Yamuna River

Ecological status and trends

नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

ASSESSMENT OF THE ECOLOGICAL STATUS OF YAMUNA RIVER FOR CONSERVATION PLANNING

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Wildlife Institute of India, Dehra Dun

This document is an output of the project Biodiversity Conservation and Ganga Rejuvenation sponsored by the National Mission for Clean Ganga, Ministry of Jal Shakti, Government of India, New Delhi.

Citation:

WII-GACMC (2022). Yamuna River: Ecological status and trends. Ganga Aqualife Conservation Monitoring Centre, Wildlife Institute of India, Dehra Dun, India. Pp.64

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YAMUNA RIVER

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ACKNOWLEDGEMENTS

Ministry of Jal Shakti
Shri Gajendra Singh Shekhawat, Hon'ble Minister
Shri Pankaj Kumar, Secretary

National Mission for Clean Ganga (NMCG)
Shri G. Asok Kumar, Director General
Shri D.P. Mathuria, Executive Director (Technical)
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Delhi Forest Department

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State Project Management Groups of Uttarakhand & Uttar Pradesh
Districts Administration
Irrigation and Water Resource Department Haryana

Support Staff
Ganga Praharis, Local community members, Frontline Forest staff

NMCG–WII Project Faculty and Team

Preface

Rivers are one of the most vital and vibrant ecosystems on earth yet largely overlooked and exploited. Considered as the lifeline of human civilizations for ages, rivers have supported some of the most ancient civilizations like the Indus valley and Egypt and they continue to support humanity in the present era. They hold great importance not just in terms of the various ecosystem services provided by them but also as a refuge for a diversity of aquatic micro and macro taxa, including fishes, amphibians, reptiles, birds, mammals and various plant species.

In the northern plains of India, the Yamuna River travels 1429 km from its origin to its confluence. Originating at Yamunotri in the Yamunotri glacier (near Saptrishi Kund), the river passes through the steep mountain range of the Himalayas, gentle terrain of the Aravalli range, Gangetic plain and joins the Ganga River at Prayagraj. Over the decades, Yamuna River has undergone changes, including ecological alterations, resulting in poor water quality and posed threat to its existence. Despite having an ecological, economic and religious significance as the longest tributary of Ganga River. The Yamuna River has been studied for its deteriorating water quality, but only a handful of ecological studies have been conducted. These studies restricted to the small patches or segments in and around Delhi NCR highlights the alarming situation of the Yamuna River. Previous studies have indicated reduction in flow in the upper-middle stretches from Yamuna Nagar due to over utilization of ground water and extraction of water at barrages. There are six barrages in Yamuna River namely Dakpathar, Hathinikund barrage, Wazirabad barrage, ITO barrage, Okhla barrage and Gokul barrage. There are eight protected areas along the river namely Govind Pashu Vihar National Park and Wildlife Sanctuary, Asan Conservation Reserve, Kalesar Wildlife Sanctuary and National Park, Okhla Bird Sanctuary, Sur Sarovar Bird sanctuary (Ramsar site) and National Chambal Sanctuary. These PAs are the repository of aquatic species.

As a part of the National Mission for Clean Ganga (NMCG), in the first phase, detailed biodiversity profiling of the Ganga River was carried out and subsequently the importance of its tributaries like the Yamuna River in supporting biodiversity was realized. With this in mind, in phase II the project “Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga” was envisaged to prepare a holistic restoration plan for the Yamuna River through the support and involvement of stakeholders of all the Yamuna states. The Wildlife Institute of India through the Biodiversity Conservation and Ganga Rejuvenation Project and this report attempts to compile biodiversity of Yamuna River through literature review and Rapid Biodiversity Assessment. This report aims to develop a thorough knowledge base for the priority species of Yamuna River, aid in biological restoration, and assist policy planners and managers to judiciously use water from the Yamuna River, in view of the needs of the aquatic species therein.

Ruchi Badola
Syed Ainul Hussain

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EXECUTIVE SUMMARY

The Yamuna River, one of the largest tributaries of Ganga, holds a socio-cultural and ecological importance at regional and global scales. Our literature review and rapid biodiversity assessment highlight that, though key aquatic faunal species such as Gangetic dolphin, smooth-coated otter and gharial continue to exist in the Yamuna River, their distribution range has reduced significantly in the past few decades. Along with these, at least nine species of turtles and several fish species including the threatened Golden mahseer and snow trout are also present in the river. Ecological studies have revealed that the river's biodiversity value is on a decline largely due to rapid deterioration of water and habitat quality, inadequate flow, loss of fisheries, increased pollution and significant changes in biotic communities.

The conservation priority species were found to be distributed mainly in the lower stretch of Yamuna River from Pachnada, Etawah to Prayagraj. During the first post-monsoon biodiversity assessment, a total of 53 sightings of Gangetic dolphins were recorded in the lower stretch of the river. Most of these sightings were in wide straight single channels where main river width was 360.47 ± 14.45 (SE) meters. During the first post-monsoon rapid biodiversity assessment, 82 individuals of gharials were sighted whereas in second post-monsoon rapid biodiversity assessment, 47 individuals were recorded in the lower zone of the Yamuna River. Hence, the stretch between Bareh to Prayagraj Ganga River Confluence is considered to be of high biodiversity value and should be prioritized for conservation.

In the Upper Himalayan zone, constructions of tourist facilities, ongoing dam projects and riverbed mining activities need to be regulated to maintain the river's hydrological and ecological integrity. In the Middle zone of the river, diversion of water for irrigation and other purposes, extensive illegal sand mining, chemical intensive farming, industrial waste disposal, presence of feral dogs near the water-birds habitat are some major threats. The Lower zone of the river is heavily polluted with highly reduced flow until its confluence with the Chambal River at Pachnada in Etawah district of Uttar Pradesh. Sand mining and fishing remain major threats in this stretch. These threats should be addressed in tandem with various important stakeholders and beneficiaries and the strategies should be location specific. It is also necessary to focus on the restoration and conservation of natural habitats and creation of more protected areas along the river to provide suitable breeding ground for the threatened species.

1. INTRODUCTION

The Yamuna is a Himalayan River originating from Yamunotri glacier in the Mussoorie range of the lower Himalayas. It is the longest and second largest tributary of the Ganga River. After Ganga, Yamuna is considered the most sacred in India and believed to absolve the sins of whoever takes a dip in the river. According to Hindu mythology, Yamuna is represented as a divine goddess riding a turtle and is associated intimately with Lord Krishna. Of the entire length of the Yamuna River, the stretch between Mathura and Agra has the greatest historical and cultural importance (Haberman, 2006). Prominent pilgrimage sites along the Yamuna River are Yamunotri (Uttarakhand), Paonta Sahib (Himachal Pradesh), Mathura, Vrindavan, Bateshwar and Prayagraj (Uttar Pradesh). The Taj Mahal, one of the Seven Wonders of the World, famous for its Mughal architecture and a UNESCO world heritage site, is also located on the right bank of Yamuna in Agra, Uttar Pradesh.

The mainstem Yamuna flows through five states, namely Uttarakhand, Himachal Pradesh, Haryana, Delhi NCR and Uttar Pradesh and the river basin covers seven states of northern, western and central India (Figure 1.1). The major characteristics of the Yamuna River are given in Table 1.1.

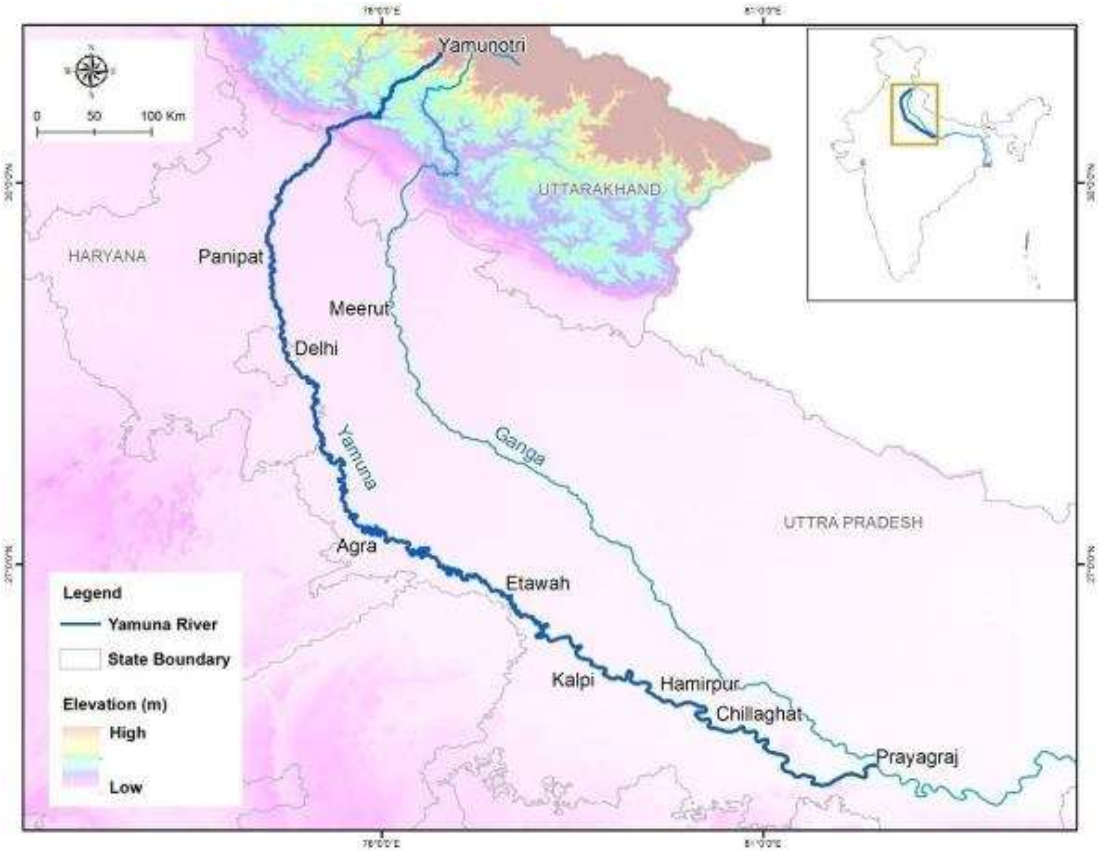

Figure 1.1 The course of the Yamuna River

Table 1.1 Characteristics of the Yamuna River

Type	Himalayan River
Passage through State/ Union Territory	Uttarakhand, Himachal Pradesh, Haryana, Delhi NCR, Uttar Pradesh
No. of Districts	38
Biogeographic zone	Himalaya (2B West Himalaya); Semi-Arid (4A Punjab Plains) & Gangetic Plains (7A Upper Gangetic Plains)
Origin	Yamunotri Glacier (Uttarkashi, Uttarakhand)
Length (km)	1429
Discharge (m^3/s) *	1249.53
Catchment area (km^2) ^	366223
No. of barrages	6
Human population density (persons/km^2)	4963
Forest cover in basin (km^2)	22814
Total irrigated area (km^2)	4402.44
Fish (no. of species) **	93
Reptiles***	Gharial[a], Mugger[b], Turtles[c]
Birds	75
Mammals	Gangetic-dolphin; Smooth coated otter; Eurasian otter
No. of Protected Areas	8

*Rai et al. (2011) ^CPCB (2006); **Sharma et al. (2017); ***[a]Adams (1867), Hornaday (1885), Whitaker (2007), Nair (2012), Bhadauria et al. (2013), Siddiqui (2019), Lang et al. (2019), Naqvi (2020); [b]Whitaker& Andrews (2003), Sharma & Singh (2015), Singh & Rao (2017); [c]Gunther (1864), Anderson (1871), Moll (1987), Iverson (1992), Hanfee (1999), Tiwari (2003), Buhlmann et al. (2009), Das & Singh (2009), Das et al. (2010), Baruah et al. (2016), Bhaskar & Mohindra (2018), Das et al. (2019), Praschag et al. (2019)

1.1 Course of the River

From its origin, the river travels 1429 km and joins the Ganga River at Prayagraj in Uttar Pradesh. It passes through the steep mountain range of Himalayas, gentle terrain of Aravalli range and Gangetic plains. The river course can be divided in three major zones - (A) Himalayan zone, (B) Middle zone and (C) Lower zone, depending upon the geomorphology of the terrain and river channel (Figure 1.2). The Himalayan and Middle zones are further subdivided into Upper and Lower sub-zones. Zone-wise characteristics of Yamuna River are given in Table 1.2.

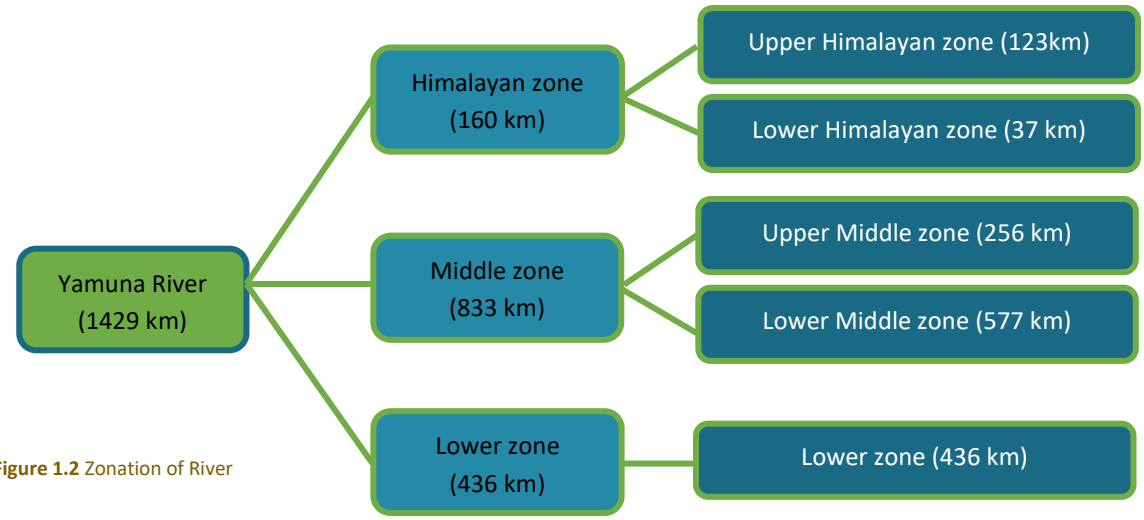

Figure 1.2 Zonation of River

Table 1.2 Zone-wise characteristics of Yamuna River

Zone	Himalayan Zone		Middle Zone		Lower Zone
Sub-Zone	Upper Himalayan Zone	Lower Himalayan Zone	Upper Middle Zone	Lower Middle Zone	-
Length (km)	123	37	256	577	436
Stretches	Yamunotri to Dak Pathar Barrage	Dak Pathar Barrage to Hathnikund Barrage	Hathnikund Barrage to Okhla Barrage	Okhla Barrage to Yamuna-Chambal Confluence	Yamuna-Chambal confluence to Ganga River confluence
Geological Characteristics	Interlocking spurs, steep rock benches, gorges, stream terrace	Terai region	Aravalli	Basaltic malwa region; Central alluvial regions; Ravines	Alluvial plains
Barrages	Nil	Dakpathar Barrage	Hathnikund Barrage; Wazirabad Barrage; ITO Barrage	Okhla Barrage; Gokul Barrage	Nil
Protected Areas	Govind Pashu Vihar National Park & Wildlife Sanctuary	Asan Conservation Reserve	Kalesar National Park and Wildlife Sanctuary; Okhla Bird Sanctuary		

1.2 Drainage and Hydrology

The Yamuna River basin covers a total catchment area of 366,223 km^2, which is about 42.5% of the Ganga basin's area and 10.7% of the total geographical area of India (CPCB, 2006). The mainstream originates from Yamunotri glacier and is joined by the tributaries Rishi Ganga, Hanuman Ganga, Tons and Giri to form the headwater of the Yamuna River in the Himalayan ranges. At Dakpathar in Uttarakhand, the river enters the Gangetic plains and a substantial amount of its water is diverted for irrigation and power generation through a canal. The river then flows through Paonta Sahib in Himachal Pradesh to reach Hathnikund in Haryana, where a second diversion is made through Eastern and Western Yamuna Canal for irrigation, often leaving the stretch between Hathnikund and Delhi dry during lean season.

