog (*Amolops formosus*)

The cascade frogs is a large-sized frog (75 mm). It is listed as Least Concern in the IUCN Red List. The body is green in colour, with dark brown or black spots. The species occurs in the upper stretch of the Ganga River between 1000 and 2500 mm asl.

Cascade frogs are obligate stream dwelling species. They are associated with streams and riparian vegetation and breed along fast-flowing waters. Their tadpoles have ventral suckers,

using which they attach themselves to rocks in fast-flowing streams. Changes in river hydrology caused by dams and deforestation are major threats.

3.4.5. Marbled toad (*Duttaphrynus stomaticus*)

This species is moderately large bodied (76 mm). It is light brown in colour, with numerous warts and marbling. A large parotid gland is present behind the eye. The marbled toad is found in open plains, grasslands, scrubland, forests, agricultural land and human habitations. It breeds in both permanent and seasonal pools, seasonal streams and slow-flowing streams. It is listed as Least Concern in the IUCN Red List. It is distributed in the upper and middle stretches of the Ganga River. Threats to the species include habitat loss and water pollution due to pesticide and herbicide use in agricultural lands.

3.4.6. Tytler's pond frog (*Hylarana tytleri*)

This is a lowland species found up to 300 m asl in the middle stretch of the Ganga River, in pools, lakes and marshes. The species generally breeds in stagnant water bodies. It is listed as Least Concern in the IUCN Red List. However, the species is threatened by water pollution due to the use of agrochemicals.

3.4.7. Indian bullfrog (*Hoplobatrachus tigerinus*)

The Indian bullfrog is a large-sized frog (134 mm). It is greenish, olive or brown in colour, with a mid-dorsal yellow line. It is a common frog with a wide distribution along the Ganga River and is listed as Least Concern in the IUCN Red List and in Schedule IV of the IWPA (1972).

This frog is found in freshwater wetlands, especially in paddy fields and ponds. It breeds during the monsoon and feeds on invertebrates, small mammals and birds. The species is reported from the middle and lower stretches of the Ganga River. The major threats to the species include loss of wetland habitats, water pollution due to agrochemical use, road mortality and consumption as food.

3.4.8. Jerdon's bullfrog (*Hoplobatrachus crassus*)

This is a large-sized frog (121 mm). Its dorsal body is brown with dark spots. Irregular glandular folds are present on the dorsal side. Jerdon's bullfrog is found in seasonally flooded

grasslands, open plains and cultivated areas and around human settlements. It is listed as Least Concern in the IUCN Red List and in Schedule IV of the IWPA (1972).

The species breeds in various types of water body, but it prefers large rivers. It has been reported from the upper, middle and lower stretches of the Ganga River. Habitat loss and collection for food are major threats.

3.4.9. Dudhwa tree frog (*Chiromantis dudhwaensis*)

The Dudhwa tree frog is a small-sized tree frog. It is brownish yellow in colour. The species is currently known only from the type locality, in Dudhwa National Park, in Uttar Pradesh, India, where it was observed and collected below 100 m asl. However, it is believed that the species occurs more widely. The arboreal species is mostly associated with scrub forests, grasslands and rural areas. The species is Data Deficient in the IUCN Red List. Although there are currently no known threats, this frog may be vulnerable to habitat loss and climatic shifts.

The population trends as well as distribution of these amphibian species cannot be inferred from the literature as information pertaining to amphibians is lacking. Detailed studies are required to identify these trends and their vulnerability to environmental and anthropogenic changes.

3.5. Fish

The unique hydrology and geo-climatic conditions of the upper, middle and lower stretches of the Ganga River support a distinctive fish fauna. Though most of the fishes presently found in the Ganga River belong to the class Actinopterygii, there are historical records of fishes of the class Elasmobranchii. Two species of stingray were found in the Ganga River up to Kanpur by Hamilton during his “Statistical and Economic Survey”, conducted between 1807 and 1814 (Chaudhuri, 1911). Later, Day (1878) and Chaudhuri (1911) also recorded these stingray species from the Ganga River specifically at Bhagalpur. Another elasmobranch, the Gangetic shark (*Glyphis gangeticus*), was reported by Muller and Henle (1839) and later by Bal and Rao (1984) in the Ganga River beyond the tidal range (ZSI, 1992). The present status of these species of the class Elasmobranchii is mostly unknown.

The earliest documented records of fish species from the Ganga River go back to 1822 , when Hamilton recorded 272 freshwater fish species (Hamilton, 1822). Later, Bilgrami (1991) reported 97 freshwater fish species along three stretches of the Ganga River, *viz.* Kalankar to Phaphamau, Buxar to Barh and Munger to Farakka. Talwar (1991) carried out a comprehensive study of the entire Ganga River and recorded a total of 375 species, including both freshwater and brackish water species. Later, Payne et al. (2004) reported 161 species from the river. Sarkar et al. (2012) reported 143 species of fish belonging to 32 families. A recent report by the Central Inland Fisheries Research Institute (ICAR-CIFRI, 2017) lists a total of 158 fish species from Tehri (Uttarakhand) to Fraserganj (West Bengal) in the mainstem of the Ganga River (Figure 3.33). Large discrepancies are seen in the number of fish species reported from the Ganga River, in various survey reports, most of which can be accounted for by the variations in sampling stretches and seasons. The report produced by CIFRI (2017) is the most comprehensive one relating to the fish species diversity of the entire mainstem of the Ganga River. Compliation of the literature on the fishes revealed that a total 240 fish species representing 60 families are found in the Ganga River (Annxure VI).

The most common fishes reported by Bilgrami (1991) in the upper stretch of the Ganga River are represented by *Schizothorax* spp., *Tor* spp., *Wallago attu* and *Notopterus* sp. In the middle stretch, the most common species included the Indian major carps, *Bagarius* sp., *Mystus* sp., *Hilsa* sp. and *Wallago attu*. Bilgrami (1991) expressed concern that the dominance of carnivorous species in the lower stretch of the river from Berhampur to Katwa could adversely affect the natural food chain. Sarkar et al. (2012) reported 10 exotic fish species, *viz. Pterygoplichthys anisitsi, Oncorhynchus mykiss, Oreochromis mossambicus, O. niloticus niloticus, Hypophthalmichthys molitrix, H. nobilis, Ctenopharyngodon idella, Cyprinus carpio, C. carpio* (var. *specularis*), and *Clariasgariepinus*. CIFRI (2017) also reported these exotic species, with an additional exotic *Salmotrutta fario* from the Ganga River.

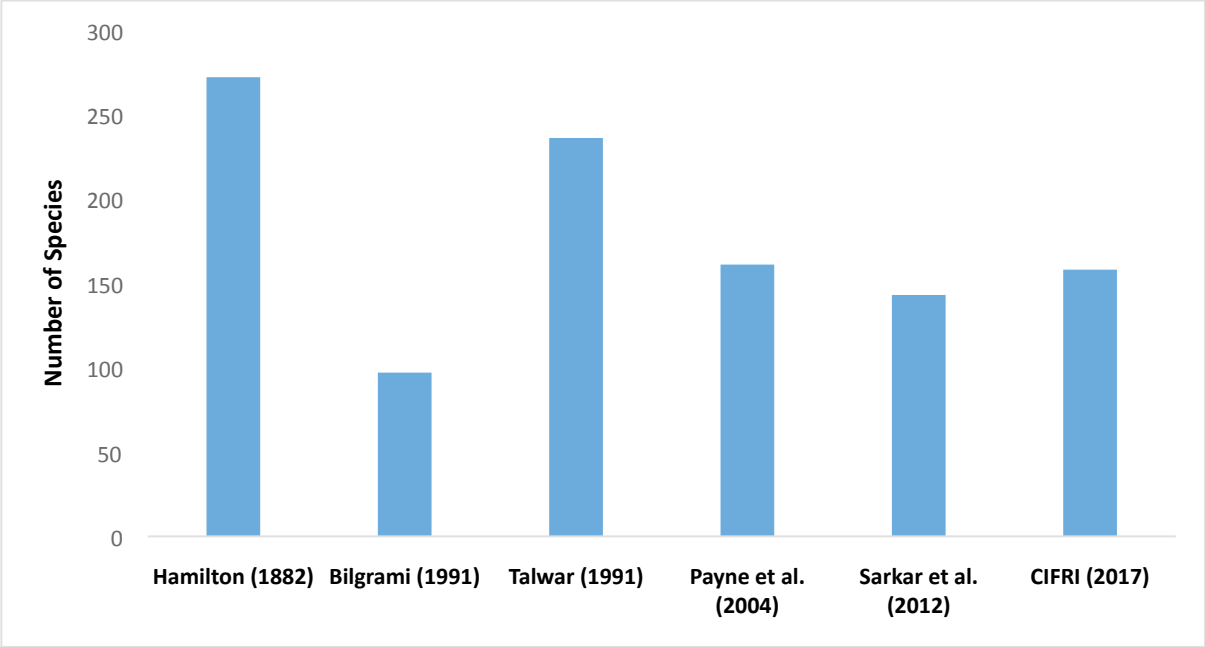

Figure 3.33. Fish species diversity in the Ganga River

3.5.1. Golden mahaseer (*Tor putitora*)

Found in streams and rivers of montane and sub-montane regions, *Tor putitora* is a major *Tor* species of the mid-hill stretches of the Himalayan region. The species is listed as Endangered in the IUCN Red List and has a declining population trend. It inhabits rapid streams with rocky bottoms, riverine wetlands and lakes. Threats to the species include overfishing, the use of modern fishing techniques and alterations of habitats. The species was once abundant in Uttarakhand (Stevens, 1905) and was also reported from the Song–Ganga confluence (Dhu, 1923) and from the Sharda and its tributaries (Macdonald, 1935). The species has also been reported from South Asia and Southeast Asia (Jha & Rayamajhi, 2010). In India, it is restricted to the upper stretches of the Ganga River (Figure 3.34). During the rapid biodiversity assessment, *T. putitora* was recorded from the upper stretch of the Ganga River.

Figure 3.34. Distribution of Golden mahaseer (*Tor putitora*)

3.5.2. Bronze featherback (*Notopterus notopterus*)

The species is found in clear streams and brackish waters. The adults are found in standing and sluggish waters of lakes, floodplains, canals and ponds (Froese & Pauly, 2017). The bronze featherback was described by Pallas (1769) as *Gymnotus notopterus* and as occurring in Indian rivers and estuaries. The species is distributed widely in Southeast Asia, Bangladesh, Cambodia, India, Laos, Burma, Nepal and Pakistan. Its status is not clear because its taxonomy is in an undetermined state at present. It has been suggested that there is a species complex (Ng, 2010). Population trend of the bronze featherback in the wild is currently unknown and it is listed as Least Concern in the IUCN Red List.

In India, this fish is widely distributed in the Indus and Ganga–Brahmaputra basins as well as in the Mahanadi, Krishna, Cauvery and other river basins in peninsular India (Talwar & Jhingran, 1991). The species was reported from the Mahanadi River near the Hirakud Dam (Jayaram & Majumdar, 1976). Specimens of the species were collected from the Gomti River near Daliganj and from Khadra, at Lucknow (Srivastava et al., 2012). The fish has been categorized as an important commercial fish by FAO (Casavas et al., 1996) for its use as food as well as the ornamental trade in the species.

3.5.3. Freshwater shark (*Wallago attu*)

Wallago attu is widely distributed in the Ganga River and its tributaries. Declared as Near Threatened in the IUCN Red List, there is a declining trend of the species in its range. *W. attu* has been reported from India, Pakistan, Bangladesh, Srilanka, Thailand, Burma, Java, Sumatra, Borneo and Afghanistan (Giri et al., 2002; Talwar & Jhingran, 1991). In earlier records, CIFRI (1964) reported 49.5 t landing of *W. Attu* in eight landing sites near the Ganga River in 1963. Ray (1998) reported that the landings at Patna decreased from 3.89 t to 1.22 t during 1988–1989. A similar decreasing trend in the landings was noted at Bhagalpur, from 12.04 t in 1988 to 0.06 t in 2006 (Montana et al., 2011; Ray, 1998).

Apart from fish landing data, primary catch data are also required to assess the population trends of fishes in the river. In such a study, Dwivedi et al. (2016) reported that the total catch of the species was 4.78% of the total catch, from August 2012 to July 2013 at landing sites at

Kanpur, Allahabad and Varanasi. However, more such quantitative studies are needed to assess the population trend of this species in the Ganga River and its basin.

3.5.4. Minor carp (*Labeo bata*)

L. bata is a benthopelagic and potamodromous species, inhabiting ponds, rivers and rivulets (Bhuiyan, 1964). It is an herbivorous column feeder. It is distributed throughout the Indian subcontinent, including Bangladesh, India, Nepal, Myanmar and Pakistan (Talwar & Jhingran, 1991). With the population trend currently unknown, the species is listed as Least Concern in the IUCN Red List. It is a commercially exploited in the Ganga River and its tributaries (Dwivedi, 2013; Dwivedi et al., 2004, 2007; Tripathi et al., 2013). Size-selective harvesting of the species is a very common practice in riverine habitats (Dwivedi & Nautiyal, 2010; Fenberg & Roy, 2008).

The abundance of the major carps including *L. bata* was greater in the middle stretches of the Ganga River. These species accounted for 53% of the catch at Agra, 45% at Kanpur and 38% at Allahabad, but they were less abundant in the lower stretches (19–26%) at Patna (Jhingran, 1991; Payne et al., 2004). In landings near Patna, the major carps represented 26.5% of the total catch in 1958–1966, and by 1993–1994, the proportion reduced to 4.0% of the total catch (Montana et al., 2011). In a survey conducted during 2001–2007, the percentage of major carps (including *L. bata*) in the total annual catch varied between 9% and 15%, reflecting a small percentage compared with the historical catches from the region (Montana et al., 2011).

3.5.5. Spotted barb (*Puntius sophore*)

P. sophore is a small-sized cyprinid, highly adapted to confined environments (Collins et al., 2012). It is widely distributed throughout India, Pakistan, China and some parts of the Southeast Asian countries (Petr, 1999; Collins et al., 2012) and is listed as Least Concern in the IUCN Red List. Historically, the species was native to Bengal and common throughout the Gangetic provinces (Hamilton, 1822). It was reported from the Ramgamga River (Atkore, 2005; Atkore et al., 2011), the Paisuni River, a tributary of the Yamuna River (Dwivedi, 2009), the Betwa River (Lakra et al., 2010b) and the upper, middle and lower stretches of the Ganga River (Das et al., 2013), including Kanpur, Allahabad and Varanasi (Dwivedi et al., 2016). In India, populations of *P. sophore* are reported to be declining owing to overexploitation (Latif et al., 2017).

From the literature review, it can be inferred that the populations of species such as the golden mahaseer, bronze featherback and spotted barb are declining due to habitat degradation and overexploitation. An overall decline in fish landings is also evident throughout the stretch.

During the rapid biodiversity assessment, a total of 114 fish species, belonging to 60 families were recorded, including the abovementioned species in their respective stretches along the Ganga River (Annexure VI). Golden Mahseer, Mahseer and Snow trouts were only encountered in the upper stretch of the Ganga River. *W. attu* was frequently observed in the middle and lower stretches of the river. *Tenualosa ilisha* was encountered in the lower stretch downstream of Farakka barrage in the mainstem Ganga River and in the Feeder Canal.

3.6. River Stretches with High Biodiversity Value

Identification of areas with high biodiversity values that are relatively intact and prioritizing them for ecological restoration is based on the 'refuge approach' to restoration. This approach provides resilience and sources for future restored sites (Beechie et al., 2008). This approach also provides a measure against the likelihood of local extirpation of species. Thus, for ecological restoration of the Ganga River, areas with high biodiversity values were identified using information obtained from the rapid biodiversity assessment. Habitat-defining variables such as water depth were also determined along the entire length of the Ganga River.

Assessment of hydrology of the river revealed that channel depth was a major limiting factor for species distribution. The thematic diagram shows the depth profile of the Ganga River from Bijnor to Nurpur during summer months (Figure 3.35).