It is then joined by the Somb River at Yamuna Nagar and the highly polluted Hindon River near Noida which along with groundwater accrual adds some water to the river. The river enters Delhi at Palla and at Wazirabad barrage water is again diverted to Delhi to be used for drinking, which barely leaves any water in the river. Another diversion is made at Okhla barrage in Noida to Agra canal for irrigation. At Mathura, water is again diverted through Gokul Barrage for drinking. After Wazirabad, the river has mainly domestic and industrial waste water contributed by sewage drains. At Bhareh, the river is joined by its longest tributary i.e., Chambal River and then it flows towards east to join the Ganga River at Prayagraj, Uttar Pradesh. Other main tributaries that join the Yamuna River in the Gangetic plain are Betwa, Sind and Ken. Out of all the tributaries, Tons and Chambal are the most important ones in terms of their discharges (CPCB, 2006). All these tributaries enrich the Yamuna River both in terms of hydrology and aquatic diversity, of which Chambal contributes the most in terms of aquatic diversity, among these Chambal is of high significance for its high ecological values.

1.3 Geology and Geomorphology

There are six main geomorphic sub-divisions of Yamuna River viz. Yamuna-Ganga fan, Piedmont zone, Marginal plain upland surfaces, Upland interfluves surfaces, River valley terrace surfaces and Active floodplain surfaces (Singh, 2018). Morainic deposits are present at the steep Upper Yamuna, along with geomorphic features such as interlocking spurs, steep rock benches, gorges and stream terraces. River terrace feature is also present along the river course. From the upper catchment area, the river descends onto the plains of Doon Valley, at Dakpathar near Dehradun. The Yamuna basin's altitude ranges between 6320 – 100 m above mean sea level (asl) from its origin to its confluence with Ganga at Prayagraj.

Out of total 366,233 km^2 basin area, around 11,700 km^2 (3.19%) is hilly (Himalayan zone) with an altitude of more than 600 m asl, 161,231 km^2 (44%) is plains and valley (Middle zone) with an altitude of 100-300 m asl and 172,917 km^2 (47.22%) is plateau region (Lower zone) with altitudinal variations between 300-600 m asl (Rai et al., 2010; Kumar et al., 2019). In the upper stretch, Yamuna flows through the Shivalik's and emerges on the plains (IITs, 2012) in the Terai region. The middle zone of the Yamuna River is an extension slope of Aravalli hills and alluvial plains whereas the lower zone is of a plateau of Basalt and Malwa regions and is ravenous.

1.4 Soil Types

Yamuna basin has eight types of soils: Alluvial, Calcareous seirozemic, Deep black, Medium black, Red-sandy, Red & Yellow, Red and Black and Brown Hill. Alluvial and black soils are fertile soils and cover more than 80% of the basin area. Of these two, the Alluvial soil covers 42% of the basin and is found in the plains and valleys, while medium black soil covers 25.5% area in Madhya Pradesh and north of the Chambal River in Rajasthan. Calcareous seirozemic soil covers only 0.5% of the basin area (CPCB, 2006; Rai et al., 2010; Sharma & Kansal, 2011; Kumar et al., 2019).

1.5 Climate

The geographical as well as the altitudinal extent of the river Yamuna is varied influences the climatic gradient. The Yamuna River basin is influenced by south-west monsoon which contribute 75-80% of annual rainfall, between June to September. Annual rainfall in the Yamuna River basin varies between 400-1200 mm (Chaudhary et al., 2019). Based on the climatic conditions, the Himalayan zone of Yamuna is considered as humid (upstream Himalayan catchment), while the middle zone is semi-arid (north-west to western catchment) and the lower zone is sub-humid (south-west catchment). Average maximum temperature in the entire Yamuna basin varies between 24˚C to 42.5˚C and average minimum temperature varies between -1˚C to 11.0˚C (Chaudhary et al., 2019). The highest wind velocity recorded in the plains is 125 km/hr with hot dusty winds during summer months.

1.6 Biogeography, Flora and Fauna

The Yamuna River falls under three distinct biogeographic zones, namely: the Himalaya, the Semi-arid and the Gangetic plains (Rodgers & Panwar, 1988). A total 22814 km^2 of the river basin is under forest cover (Figure 1.3).

The Himalayan zone of the Yamuna River basin falls under Himalaya biogeographic zone and West Himalaya (2B) biogeographic province. Within West Himalaya province there are five forest types namely, 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 (*P. 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 thibetanusl*) and Himalayan monal (*Lophophorus impejanus*) (Rodgers & Panwar, 1988) are some representative terrestrial species of this zone. Representative aquatic faunal species of this biogeographic zone include the golden mahaseer (*Tor putitora*), snow trout (*Schizothorax richardsonii*), mahseer (*Tor tor*) (Bilgrami, 1991; Rao, 2001), Eurasian otter (*Lutra lutra*) and smooth-coated otter (*Lutrogale perspicillata*) (Hussain, 2002; Nawab & Hussain, 2012).

The middle stretch of the Yamuna River basin falls broadly under two biogeographic zones- the Semi-arid and the Gangetic plains. In the Semi-arid zone, major portion falls in Punjab plains (4A) biogeographic province. The Punjab plains is represented by two major forest types namely, Tropical Dry deciduous forest (*Anogeissus latifolia, Anogeissus pendula, Bosewellia serrata* etc) and Tropical Thorn Forest (*Acacia* sp., *Butea monosperma, Prosopis cineraria*) (Champion & Seth, 1968).

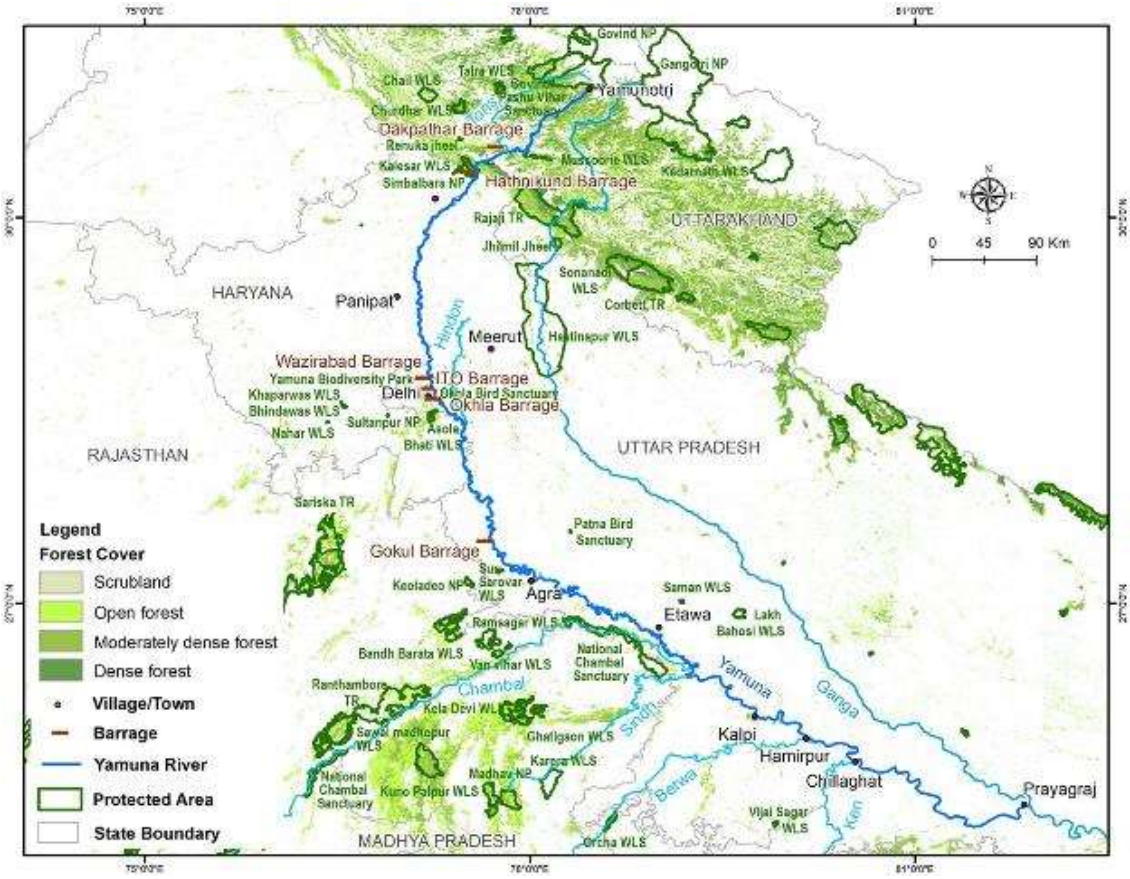

Figure 1.3 Forest Cover of Yamuna River Basin

The faunal species in the middle include the blackbuck (*Antilope cervicapra*), nilgai (*Boselaphus tragocamelus*) and the leopard (*Panthera pardus*) (Rodgers & Panwar, 1988), painted stork (*Mycteria leucocephala*), sarus crane (*Antigone antigone*). Gharial (*Gavialis gangeticus*) are the representative aquatic species of this stretch.

The lower stretch of Yamuna falls under the Upper Gangetic plains (7A) biogeographic province of the Gangetic plains biogeographic zone. This zone is represented by two major forest types viz., 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 faunal species of this zone are Indian skimmer (*Rynchops albicollis*), painted stork (*Mycteria leucocephala*), oriental darter (*Anhinga melanogaster*), Gangetic dolphin (*Platanista gangetica*) and Gharial (*Gavialis gangeticus*) (Rodgers & Panwar, 1988).

1.7 Demography

The Yamuna River flows through 38 districts of five states (Figure 1.4). 784.1 million people are estimated to reside in these districts, 70% of which reside in Uttar Pradesh (GOI, 2011). Table 1.3 shows state wise share of the population. Along the Yamuna, rate of urbanization is higher in Haryana and Delhi than Uttarakhand and Himachal Pradesh (Kumar et al., 2019). The major urban settlements situated along or near the Yamuna River are Yamuna Nagar, Sonepat, Delhi, Gautam Buddha Nagar, Faridabad, Mathura, Agra and Etawah (CPCB, 2006). Delhi has the highest population density followed by Uttar Pradesh and Haryana.

Table 1.3 Human density along the Yamuna River (Source: GOI, 2011)

Stretch	State	Person	Density (individuals/km^2)
Upper	Uttarakhand	2645711	253
Middle	Himachal Pradesh	529855	188
Lower	Haryana	8227408	1021
	Delhi	11951740	18421
	Uttar Pradesh	55056362	2504

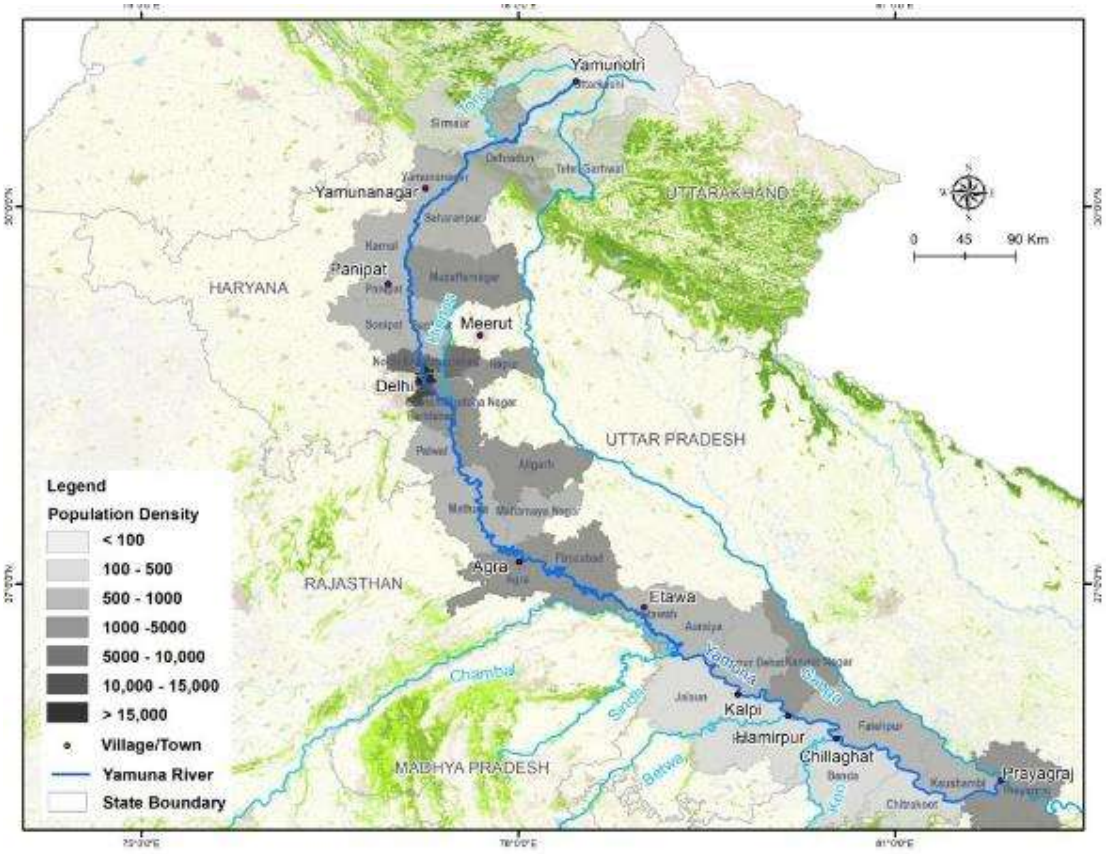

Figure 1.4 Population density along the Yamuna River

1.8 Land Use Land Cover

According to the NRSC land use land cover map of Yamuna River basin, agriculture, fallow land and forest are the major land use (Figure 1.5). Agriculture is the dominating class, covering 50.48% of the basin, followed by fallow land and forest (Figure 1.6). Majority of the built-up areas along the Yamuna River falls in Gautam Buddha

Nagar district followed by Kanpur Nagar and Delhi. Between 2005 and 2015, area under agriculture has increased the most in the basin while area under fallow land has decreased the most. A positive trend has been observed in other classes as well.