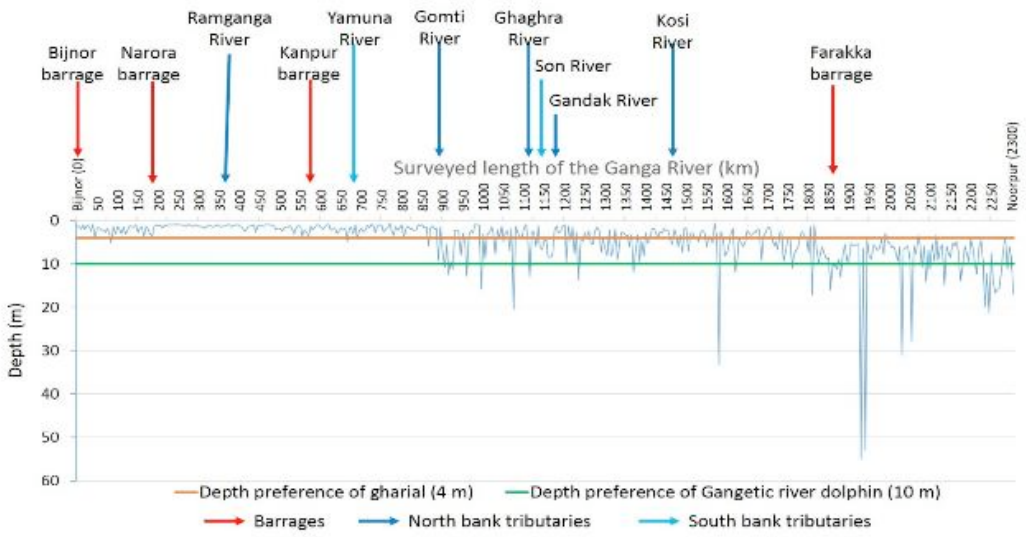

Figure 3.35. Depth profile of the Ganga River from Bijnor to Nurpur

According to the depth profile, depth categories were identified that answered to the preference of umbrella species, the Gangetic river dolphin and the gharial (Figure 3.35). These species showed a preference for depths ≥ 4 m, which were available in scattered pools in approximately 38.7% of the river stretch assessed (Figures 3.35 and 3.36). Shallow areas (depth <4 m) prevail throughout the stretch. These shallow areas act as a barrier to the lateral movement of these large-bodied aquatic animals.

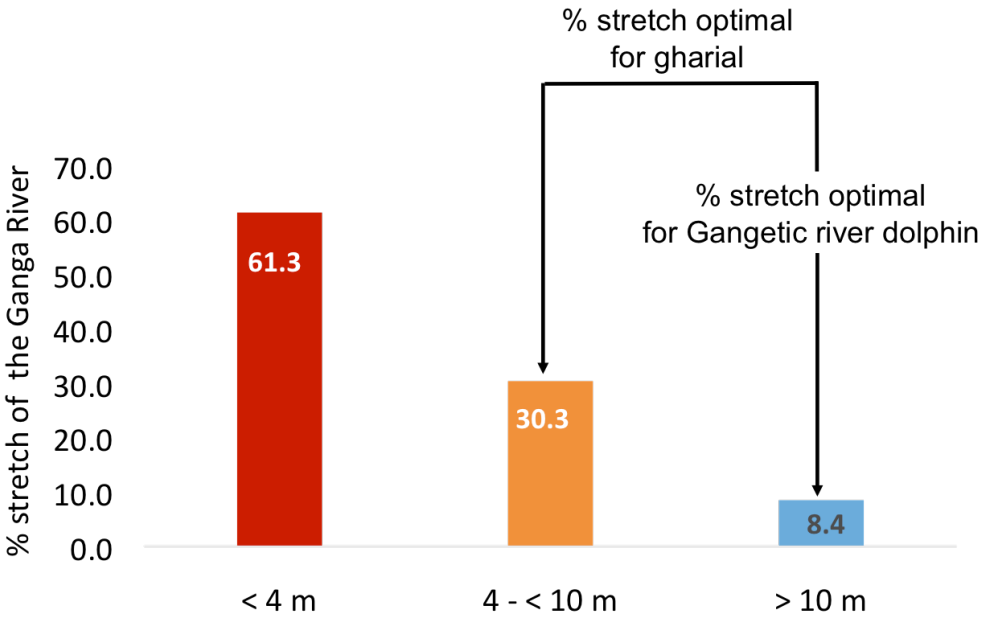

Figure 3.36. Depth class distribution of the Ganga River during summer and optimal accessible stretch for umbrella species

The distributions of priority species such as the Gangetic river dolphin, otters, island-nesting birds such as the Indian skimmer, the gharial and the mugger were overlaid in the GIS domain (Figure 3.37). These were integrated with habitat characteristics and the assemblage of benthic macroinvertebrates, periphyton and plankton along the Ganga River. Thus six stretches covering about 50% of the Ganga River's length that have a high biodiversity value were identified along the Ganga River (Figure 3.37).

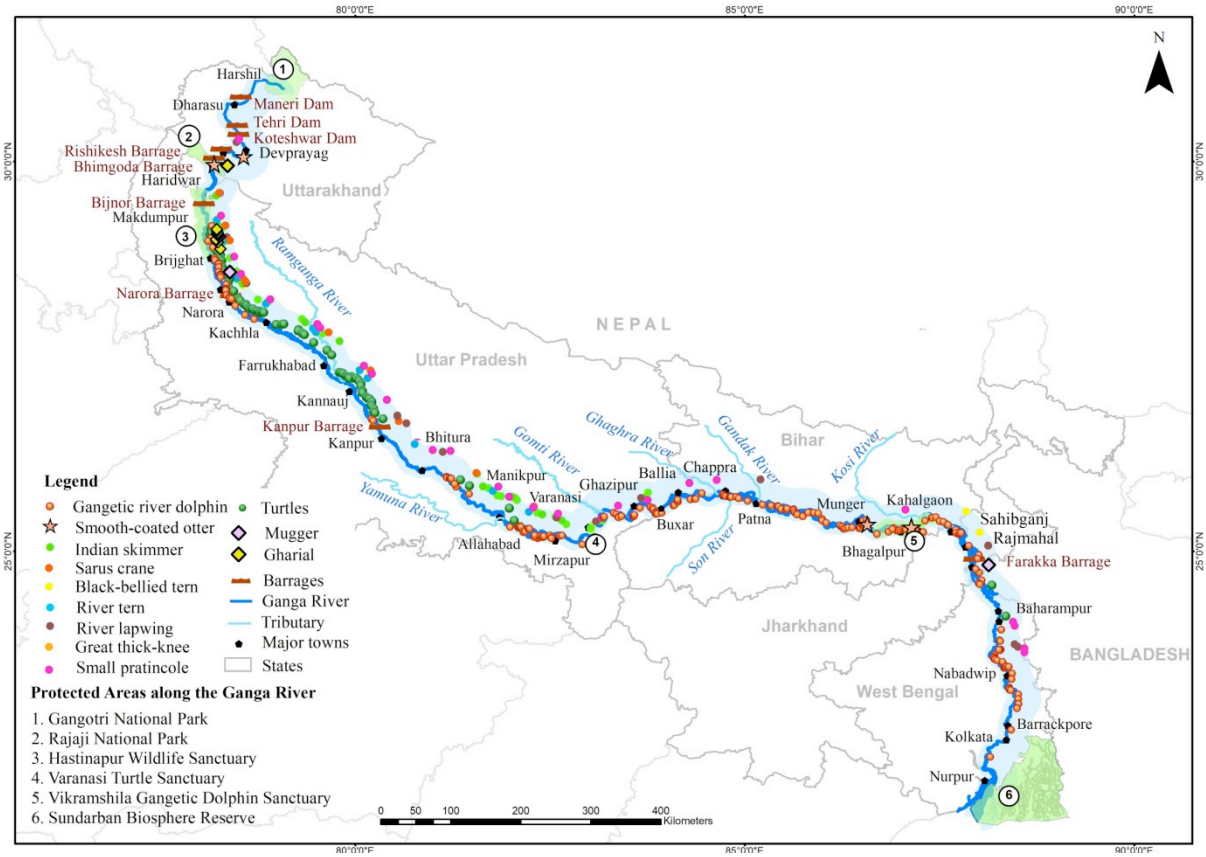

Figure 3.37. High biodiversity stretches and distribution of priority species along the Ganga River

Stretch I: Devprayag to Rishikesh, Uttarakhand

This stretch starts at Devprayag, the confluence of the Alaknanda and Bhagirathi rivers, and ends at Rishikesh, traversing along 61 km length of the Ganga River in the state of Uttarakhand. The zone is characterized by rapids with rocky bottoms, deep gorges and gentle slopes. The local communities in this region are dependent on the Ganga River for domestic water usage, their livelihoods from religious and adventure tourism and fishing.

Biodiversity value and ecological significance

I. This zone nurtures about 56 species of fish including the Endangered golden mahaseer and the Critically Endangered snow trout. Semi-aquatic mammals such as the smooth-coated and Eurasian otters have also been reported from this stretch. About 93 phytoplankton species, 76 periphyton species and 19 zoobenthic species that form important components of the food web have been recorded from this zone.
II. This stretch of the Ganga River, along with its tributaries such as the Nayar River, provides a breeding ground for thegolden mahaseer.
III. This stretch forms the headwaters for the lower stretches of the Ganga River.
IV. The presence of riffles and pools in this stretch provides habitat heterogeneity for the benthic flora and periphyton.

Stretch II: Makdumpur to Narora, Uttar Pradesh

This stretch is a 110 km length of the Ganga River from Makdumpur, in Jyotibha Phule Nagar District, to Narora, in Bulandshahar District, Uttar Pradesh. This stretch of the river is mostly meandering with extensive alluvium, sandbars and mid-river islands. The flow regime of this stretch is highly altered by the Bijnor Barrage upstream and the Narora Barrage, at the end of the stretch. During summer months the river depth ranged from 1.6 m to 5.2 m, with a mean value of 2.3 m. There are major human settlements in Garhmukteshwar, Anupshahar and Narora. The urban population and the local communities in this region are dependent on the Ganga River for daily ablutions, drinking water, agriculture and irrigation.

Biodiversity value and ecological significance

I. A total of 27 individuals of the Critically Endangered gharial and the mugger, 41 Gangetic river dolphins and >800 turtles, including 176 individuals of *Batagur* sp., 50 *Nilssonia gangetica* and 619 individuals of *Pangshura* sp., were encountered within this zone. More than 80 fish species and about 140 bird species were recorded within this zone. About 35 phytoplankton species and 31 zooplankton species have been recorded from this zone.
II. Within this stretch, that Ganga River flows through Hastinapur Wildlife Sanctuary for about 37 km and stretch from Brijghat to Narora, a wetland of international importance.
III. Presence of sandbars, mid-river islands, backwaters and floodplain wetlands provide habitat mosaics for different aquatic biota.

Stretch III: Bhitaura to Ghazipur, Uttar Pradesh

This stretch is a 450 km length of the Ganga River from Bhitaura, Fatehpur District, to Ghazipur, Ghazipur District, Uttar Pradesh. This stretch is highly braided and anastomosed and passes through an extensive alluvial plain. The flow regime of this stretch is altered by the Kanpur Barrage upstream, and hence the river depth reaches a value as low as 1.1 m. However, the Yamuna River, a major tributary, joins it near Allahabad, and the flow regime improves significantly, resulting in an increased river depth of up to 20.4 m. This stretch has an average depth of 3.7 m in summer months (range 1.1–20.4 m). There are dense human settlements at Fatehpur, Mirzapur, Mughalsarai, Allahabad and Varanasi. The urban population and rural communities in this region are dependent on the Ganga River for their daily ablutions, municipal and industrial water extraction, religious tourism, fishing and irrigation.

Biodiversity value and ecological significance

I. A total of 269 Gangetic river dolphins, 193 Indian skimmers and individuals of *Batagur* sp. and *Nilssonia gangetica* were encountered in this zone. A total of 50 fish species were encountered. The zone is also known to harbour about 357 phytoplankton species, 42 zooplankton species, 19 periphtyon species and 45 zoobenthic species.
II. The zone includes Kachhua Sanctuary, a 7 km stretch of the Ganga Riverfrom Rajghat to Ramnagar, in Varanasi.
III. Sandbars, meander belts and ox-bow lakes provide a mosaic of habitats for different aquatic biota.

Stretch IV: Chhapra to Kahalgaon, Bihar

The stretch isa 296 km length of the Ganga River from Chhapra, Saran District, to Kahalgaon, Bhagalpur District, in the state of Bihar. The river in this stretch is very wide, highly braided and meandering and passes through an extensive alluvial plain. The flow regime of this stretch is enhanced by substantial inflows from the Ghaghra and Son rivers near Chhapra and from the Gandak River at Patna. During summer months the depth ranged from 1.6 m to 33.2 m, with a mean value of 4.7 m. There are major human settlements at Chhapra, Patna, Munger and Bhagalpur. The urban population and rural communities in this

region are dependent on the Ganga River for their daily ablutions, drinking water, irrigation, fishing, municipal and industrial water, sand mining and daily communte.

Biodiversity value and ecological significance

I. A total of 141 Gangetic river dolphins and two smooth-coated otters were encountered within the zone. About 61 fish species and more than 80 phytoplankton and zooplankton species have been recorded from this stretch.
II. About 50 km of this stretch passes through Vikramshila Gangetic Dolphin Sanctuary, from Sultanganj to Kahalgaon.
III. Large, stable islands, meanders and ox-bow lakes provides a mosaic of habitats for the aquatic fauna.

Stretch V: Sahibganj to Rajmahal, Jharkhand

The stretch is a 34 km of the Ganga River, from Sahibganj to Rajmahal, Sahibganj District, in the state of Jharkhand. The river here is very wide, highly braided and anastomosing, with multichannel formation on an alluvial plain. Channel splitting takes place and convex sandbars are formed due to the low-energy channel flow and poor lateral stability. The flow regime of this zone is enhanced by substantial inflows from the Kosi River near Katihar District, Bihar. During summer months the depth ranged from 1.5 m to 17.0 m, with a mean value of 5.8 m. There are major human settlements at Sahibganj and Rajmahal. The urban population and rural communities in this region are dependent on the Ganga River for their daily ablutions, religious activities and drinking water and for fishing and irrigation.

Biodiversity value and ecological significance

I. Seven Gangetic river dolphins and one smooth-coated otter, were encountered in this stretch. About 89 species of fish, 182 phytoplankton species and 40 zooplankton species have been recorded from this stretch.
II. The habitat mosaic of this stretch includes deep pools, sandbars and mid-river islands, which are potential habitats for freshwater turtles, island-nesting birds and dolphins.

Stretch VI: Baharampur to Barrackpore (246 km), West Bengal

Approximately 246 km length of the Ganga River, from Baharampur, Murshidabad District, to Barrackpore, North 24-Parganas District, West Bengal, is identified as the sixth high biodiversity stretch. The river is highly meandering, with convex sandbars and a few mid-

river islands. The flow regime of this zone is enhanced by the feeder canal originating from Farakka Barrage and meeting the main channel, Hooghly, at Ahiran, Murshidabad District. The Ganga River receives substantial inflows from the Mayurakshi and Ajay rivers at Bardhaman District. During summer months, the depth of the river ranged from 2.9 m to 31.0 m, with a mean value of 8.1 m. There are major human settlements at Baharampur, Katwa, Kalyani and Barrackpore. The urban population and rural communities in this region are dependent on the Ganga River for their daily ablutions, religious activities and drinking water and for industrial water and irrigation.

Biodiversity value and ecological significance

I. A total of 49 Gangetic river dolphins were encountered along this stretch. A total of 25 fish species, 44 phytoplankton species and 21 zooplankton species have been recorded from this zone.
II. Meanders with convex sandbars and mid-river islands provide a mosaic of habitats for the aquatic fauna.

4. THREATS TO THE GANGA RIVER

The Ganga River, along with the Brahmaputra River, forms one of the largest and most diverse river systems of the world, spanning 10 biomes (Nilsson et al., 2005). The varied geomorphological features along the Ganga River, coupled with climatic variations, results in a continuous gradient of habitats for various life forms, right from the headwaters to the mouth.