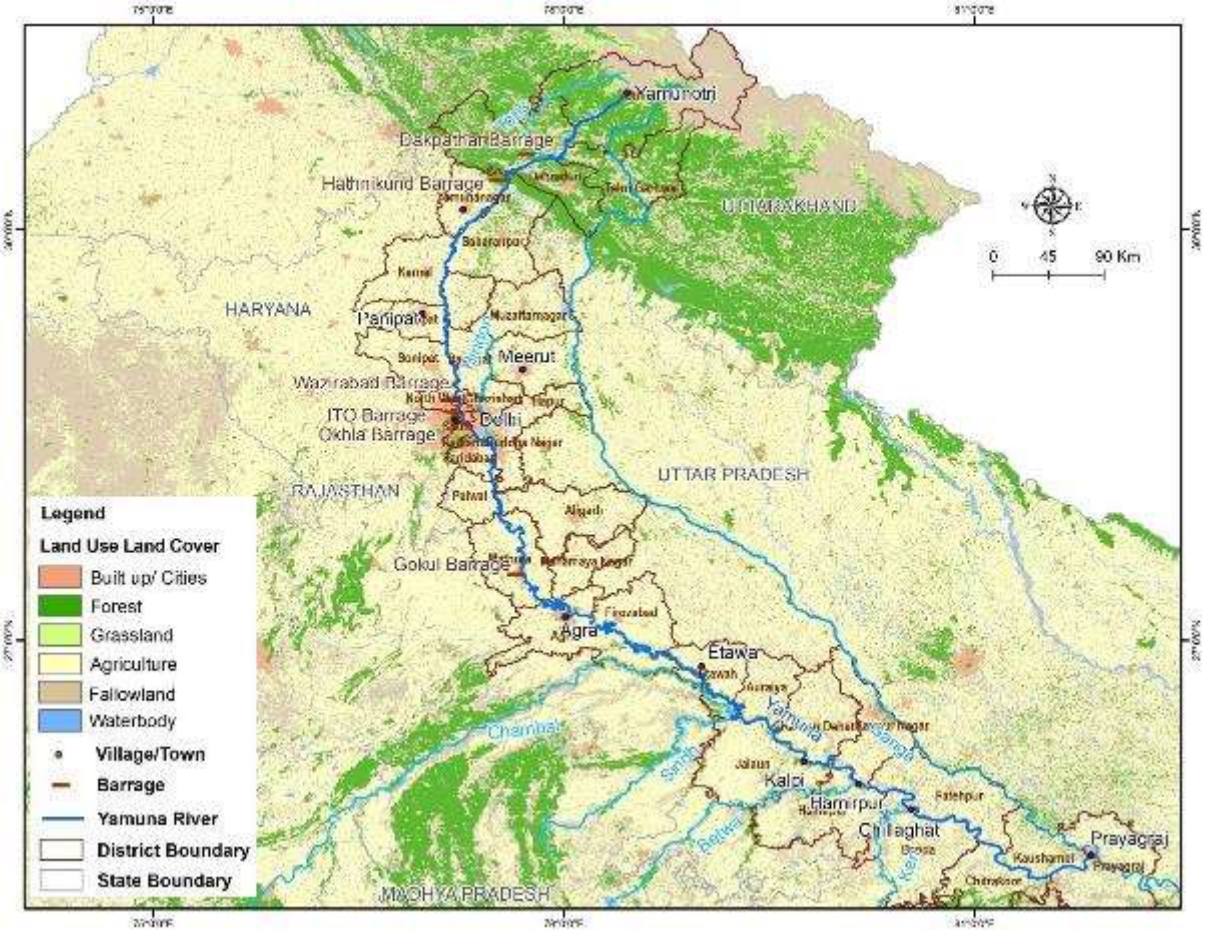

Figure 1.5 Land use land cover along the Yamuna River

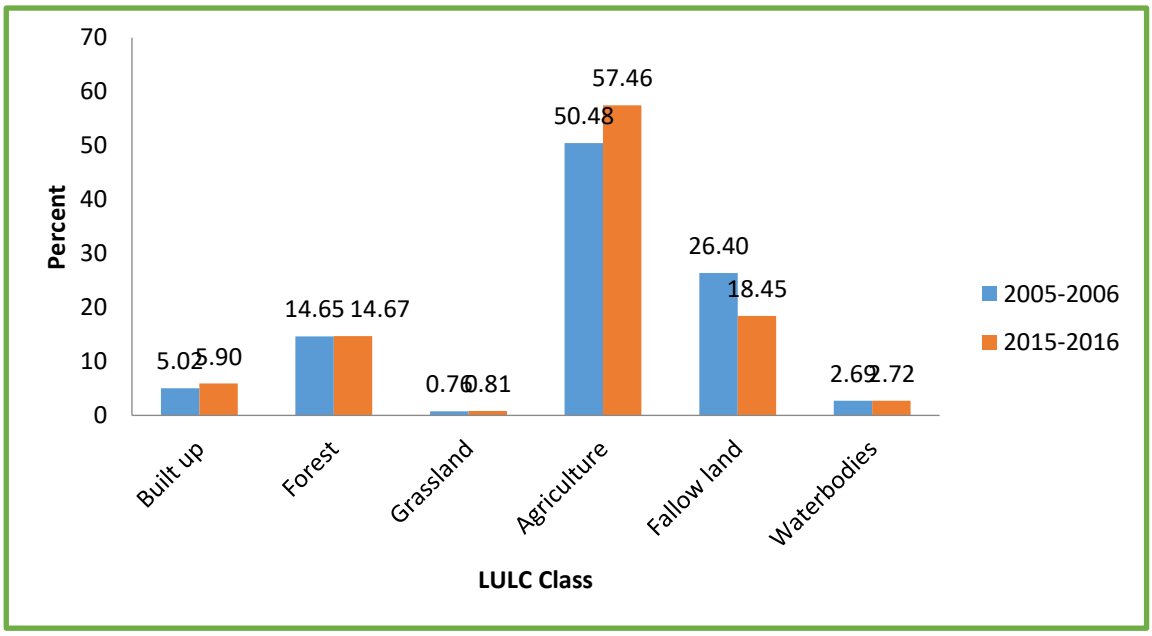

Figure 1.6 Land use land cover changes along the Yamuna River (Source: NRSC)

2. Status of Aqualife of Yamuna River

Literature review and rapid biodiversity surveys allowed an assessment of current and historical status of threatened aquatic fauna of the river. Key aquatic species such as Gangetic dolphin, smooth-coated otter and gharials are present in the Yamuna River. Along with these, at least nine species of turtles and several fish species including the threatened golden mahseer and snow trout are also found in the river. Ecological studies have revealed that river's biodiversity value is on a decline largely due to rapid deterioration of water quality, loss of fisheries, increased pollution and significant changes in biotic communities.

2.1 Methodological Framework

Extensive literature review was carried out to assess the status of key aquatic species of the Yamuna River. Online search engines and databases like Google Scholar, JSTOR were used for the collection and compilation of information. Information on historical and current distribution of species was compiled through literature review. Data from the first rapid biodiversity survey which was carried out during January- March 2020 is also incorporated in the synthesis.

The rapid biodiversity survey was carried out in the post monsoon season during January to March 2020 and October to December 2020, covering a distance of 1430 km from Janki Chatti, Uttarakhand to Prayagraj in Uttar Pradesh. Due to insufficient water depth in upper and middle stretch of the river and other logistical constraints, boat survey was not conducted. In these zones, a vehicle survey was conducted from Janki Chatti up to Yamuna-Chambal confluence covering 945 km of the river in the upper and middle stretch. In these stretches, bird survey was done by total count method at every 5 km distance alongside the river. Whenever opportunity permitted, local fishermen were interviewed regarding the type of fishing gear, fishing practice and the fish species they usually encounter in their everyday fishing. Simultaneously their catch was also catalogued.

In the lower stretch, 436 km of the Yamuna River was surveyed from Yamuna-Chambal confluence at Pachnada, Etawah to Yamuna-Ganga confluence at Prayagraj in Uttar Pradesh. This stretch was covered in six days using a motorized inflatable boat with the capacity of eight persons. The boat based direct total count method was used (Smith & Reeves 2000, Sinha & Sharma 2003) for the estimation of encounter rate of higher freshwater vertebrates. Water and habitat parameters were recorded at equal segments of 5 km for the individual segments and simultaneously river morphology data such as channel type, bank substrate, and water physical and chemical parameters namely; temperature and depth were recorded. Through the rapid biodiversity survey, a preliminary ecological status and threat profile for the Yamuna River was generated.

2.2 Mammals

From the literature review, it was found that two aquatic mammals i.e., Gangetic dolphin and smooth-coated otters are found in Yamuna River (Annexure I). Recent studies have reported presence of the Gangetic dolphin in the lower stretch of Yamuna mainstem, but no recent records of smooth-coated otters were found from the river.

Gangetic dolphin (*Platanista gangetica*)

In the 19th century, the Gangetic dolphin was found throughout the Yamuna downstream of Delhi (Anderson, 1878). The species persisted in the Yamuna near Delhi as late as 1967, when a specimen caught in fishermen's net was brought to Delhi Zoo (perscomm by Kailash Sankhla reported in Sinha, 1997). In late 20th century, several population surveys of Gangetic dolphin were conducted, but none of these surveys were systematic (Jones, 1982; Mohan, 1989; Sinha & Kannan, 2014). In last few decades, no records were found in middle stretch of the Yamuna River except in its tributaries (Sinha & Sharma, 2003). One study conducted during 1982-1985 mentioned the presence of Gangetic dolphin in Chambal River between Batesura to Bareh near the confluence with Yamuna River (Singh & Sharma, 1985; Sinha & Kannan, 2014). A survey conducted in the tributaries of

Yamuna in 1998 reported eight individuals from Ken (from confluence of Yamuna at Chilla to Sindhan), six from the Betwa (from confluence of Yamuna at Hamirpur to Orai) and five from the Sind River (Sinha et al., 2000; Behera et al., 2013). Another survey in 2012 reported 31 individuals between Chambal-Yamuna and Yamuna-Ganga confluence (Behera et al., 2013).

During the first post monsoon biodiversity assessment (January to March, 2020), a total of 53 sightings of Gangetic dolphins were recorded in the lower stretch of Yamuna River from Pachnada, Etawah to Prayagraj (Figure 2.1), these included 19 adults, 20 sub-adult and 14 calves. The maximum number of sightings (N= 47) were recorded from Menupur, Jalaun to Mehramau, Kaushambi. The encounter rate of dolphin was 0.13±0.05 (SE) sighting/km. Most of the observations were in water depth between 2 to 6 meters.

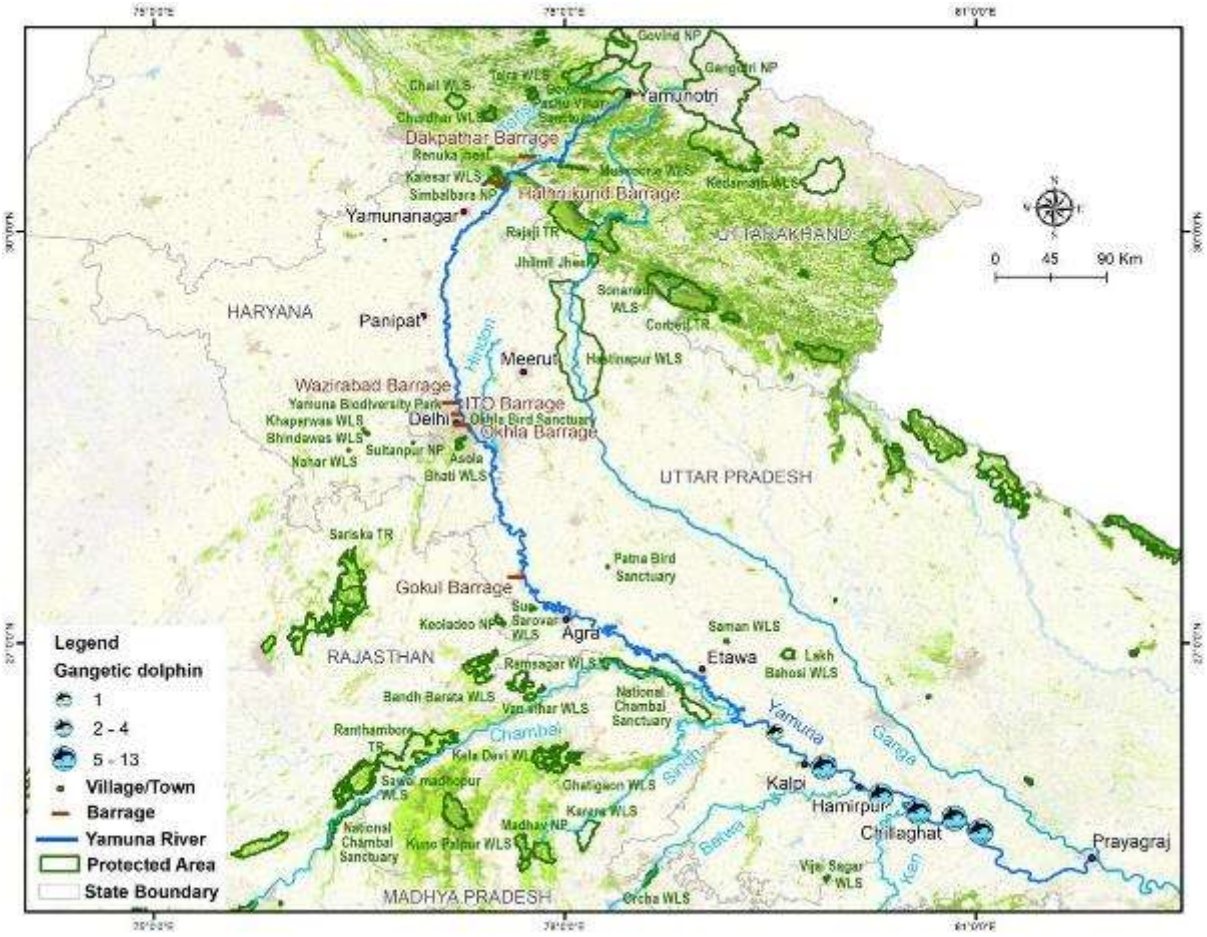

Figure 2.1 Distribution of Dolphin during first post-monsoon biodiversity assessment

During the second post-monsoon biodiversity assessment (October to December 2020), a total of 13 sightings of Gangetic dolphins were recorded (Figure 2.2). Of this total count, 54% were adults, 31% sub-adults and 15% were neonates with mean group size of 4.43 ± 0.02 (SE) sighting/km. The encounter rate of dolphins was very low compared to the first post monsoon survey which was likely due to weather conditions leading to very poor visibility. Dolphins were encountered in deep water pools where average water depth was 10.87±0.41 (SE) metres. Most of these sightings were in wide straight single channels where the average river width was 360.47±14.45 (SE) metres.

Generally, Gangetic dolphin prefers deep water river stretches and river confluences with deep water pools (Sinha 1997; Biswas & Baruah, 2000; Wakid, 2009; Kelkar et al., 2010; Chowdhury et al. 2016). However, the dolphins even use relatively shallow water pools during dry months (Choudhary et al., 2012). In the Yamuna River, Gangetic dolphin has been known to be restricted between Pachnada and Prayagraj stretch (Taigor, 2020).

During the present survey, sightings of Gangetic dolphin were also restricted to deep water pools after Kalpi. The less number of dolphin sightings could be due to low visibility due to haze and fog. However, presence of dolphin calves in the Yamuna stretch indicates breeding population. The use of gill net fishing in the Yamuna may be a threat for Gangetic dolphins as in the Ganga River (Smith & Reeves, 2000). Apart from fishing, pollution, barrages and mining also negatively impact dolphins (Kumar, 1996; Chowdhury et al., 2016; Choudhury et al., 2019). In addition, river flow alteration negatively affects both dolphins and gharials (Hussain 2009; Choudhary et al. 2012).

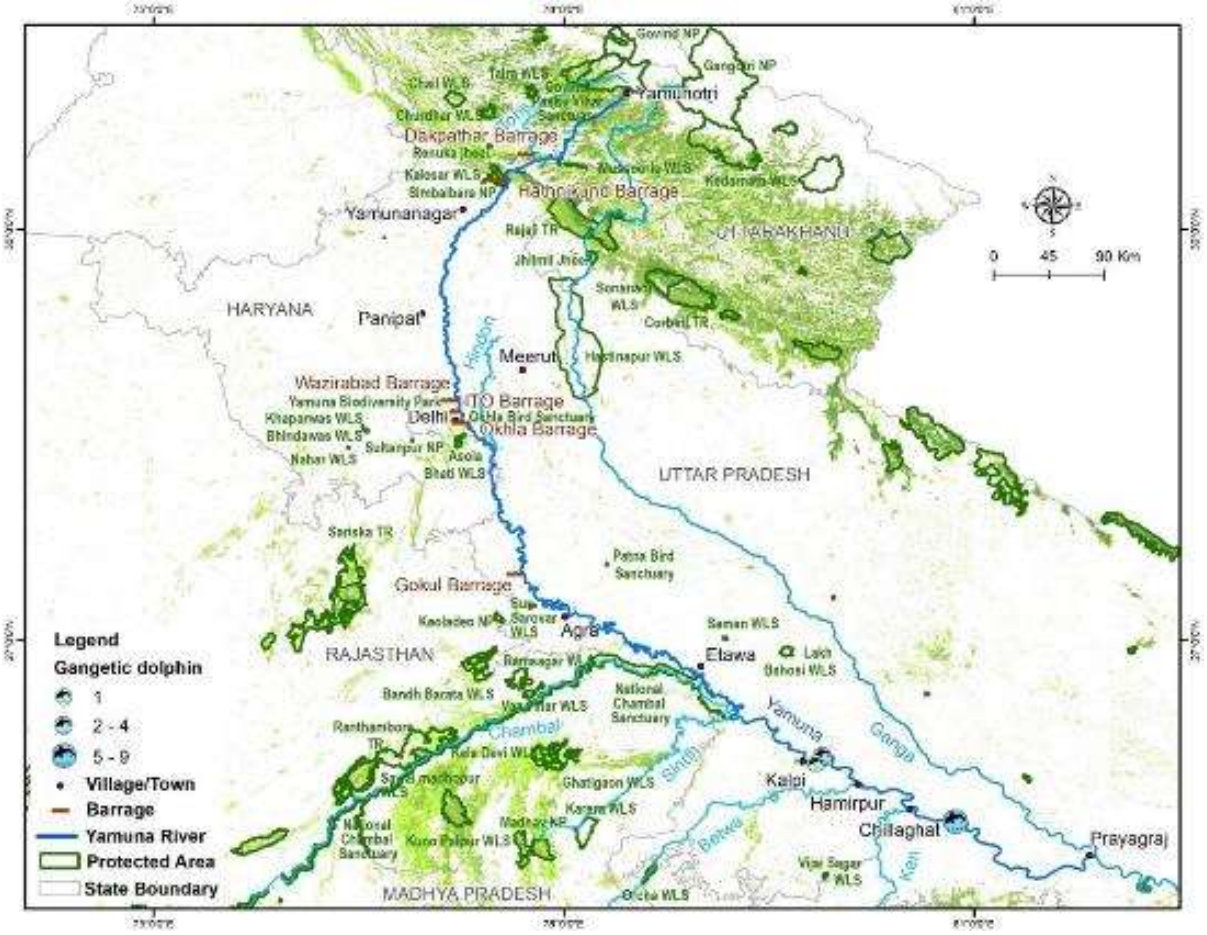

Figure 2.2 Distribution of Dolphin during second post-monsoon biodiversity assessment

Smooth-coated otter (*Lutrogale perspicillata*)

Historically, smooth-coated otter was distributed in Terai regions and in the Yamuna River, as reported in late 19th century (Atkinson, 1882). In the Yamuna basin Nawab (2013) confirmed the presence of this species in Keoladeo National Park (Bharatpur) and National Chambal Sanctuary (Kota) in Rajasthan. Otter sightings along the Yamuna River have not been reported in recent times. During this survey, the smooth-coated otters were not seen.

Eurasian otter (*Lutra lutra*)

Historically, the Eurasian otter was found in Terai regions and streams of Himalayan foothills in the Yamuna basin (Atkinson, 1882). There are no recent studies which report the presence of this species in the Yamuna River. The species was not seen during this survey.

2.3 Avifauna

Studies documenting avifauna along the Yamuna vary in spatial as well as temporal coverage. Most of these studies are from the barrages and associated water-bodies. Tak et al. (2010) recorded 31 waterbirds species from the Hathinikund barrage, Kaushik & Gupta (2013) found 60 waterbirds species from the Asan Conservation Reserve, Mazumdar (2017) found 70 waterbird species and Urfi (2003) reported 302 both water and terrestrial bird species from Okhla Barrage Bird Sanctuary. Thus, none of these studies provides the holistic information about the bird species along the entire length of the Yamuna. As a result, there is no detailed information available on the population status of waterbirds in the Yamuna River.

The present studies fulfilled this information gap. A total 156 waterbirds and water associated species have been recorded in the Yamuna River basin which includes 103 species sighted during the present biodiversity assessment (Annexure II). During the first post-monsoon biodiversity assessment, 83 species of waterbirds belonging to 11 orders, and 21 families, were recorded along the Yamuna River. Overall, Anatidae (17%) was the most abundant family, followed by Scolopacidae (16%) (Figure 2.3). Of the 83 bird species, 33% species were carnivores, 13% species were piscivores/carnivores, 11% species were piscivores/insectivores, 11% species were omnivores, 11% species were insectivores, 9% species were herbivores, 5% species were piscivores, 4% species were herbivores/carnivores, 1% species were carnivore/herbivore, 1% species were carnivore/Insectivore and rest 1% species were herbivore/insectivore (Figure 2.4).Out of the 83 species, 41% species were resident, 15% species were resident with local movement, 9% species were resident with winter influx, and 35% species were winter migrant (Figure 2.5). Out of all the recorded species, two species were “Endangered”, nine species were “Near Threatened”, three species were Vulnerable and the rest of the species were Least Concern as per the IUCN Red list of Threatened Species (Table 2.1) (Figure 2.6).

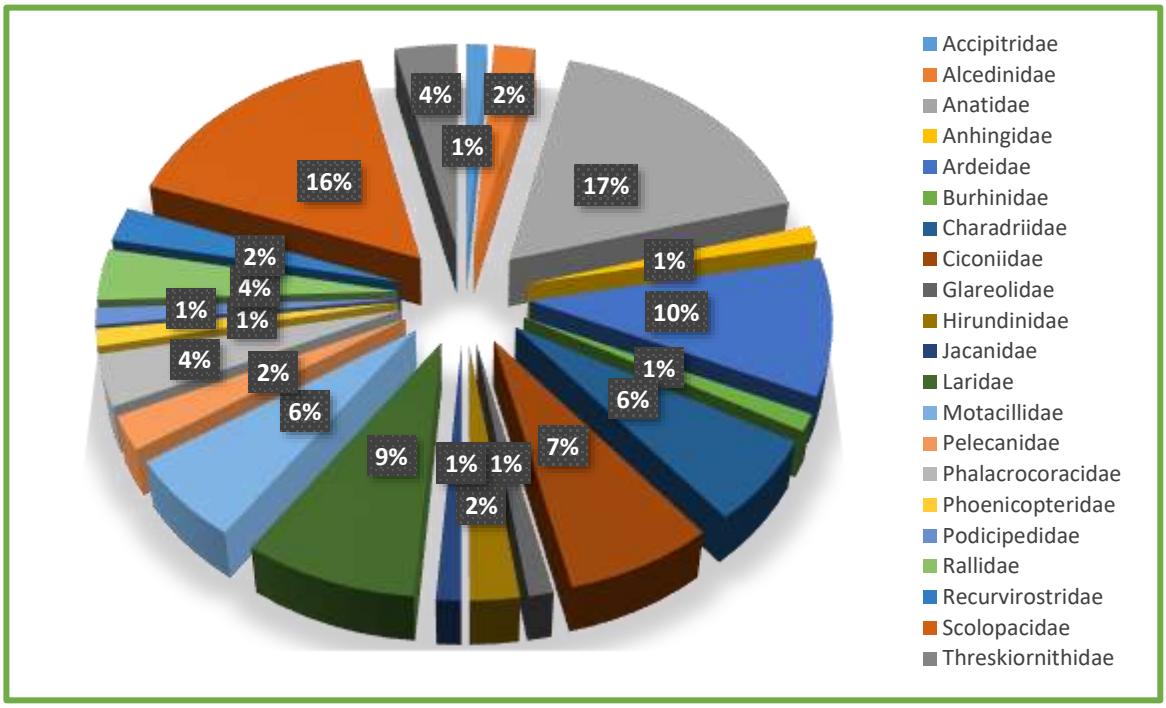

Figure 2.3 Family wise composition of waterbirds communities along the Yamuna River during first post-monsoon biodiversity assessment

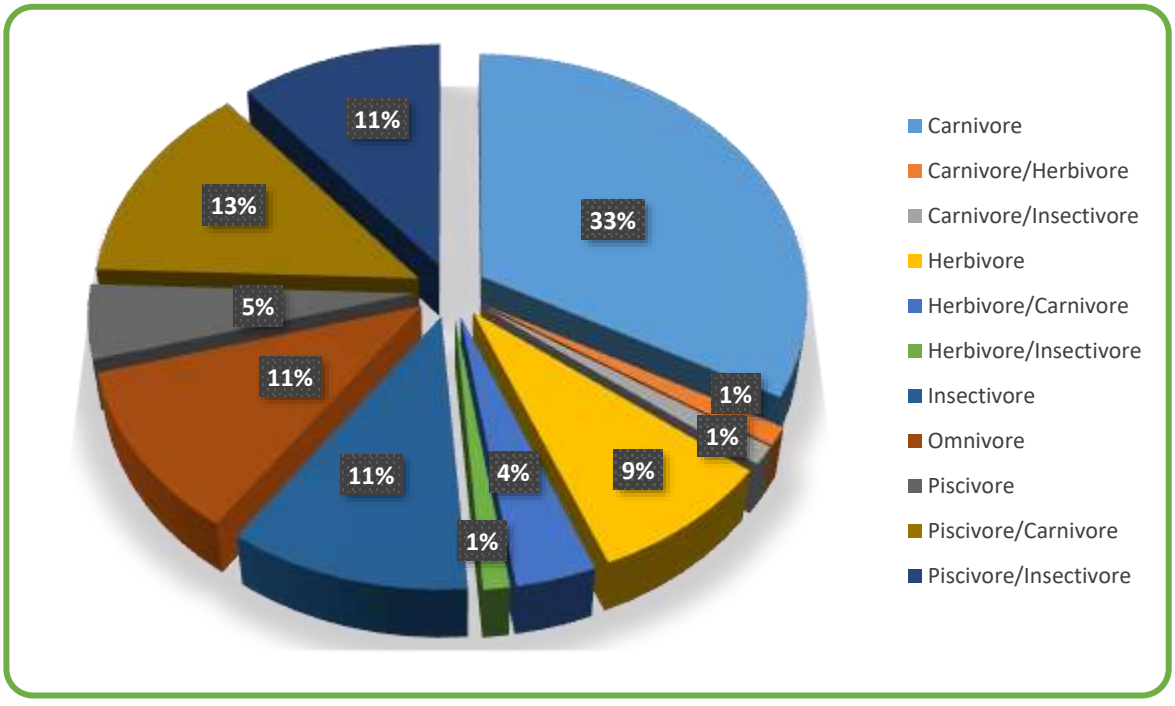

Figure 2.4 Feeding guilds composition of Waterbird communities along the Yamuna River during first post-monsoon biodiversity assessment