This continuous yet varied gradient of habitats and life forms, results in differential availability of resources, which has been critical in shaping the local economy along the river. The Ganga River basin also hosts a dense population of diverse stakeholders having varied resource uses and linked culturally, religiously, socially and economically to the river. The differential resource use by different stakeholders has resulted in varied impacts and threats along the length of the Ganga River. Therefore, for successful ecological restoration of the river, identification of site-specific threats and ways of minimizing or eliminating them is a prerequisite (Pressey et al., 2007; Palmer et al., 2010). Given this, the following sections describe the threats specific to the upper, middle and lower stretches of the Ganga River.

4.1. Threats to the upper stretch of the Ganga River

Located amidst the Himalayan mountain range, this stretch of the river is highly sensitive and ecologically fragile. The stretch is high in biodiversity value-hosting habitats for endangered species such as otters, the snow trout and the golden mahaseer. The human population density is low (190 persons/km^2) compared with the middle and lower stretches. The following are the specific threats faced by this sstretch:

- Significant structural changes have occurred in this stretch due to 16 hydroelectric projects in the Bhagirathi and Alaknanda basins. The physical habitat of the river is further threatened by 14 projects under construction and 39 proposed projects in the Bhagirathi and Alaknanda basins.
- 70.7% of the Bhagirathi River and 48.0% of the Alaknanda River are affected by inundation and diversion, which have disrupted the longitudinal connectivity and water flow. As a result, 28.6% and 35.2% of the Bhagirathi and Alaknanda river channels have turned into ecological deserts (AHEC, 2011). A decline in the population of the golden mahaseer population due to the Tehri Dam acting as a migration barrier has been noted upstream of the Bhagirathi River (Sharma, 2003).

- The flow regime in the headwaters is vulnerable to the retreat of the Gangotri glacier (Singh et al., 2017). The glacial melt is expected to increase summer flows for some years until the disappearance of the glacier, which would be followed by a reduction in the flow (Mall et al., 2006).
- The altered flows due to structural and climatic changes cause disruptions in the life history strategies of many in-stream organisms and affect the food web (Nautiyal, 2010).
- The climate and hydrological changes have transformed the thermal gradient in this stretch of the river, leading to a shrunken distribution range of cold water fish species such as *Schizothorax* sp. and upstream range extensions of several fish species such as *Cyprinus carpio* (Sarkar et al., 2012).

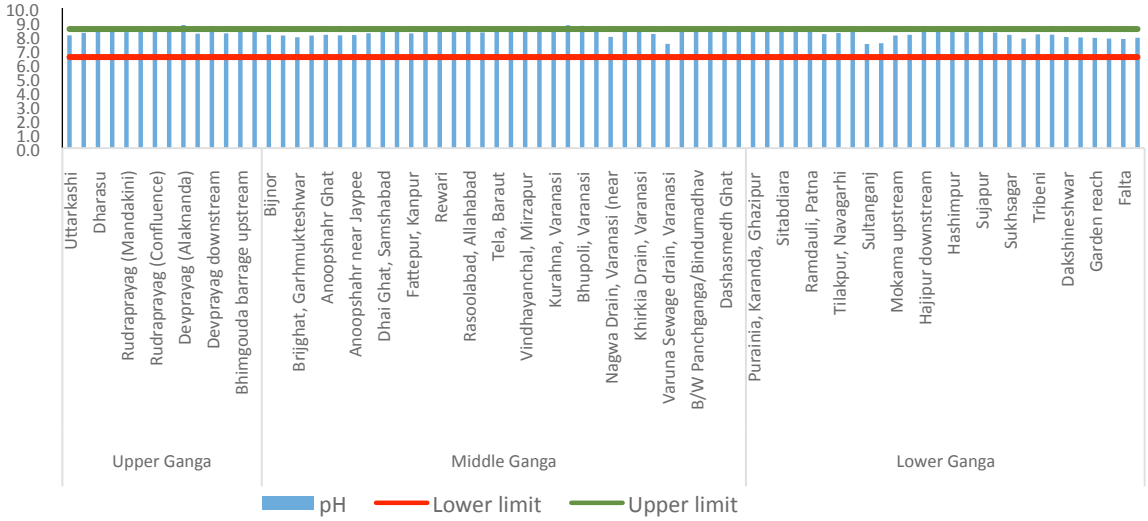

Figure 4.1. pH level in the upper, middle and lower stretches of the Ganga River

- Analysis of the water quality of the upper stretch of the Ganga River as assessed by CPCB at 10 locations between 2003 and 2014 reveals that the pH ranged from 6.6 to 8.5. Over the study years, the DO showed an overall decreasing trend, from 9.2 mg/L to 8.0 mg/L, and the BOD showed an increasing trend, from 1.3 mg/L to 1.9 mg/L. The BOD increased above the permissible limit (≤ 3 mg/L) near Satyanarayan Temple, downstream of Raiwala and Haridwar, and the DO dropped below the critical point (5.4 mg/L) at Haridwar. During the present study the pH was found to be in the alkaline range (8.05–8.79) between Uttarkashi and the Bhimgoda Barrage (Figure 4.1). The average DO concentration was 9.3 ± 0.3 mg/L (Figure 4.2), and the nitrate concentration was 2.2 ± 0.2 mg/L (Figure 4.3). Two active drains were observed downstream of Rishikesh Barrage and Haridwar (Figure 4.4; Table 4.1).

Critical locations

In this stretch, the nitrate concentration was highest (3.7 mg/L) for Haridwar, downstream of Bhimgoda Barrage (Figure 4.4). It is evident that the organic pollutant load is higher at Haridwar, which could deplete the DO beyond the critical level (≥5 mg/L) and affect the aquatic biota.

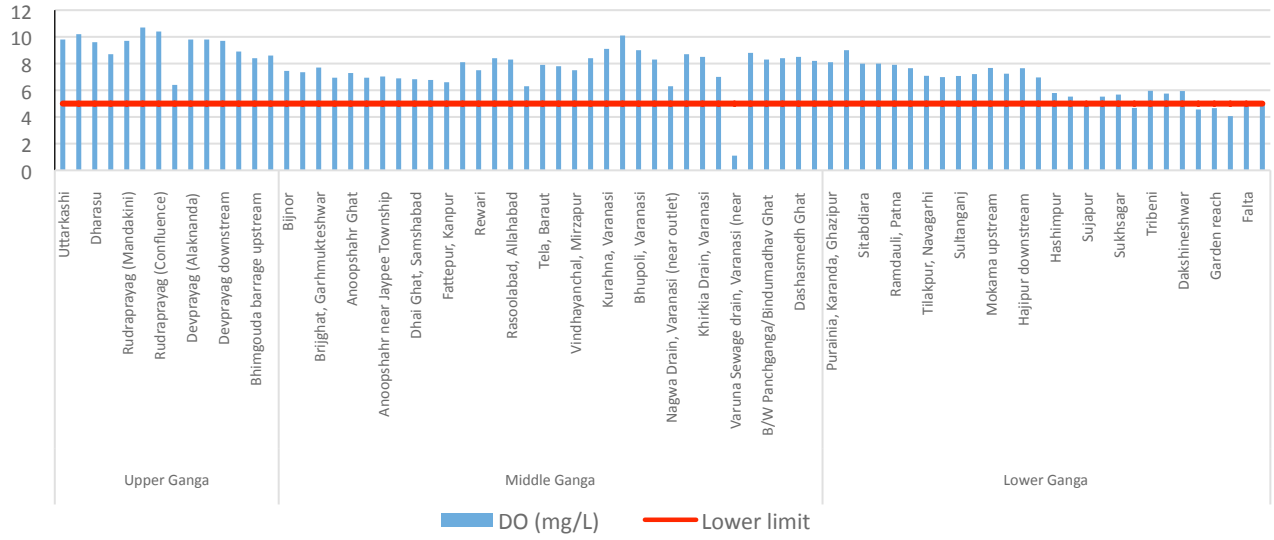

Figure 4.2. DO (mg/L) in the upper, middle and lower stretches of the Ganga River

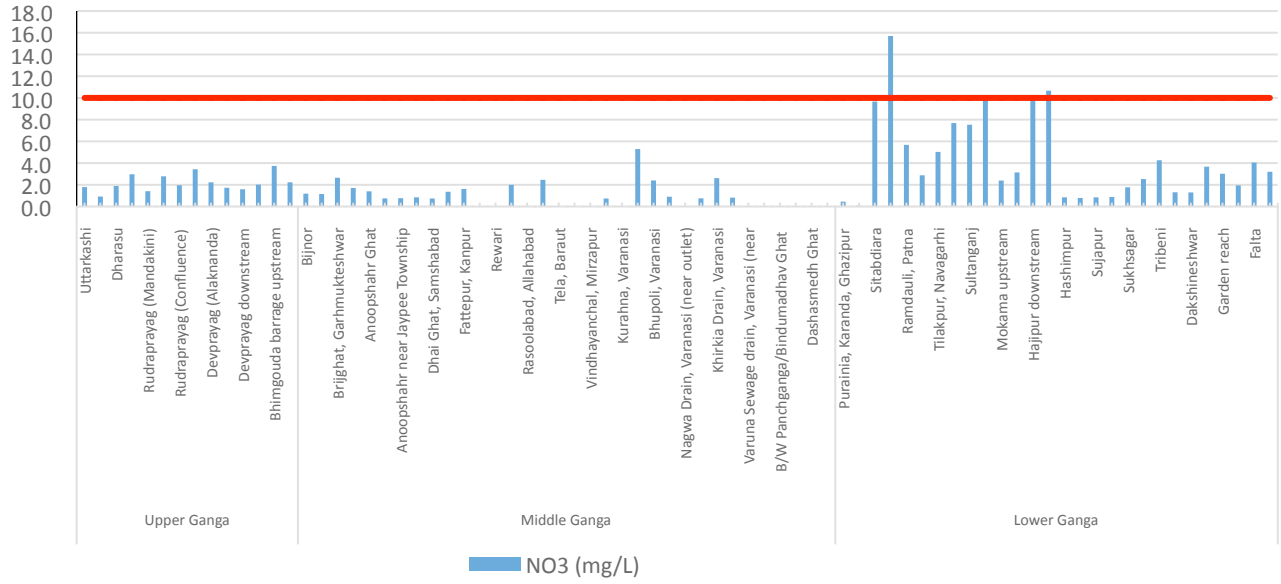

Figure 4.3. Nitrate concentration in the upper, middle and lower stretches of the Ganga River

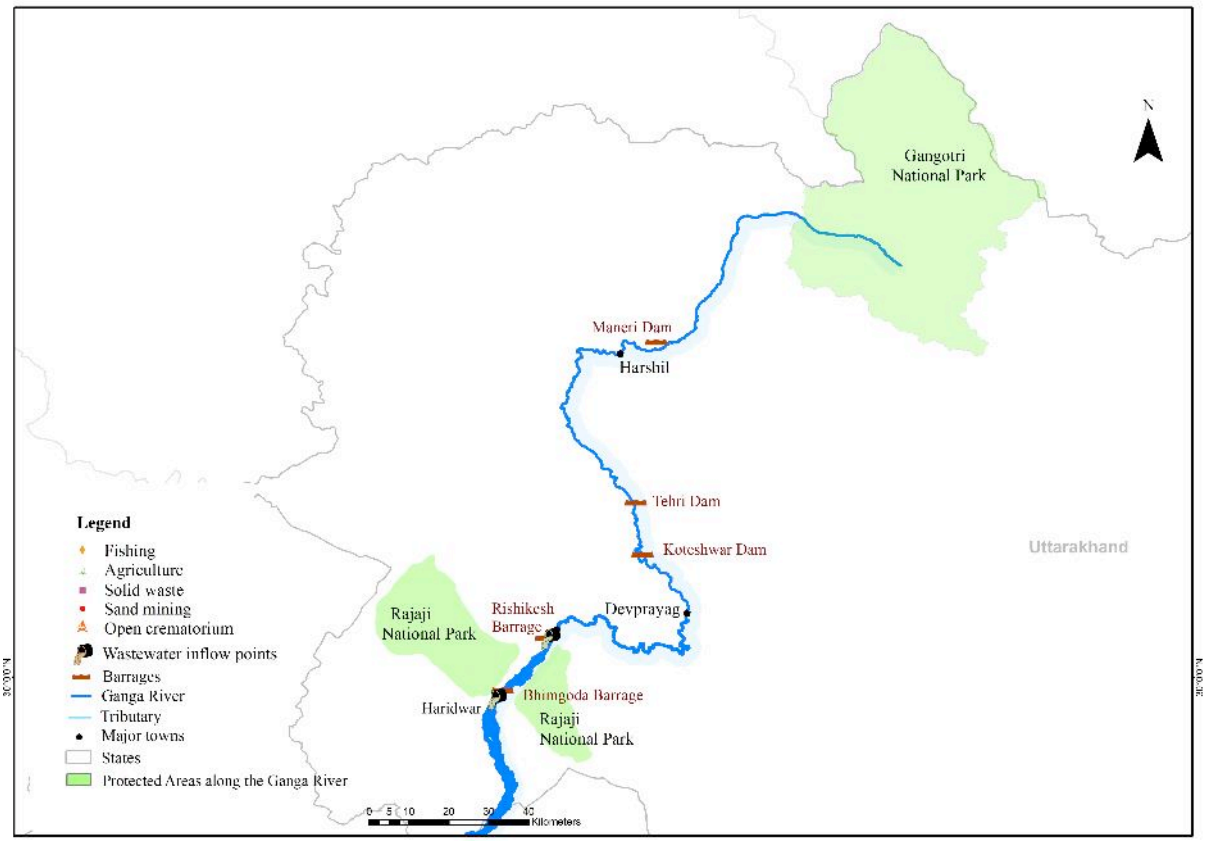

Figure 4.4. Spatial distribution of threats to the biodiversity in the upper stretch of the Ganga River

Table 4.1. Active wastewater inflow points along the Ganga River

Sl. no.	Place	Geographic location		Type of wastewater
		Latitude	Longitude	
1	Anupshahr	28.35149	78.27200	Sewage treatment plant outlet
2	Ghatia Ghat, Farrukhabad	27.41547	79.62725	Sewage
3	Mehndi Ghat	27.01294	79.98461	Small drains
4	Bithur, Kanpur	26.61535	80.27442	Sewage
5		26.50056	80.32013	Industrial effluent
6		26.49638	80.32536	Sewage
7		26.49147	80.33330	Sewage
8		26.48378	80.35062	Sewage
9	Kanpur city	26.47454	80.36568	Sewage
10		26.46869	80.37277	Sewage
11		26.46567	80.37600	Sewage
12		26.44514	80.39501	Industrial effluents
13		26.43141	80.41152	Industrial effluents
14	Allahabad	25.50416	81.86130	Sewage
15		25.50338	81.87253	Sewage
16	Mirzapur	25.15864	82.58467	Sewage

Sl. no.	Place	Geographic location		Type of wastewater
		Latitude	Longitude	
17	Purana Setu, Varanasi	25.26774	83.01821	Sewage
18	St. Ravidas Park, Varanasi	25.28371	83.01180	Sewage
19	Harischandra Ghat, Varanasi	25.29786	83.00814	Sewage
20	Downstream of Rajghat Bridge, Varansi	25.32575	83.03923	Sewage
21	Varuna confluence, Saray Mohana	25.32864	83.04503	Sewage
22	Jhandatar, Ghazipur	25.58135	83.59493	Sewage
23	Near Ghazipur Bridge	25.58508	83.60267	Sewage
24	Buxar	25.58526	83.98525	Sewage
25	Danapur	25.64593	85.05993	Sewage
26	Downstream of Danapur	25.64706	85.11176	Sewage
27	Patna	25.62233	85.16379	Sewage
28	Barh	25.48718	85.70846	Sewage
29	NTPC, Barh	25.50471	85.75761	NTPC outlet
30	NTPC, Barauni	25.36854	86.00635	NTPC outlet
31	Jamalpur	25.37152	86.54046	Sewage
32	Kahalgaon	25.26631	87.22543	Sewage
33	Farakka	24.75905	87.90965	NTPC outlet
34	Azimganj-Jiaganj	24.24178	88.25825	Sewage
35	Berhampore	24.11547	88.24617	Sewage
36	Kashiganj, Katwa	23.64273	88.14476	Sewage
37	Nabadwip	23.41174	88.37898	Sewage
38	Tribeni NTPC outlet	22.99142	88.40703	NTPC outlet
39	Tribeni	22.97104	88.40680	Sewage
40	Kalyani	22.92951	88.40748	Sewage
41	Downstream of Kalyani	22.91978	88.40249	Sewage
42	Chandan Nagar	22.85857	88.37097	Sewage
43	Bandel	22.84007	88.37442	Sewage
44	Bandel	22.82117	88.35438	Sewage
45	Downstream of Bandel	22.78862	88.34006	Sewage
46	NTPC, Barrackpore	22.72688	88.35859	NTPC outlet
47	Uttarpara	22.67203	88.35517	Sewage
48	Near Bally Bridge	22.66410	88.35332	Sewage
49	Bally	22.63855	88.35870	Sewage
50	Downstream of Bally	22.61497	88.36162	Sewage
51	Bag Bazar	22.60837	88.35798	Sewage
52	Bata Nagar	22.51383	88.21169	Sewage

4.2. Threats to the middle stretch of the Ganga River

This stretch is characterized by large, fertile floodplains that are extensively used for agriculture. The original vegetation has been replaced by crops. The human density is about

820 persons/km^2. This stretch hosts a significant populations of the Gangetic river dolphin, gharial, mugger, turtles and island-nesting birds. Threats specific to this stretch include the following.

- Water abstraction from the Upper Ganga Canal at Bhimgoda, Haridwar, Middle Ganga Canal at Bijnor and Lower Ganga Canal and Parallel Lower Ganga Canal at Narora has reduced the flow of the Ganga River to 10% of the natural flow regime, resulting in disruption of the horizontal and longitudinal connectivity between habitats for the priority species.
- Bank feature alteration due to agriculture, construction and sand mining has disrupted the lateral connectivity of the river. Extensive sandbar cultivation has rendered the habitat unsuitable for use as nesting sites by turtles and island-nesting birds.
- Unsustainable biological resource extraction using destructive methods is ubiquitous in this stretch of the Ganga River.
- Analysis of the water quality parameters assessed by CPCB between 2003 and 2014 in the middle stretch at 20 locations reveals that the pH ranged from 7.3 to 8.8. The DO showed an overall increasing trend from 7.4 mg/L to 7.9 mg/L. Subsequently the BOD showed an overall decreasing trend from 4.31 mg/L to 3.2 mg/L, which is higher than the permissible limit (≤ 3 mg/L). The BOD was well above the permissible limit at Narora, Kannauj, Kanpur, Dalmau, Kala Kankar, Allahabad and Varanasi. During the present study the pH ranged from 7.4 mg/L to 8.8 mg/L between Bijnor and Varanasi (Figure 4.1). The mean nitrate concentration was low, at 1.6 ± 0.2 mg/L (Figure 4.2), which resulted in an optimal mean DO concentration of 7.5 ± 0.2 mg/L (Figure 4.3). Within this stretch, there were 21 active wasterwater inflow points (mainly raw sewage and industrial discharge) (Figure 4.5; Table 4.1).

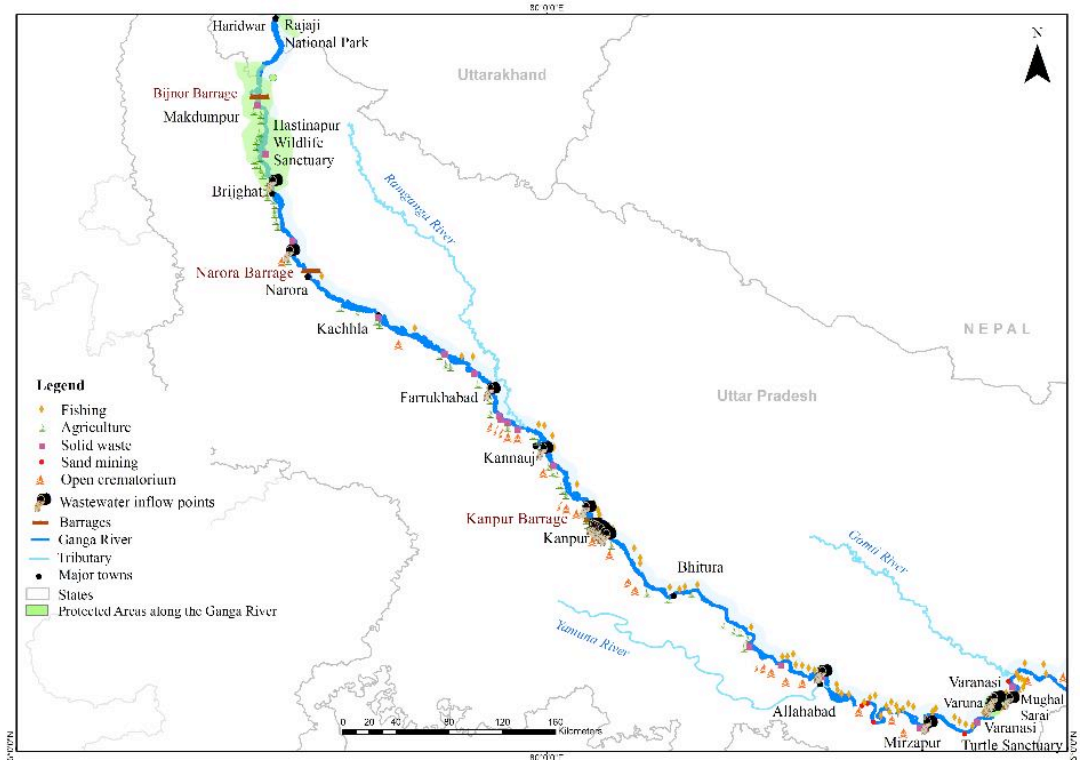

Figure 4.5. Spatial distribution of threats to the biodiversity in the middle stretch of the Ganga River

Kanpur city accounted for the greatest number of discharge points (9) (Figure 4.5). Indiscriminate use of synthetic chemicals in the agricultural and healthcare sectors releases persistent pollutants (PPs) such as heavy metals, polychlorinated bi-phenyls (PCBs) and perfluorinated compounds (PFCs). Both PCBs and PFCs are endocrine disrupting chemicals (EDCs) as these interfere with the hormonal and immune systems of aquatic species through bioaccumulation and biomagnification along the food chain (Bergman et al., 2012; Senthilkumar et al., 1999) as has been reported in the food web of the Gangetic river dolphin (Yeung et al., 2009).

Critical locations

- The DO was critically low (1.1 mg/L) at the conlfuence of the Varuna sewage drain and the Ganga River, near Varanasi (Figure 4.2). The nitrate concentration was higher (5.3 mg/L) where the output of the Mughal Sarai sewage treatment plant runs into the Ganga River, near Raona village, in Varanasi (Figure 4.3). The mixing of sewage at this location might have created eutrophic conditions and elevated the DO to 10.1 mg/L.

- In the middle stretch of the Ganga River, two areas with high concentrations of all the threats to the aquatic diversity can be identified (Figure 4.5). These include the area between Farrukabad and Kanpur and between Allahabd and Varanasi.

4.3. Threats to the lower stretch of the Ganga River

The floodplains and the natural vegetation of this stretch of the river have also been extensively replaced by croplands. This is the most densely populated of the three stretches (950 persons/km^2). Representative animal species of this stretch include the Gangetic river dolphin, otters, the saltwater crocodile and turtles, particularly *Batagur baska*. The following are the threats specific to this stretch:

- The Farakka Barrage has resulted in structural changes and modified flow regimes, leading to sediment and nutrient accretion. Increased freshwater inflow from the Farakka Barrage into the Hooghly River has significantly changed the salinity regime, water transparency, suspended sediments and nutrient load and altered the freshwater fish assemblage. The freshwater fishes (such as *Apocryptes bato*, *Goniolosa manminna* and *Labeo* sp.) that were found only from Nabadwip to Nawabganj in West Bengal during the pre-Farakka Barrage period are now available in the Godakhali-Uluberia region, signifying a shift of at least 60 km of the freshwater zone towards the mouth of the estuary (Manna, 2013).
- Unsustainable biological resource extraction is also widespread in this stretch of the river. Destructive fishing techniques and intentional capture of Gangetic river dolphins, turtles and storks (Choudhary & Mishra, 2006) have led to mortality and reduced populations of these species. *Batagur baska* and *Glyphis gangeticus* have also been extirpated due to indiscriminate killing (Compagno, 2007; Moll et al., 2009).
- Bank feature alteration due to land-use changes such as agriculture, construction activities and sand mining has disrupted the lateral connectivity of the river in the floodplain. Sandbar cultivation in the states of Bihar and Jharkhand has rendered the habitat unsuitable for use as nesting sites by turtles and island-nesting birds.
- A comparison of water quality parameters from 2003 to 2014 as assessed by CPCB in the lower stretch at 35 locations reveals that the pH ranged from 7.3 to 8.8. The DO showed an overall increasing trend from 7.2 mg/L to 7.5 mg/L, and subsequently the BOD showed an overall decreasing trend from 2.4 mg/L to 2.8 mg/L. Ghazipur, in Uttar Pradesh, and Baharampur, Ghoshpara, Serampore, Dakshineshwar, Shivpur, Garden Reach, Uluberia,

Palta and Diamond Harbour, in West Bengal, were critical locations where the BOD was well above the permissible limit. The water quality parameters assessed during the present study in the lower stretch from Ghazipur to Diamond Harbour reveal that the pH was in the alkaline range (7.4–8.5) (Figure 4.1). The average nitrate concentration was high (4.3 ± 0.5 mg/L) (Figure 4.3), which lowered the average DO to 6.2 ± 0.1 mg/L (Figure 4.2). 31 active wastewater inflow points (raw sewage and industrial discharge) were observed during the present study (Figure 4.6; Table 4.1).

- The large city of Kolkata produces 5114 tonnes/day of solid waste, of which 10% is plastic (Das & Bhattacharya, 2013; Singh & Francis, 2017). This untreated plastic waste disrupts the biodiversity (Dey et al., 2014) and reaches the Bay of Bengal at a rate of 0.12 million tonnes per year (Lebreton et al., 2017).

Critical locations

- In the Lower Ganga, the first critical stretch is Sitab Diara to Ajimganj/Jiagang, which includes critical locations, *viz*. Munger, Kahalgaon, Sahibganj, Revelganj and Ajimganj/Jiaganj, where the nitrate level was >10 mg/L (Figures 4.3 and 4.6). The second ctirical stretch identified in this stretch falls between Barrackpore and Falta (Figure 4.6), where the major wastewater inflow points elevated the nitrate level and lowered the DO concentration below 5 mg/L at Sujapur, Batanagar, Shibpur, Garden Reach, Uluberia and Falta.

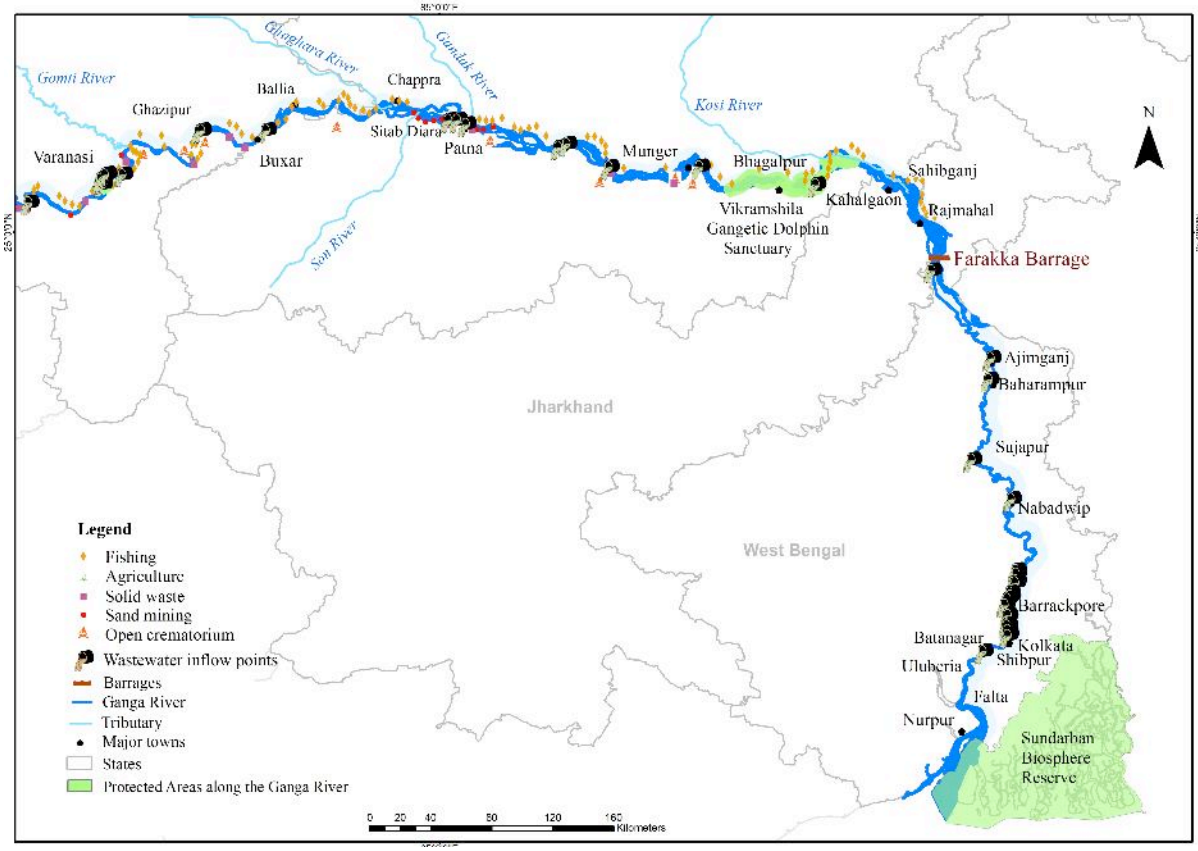

Figure 4.6. Spatial distribution of threats to the biodiversity in the lower stretch of the Ganga River

4.4. Conclusions

It is evident from the plethora of literature that the ecological integrity of the Ganga River is threatened throughout its course. Each stretch has its unique set of ecological assemblage and threats. The upper stretch of theriver is threatened by structural changes in its morphology due to altered flow regime and climate change. Bank alteration, unsustainable resource extraction and changes in water quality are dominant threats in the middle and lower stretches of the river. Thus, it can be deduced that alteration of the structural morphology of the river is the key threat, leading to habitat degradation and biodiversity loss. These existing threats are furher heightened by the impacts of climate change and altered water quality, questioning the survival of the aquatic species.

In order to maintain the ecological integrity of the river, it is crucial to address the stretch-specific threats, keeping in view the current global river conservation situation. In the upper stretch of the Ganga River, the focus should be on maintaining the natural structural features of the river, and micro-hydel power projects should be considered instead of larger dams in

this stretch. In the middle and lower stretches of the river, restoration of the hydrology regime through flow augmentation to a near-natural condition would be the key to bringing about ecological restoration in the river ecosystem. A holistic approach should consider assessment of 'flow-ecology' relationships of designated aquatic umbrella species and then integrate the eco-hydrological requirements of these species during the conception of nature-oriented and ecologically relevant e-flow targets (Hussain et al., 2011). This flow restoration would, in turn, enhance the suitability of the habitat for the aquatic biota, improve the flow regime and retain enough water in the Ganga River to dilute the heavy pollution load.

The concentration of nitrate in natural rivers is typically low (<1 mg/L). The preliminary assessment of the water quality of the Ganga River reveals that the wastewater inflow has altered the water qaulity at specific locations and elevated the nitrate and BOD concentrations above critical levels. An excess organic load, especially nitrate, can rapidly deplete the dissolved oxygen concentration and can become toxic to aquatic organisms, mainly fishes, at >10 mg/L or a higher level. Hence, the critical locations identified with respect to detoriated water quality should be the focus of intervention efforts.