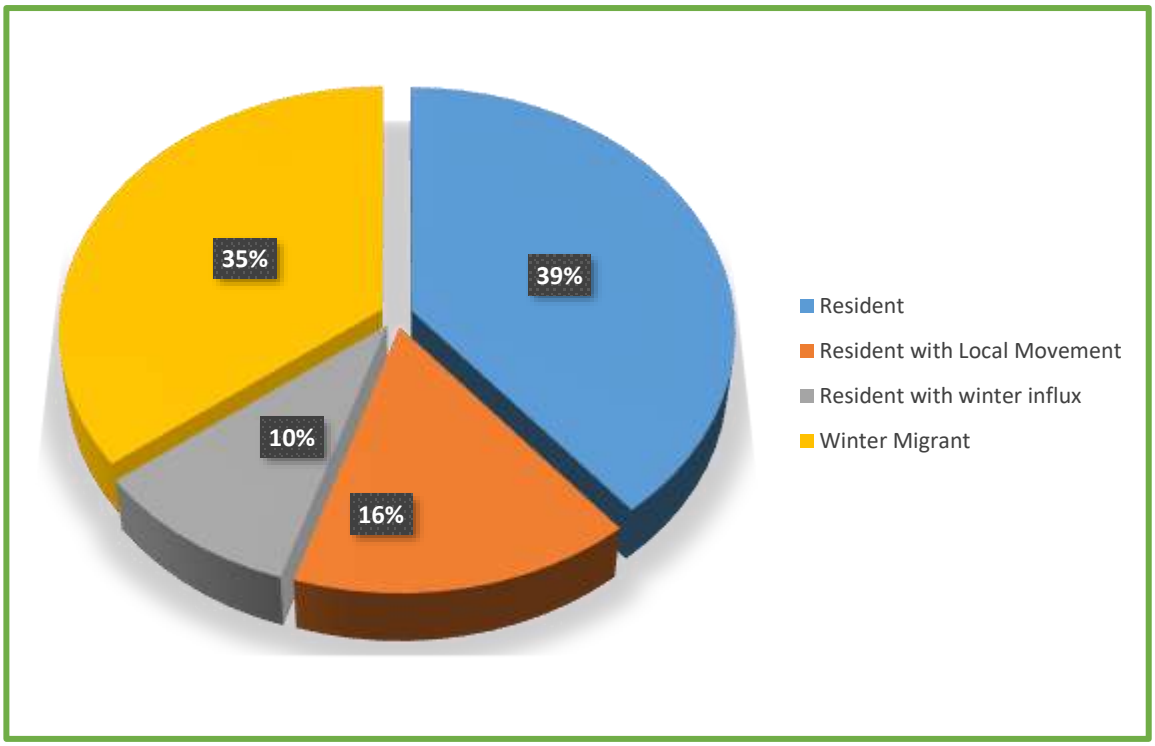

Figure 2.5 Residential Status of Waterbird communities along the Yamuna River during first post-monsoon biodiversity assessment

Table 2.1 RET Species present across the Yamuna River during first post-monsoon biodiversity assessment

Family	Species	Scientific Name	IUCN Status
Accipitridae	Steppe Eagle	*Aquila nipalensis* (Hodgson, 1833)	EN
Anatidae	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU
	Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	NT
Anhingidae	Oriental Darter	*Anhinga melanogaster* (Pennant, 1769)	NT
Burhinidae	Great Thick-knee	*Esacus recurvirostris* (Cuvier, 1829)	NT
Charadriidae	River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT
Ciconiidae	Asian Woollyneck	*Ciconia episcopus* (Boddaert, 1783)	NT
	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT
	Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	NT
Laridae	Black-bellied Tern	*Sterna acuticauda* (Gray, 1831)	EN
	River Tern	*Sterna aurantia* (Gray, 1831)	VU
Pelecanidae	Dalmatian Pelican	*Pelecanus crispus (*Bruch, 1832)	NT
Scolopacidae	Curlew Sandpiper	*Calidris ferruginea* (Pontoppidan 1763)	NT
	Eurasian Curlew	*Numenius arquata* (Linnaeus, 1758)	NT

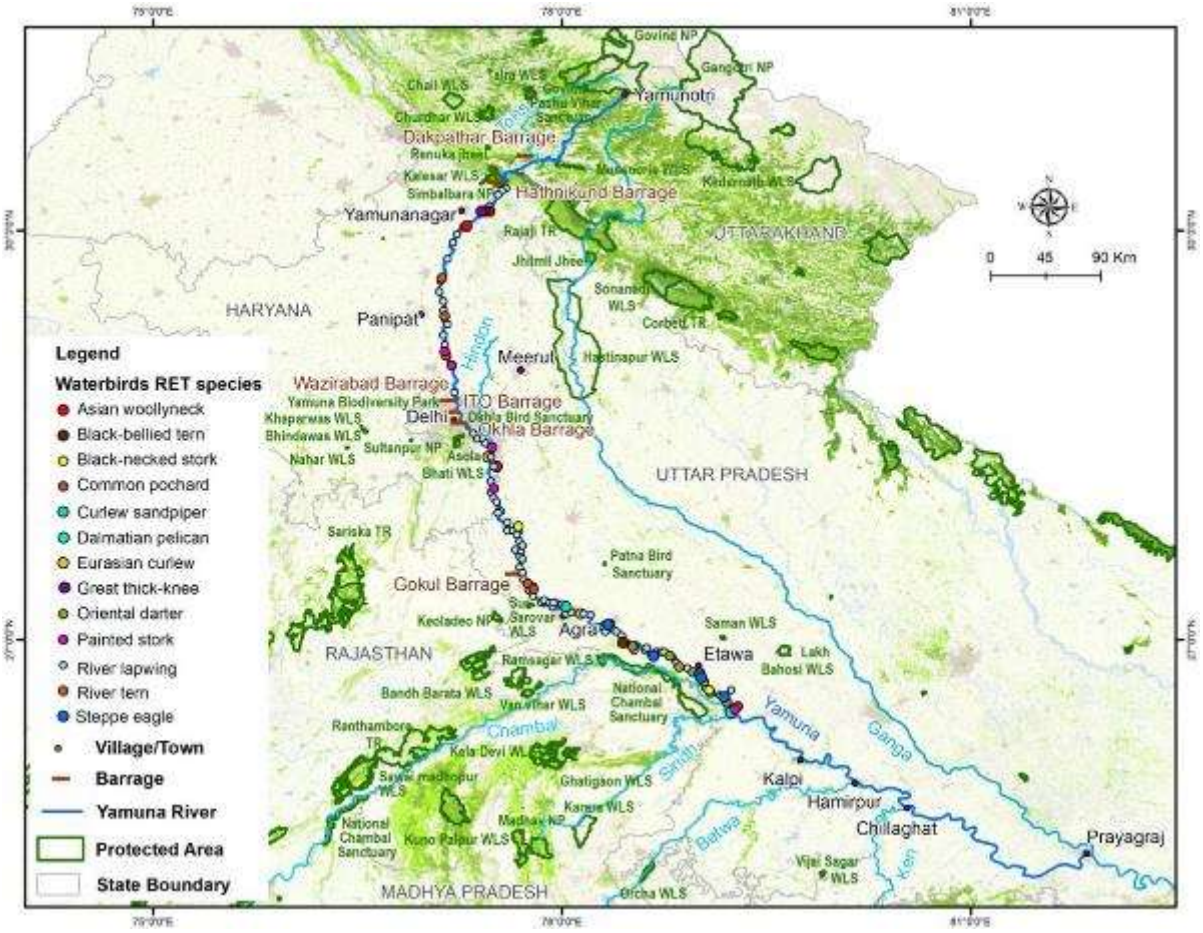

Figure 2.6 Distribution of RET species during the first post-monsoon biodiversity assessment

During the second post-monsoon biodiversity assessment, 68,310 individuals of 13 orders, 25 families, 52 genera and 94 species, were recorded along the Yamuna River. Of which, Anatidae (15%) was the most abundant family followed by Scolopacidae (12%) (Figure 2.7). The family Anatidae had the maximum number of observed individuals (n= 17,777) followed by Phalacrocoracidae (n= 12,447) and Glareolidae (n= 10,234).

Feeding guild wise, of 94 waterbird species, 31% were carnivores, 13% were omnivores, 12% were piscivores/carnivores, piscivores/insectivores and insectivores respectively, 6% were herbivores, 4% were carnivores/herbivores and piscivore respectively, 3% were herbivore/carnivore, 2 % were insectivores/herbivores and 1% were carnivore/insectivore (Figure 2.8). Out of the 94 species, 42% species were resident, 16% species were resident with local movement, 13% species were resident with winter influx, and 29% species were winter migrant (Figure 2.9).

Out of all the recorded species, 15 were RET, which included two were “Endangered”, nine were “Near Threatened” species, and four were Vulnerable, as per the IUCN Red List of Threatened Species (Table 2.2) (Figure 2.10).

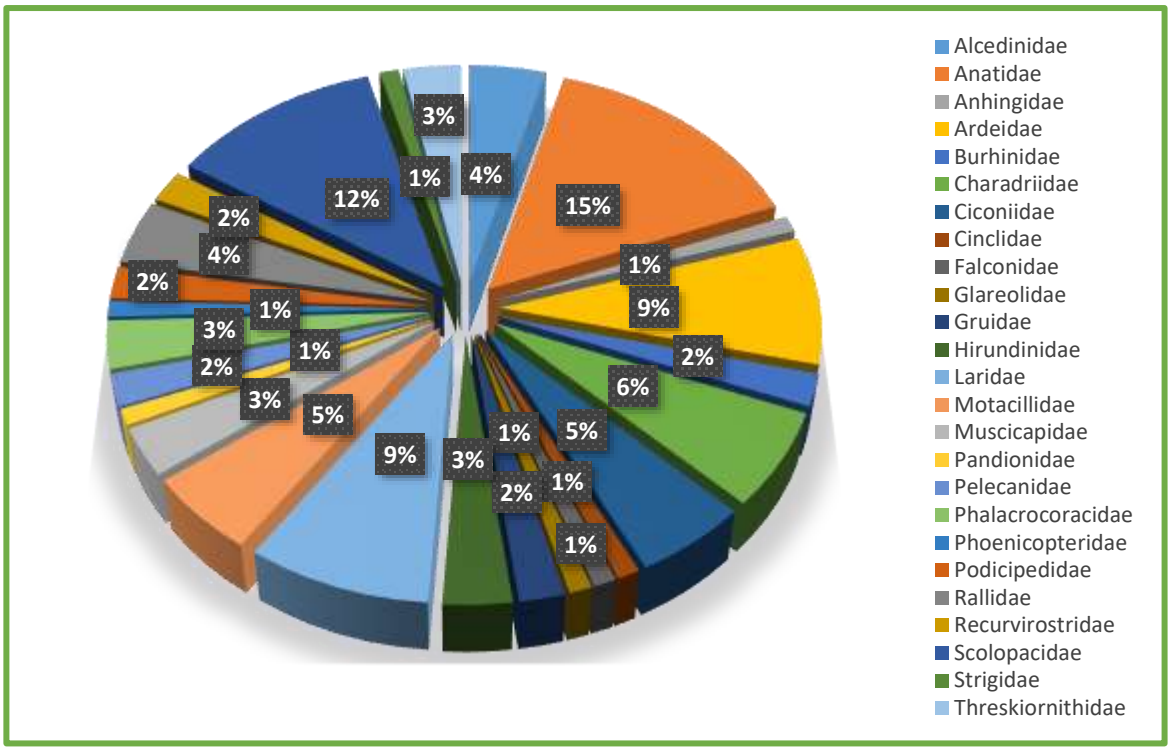

Figure 2.7 Family wise composition of waterbirds communities along the Yamuna River during second post-monsoon biodiversity assessment

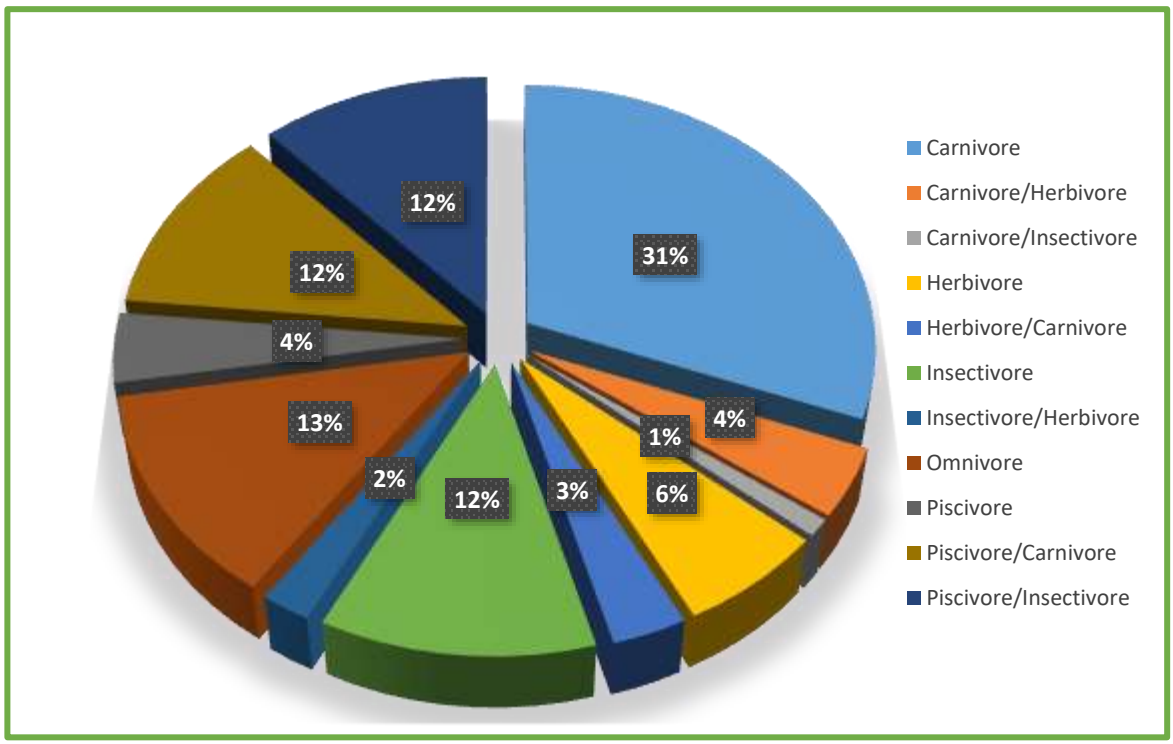

Figure 2.8 Feeding guilds composition of Waterbird communities along the Yamuna River during second post-monsoon biodiversity assessment

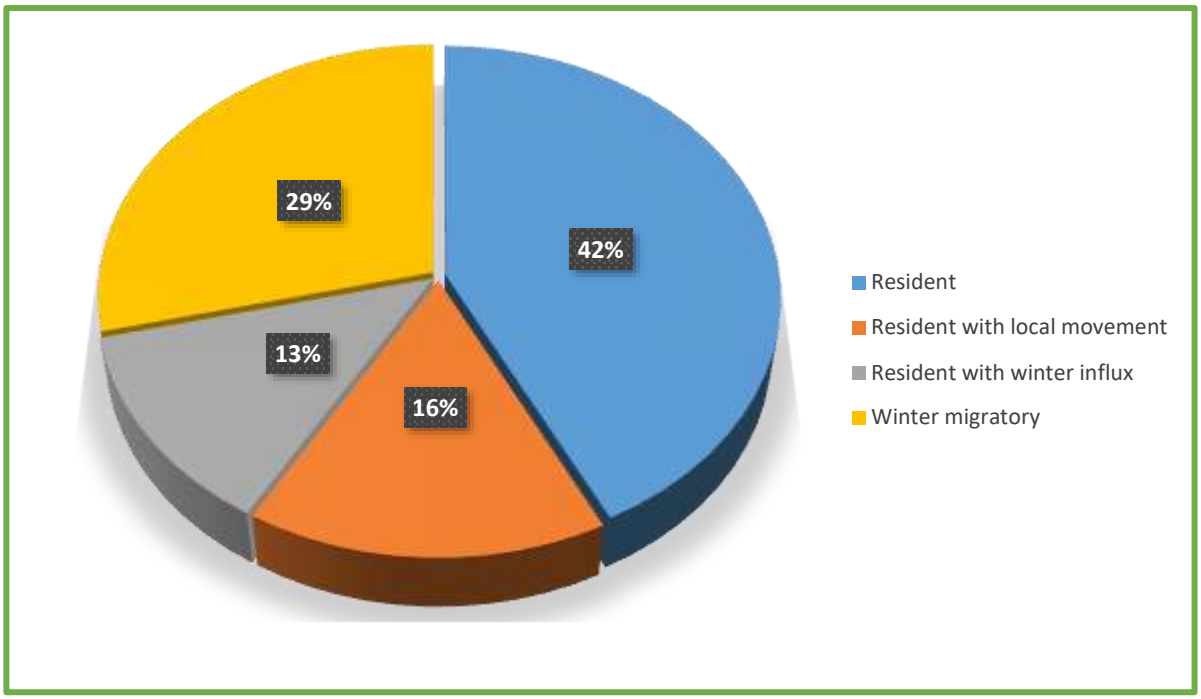

Figure 2.9 Residential Status of Waterbirds communities along the Yamuna River during second post-monsoon biodiversity assessment

Table 2.2 RET Species present across the Yamuna River during second post-monsoon biodiversity assessment

Family	Species	Scientific Name	IUCN Status
Anatidae	Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU
Anhingidae	Oriental Darter	*Anhinga melanogaster* (Pennant, 1769)	NT
Burhinidae	Great Thick-knee	*Burhinus oedicnemus* (Cuvier, 1829)	NT
Charadriidae	River Lapwing	*Vanellus duvaucelli* (Lesson, 1826)	NT
Laridae	Black-bellied Tern	*Sterna acuticauda* (Gray, 1831)	EN
	Indian Skimmer	*Rynchops albicollis* (Swainson, 1838)	EN
	River Tern	*Sterna aurantia* (Gray, 1831)	VU
Ciconiidae	Asian Woollyneck	*Ciconia episcopus* (Boddaert, 1783)	NT
	Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT
	Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	NT
Gruidae	Sarus Crane	*Antigone antigone* (Linnaeus, 1758)	VU
Pelecanidae	Dalmatian Pelican	*Pelecanus crispus (*Bruch, 1832)	NT
Scolopacidae	Curlew Sandpiper	*Calidris ferruginea* (Pontoppidan 1763)	NT
	Eurasian Curlew	*Numenius arquata* (Linnaeus, 1758)	NT
Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790)	NT

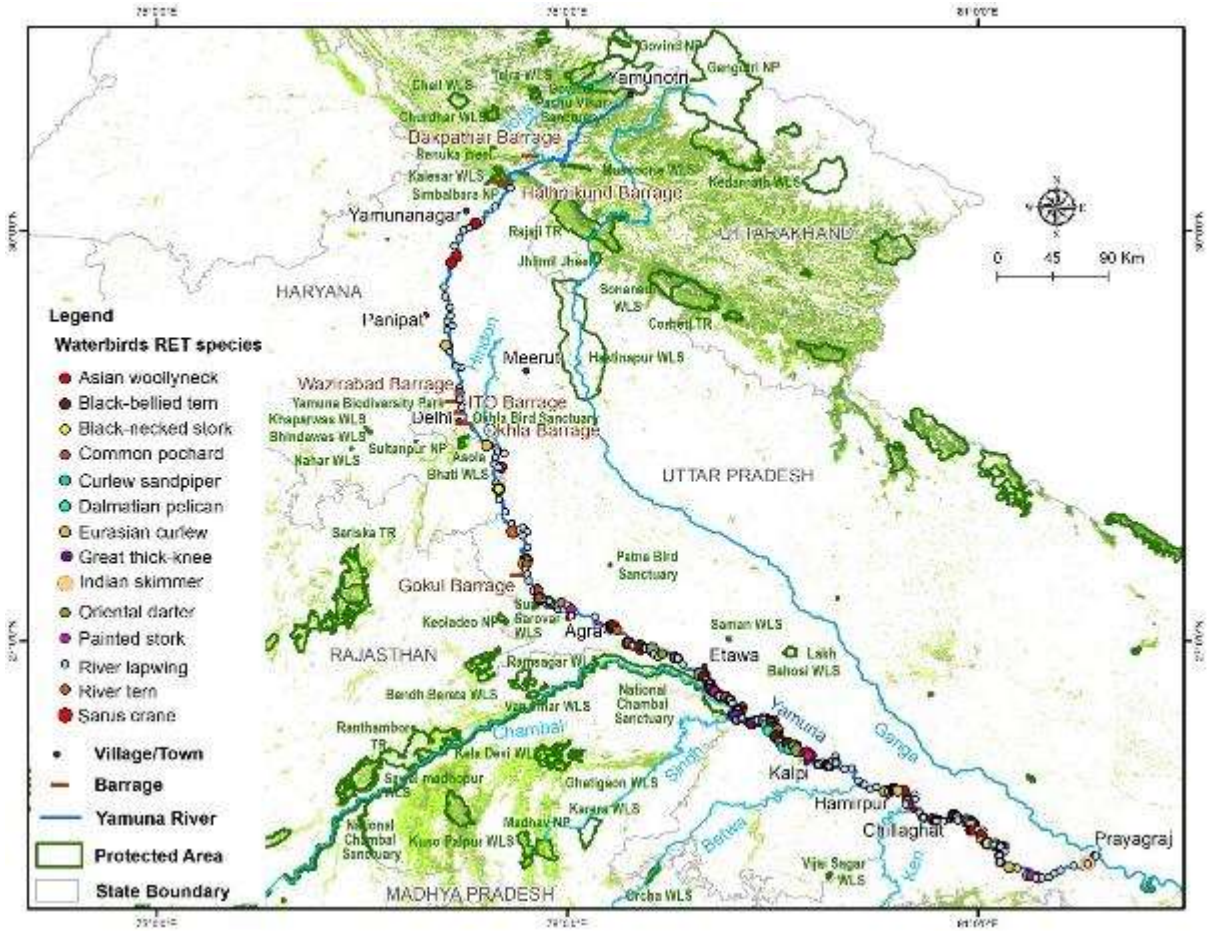

Figure 2.10 Distribution of RET species during the second post-monsoon biodiversity assessment

In comparison to first post-monsoon survey, more number of waterbird species were recorded in second post-monsoon survey of the Yamuna River. During the second post monsoon survey some of the rarely sighted species like greater flamingo, great white pelican, Indian skimmer, and dalmatian pelican were found along the Yamuna River. In terms of RET species, Indian skimmer was recorded in a sandy river island at the opposite bank of intensive sand mining site at Prayagraj. The Endangered Black-bellied tern was recorded at multiple sites. The Near-threatened Asian woolly-necked was also recorded at a few sites between Bareh to Prayagraj. Among large waterbird species, a few greater flamingo flocks were observed along the Yamuna River near Sur Sarovar Wetland in Agra and Bareh. Generally, flamingos are known to visit Sur Sarovar sanctuary during winters. The great white and dalmatian pelicans were mostly encountered between Bareh and Kalpi, during both the surveys. Painted Stork and Eurasian Spoonbill were frequently sighted, mostly resting on the sandy shorelines and islands along the Yamuna River. Two flocks of common crane were sighted in Dostpur and Bhadaura while three individuals of Indian sarus crane were recorded in the Shergarh and one individual was recorded in the Raghavpur on the banks of the Yamuna River. The mosaic of wetlands and cultivated lands of Etawah and Mainpuri districts are known to be the breeding habitats of Sarus crane (Gopi Sundar, 2011). The Near-Threatened black-necked storks were also sighted along the Yamuna River.

Being a part of Central Asian Flyway, most of the migrants dominated by Anatidae family arrive from the Central Asian wetlands to the Yamuna River during winters and depart during onset of summer season (Kalra et al., 2011; Prins & Namgail, 2017). Nonetheless, ~70% of waterbird species were 'Resident species'. The presence of carnivorous birds indicates availability of fishes, zooplanktons and zoo benthos in the Yamuna River (GRBMP, 2015). Thus, due to availability of prey, some of the large body-size waterbirds viz., pelicans, flamingos, storks and cormorants were found using different stretches of the Yamuna River.

Among scavenging raptors, Egyptian vulture (*Neophron percnopterus*) was the only species encountered during the second post-monsoon survey, it was mostly recorded from the Lower zone of Yamuna River. Among raptors, osprey (*Pandion haliaetus*) mostly dominated the lower zone of the Yamuna River from Bareh to Prayagraj whereas; upper stretch was mostly dominated by the black kite (*Milvus migrans*).

Sarus crane (*Antigone antigone*)

Most recent studies have found that the state of Uttar Pradesh remains the species stronghold, with a population estimated at over 12,246 individuals (Kumar & Kanaujia, 2017). Urfi (2003) reported the species from Okhla Barrage Bird Sanctuary. During first post-monsoon survey, no individual was recorded along the banks of the Yamuna River. However, in the second survey, four individuals were recorded along the Yamuna River.

Black-bellied tern (*Sterna acuticauda*)

Ganguli (1975) reported it as a resident, being fairly common in the Yamuna River. Kaushik & Gupta (2013) reported the species from Asan Conservation Reserve. Extensive studies are needed to assess the population trend of this species in the Yamuna River. During the first post-monsoonsurvey, only seven individuals were recorded from Rihauli in the Agra district. In second survey, 47 individuals were recorded along the Yamuna River.

Little pratincole (*Glareola lactea*)

Urfi (2003) reported the species from Okhla Barrage Bird Sanctuary. During the first post-monsoon survey, 86 individuals were recorded along the Yamuna River. The maximum sighting of 57 individuals was recorded from Aie in Firozabad district, followed by 22 individuals from Asroli and seven individuals from Rihauli in Agra district. During the second survey, 10234 individuals were recorded along the Yamuna River.

Painted stork (*Mycteria leucocephala*)

Urfi (2003) recorded a flock of up to 80 individuals from Okhla Barrage Bird Sanctuary, Majumdar (2017) also reported the species from Okhla Bird Sanctuary. Kaushik & Gupta (2013) reported the species from Asan Conservation Reserve. During the first post-monsoon survey, 50 individuals were recorded along the Yamuna River. In the middle stretch, 13 individuals were recorded from Aseva in Auraiya district, followed by 12 individuals from Rihauli in Agra district and 11 individuals from Chandauli in Auraiya district. This species was also recorded in the lower stretch of the Yamuna River. During second survey, 600 individuals were recorded from middle and lower stretches of the Yamuna River.

Indian Skimmer (*Rynchops albicolis*)

Urfi (2003) reported Indian skimmer from Okhla barrage bird sanctuary. During first post-monsoon survey no individuals were sighted. However, during second survey, 147 individuals were sighted near Prayagraj along the Yamuna River.

River lapwing (*Vanellus duvaucelii*)

Kaushik & Gupta (2013) reported the species from Asan Conservation Reserve; Tak et al., (2010) from Hathinikund Barrage; Urfi (2003) and Majumdar (2017) from Okhla Bird Sanctuary. During the first post-monsoon survey, 315 individuals were recorded along the Yamuna River. The maximum sighting of 21 individuals was recorded from Amit Nagar, followed by 15 individuals from Garhi Samstipur in Gautam Budh Nagar district, and 13 individuals from Silaita Madhaiyan in Etawah district. This species was also recorded in the lower stretch of the Yamuna River. During second survey, 47 individuals were recorded along the Yamuna River.

River Tern *(Sterna aurantia)*

The species has been reported from the Asan Conservation Reserve (Kaushik and Gupta, 2013), Hathinikund barrage (Tak et al., 2010) and from the Okhla Bird Sanctuary (Urfi, 2003; Majumdar, 2017). During the first post-monsoon survey, six individuals were recorded from themiddle stretch. Two individuals were recorded form Mustfabad in Karnal district and Memarpur in Sonipat district respectively, and one individual was recorded from Quamashpur in Panipat district and Brahmananda in Mathura district respectively. During second survey, 29 individuals were recorded in the middle and lower stretch of the river.

Great thick-knee (*Esacus recurvirostris*)

Urfi (2003) reported the species from Okhla Bird Sanctuary. During the first post-monsoon survey, one individual was sighted from Mandhauli ghat in Yamuna Nagar district. During second survey, 17 individuals were recorded from middle and lower stretch of the Yamuna River.

Black stork (*Ciconia nigra*)

The species has been reported from the Hathinikund barrage (Tak et al., 2010) and Okhla Bird Sanctuary (Urfi, 2003). During the first post-monsoon survey, five individuals were reported from Tajewala (5 km downstream of Hathinikund) in Yamuna Nagar district. However, during second survey, no individuals were recorded.

2.4 Reptiles

Crocodilians

Of the three crocodilian species present in India, Gharial and Mugger (Annexure III) are reported from Yamuna River and its tributaries. Historically found throughout the Indo-Gangetic plains and in stretches of Yamuna mainstem (Smith, 1939), their numbers have rapidly declined to just a few individuals and restricted to a few locations after Agra.