5. CONSERVATION IMPLICATIONS

The Ganga River is a repository of various life forms, resulting from the variations in its geomorphological and fluvial processes. This diversity of species or life forms is crucial for reducing the risk of ecological collapse and maintaining ecosystem services, which are essential for societal well-being. The current state of the Ganga River as evident from the rapid biodiversity assessment, coupled with an extensive review of secondary literature, highlights the need for its ecological restoration whilst considering the varied geomorphological, climatic and ecological features and societal aspects. An effective ecological restoration plan essentially needs to consider the biotic and abiotic components of the ecosystem, *viz.* species composition and abundance, the characteristics of the habitat and its use by species, an assessment of the threats faced by important taxa and distinct spatial zones requiring differential treatment (McDonald et al., 2016). In view of the foregoing discussion, the following points have been inferred for the conservation of aquatic diversity aiming at rejuvenation of the Ganga River.

Stretch-specific implications

- The diverse uses of resources in different stretches of the river have given rise to different threats, and hence measures to address these threats should be stretch-specific. Flow maintenance, preservation of umbrella species and identification of the priority areas are key concepts that can be applied to the assessment of stretch-specific requirements.
- The upper stretch of the Ganga River has undergone structural changes and is unlikely to revert to its natural hydrological patterns. Construction of further hydroelectric projects in this stretch will compromise the ecological, religious and recreational values of the river. This can be averted by incorporating sustainable and efficient water use practices in norms with modern abstraction techniques which should be reflected in the water policy and allocation guidelines.
- The middle and ower stretches of the Ganga River are facing severe changes in water quality due to the wasterwater from domestic and industrial sources and agricultural run-off. Altered water quality is aggravated by the low flow condition. Intensive agriculture along the banks of the river and on the river islands and sand mining in these stretches has altered the habitat for island-nesting species of bird and turtle. The lower stretch of the Ganga River is also highly modified by the Farakka Barrage, leading to flow alterations and changes in the salinity regimes in the estuarine areas, leading to changes in the species assemblage. Addressing these problems is not only a river conservation issue but also a

social one owing to the high dependence of the dense populations of the local communities living along the banks of the river.

River hydraulics

- Assessment of the hydrology of the Ganga River revealed that the channel depth is a major limiting factor for the distribution of the species. Only 38.7% of the river had a suitable depth for the umbrella species, *viz*. the Gangetic river dolphin and gharial, during summer months.
- As the natural flow cannot be restored due to the highly fragmented state of the river, restoration of the catchment area and periodic reservoir releases should be carried out.
- Prioritizing efficient water usage in consonance with the needs of aquatic species through the ecologically sound and economically just water budget and policy would augment flows.
- The flow restoration would enhance the suitability of the habitat for the aquatic biota, improve the flow regime and retain sufficient water in the Ganga River to dilute the pollution load.

Species restoration

- It is evident from the literature that the populations of the umbrella species, such as the Gangetic river dolphin, otters, the gharial and the mugger in the Ganga River have become highly fragmented over time. Historically, these species had wider distributions in the Ganga River and its tributaries. However, due to the loss of longitudinal and lateral connectivity and unsuitable habitat conditions, they are now restricted to small stretches of the river.
- Nevertheless, the rapid biodiversity assessment revealed the presence of priority species and suitable habitats along some stretches of the Ganga River, including the protected areas. On the basis of the abundance and distribution of priority aquatic species, areas with higher biodiversity values were identified. These areas should be taken up for planning ecological restoration of the Ganga River.
- Crocodilians and turtles are highly sensitive to anthropogenic habitat alterations and are therefore conservation-dependent species. However, most of the habitat of these animals along the Ganga River is not protected. Anthropogenic activities such as bank alteration, sandbar cultivation and sand mining have resulted in competitive use of sandy banks and loss of basking and nesting beaches, threatening the survival of these taxa. Thus, efforts to

conserve these species should emphasize science-based restoration with the support of the local community. Therefore, aligning conservation initiatives with local livelihoods is a prerequisite of the restoration process and is currently being carried out under the community-based conservation component of the project. Awareness programmes and rescue programmes for species in distress are needed to protect these species.

- Amphibians are the least studied group along the Ganga River, and hence information pertaining to them is either unavailable or scanty. Therefore, extensive studies are needed to assess the population trends of these species in the Ganga River and its basin.
- Ganga basin has several seasonally flooded wetlands, permanent lakes and marshes, which serve as major migratory waterbird habitats. Some of these have been declared as PAs, for e.g., Jhilmil Conservation Reserve in Uttarakhand, Surhataal Wildlife Sanctuary in Uttar Pradesh, Kusheshwar Asthan Bird Sanctuary in Bihar and Udhuwa Bird Sanctuary in Jharkhand. These wetlands are kidneys of the landscapes and needs restoration measures. The migratory waterbirds use sandy islands and sand banks of the Ganga River for roosting and the resident water birds such as Indian skimmer, Small Indian pratincole and River terns for breeding, hence these habitats need to be restored and protected

Emergent situations

- Incidental mortality of the priority species and a lack of concerted efforts to address this are a major concern.
- In order to be prepared for such situations, rescue protocols involving stakeholders as well as a network of rehabilitation areas need to be established along the river. Work has already been initiated in this regard by the NMCG-WII project, and rescue and rehabilitation of aquatic wildlife under stress has already been initiated.
- For the long-term success of this operation, it is important to build the capacity of the frontline staff of the forest department, local communities and other stakeholders of the five Ganga River states so that they are able to successfully carry out rescue operations of priority aquatic species. These activities are currently being carried out under the training component of the NMCG-WII project.

Way forward

- Planning for ecological restoration of an ecosystem starts with exploring its historical and present day conditions, for which a literature review and rapid biodiversity assessment were carried out. These also helped identify areas with high biodiversity values.

- The PAs along the Ganga River account for only around 15.5% of the total river stretch. However, these areas provide undisturbed habitats and are repositories of aquatic umbrella species such as Gangetic river dolphin, otters and crocodilians. Increasing the PA network by covering biodiversity-rich stretches of the Ganga River through strategic planning and with the involvement and support of local communities should be incorporated in the conservation process.
- The water quality of the Ganga River has been severely altered due to domestic, industrial and agricultural sediment accretion. Evidence of bioaccumulation and biomagnification has also been documented along the food chain and food web of aquatic species of the Ganga River. Further aquatic ecotoxicological research is needed to assess the implications of altered water quality for the long-term survival of the species.
- Impacts of climate change are exacerbating the threats of the Ganga River in the form of an unpredictable flow regime and changes in both the upstream and downstream distribution ranges of species. The restoration process should thus take into account the externalities caused by climate change, using future scenario modelling techniques to make climate change projections and evaluate their impacts on species and habitats.
- Planning restoration is not only a river conservation issue but also a social one owing to the high dependence of the dense populations of the local communities living along the banks of the Ganga River. Thus, efforts are under way to create awareness among stakeholders and garner local support for conservation. Site-specific strategies are being developed by aligning the livelihoods of the local people with conservation priorities. These communities are also being made aware about the role of an ecologically intact Ganga River in enhancing the quality of life.

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ANNEXURE I Probable mammalian species of the Ganga River

Family	Common Name/s	Scientific Name	IUCN status	IWPA status	Previous studies	Present study
Catecea	Gangetic river dolphin	*Platanista gangetica* (Roxburgh, 1801)	EN	Schedule I	b, i, j, k, m, n	+
Carnivora	Smooth-coated otter	*Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826)	VU	Schedule II	c, d, f, g, h, m, o	+
	Eurasian otter	*Lutra lutra* (Linnaeus, 1758)	NT	Schedule II	d, e, l	-
	Small clawed otter	*Aonyx cinereus* (Illiger, 1815)	VU	Schedule I	a, c	-

[a] Jerdon (1874); [b] Anderson (1878); [c] Blanford (1881); [d] Atkinson (1882); [e] Sclater (1891); [f] Hinton and Fry (1923); [g] Pocock (1941), [h] Atkinson (1974); [i] Jones (1982); [j] Behera (1995); [k] Sinha (1999); [l] Hussain (2002); [m] Choudhary et al. (2006); [n] Sinha et al. (2010); [o] Nawab & Hussain (2012)

ANNEXURE II Probable waterbird and water associated bird species of the Ganga River

Family	Common Name/s	Scientific Name	IUCN Status	IWPA status	Habitat	Previous Study	Present Study
Podicipedidae	Little Grebe, Dabchick	*Tachybaptus ruficollis*(Pallas, 1764)	LC	Schedule IV	**T/A**	b,c,e,f	+
	Great Crested Grebe	*Podiceps cristatus*(Linnaeus, 1758)	LC	Schedule IV	A	c,f	+
Phalacrocoracidae	Little Cormorant	*Microcarbo niger* (Vieillot, 1817), *Phalacrocorax niger* (Vieillot, 1817)	LC	Schedule IV	A	b,e,f	+
	Indian Cormorant, Indian Shag	*Phalacrocorax fuscicollis* (Stephens, 1826)	LC	Schedule IV	A	b,e,f	+
	Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	LC	Schedule IV	A	a	+
Anhingidae	Oriental Darter, Darter, Snake Bird	*Anhinga melanogaster* Pennant, 1769	NT	Schedule IV	A	b,d	+
Ardeidae	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	LC	Schedule IV	A	b,e,f	+
	Grey Heron	*Ardea cinerea* Linnaeus, 1758	LC	Schedule IV	A	a	+
	Purple Heron	*Ardea purpurea* Linnaeus, 1766	LC	Schedule IV	T	a,b,e,f	+
	Great White Egret, Large Egret, Great Egret	*Ardea alba* (Linnaeus, 1758), *Casmerodius albus* Linnaeus, 1758, *Egretta alba* (Stotz et al., 1996)	LC	Schedule IV	A	b,e,f	+
	Intermediate Egret, Median Egret	*Ardea intermedia* (Wagler, 1829), *Mesophoyx intermedia* (Wagler, 1829)	LC	Schedule IV	A	b,e	+
	Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	LC	Schedule IV	A	b,e,f	+
	Indian Pond-Heron, Paddyfield Bird	*Ardeola grayii* (Sykes, 1832)	LC	Schedule IV	T	a,e,f	+
	Green-backed Heron, Little Green Heron, Striated Heron	*Butorides striata* (Linnaeus, 1758), *Butorides striatus* (Linnaeus, 1758)	LC	Schedule IV	A		+
	Black-crowned	*Nycticorax nycticorax*	LC	Schedule IV	A	b	+

	Night-Heron	(Linnaeus, 1758)					
	Yellow Bittern	*Ixobrychus sinensis* (Gmelin, 1789)	LC	Schedule IV	A	a,f	
	Black Bittern	*Ixobrychus flavicollis* (Latham, 1790), *Dupetor flavicollis* (Latham, 1790)	LC	Schedule IV	A		+
Ciconiidae	Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	NT	Schedule IV	A	b,d	+
	Asian Openbill-Stork, Openbill Stork	*Anastomus oscitans* (Boddaert, 1783)	LC	Schedule IV	A	b,e	+
	Asian Wolly-necked Stork, White-necked Stork, Woolly-necked Stork	*Ciconia episcopus* (Boddaert, 1783)	VU	Schedule IV	A	b	+
	White Stork	*Ciconia ciconia* (Linnaeus, 1758)	LC	Schedule I	A	a	
	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790), *Xenorhynchus asiaticus* (Latham, 1790)	NT	Schedule IV	A	a,d	+
	Lesser Adjutant-Stork	*Leptoptilos javanicus* (Horsfield, 1821)	VU	Schedule IV	A	d,e	+
	Greater Adjutant-Stork	*Leptoptilos dubius* (Gmelin, 1789)	EN	Schedule IV	T	a,d	+
Threskiornithidae	Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	LC	Schedule IV	T	f	+
	Black-headed Ibis, Oriental White Ibis	*Threskiornis melanocephalus* (Latham, 1790)	NT	Schedule IV	T	a,d,e,f	+
	Red-naped Ibis, Black Ibis	*Pseudibis papillosa* (Temminck, 1824)	LC	Schedule IV	A	a,b,d,e	+
	Eurasian Spoonbill, Spoonbill Stork	*Platalea leucorodia* (Linnaeus, 1758)	LC	Schedule IV	T	a,b	+
Anatidae	Fulvous Whistling Duck, Large Whistling-Duck, Large Whistling Teal	*Dendrocygna bicolor* (Vieillot, 1816)	LC	Schedule I	A	c,e	

	Lesser Whistling-Duck, Lesser Whistling-Teal	*Dendrocygna javanica* (Horsfield, 1821)	LC	Schedule IV	A	b,c,e,f	+
	Lesser White-fronted Goose	*Anser erythropus* (Linnaeus, 1758)	VU	Schedule IV	A	d	
	Greylag Goose	*Anser anser* (Linnaeus, 1758)	LC	Schedule IV	A	a,c,d	+
	Bar-headed Goose	*Anser indicus* (Latham, 1790)	LC	Schedule IV	A	a,b,c,d	+
	Ruddy Shelduck, Brahminy Shelduck, Brahminy Duck	*Tadorna ferruginea* (Pallas, 1764)	LC	Schedule IV	A	a,b,c,d,f	+
	Common Shelduck	*Tadorna tadorna* (Linnaeus, 1758)	LC	Schedule IV	A	a	+
	African Comb Duck, Knob-billed Duck	*Sarkidiornis melanotos* (Pennant, 1769)	LC	Schedule IV	A	b,d,f	+
	Cotton Teal, Cotton Pygmy-goose	*Nettapus coromandelianus* (Gmelin, 1789)	LC	Schedule IV	A	b,c,d,f	+
	Gadwall	*Mareca strepera* (Linnaeus, 1758), *Anas strepera* (Linnaeus, 1758)	LC	Schedule IV	A	a,b,c,d,e,f	+
	Falcated Duck	*Mareca falcata* (Georgi, 1775), *Anas falcata* (Georgi, 1775)	NT	Schedule IV	A	d	
	Eurasian Wigeon	*Mareca penelope* (Linnaeus, 1758), *Anas penelope* (Linnaeus, 1758)	LC	Schedule IV	A	c,f	+
	Mallard	*Anas platyrhynchos* (Linnaeus, 1758)	LC	Schedule IV	A	b	+
	Indian Spot-billed Duck, Spot-billed Duck	*Anas poecilorhyncha* (J.R.Forester, 1781)	LC	Schedule IV	A	b,d,f	+
	Northern Shoveler, Shoveler	*Spatula clypeata* (Linnaeus, 1758), *Anas clypeata* (Linnaeus, 1758)	LC	Schedule IV	A	a,b,c,f	+
	Northern Pintail	*Anas acuta* (Linnaeus, 1758)	LC	Schedule IV	A	b,c,e,f	+
	Garganey, Blue-winged Teal	*Spatula querquedula* (Linnaeus, 1758), *Anas querquedula* (Linnaeus, 1758)	LC	Schedule IV	A	b,b,f	+

	Eurasian Teal, Common Teal, Green-winged Teal	*Anas crecca* (Linnaeus, 1758)	LC	Schedule IV	A	c,f	+
	Marbled Teal	*Marmaronetta angustirostris* (Menetries, 1832)	VU	Schedule IV	A	d	
	Red-crested Pochard	*Netta rufina* (Pallas, 1773)	LC	Schedule IV	A	a,c,d,e,f	+
	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	Schedule IV	A	b,c,d,f	+
	Ferruginous Duck, Ferruginous Pochard, White-eyed Pochard	*Aythya nyroca* (Guldenstadt, 1770)	NT	Schedule IV	A	c,d,e,f	+
	Baer's Pochard	*Aythya baeri* (Radde, 1863)	CR	Schedule IV	A	d	
	Tufted Duck, Tufted Pochard	*Aythya fuligula* (Linnaeus, 1758)	LC	Schedule IV	A	c,f	+
	Goosander, Common Merganser	*Mergus merganser* (Linnaeus, 1758)	LC	Schedule IV	A		+
Accipitridae	Black-shouldered Kite, Black-winged Kite	*Elanus caeruleus* (Desfontaines, 1789)	LC	Schedule IV	A	b,f	
	Black Kite, Common Pariah Kite	*Milvus migrans* (Boddaert, 1783)	LC	Schedule IV	T	b,f	
	Brahminy Kite	*Haliastur indus* (Boddaert, 1783)	LC	Schedule IV	T		+
	Pallas's Fish-Eagle	*Haliaeetus leucoryphus* (Pallas, 1771)	EN	Schedule IV	T	d	+
	Lesser Fish-eagle, Lesser Grey-headed Fish-Eagle	*Ichthyophaga humilis* (S.Muller & Schlegel, 1841)	NT	Schedule IV	A	d	
	Grey-headed Fish-Eagle	*Ichthyophaga ichthyaetus* (Horsfield, 1821)	NT	Schedule IV	T	d	+
	Egyptian Vulture, White Scavenger Vulture	*Neophron percnopterus* (Linnaeus, 1758)	EN	Schedule IV	A	d	
	Western Marsh-Harrier, Eurasian Marsh Harrier	*Circus aeruginosus* (Linnaeus, 1758)	LC	Schedule IV	T	b,c,f	+
	Greater Spotted	*Clanga clanga* (Pallas, 1811),	VU	Schedule IV	A	d	+

	Eagle	*Aquila clanga* (Pallas, 1811)					
	Steppe Eagle	*Aquila nipalensis* (Hodgson, 1833)	EN	Schedule IV	T		
Pandionidae	Osprey	*Pandion haliaetus* (Linnaeus, 1758)	LC	Schedule I	T	f	+
Falconidae	Red-headed Falcon	*Falco chicquera* (Daudin, 1800)	NT	Schedule I	A		
	Peregrine Falcon	*Falco peregrinus* (Tunstall, 1771)	LC	Schedule I	T		+
Gruidae	Sarus Crane	*Antigone antigone* (Linnaeus, 1758), *Grus antigone* (Linnaeus, 1758)	VU	Schedule IV	T	b,c,d	+
	Demoiselle Crane	*Anthropoides virgo* (Linnaeus, 1758), *Grus virgo* (Linnaeus, 1758)	LC	Schedule IV	A	a,b	+
	Common Crane	*Grus grus* (Linnaeus, 1758)	LC	Schedule IV	T	a	+
Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	LC	Schedule IV	T	b,e,f	+
	Baillon's Crake	*Zapornia pusilla* (Pallas, 1776), *Porzana pusilla* (Pallas, 1776)	LC	Schedule IV	A	f	
	Purple Moorhen, Purple Swamphen	*Porphyrio porphyrio* (Linnaeus, 1758)	LC	Schedule IV	A	b,d,e,f	+
	Common Moorhen	*Gallinula chloropus* (Linnaeus, 1758)	LC	Schedule IV	A	b,f	+
	Common Coot, Eurasian Coot, European Coot	*Fulica atra* (Linnaeus, 1758)	LC	Schedule IV	A	b,c,e,f	+
Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli, 1786)	LC	Schedule IV	A	b,e,f	+
	Bronze-winged Jacana	*Metopidius indicus* (Latham, 1790)	LC	Schedule IV	A	b,e,f	+
Charadriidae	Little Ringed Plover	*Charadrius dubius* (Scopoli, 1786)	LC	Schedule IV	A	b,f	+
	Kentish Plover	*Charadrius alexandrinus* (Linnaeus, 1758)	LC	Schedule IV	A		+
	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT	Schedule IV	A	b,d	+

	Grey-headed Lapwing	*Vanellus cinereus* (Blyth, 1842)	LC	Schedule IV	A	c,e,f	+
	Yellow-wattled Lapwing	*Vanellus malabaricus* (Boddaert, 1783)	LC	Schedule IV	T	f	
	Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	LC	Schedule IV	T	b,e,f	+
Scolopacidae	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	LC	Schedule IV	T	e,f	
	Black-tailed Godwit	*Limosa limosa* (Linnaeus, 1758)	NT	Schedule IV	A	d	+
	Eurasian Curlew	*Numenius arquata* (Linnaeus, 1758)	NT	Schedule IV	A	d	+
	Spotted Redshank	*Tringa erythropus* (Pallas, 1764)	LC	Schedule IV	A		+
	Common Redshank	*Tringa totanus* (Linnaeus, 1758)	LC	Schedule IV	A	c,f	+
	Marsh Sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	LC	Schedule IV	A	f	+
	Common Greenshank	*Tringa nebularia* (Gunnerus, 1767)	LC	Schedule IV	A	b,f	+
	Green Sandpiper	*Tringa ochropus* (Linnaeus, 1758)	LC	Schedule IV	A	b,c,f	+
	Wood Sandpiper	*Tringa glareola* (Linnaeus, 1758)	LC	Schedule IV	A	c,e,f	+
	Common Sandpiper	*Actitis hypoleucos* (Linnaeus, 1758)	LC	Schedule IV	T	b,c,f	+
	Little Stint	*Calidris minuta* (Leisler, 1812)	LC	Schedule IV	A	e,f	+
	Curlew Sandpiper	*Calidris ferruginea* (Pontoppidan, 1763)	NT	Schedule IV	A	b	
	Ruff	*Philomachus pugnax* (Linnaeus, 1758)	LC	Schedule IV	A		+
Recurvirostridae	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	LC	Schedule IV	A	b,f	+
	Pied Avocet	*Recurvirostra avosetta* (Linnaeus, 1758)	LC	Schedule IV	A	b	+
Burhinidae	Great Thick-knee, Great Stone-Plover	*Esacus recurvirostris* (Cuvier, 1829)	NT	Schedule IV	A	b,d	+
Glareolidae	Little Pratincole, Small Pratincole	*Glareola lactea* (Temminck, 1820)	LC	NL	A	b,d,f	+
Laridae	Pallas's Gull	*Ichthyaetus ichthyaetus* (Pallas,1773), *Larus*	LC	NL	A	b	+

		ichthyaetus (Pallas, 1773)					
	Brown-headed Gull	*Chroicocephalus brunnicephalus* (Jerdon, 1840), *Larus brunnicephalus* (Jerdon, 1840)	LC	Schedule IV	A	a,e	+
	Black-headed Gull	*Larus ridibundus* (Linnaeus, 1766)	LC	NL	A	e	+
	Gull-billed Tern	*Gelochelidon nilotica* (Gmelin, 1789)	LC	NL	A	b	
	River Tern	*Sterna aurantia* (J.E.Gray, 1831)	NT	NL	A	a,b,d	+
	Common Tern	*Sterna hirundo* (Linnaeus, 1758)	LC	NL	A		+
	Little Tern	*Sternula albifrons* (Pallas, 1764), *Sterna albifrons* (Pallas, 1764)	LC	NL	A	d	+
	Black-bellied Tern	*Sterna acuticauda* (J.E.Gray, 1831)	EN	NL	A	b,d	+
Laridae	Indian Skimmer	*Rynchops albicollis* (Swainson, 1838)	VU	NL	A	b,d	+
Strigidae	Eurasian Eagle-Owl	*Bubo bubo* (Linnaeus, 1758)	LC	Schedule IV	A		
	Spotted Owlet	*Athene brama* (Temminck, 1821)	LC	Schedule IV	T		
Alcedinidae	Small Blue Kingfisher, Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	LC	Schedule IV	T	e,f	+
	Stork-billed Kingfisher	*Pelargopsis capensis (Linnaeus, 1766)* (Linnaeus, 1766)	LC	Schedule IV	A	f	
	White-breasted Kingfisher, White-throated Kingfisher	*Halcyon smyrnensis* (Linnaeus, 1758)	LC	Schedule IV	A	b,e,f	+
	Crested Kingfisher, Greater Pied Kingfisher	*Megaceryle lugubris* (Temminck, 1834)	LC	Schedule IV	A		+
	Pied Kingfisher	*Ceryle rudis* (Linnaeus, 1758)	LC	Schedule IV	A	b,e,f	+
Hirundinidae	Plain Martin	*Riparia palridicola* (Vieillot, 1871)	LC	NL	A		+
	Barn Swallow, Common	*Hirundo rustica* (Linnaeus, 1758)	LC	NL	T	e	+

	Swallow						
	Wire-tailed Swallow	*Hirundo smithii* (Leach, 1818)	LC	NL	T	b	
	Red rumped Swallow	*Cecropis daurica* (Linnaeus, 1771)	LC	NL	T	+	
Motacillidae	White Wagtail	*Motacilla alba* (Linnaeus, 1758)	LC	NL	A		+
	Large Pied Wagtail, White-browed Wagtail	*Motacilla maderaspatensis* (Gmelin, 1789)	LC	NL	T	e,f	+
	Citrine Wagtail	*Motacilla citreola* (Pallas, 1776)	LC	NL	T	e,f	+
	Western Yellow Wagtail	*Motacilla flava* (Linnaeus, 1758)	LC	NL	T	e,f	+
	Grey Wagtail	*Motacilla cinerea* (Tunstall, 1771)	LC	NL	T		+
Muscicapidae	Black Redstart	*Phoenicurus ochruros* (Gmelin, 1774)	LC	Schedule IV	T		+
	Plumbeous Water Redstart, Plumbeous Redstart	*Phoenicurus fuliginosus* (Vigors, 1831), *Rhyacornis fuliginoses* (Vigors, 1831)	LC	Schedule IV	T		+
	White-capped water Redstart	*Phoenicurus leucocephalus* (Vigors, 1831)	LC	Schedule IV	A		+
Pelecanidae	Great White Pelican, White Pelican	*Pelecanus onocrotalus* (Linnaeus, 1758)	LC	Schedule IV	A		+

[a] Bilgrami (1991); [b] Khan et al. (2013); [c] Khan et al. (2016); [d] Rahmani et al. (2016); [e] Satya Prakash et al. (2016); [f] Chowdhury (2017)

ANNEXURE III Probable crocodilian species of the Ganga River

Family	Common Name/s	Scientific Name	IUCN status	IWPA status	Previous studies	Present study
Crocodylidae	Mugger, Marsh crocodile	*Crocodylus palustris* (Lesson, 1831)	VN	Schedule I	a, h, g	+
	Saltwater crocodile	*Crocodylus porosus* (Schneider, 1801)	LC	Schedule I	c, d, f	-
Gavialidae	Gharial	*Gavialis gangeticus* (Gmelin in Linnaeus, 1789)	CR	Schedule I	a, b, e, j	+

[a] Boulenger (1890); [b] Smith (1931); [c] Daniel (1970); [d] Bustard & Choudhury (1981); [e] Wright (1982); [f] Saha et al (2011); [g] Joshi (2013); [h] Sharma & Singh (2015); [i] Bharati et al. (2016); [j] Nawab et al. (2016)

ANNEXURE IV Probable turtle species of the Ganga River

Family	Common Name/s	Scientific Name	IUCN status	IWPA status	Previous studies	Present study
Geoemydidae	Northern river terrapin	*Batagur baska* (Gray, 1830) *Emys baska* (Gray, 1830)	CR	Schedule I	s, o,	-
	Red-crowned Roofed Turtle, Bengal Roof Turtle	*Batagur kachuga* (Gray, 1831) *Kachuga kachuga* (Gray, 1831)	CR	Schedule I	b, t, s	-
	Three-striped roofed turtle	*Batagur dhongoka* (Gray, 1832) *Kachuga dhongoka* (Gray, 1832)	EN	NL	a	+
	Spotted Pond Turtle, Black Pond Turtle, Black Spotted Turtle	*Geoclemys hamiltonii* (Gray, 1830)	VU	Schedule I	m, b, e	+
	Crowned River Turtle	*Hardella thurjii* (Gray, 1831)	VU	NL	d, m	+
	Indian Black Turtle	*Melanochelys trijuga* (Schweigger, 1812)	NT	NL	g, m, h,	+
	Brown Roofed Turtle	*Pangshura smithii* (Gray, 1863) *Batagur smithii* (Gray, 1863) *Kachuga smithii* (Gray, 1863)	NT	NL	d, h, i	+
	Indian roofed turtle	*Pangshura tecta* (Gray, 1830) *Kachuga tecta* (Gray, 1830)	LC	Schedule I	k, l	+
	Indian Tent Turtle	*Pangshura tentoria* (Gray, 1834) *Kachuga tentoria* (Gray, 1834)	LC	NL	i	+
Trionychidae	Indian Narrow-headed Softshell Turtle	*Chitra indica* (Gray, 1830) *Trionyx indicus* (Gray, 1830)	EN	NL	c, n, h, a, e	+
	Indian Softshell Turtle	*Nilssonia gangetica* (Cuvier, 1825) *Aspideretes gangeticus* (Cuvier, 1825) *Trionyx gangeticus* (Cuvier, 1825)	VU	Schedule I	c, p, a	+
	Indian Peacock Softshell Turtle	*Nilssonia hurum* (Gray, 1830) *Aspideretes hurum* (Gray, 1830) *Trionyx hurum* Gray, 1830	VU	Schedule I	c, p, g, r, e	+
	Indian Flapshell Turtle	*Lissemys punctata* (Lacépède, 1788)	LC	Schedule I	q, j	+

[a] Gunther (1864); [b]Anderson (1871); [c]Annandale (1912); [d] Chaudhuri (1912); [e] Smith (1931); [f] Daniel & Shull (1964); [g] Moll & Vijaya (1986); [h] Das (1991); [i] Rao (1993); [j] Whitaker (1997); [k] Choudhury et al. (2000); [l] Praschag et al. (2007); [m] Das & Bhupathy (2009); [n] Das & Singh (2009); [o] Moll et al. (2009); [p] Das et al. (2010); [q] Bhupathy et al. (2014); [r] Sinha, et al. (2014); [s] IUCN (2016); [t] Gray (2017)

ANNEXURE V Probable amphibian species of the Ganga River

Family	Common Name/s	Scientific Name	IUCN status	IWPA status	Previous studies	Present Study
Ranidae	Günther's Stream Frog	*Amolops afghanus* (Günther, 1858)	NL	NL	i	-
	Dehradun Stream Frog	*Amolops chakrataensis* (Ray, 1992)	DD	NL	i, n	-
	Assam Cascade Frog	*Amolops himalayanus* (Boulenger, 1888) *Amolops formosus* (Günther, 1876)	LC	NL	h, i, n, q	-
	Jaunsar Stream Frog	*Amolops jaunsari* (Ray, 1992)	DD	NL	i, n	-
	Marbled Cascade Frog	*Rana senchalensis* (Chanda, 1987 "1986") *Amolops marmoratus* (Blyth, 1855)	LC	NL	h, n	-
	Common Green Frog	*Hylarana erythraea* (Schlegel, 1837) (*H. tytleri* was recently removed from the synonymy of *Hylarana erythraea* by Ohler and Mallick, (2002).	LC	NL	b, d, f	-
	Leaf Frog	*Hylarana tytleri* (Theobald, 1868)	LC	NL	v	-
Rhacophoridae	Dudhwa Tree Frog	*Chiromantis dudhwaensis* (Ray, 1992) *Chirixalus dudhwaensis* (Ray, 1992)	DD	NL	p, q	-
	Himalayan Tree Frog	*Polypedates maculatus* ssp. *himalayensis* (Annandale, 1912) *Polypedates maculatus* (Gray, 1830)	LC	NL	a, d, f, g, h, k, n, o, q, s	-
	Bengal Whipping Frog	*Polypedates taeniatus* (Boulenger, 1906)	LC	NL	p, q	-
	Himalayan Toad	*Bufo cyphosus* (Ye, 1977) *Duttaphrynus himalayanus* (Günther, 1864)	LC	NL	h, i, n, q	-
	Black-spectacled Toad	*Ansonia kamblei* (Ravichandran and Pillai, 1990) *Duttaphrynus melanostictus* (Schneider, 1799)	LC	NL	a, d, f, g, h, j, n, o, p, q, r, s	+
	Marbled Toad	*Duttaphrynus stomaticus* (Lütken, 1864) *Bufo stomaticus* (Lütken,	LC	NL	b, d, f, g, h, i, n, o, p, q, s, u	+
	Marbled Toad	*Duttaphrynus stomaticus* (Lütken, 1864) *Bufo stomaticus* (Lütken, 1864)	LC	NL	b, d, f, g, h, i, n, o, p, q, s, u	+