Gharial (*Gavialis gangeticus*)

Gharial was historically distributed throughout the stretch of Yamuna in the Indo-Gangetic plains and old references suggest that they were in abundant numbers (Adams, 1867; Hornaday, 1885; Whitaker, 2007). Hornaday (1885) sighted 64 gharial individuals in two hours on the banks of the Yamuna River in Uttar Pradesh. However, currently its distribution has been severely restricted to few isolated patches as fragmented breeding populations in the middle stretch with scattered individuals. Additionally, a few nesting sites have been reported in the middle stretch.

Nair (2012) reported eight gharial individuals in a 12 km stretch downstream of the Ken-Yamuna confluence, of which seven were hatchlings and one was a yearling. A survey by WWF India between Bateshwar Ghat, Agra to Dibholi Ghat, Etawah during 2011-2013 reported first record of nesting of gharial about 10 km upstream from Yamuna-Chambal confluence (Bhadauria et al., 2013). In 2019, second record of gharial nesting was made near Yamuna-Chambal confluence (Siddiqui, 2019) and again in 2020, 43 juveniles were found to have emerged and seen with the adults in the Yamuna River, near Etawah (Naqvi, 2020). In the Yamuna River basin, a major and also the largest population of gharial is present in the Chambal River, while minor populations are present in the Son and Ken rivers (Lang et al., 2019). National Chambal Sanctuary (NCS), Son River Sanctuary and Ken Gharial Sanctuary are the three protected area dedicated for gharial conservation in the basin.

A total of 82 individuals, were sighted during the first post-monsoon survey of which four were sub-adults, 14 were juvenile, 46 were yearling and 18 were hatchlings. No adults were seen (Figure 2.11). Smaller size class individuals with most sightings between Pachnada to Menupur near the confluence with Chambal suggests these individuals were washed off from the Chambal River during the monsoon floods. A decrease in the number of sightings was observed towards Prayagraj (Figure 2.12). The encounter rate of gharial was 0.24±0.13 (SE) sighting/km.

A total of 47 individuals of gharial were recorded during second post-monsoon survey. Of these 47 individuals 6% were adults, 32% were sub-adults and 21% were juveniles and 41% were yearlings (Figure 2.13). The average group size was 3.92±1.30 (SE) individuals (Figure 2.14). The encounter rate of gharial was 0.33±0.06 (SE) sighting/km. Most of the individuals were recorded in the sandy riverine islands (50%) followed by clay (33%) and sandbar (17 %) in proximity to agriculture land. The average depth of water near gharial basking site was 1.94 ± 0.25 (SE) meters.

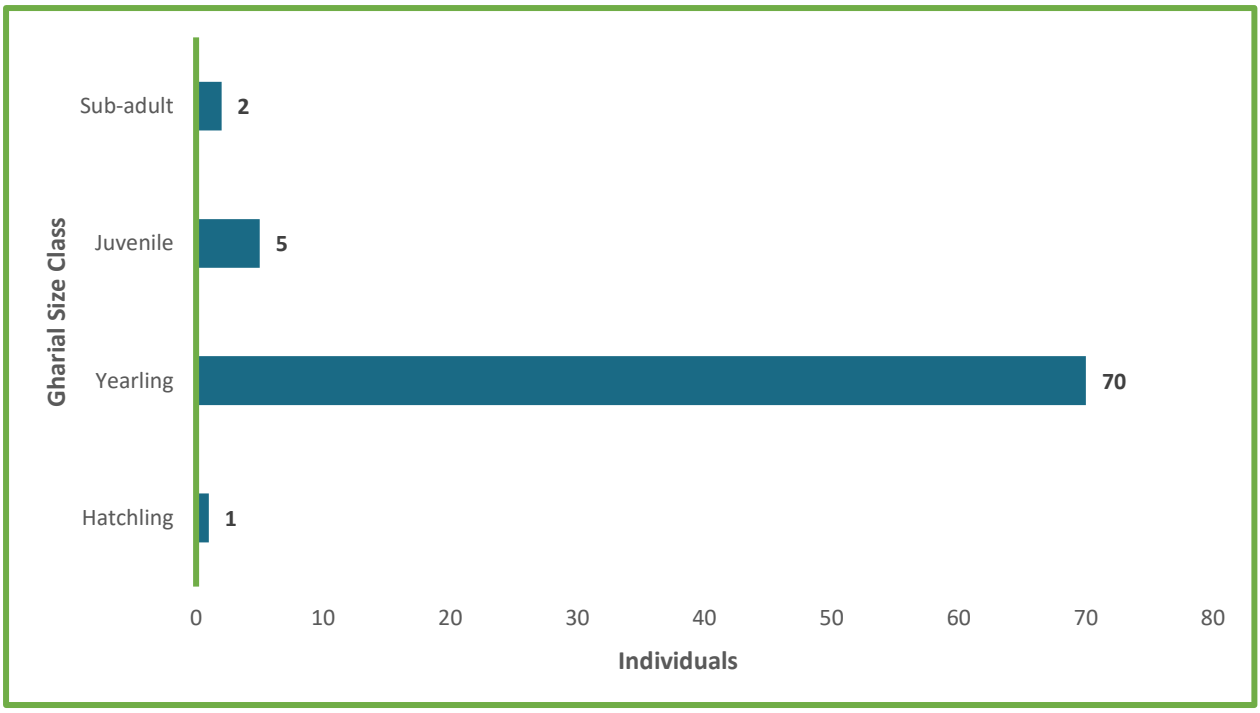

Figure 2.11 Gharial population as per the first post-monsoon biodiversity assessment

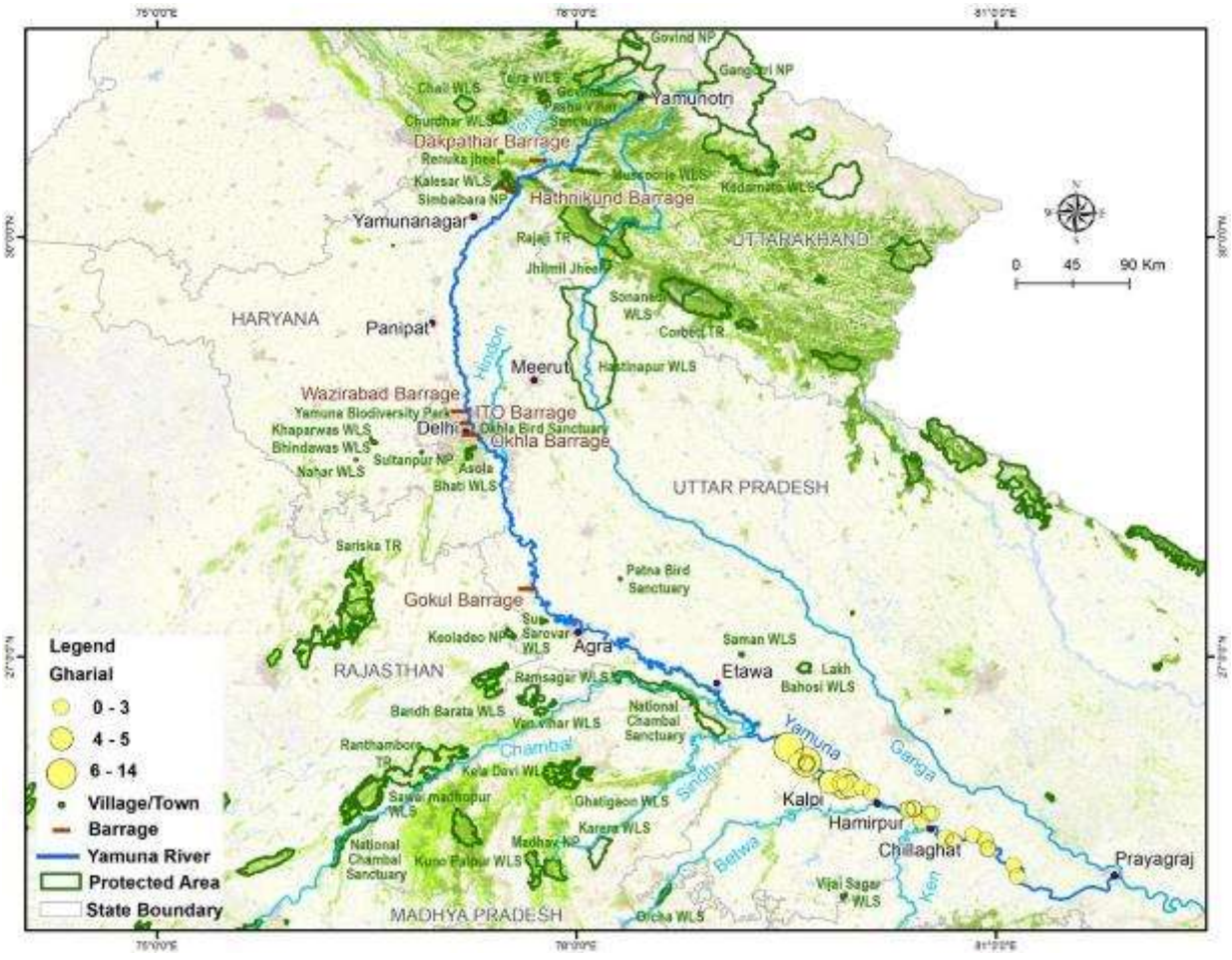

Figure 2.12 Distribution of gharial during first post-monsoon biodiversity assessment

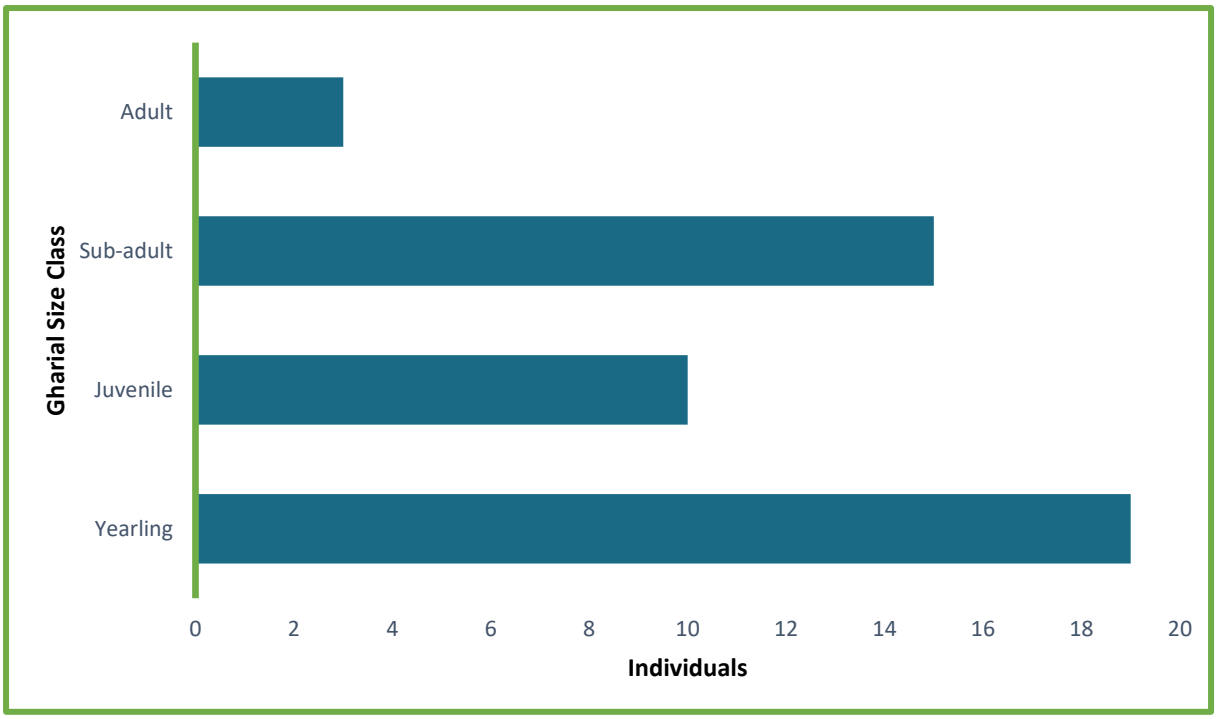

Figure 2.13 Gharial population as per the second post-monsoon biodiversity assessment

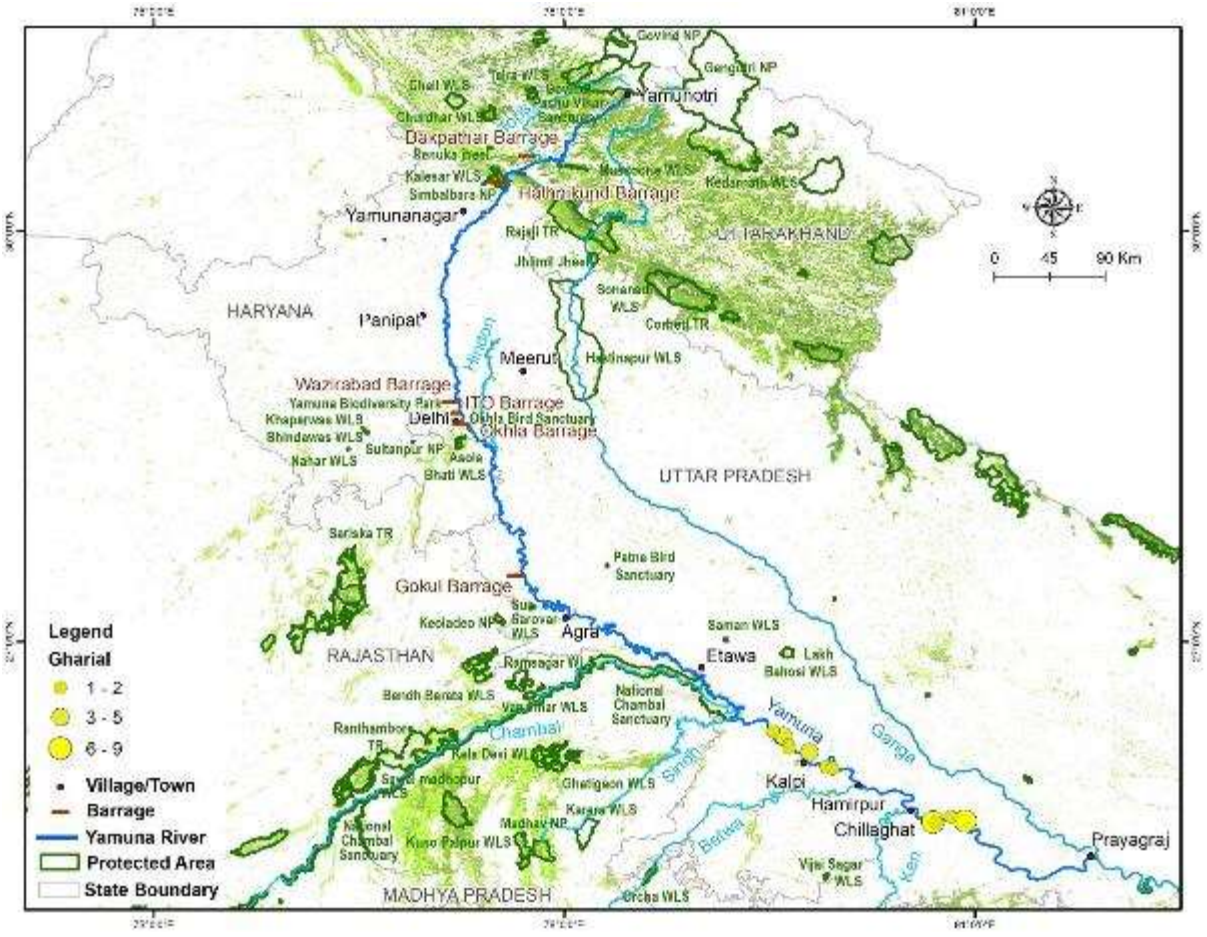

Figure 2.14 Distribution of gharial during second post-monsoon biodiversity assessment

Mugger (*Crocodylus palustris*)

Though the distribution range of mugger includes Yamuna basin (Whitaker & Andrews, 2003), the status and distribution of the crocodile in the Yamuna mainstem has largely been understudied. Some patchy opportunistic individual sightings and record of human-mugger conflict suggest that the Gangetic plain stretch of Yamuna mainstem may have a few individuals. In the Yamuna River basin, a breeding population of mugger has been reported from Chambal River, mostly in the stretch protected as NCS (Sharma & Singh, 2015; Singh & Rao, 2017). No individual was sighted during the both the surveys.