	Indian Skipping Frog	*Euphlyctis cyanophlyctis* ssp. *microspinulata* (Khan, 1997) *Euphlyctis cyanophlyctis* (Schneider , 1799)	LC	NL	a, d, f, g, h, j, k, n, o, p, q, s, t	+
	Indian Green Frog	*Euphlyctis hexadactylus* (Lesson, 1834)	LC	Schedule IV	d, f, u	-
	Asian Grass Frog	*Fejervarya limnocharis* (Gravenhorst, 1829) *Rana limnocharis* (Gravenhorst, 1829)	LC	NL	d, f, g, h, j, k, n, o, q, s, t	-
	Hill Cricket Frog	*Fejervarya syhadrensis* (Annandale, 1919)	LC	NL	n	-
	Terai Cricket Frog	*Fejervarya teraiensis* (Dubois, 1984)	LC	NL	l, o, p, q	-
	Jerdon's Bullfrog	*Hoplobatrachus crassus* (Jerdon, 1854 "1853")	LC	Schedule IV	d, f, g, i, k, n, q, s	-
	Indian Bullfrog	*Rana gracilis* (Stoliczka, 1870) *Hoplobatrachus tigerinus* (Daudin, 1802)	LC	Schedule IV	a, d, f, g, h, k, m, n, o, p, q, s, t	+
	Annandale's Paa Frog	*Nanorana annandalii* (Boulenger, 1920) *Rana annandalii* (Boulenger, 1920)	NT	NL	n	-
	Blanford's Paa Frog	*Rana yadongensis* (Wu, 1977) *Nanorana blanfordii* (Boulenger, 1882)	LC	NL	h, n	-
	Sikkim Paa Frog	*Nanorana liebigii* (Günther, 1860) *Megalophrys gigas* (Blyth, 1854)	LC	NL	n	-
	Nepal Paa Frog	*Rana tuberculata* (Tilak and Roy, 1985) *Nanorana minica* (Dubois, 1975)	VU	NL	e, h, n	-
	Himalaya Paa Frog	*Nanorana vicina* (Stoliczka, 1872)	LC	NL	q	-
	Green Puddle Frog	*Osteosternum amoyense* (Wu, 1929) *Occidozyga lima* (Gravenhorst, 1829)	LC	NL	f	-
	Indian Burrowing Frog	*Sphaerotheca strachani* (Murray, 1884) *Sphaerotheca breviceps* (Schneider, 1799)	LC	NL	d, f, g, h, i, n, o, q, s	-
	Marble Sand Frog	*Sphaerotheca rolandae* (Dubois, 1983)	LC	NL	q	-
	Marble Sand Frog	*Sphaerotheca rolandae* (Dubois, 1983) *Rana breviceps* ssp. *rolandae* (Dubois, 1983)	LC	NL	q	-
	Maskey's Burrowin	*Sphaerotheca maskeyi* (Schleich and Anders,	LC	NL		+

	Ant Frog	*Diplopelma carnaticum* (Jerdon, 1854) *Microhyla ornata* (Duméril & Bibron, 1841)	LC	NL	d, f, g, h, i, j, n, o, p, q, s	-

[a] Anderson (1871); [b] Sclater (1892); [c] Tilak & Hussain (1977); [d] Sarkar (1984); [e] Tilak & Roy (1985); [f] Sarkar et al. (1992); [g] Ray & Tilak (1995); [h] Ray (1995); [i] Ray (1999); [j] Hussain (2003); [k] Mehta & Uniyal (2007); [l] Hegde (2009); [m] Singh et al. (2009); [n] Bahuguna & Bhutia (2010); [o] Hegde & Roy (2011); [p] Das et al. (2012); [q] Kanaujia & Kumar (2013); [r] Bahuguna et al. (2014); [s] Hussain (2015); [t] Bahuguna et al. (2017); [u] Bilgrami (1991) ; [v]Pratihar & Deuti (2011)

ANNEXURE VI Probable fish species of the Ganga River

Family	Common Name/s	Scientific Name	IUCN Status	Previous Studies	Present Study
Adrianichthyidae	-	*Oryzias melastigma* (McClelland, 1839)	LC	d,e	
Ambassidae	Elongate glass perchlet	*Chanda nama* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,k	+
	Highfin glassy perchlet	*Parambassis lala* (Hamilton, 1822)	NT	a,h	+
	Indian glassy fish	*Parambassis ranga* (Hamilton, 1822)	LC	b,c,d,e,f,h,i,j,k	+
	Himalayan glassy perchlet	*Pseudambassis baculis* (Hamilton, 1822)	LC	a,b,c,d,e,i	+
Amblycipitidae	Biting catfish, Indian torrent catfish	*Amblyceps mangois* (Hamilton, 1822)	LC	a,b,d,f,i	+
Anabantidae	-	*Anabas cobojius* (Hamilton, 1822)	DD	a,b,c,d,e,f,h,i,j,k	
	Climbing perch	*Anabas testudineus* (Bloch, 1792)	DD	a,b,c,d,e,f,i	+
Anguillidae	European eel	*Anguilla anguilla* (Linnaeus, 1758)	CR	a,b,c,d,e,f,h,i,k	
	Indian mottled eel	*Anguilla bengalensis* (Gray, 1831)	NT	a,d,i	
Aplocheilidae	Blue panchax	*Aplocheilus panchax* (Hamilton, 1822)	LC	a,b,d,e,f,h,j,k	
Ariidae	Threadfin sea catfish	*Arius arius* (Hamilton, 1822)	LC	a,d	
	Gagora catfish	*Arius gagora* (Hamilton, 1822)	LC	a,d,e,h	
Badidae	Badis	*Badis badis* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,j,k	+
Bagridae	Batasio, bojori	*Batasio batasio* (Hamilton, 1822)	LC	a,e,h,i	
	Menoda catfish	*Hemibagrus menoda* (Hamilton, 1822)	LC	a,b,c,d,i	
	Day's mystus	*Mystus bleekeri* (Day, 1877)	LC	b,c,d,e,f,g,h,i,j	+
	Gangetic mystus	*Mystus cavasius* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j,k	+
	Long-whiskered catfish	*Mystus gulio* (Hamilton, 1822)	LC	d,e,g,h,j,k	
	Tengara mystus	*Mystus tengara* (Hamilton, 1822)	LC	a,b,d,f,h,i,k	+
	Striped dwarf catfish	*Mystus vittatus* (Bloch, 1794)	LC	b,c,d,e,f,g,h,i,j,k	+
	Rita	*Rita rita* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j,k	+
	Long-whiskered Catfish	*Sperata aor* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j,k	+
	Giant river-catfish	*Sperata seenghala* (Sykes, 1839)	LC	b,c,d,e,f,g,h,i,j,k	+
Balitoridae	-	*Aborichthys elongatus* (Hora,1921)	LC	h	
	Mottled loach, Sand loach, Striped loach	*Acanthocobitis botia* (Hamilton, 1822)	LC	a,c,d,e,f,h,i	+
	-	*Nemacheilus doonensis* (Tilak & Husain, 1977)	DD	d	
	Moorangi	*Nemacheilus mooreh* (Sykes, 1839)	LC	i	
	-	*Schistura corica* (Hamilton, 1822)	LC	a,d,f,i	

Belonidae	Banded needlefish	*Strongylura leiura* (Bleeker, 1850)	NL	d,h	
	Freshwater garfish	*Xenentodon cancila* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j,k	+
Carcharhinidae	Gangetic shark	*Glyphis gangeticus* (Müller & Henle, 1839)*	CR	d	
Chacidae	Squarehead catfish	*Chaca chaca* (Hamilton, 1822)	LC	a,b,c,d	+
Channidae	Borna snakehead	*Channa amphibeus* (McClelland, 1845)	LC	a,b,d	
	Barca snakehead	*Channa barca* (Hamilton, 1822)	DD	b,d	
	Dwarf snakehead	*Channa gachua* (Hamilton, 1822)	LC	a,b,c,f,k	
	Bull's eye snakehead, Great snakehead	*Channa marulius* (Hamilton, 1822)	LC	a,b,c,d,f,g,h,i,k	+
	Asiatic snakehead	*Channa orientalis* (Bloch & Schneider, 1801)	NL	b,d,e,f,h,i,j,k	+
	Spotted snakehead, Goroi	*Channa punctata* (Bloch, 1793)	LC	a,b,c,d,e,f,g,h,i,j,k	+
	Golden snakehead, Assamese snakehead, sengalee	*Channa stewartii* (Playfair, 1867)	LC	b,d,e,i	
	Snakehead murrel, Shoal	*Channa striata* (Bloch, 1793)	LC	a,b,c,d,e,f,g,h,i,k	+
Cichlidae	Green chromide, Pearlspot cichlid	*Etroplus suratensis* (Bloch, 1790)	LC	a,j	
	Mozambique tilapia	*Oreochromis mossambicus* (Peters, 1852)	NT	i	+
	Tilapia	*Oreochromis niloticus* (Linnaeus, 1758)	NL	h,i	+
Clariidae	Clarias catfish	*Clarias batrachus* (Linnaeus, 1758)	LC	b,d,e,f,g,h,i,k	
	African catfish	*Clarias gariepinus* (Burchell, 1822)	LC	h,i	+
	Mangur	*Clarias magur* (Hamilton, 1822)	EN	a	+
Clupeidae	Shortnose gizzard shad	*Anodontostoma chacunda* (Hamilton, 1822)	LC	a,d,e,h,i,j,k	
	The Ganges river sprat	*Corica soborna* (Hamilton, 1822)	LC	a,d,f,h,j	
	White sardine	*Escualosa thoracata* (Valenciennes, 1847)	LC	e,h	
	Ganges river gizzard shad	*Gonialosa manmina* (Hamilton, 1822)	LC	a,d,h,i	
	Indian river shad	*Gudusia chapra* (Hamilton, 1822)	LC	a,c,d,e,f,g,h,i,j	+
	Hilsa	*Tenualosa ilisha* (Hamilton, 1822)	LC	a,c,d,e,f,g,h,I,j	+
Cobitidae	Almorha loach, Pakistani loach, Yo-Yo loach	*Botia almorhae* (Gray, 1831)	LC	b,d,i	
	Bengal loach, Queen loach	*Botia dario* (Hamilton, 1822)	LC	a,b,c,d,f,h,i	+
	Hora loach	*Botia dayi* (Hora, 1932)	NL	b,c,d,f,h	+
	Y-loach	*Botia lohachata* (Chaudhuri,	NL	b,c,d,f,h,i	+

		1912)			
	Gangetic loach	*Botia rostrata* (Günther, 1868)	VU	b,d,h	+
	Peppered loach, Guntea loach, Scavenger loach	*Lepidocephalichthys guntea* (Hamilton, 1822)	LC	a,c,d,e,f,h,i,j,k	+
	-	*Pangio pangia* (Hamilton, 1822)	LC	a,f,h	+
Cynoglossidae	Gangetic tongue-sole	*Cynoglossus cynoglossus* (Hamilton, 1822)	NL	a,d,h	
	Long tonguesole	*Cynoglossus lingua* (Hamilton, 1822)	NL	a,d,e	
	Speckled tongue-sole	*Cynoglossus puncticeps* (Richardson, 1846)	NL	d,e	
Cyprinidae	Indian carpltet	*Amblypharyngodon microlepis* (Bleeker, 1853)	LC	c,d,i	
	Mola carplet, Pale carplet	*Amblypharyngodon mola* (Hamilton, 1822)	LC	a,b,c,f,i,j,k	+
	Jaya, choto-piali.	*Aspidoparia jaya* (Hamilton, 1822)	LC	a,b,c,d,f,h,i	+
	Kalabans	*Bangana dero* (Hamilton, 1822)	LC	a,c,d,e,f,h,i	+
	Common barb, Spotted barb	*Barbodes binotatus* (Valenciennes, 1842)	LC	i	
	Barred baril	*Barilius barila* (Hamilton, 1822)	LC	a,b,d,f,h,i	
	Barna baril	*Barilius barna* (Hamilton, 1822)	LC	a,b,d,e,f,i	
	Hamilton's barila, Dudhnea, Gheur	*Barilius bendelisis* (Hamilton, 1807)	LC	a,b,c,d,e,f,h,i	+
	Shacra baril	*Barilius shacra* (Hamilton, 1822)	LC	a,b,d,f,h	
	Tileo baril	*Barilius tileo* (Hamilton, 1822)	LC	a,d,h,i	
	Vagra baril	*Barilius vagra* (Hamilton, 1822)	LC	a,b,d,f,h,i	+
	Morar, Ray-finned fish	*Cabdio morar* (Hamilton, 1822)	LC	a,b,c,d,f,h,i	+
	Chaguni, Lal puti	*Chagunius chagunio* (Hamilton, 1822)	LC	a,b,d,e,f,h,i,j	+
	Silver hatchet, Chela	*Chela cachius* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i	
	Mrigal, Mirka	*Cirrhinus mrigala* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Reba carp	*Cirrhinus reba* (Hamilton, 1822)	LC	a,b,c,d,f,i,j	+
	Gangetic latia	*Crossocheilus latius* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,	+
	Grass carp	*Ctenopharyngodon idella* (Valenciennes, 1844)	NL	h,i	+
	Wild common carp	*Cyprinus carpio* (Linnaeus, 1758)	VU	h,i	+
	-	*Cyprinus carpio* (Var. *specularis*) (Linnaeus, 1758)	NL	h,i	
	Dangila danio	*Danio dangila* (Hamilton, 1822	LC	a,b,c,d,f	
	Zebra fish, Anju	*Danio rerio* (Hamilton,	LC	a,c,e,h	

		1822)			
	-	*Devario affinis* (Blyth, 1860)	DD	d,e	
	Debari, Devario	*Devario devario* (Hamilton, 1822)	LC	a,b,c,d,f,h,i	+
	Flying barb	*Esomus danrica* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j,k	
	Annandale garra, Tunga garra	*Garra annandalei* (Hora, 1921)	LC	b,c,f	
	Gotyla	*Garra gotyla* (Gray, 1830)	LC	b,c,d,i	+
	Lamta garra	*Garra lamta* (Hamilton, 1822)	LC	a,b,f,h	
	Catla	*Gibelion catla* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Silver carp	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	NT	h,i,j	+
	Bighead carp	*Hypophthalmichthys nobilis* (Richardson, 1845)	DD	h,i	+
	Angra labeo	*Labeo angra* (Hamilton, 1822)	LC	a,b,d,f,h,i	
	Minor carp, Bata, Bata labeo	*Labeo bata* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Boga labeo	*Labeo boga* (Hamilton, 1822)	LC	a,d,e,f	+
	Boggut labeo	*Labeo boggut* (Sykes, 1839)	LC	d,i	
	Karnataka labeo, Orange-fin labeo	*Labeo calbasu* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Kali, Boalla	*Labeo dyocheilus* (McClelland, 1839)	LC	b,d,f,h,i	+
	Fringed-lipped peninsula carp	*Labeo fimbriatus* (Bloch, 1795)	LC	a,i	+
	Kuria labeo	*Labeo gonius* (Hamilton, 1822)	LC	a,c,d,f,h,i	+
	Pangusia labeo	*Labeo pangusia* (Hamilton, 1822)	NT	a,b,d,f,h,i	+
	Rohu	*Labeo rohita* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Indian hatchetfish	*Laubuca laubuca* (Hamilton, 1822)	LC	a,b,c,d,f,h,i,j,k	+
	Bengala barb	*Megarasbora elanga* (Hamilton, 1822)	LC	a,d,h,i	
	Gila khani, Cotio	*Osteobrama cotio* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j	+
	Rosy barb, Red barb	*Pethia conchonius* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j,k	+
	Golden dwarf barb	*Pethia gelius* (Hamilton, 1822)	LC	a,b,d,f,k	
	Glass-barb	*Pethia guganio* (Hamilton, 1822)	LC	a,b,d,f	
	Spottedsail barb, Dwarf barb, Phutuni barb	*Pethia phutunio* (Hamilton, 1822)	LC	a,b,d,f,h,i,k	
	Ticto barb, Firefin barb, Tic-tac-toe barb, Two-spot barb	*Pethia ticto* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j,k	+
	Chola barb, Green barb, Swamp barb	*Puntius chola* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i	+
	Puntio barb	*Puntius puntio* (Hamilton, 1822)	NL	a,d,i	

	Spotfin swamp barb, Pool barb, Stigma barb	*Puntius sophore* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,k	+
	Onespot barb, Teri barb	*Puntius terio* (Hamilton, 1822)	LC	a,b,d,f,h,i,k	+
	Indian trout	*Raiamas bola* (Hamilton, 1822)	LC	a,b,c,d,f,g,h,i	+
	Slender barb, Blackline rasbora, Striped rasbora	*Rasbora daniconius* (Hamilton, 1822)	LC	a,b,d,f,h,i,k	+
	Gangetic scissortail rasbora	*Rasbora rasbora* (Hamilton, 1822)	LC	a,b,d,h,i	
	Large razorbelly minnow	*Salmophasia bacaila* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j,k	+
	Finescale razorbelly minnow	*Salmostoma phulo* (Hamilton, 1822)	LC	a,d,e,f,h,i,j	+
	Alghad snowtrout, Chush snowtrout	*Schizopyge niger* (Heckel, 1838)	NL	f	
	Dapeghat snowtrout, Grot snowtrout, Ladakh snowtrout, Sattar snowtrout	*Schizothorax curvifrons* (Heckel, 1838)	NL	f,i	
	Chirruh snowtrout	*Schizothorax esocinus* (Heckel, 1838)	NL	f	
	Kunar snowtrout	*Schizothorax labiatus* (McClelland, 1842)	NL	f	
	Hill trout	*Schizothorax plagiostomus* (Heckel, 1838)	NL	f,i	+
	Dinnawah snowtrout	*Schizothorax progastus* (McClelland, 1839)	LC	d,i	
	Common snowtrout	*Schizothorax richardsonii* (Gray, 1832)	VU	b,d,f,g,h,i	+
	Gora-chela	*Securicula gora* (Hamilton, 1822)	LC	b,c,d,e,h,i	+
	Olive barb, Peninsular olive barb	*Systomus sarana* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j,k	+
	Dark mahasheer	*Tor chelynoides* (McClelland, 1839)	NL	b,f,i	+
	Putitor mahseer, Golden mahaseer	*Tor putitora* (Hamilton, 1822)	EN	a,b,c,d,f,g,h,i	+
	Mahseer	*Tor tor* (Hamilton, 1822)	NT	a,b,c,d,f,g,h,i	+
Dasyatidae	Gangetic stingray	*Himantura fluviatilis* (Hamilton, 1822)*	NL	a,d	
Eleotridae	Brown spinecheek Gudgeon, Dusky sleeper	*Eleotris fusca* (Forster, 1801)	LC	e,h,j,k	
Engraulidae	Anchovy, Frill-tailed anchovy	*Coilia ramcarati* (Hamilton, 1822)	NL	a,d,e	
	Short-hairfin anchovy	*Setipinna brevifilis* (Valenciennes, 1848)	NL	d,h,i	+
	Gangetic anchovy, Gangetic hairfin anchovy	*Setipinna phasa* (Hamilton, 1822)	LC	c,d,e,f,g,h,i,j	+
	Scaly hairfin anchovy	*Setipinna taty* (Valenciennes, 1848)	LC	d,e	
	Hamilton's thryssa, Phansha	*Thryssa hamiltonii* (Gray, 1835)	NL	d,e	
Erethistidae	Giant moth catfish	*Erethistes pusillus* (Müller &	LC	c,e,h,i	+

		Troschel, 1849)			
	-	*Erethistoides pipri* (Hora, 1950)	DD		+
	Kosi hara	*Hara hara* (Hamilton, 1822)	LC	a,b,c,d,f	
	Sylhett hara	*Hara jerdoni* (Day, 1870)	LC	a,b,d	
Gerreidae	Gangetic silvery-biddy, Small bengal silvery-biddy	*Gerres setifer* (Hamilton, 1822)	NL	a	
Gobiidae	-	*Amblyeleotris gymnocephala* (Bleeker, 1853)	NL	d	
	Cheeng	*Apocryptes bato* (Hamilton, 1822)	NL	a,d,f,h,j	+
	Boddart's goggle-eyed goby, Blue-spotted mudskipper	*Boleophthalmus boddarti* (Pallas, 1770)	LC	a,d,k	
	Bareye Goby, Belay	*Glossogobius giuris* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j,k	+
	Rubicundus eelgoby	*Odontamblyopus rubicundus* (Hamilton, 1822)	NL	a,d,e,h,j,k	
	-	*Pseudapocryptes lanceolatus* (Cuvier, 1816)	LC	e,h,j,k	
	-	*Stigmatogobius sadanundio* (Hamilton, 1822)	NL	a,d,k	
Hemiramphidae	Black-barred halfbeak	*Hemiramphus far* (Forsskål, 1775)	NL	j	
	Congaturi halfbeak	*Hyporhamphus limbatus* (Valenciennes, 1847)	LC	c,d,i	
Heteropneustidae	Stinging catfish	*Heteropneustes fossilis* (Bloch, 1794)	LC	a,b,c,d,e,f,g,h,i,j,k	+
Latidae	Barramundi, Bhetki	*Lates calcarifer* (Bloch, 1790)	NL	a,d,e,g,h,j	
Leiognathidae	Deep pugnose ponyfish	*Secutor ruconius* (Hamilton, 1822)	NL	a,j	
Loricariidae		*Pterygoplichthys anisitsi* (Eigemann & Kennedy, 1903)	NL	i	
Mastacembelidae	Goichi	*Macrognathus aculeatus* (Bloch, 1786)	NL	a,c,f	
	Spiny Eel	*Macrognathus aral* (Bloch & Schneider, 1801)	LC	b,d,e,g,h,i,j,k	+
	Barred spiny eel or Indian spiny eel	*Macrognathus pancalus* (Hamilton, 1822)	LC	b,c,d,e,g,h,i,j,k	+
	Spiny eel	*Mastacembelus armatus* (Lacepède, 1800)	LC	a,b,c,d,e,f,g,h,i,j,k	+
Mugilidae	-	*Liza tade* (Forsskål, 1775)	DD	d,e	
	River mullet	*Mugil cephalus* (Linnaeus, 1758)	LC	a,d,e	
	Largescale mullet	*Planiliza macrolepis* (Smith, 1846)	NL	a,d,e,g,h	
	Corsula mullet	*Rhinomugil corsula* (Hamilton, 1822)	LC	a,c,d,e,f,g,h,i,j	+
	Yellowtail mullet	*Sicamugil cascasia* (Hamilton, 1822)	LC	a,b,c,d,f,h,i,j	+
Muraenesocidae	Daggertooth pike-conger	*Muraenesox cinereus* (Forsskål, 1775)	NL	k	
Nandidae	Gangetic leaf fish, Nanda, Mottled nandus	*Nandus nandus* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j,k	+

Balitoridae	Mura, Murangi	*Nemacheilus denisoni* (Day, 1867)	LC	i	
	-	*Schistura devdevi* (Hora, 1935)	NT	i	
	-	*Schistura gangetica* (Menon, 1987)	NL	d,h	
	-	*Schistura multifasciata* (Day, 1878)	LC	f	
	Puinya	*Schistura rupecula* (McClelland, 1838)	LC	d,f,i	
	Savon khorka	*Schistura savona* (Hamilton, 1822)	LC	a,d,f	
	Dari	*Schistura scaturigina* (McClelland, 1839)	LC	f,h	
Notopteridae	Indian featherback, Kandla	*Chitala chitala* (Hamilton, 1822)	NT	a,e,g,h,i,k	+
	Ocellated featherback, Clown featherback fish, Clown knifefish, Spotted knifefish	*Chitala ornata* (Gray, 1831)	LC	b,c,d,f,h,j	
	Bronze featherback,Feather back, Grey feather back	*Notopterus notopterus* (Pallas, 1769)	LC	a,b,c,d,e,f,g,h,i,j,k	+
Ophichthidae	Bengal's snake-eel	*Pisodonophis boro* (Hamilton, 1822)	LC	a,d,h,j,k	
Osphronemidae	Sunset gourami	Trichogaster chuna (Hamilton, 1822)	LC	a,d,f,h,k	+
	Banded gourami, Giant gourami, Stripled gourami	*Trichogaster fasciata* (Bloch & Schneider, 1801)	LC	a,c,d,e,f,h,i,j,k	+
	Thick-lipped gourami	*Trichogaster labiosus* (Day, 1877)	LC	d	
	Dwarf gourami	*Trichogaster lalius* (Hamilton, 1822)	LC	a,d,h,k	+
Pangasiidae	Pungas, Pongas	*Pangasius pangasius* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j,k	
Platycephalidae	Bartail flathead	*Platycephalus indicus* (Linnaeus, 1758)	DD	d,h,j	
Plotosidae	Canine catfish eel	*Plotosus canius* (Hamilton, 1822)	NL	a,d,k	
Polynemidae	Bamin	*Eleutheronema tetradactylum* (Shaw, 1804)	NL	d,e	
	Indian salmon	*Polynemus paradiseus* (Linnaeus, 1758)	NL	a,e,g,j,k	
Pristigasteridae	Bigeye ilisha, Indian ilisha	*Ilisha megaloptera* (Swainson, 1839)	LC	a,c,d,h	
Psilorhynchidae	Balitora minnow	*Psilorhynchus balitora* (Hamilton, 1822)	LC	a,b,d,f	
	Sucatio minnow	*Psilorhynchus sucatio* (Hamilton, 1822)	LC	a,b,d	
Salmonidae	Rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)	NL	i	+
Scatophagidae	Spotted Butter Fish, Spotted Scad	*Scatophagus argus* (Linnaeus, 1766)	LC	a,d,g,h,j	
Schilbeidae	Gangetic ailia	*Ailia coila* (Hamilton, 1822)	NT	a,b,c,d,e,f,h,i,j,k	+

	Garua Bachcha, Guarchcha	*Clupisoma garua* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Kocha garua	*Clupisoma montana* (Hora, 1937)	LC	b,f	
	Murius vacha	*Eutropiichthys murius* (Hamilton, 1822)	LC	a,d,h,i,j	+
	Vacha, tunti	*Eutropiichthys vacha* (Hamilton, 1822)	LC	a,b,c,d,e,f,g,h,i,j	+
	Indian potasi	*Neotropius atherinoides* (Bloch, 1794)	LC	e,h,j	+
	Silond catfish, Silondia vacha, Silong catfish	*Silonia silondia* (Hamilton, 1822)	LC	a,b,c,d,f,g,h,i,j	+
Sciaenidae	Big-eyed jewfish, Coitor croacker, Ganges croaker	*Johnius coitor* (Hamilton, 1822)	LC	a,c,d,f,h,i	+
	Gangetic bola	*Johnius gangeticus* (Talwar, 1991)	NL	d,h,i,j	+
	Bronze croaker	*Otolithoides biauritus* (Cantor, 1849)	NL	d,e	
	Pama	*Otolithoides pama* (Hamilton, 1822)	NL	d,f	
	Panna croacker	*Panna microdon* (Bleeker, 1849)	NL	d,e,i	
Sillaginidae	Gangetic sillago, Gangetic whiting	*Sillaginopsis panijus* (Hamilton, 1822)	NL	a,d,e,g,h,j	
Siluridae	Indian butter-catfish	*Ompok bimaculatus* (Bloch, 1794)	NT	a,b,c,d,e,f,g,h,i,k	+
	Pabdah catfish	*Ompok pabda* (Hamilton, 1822)	NT	a,b,d,e,f,g,h,i,j,k	+
	Pabo catfish	*Ompok pabo* (Hamilton, 1822)	NT	a,b,c,d,e,i	
	Parhin, Helicopter catfish	*Wallago attu* (Bloch & Schneider, 1801)	NT	a,b,c,d,e,f,g,h,i,j,k	+
Sisoridae	Devil catfish, Dwarf goonch	*Bagarius bagarius* (Hamilton, 1822)	NT	a,b,c,d,e,f,g,h,i,j,k	+
	Giantdevil catfish, Goonch	*Bagarius yarrelli* (Sykes, 1839)	NT	b,h,i	+
	Indian gagata	*Gagata cenia* (Hamilton, 1822)	LC	a,b,c,d,e,f,h,i,j	+
	Gangetic gagata	*Gagata gagata* (Hamilton, 1822)	LC	a,b,d,h,j	
	-	*Gagata sexualis* (Tilak, 1970)	LC	b,d,f,h,j	+
	-	*Glyptothorax alaknandi* (Tilak, 1969)	LC	b,d	
	-	*Glyptothorax annandalei* (Hora, 1923)	LC	b,f	
	-	*Glyptothorax brevipinnis* (Hora, 1923)	DD	d,f,i	
	-	*Glyptothorax cavia* (Hamilton, 1822)	LC	a,b,d,f,h	+
	-	*Glyptothorax conirostris* (Steindachner 1867)	DD	b,f	
	-	*Glyptothorax garhwali* (Tilak, 1969)	LC	b,d	
	Catfish	*Glyptothorax gracilis* (Günther, 1864)	DD	b,d	+

	-	*Glyptothorax horai* (Fowler, 1934)	LC	d,f	
	-	*Glyptothorax madraspatanus* (Day, 1873)	EN	f	
	River cat fish, Nayid	*Glyptothorax pectinopterus* (McClelland, 1842)	LC	d,f,i	
	Telchitta, Dhal magur	*Glyptothorax telchitta* (Hamilton, 1822)	LC	a,b,f,h,i,j	
	Three lined catfish	*Glyptothorax trilineatus* (Blyth, 1860)	LC	f	
	Kosi nangra	*Nangra nangra* (Hamilton, 1822)	LC	a,b,c,d,f,i	
	Sisor catfish	*Sisor rabdophorus* (Hamilton, 1822)	LC	a,b,c,d,h,i	
Soleidae	Oriental-sole	*Brachirus orientalis* (Bloch & Schneider, 1801)	NL	h,j	
Sparidae	Yellowfin seabream	*Acanthopagrus latus* (Houttuyn, 1782)	DD	a,d,j	
Synbranchidae	Rice swampeel, Asian swamp eel	*Monopterus albus* (Zuiew, 1793)	LC	i	
	Gangetic mudeel, Cuchi	*Monopterus cuchia* (Hamilton, 1822)	LC	a,d,e	
Syngnathidae	–Crocodile-tooth Pipefish	*Microphis cuncalus* (Hamilton, 1822)	LC	d,j	
Synodontidae	Bombay duck	*Harpadon nehereus* (Hamilton, 1822)	NL	a,d,g	
Terapontidae	Tiger perch, Crescent grunter, Jarbua terapon	*Terapon jarbua* (Forsskål, 1775)	LC	a,d,e	
Tetraodontidae	Ocellated pufferfish	*Leiodon cutcutia* (Hamilton, 1822)	LC	a,c,d,f,h,i,j,k	+
	Green pufferfish, Ceylon pufferfish, Spotted pufferfish	*Tetraodon fluviatilis* (Hamilton, 1822)	LC	a,c,d,f,i,k	
Toxotidae	Spotted archerfish	*Toxotes chatareus* (Hamilton, 1822)	NL	a,d,h	

[a]Hamilton (1822); [b]Menon (1962); [c]Bilgrami (1991); [d]Talwar (1991); [e]Mishra et al (2003); [f]Payne et al (2004); [g]Vass et al (2010); [h]Das et al (2010); [i]Sarkar et al (2012); [j]Nath & Patra (2015); [k]Dubey et al (2015)

*Note: Only two species *viz*, *Glyphis gangetica* (Gangetic shark) and *Himantura fluviatilis* (Gangetic stingray) have been placed in Schedule I of the Indian Wildlife (Protection) Act, 1972 (IWPA).