Turtles

Goddess Yamuna is famously depicted riding a turtle in the Indian mythology. The river was once famous for its diversity of turtles but now their distribution has been severely limited to certain stretches. The Upper Gangetic plain, which includes the Yamuna basin, is one of the high turtle richness areas in India and is estimated to have 8—10 turtle species (Buhlmann et al., 2009). A total of nine species of fresh water turtles have been recorded from the Yamuna River which includes five species sighted during the present study (Annexure III).

During the first post-monsoon survey, 569 individuals of turtles were sighted from the lower stretch of the Yamuna River of which 545 individuals belonged to genus *Pangshura*, 13 belonged to *Nilssonia*, 10 belonged to *Lissemys* and one belonged to *Batagur* (Figure 2.15).

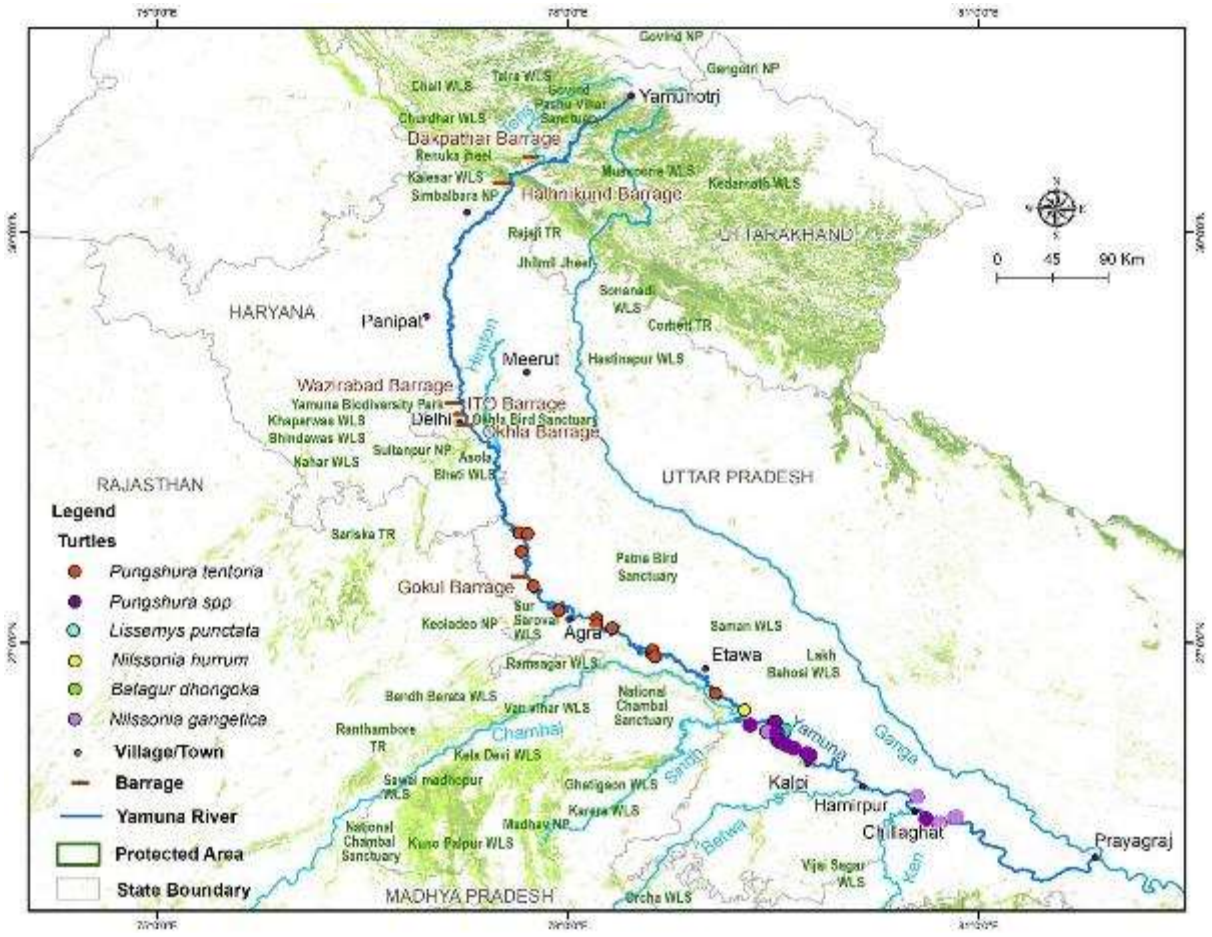

Figure 2.15 Distribution of turtles during first post-monsoon biodiversity assessment

During the second post-monsoon survey, 202 turtles were sighted along the Yamuna River which belonged to *Pangshura* genus. These sightings were recorded from middle and lower stretch of the river (Figure 2.16).

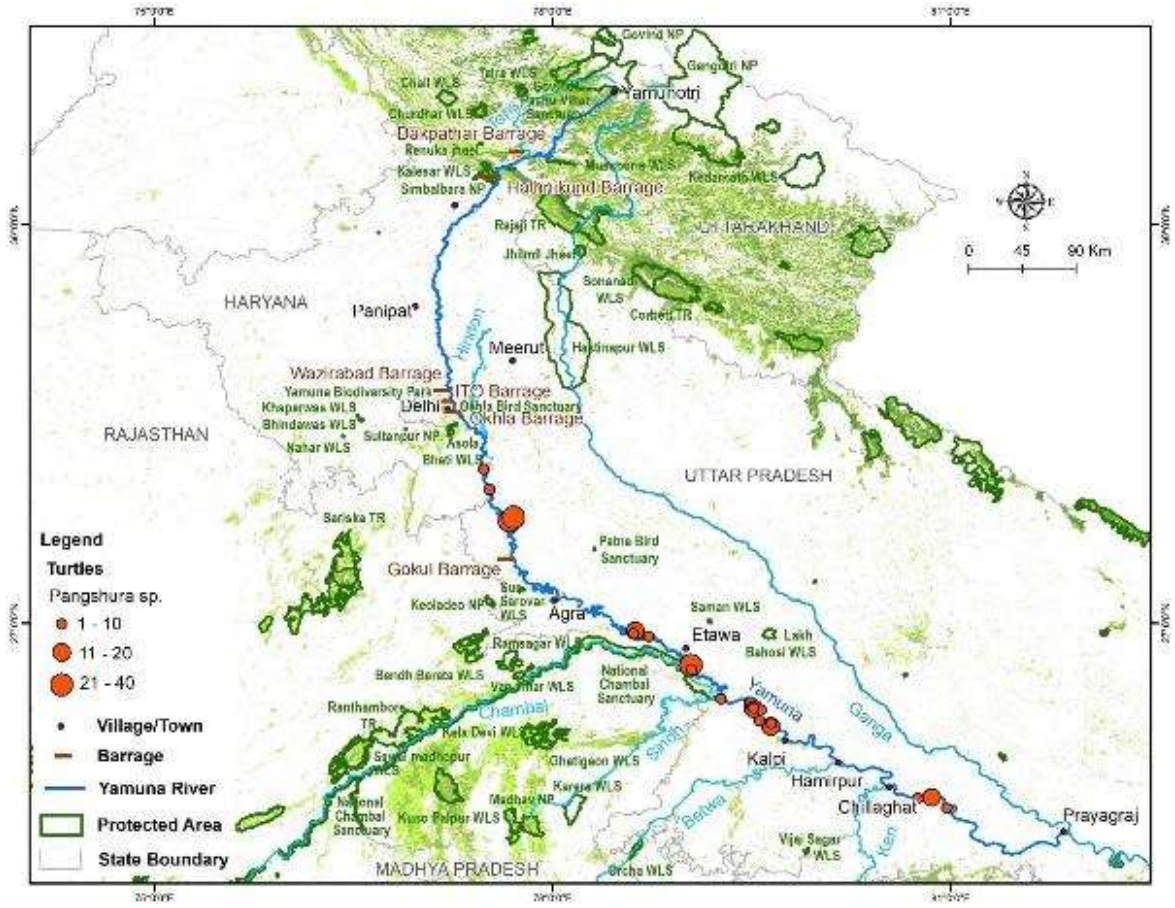

Figure 2.16 Distribution of turtles during second post-monsoon biodiversity assessment

A comprehensive and recent checklist of turtle species for the Yamuna River is missing due to lack of systematic survey and species-specific studies for which an intensive study is required.

Red-crowned roofed turtle *(Batagur kachuga)*

Historically the species is said to have been distributed throughout the Ganga River system which also includes Yamuna River (Praschag et al., 2019). One record from Agra by Anderson (1871) suggests that it might have been present in Yamuna. But there is not enough information to assess the historical status of the species in the river. This species finds no mention in the recent literature except for one study which recorded this species from Etawah (Tiwari, 2003). Only the Chambal River supports the remaining viable population of this species (Praschag et al., 2019). During both the surveys, it was not seen in the Yamuna River.

Three-striped roofed turtle (*Batagur dhongoka*)

Historically, it is said to have been abundantly distributed in the Ganga River system presumably also including the Yamuna River suggesting that it might have been present in the river (Gunther 1864), however there is insufficient information to assess its historical status in the river. Tiwari (2003) recorded the species from Yamuna at Etawah. The species is restricted to the NCS along the Chambal River (Das et al., 2019). The species was not seen during the surveys.

Crowned river turtle (*Hardella thurjii)*

The species has been recorded in Yamuna River upstream of Yamuna-Chambal confluence and in the Chambal River by Iverson (1992). No recent records of the species were found. The species was not seen during the surveys.

Indian roofed turtle *(Pangshura tecta)*

Historically, it was recorded from Yamuna in Agra by Anderson (1871) and said to be distributed throughout the Gangetic plains stretch of Yamuna (Iverson, 1992). No recent records of the presence of this species along the Yamuna River were found. The species was not seen during the surveys.

Indian tent turtle *(Pangshura tentoria*)

Gunther (1864) and Anderson (1871) recorded its subspecies *P. tentoria flaviventer* from Yamuna in Agra. Moll (1987) recorded *P. tentoria flaviventer* and *P. t. circumdata* from Yamuna at Agra and its tributary the Hindon River at Ghaziabad. In recent years, Baruah et al. (2016) recorded presence of *P. tentoria flaviventer* at Etawah. During first assessmentpost-monsoon survey, 215 species was recorded from middle stretch (Agra, Mathura, Firozabad, Fatehabad, Etawah).

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

It was historically distributed throughout the Gangetic plains stretch of the Yamuna and the Chambal rivers (Gunther, 1864; Iverson, 1992). Tiwari (2003) recorded the species from Yamuna in Etawah. Bhaskar and Mohindra (2018) recorded it from Agra. It has also been reported from the Chambal River by Hanfee (1999) and Das & Singh (2009). The species was not seen during the surveys.

Indian softshell turtle (*Nilssonia gangetica*)

Historically, it was distributed in the Ganga River and its tributaries including the Yamuna River. It was recorded near Yamuna-Chambal confluence by Iverson (1992). Tiwari (2003) recorded the species from Etawah. The species was not seen during the surveys.

Indian peacock softshell turtle (*Nilssonia hurum*)

It has been reported near Yamuna-Chambal confluence (Iverson, 1992). Das et al. (2010) have reported its nests in Chambal. Bhaskar &Mohindra (2018) mention presence of the species in Agra. During the first post-monsoon survey, one individual was sighted in Auraiya in the middle stretch.

Indian flapshell turtle (*Lissemys punctata*)

It has been reported in Gangetic plains stretch of Yamuna (Iverson, 1992). Tiwari (2003) recorded the species from Etawah. Bhaskar & Mohindra (2018) recorded its presence in the Yamuna River at Agra. During the first survey, 10 individuals were sighted in the lower stretch of the Yamuna River.

2.5 Amphibians

A basin wise study of amphibians has not been conducted so far. Poddar et al. (1998) reported species of anurans from Agra. Rizvi et al. (2010) studying helminth parasites in anurans reported presence of three species of anurans from the Kalesar National Park in the Yamuna basin. Hence a systematic study on the amphibians of Yamuna basin is still lacking. A checklist of amphibian species likely to be present in the basin is provided in the Annexure IV.

2.6 Fish

Joshi et al. (2016) reported 112 fish species belonging to 10 orders, 29 families and 73 genera from the Yamuna River, whereas Sharma et al. (2017) reported 93 fish species belonging to 23 families. Since the Yamuna River is the tributary of the Ganga River fish diversity can be considered similar on the basis of rapid assessment, but for more precise information, intensive experimental fishing is need to be performed in the complete stretch of river to assess the current scenario/trend of the fish diversity. A total of 79 fish species have been recorded in Yamuna River that includes 11 species identified during the post-monsoon survey (Annexure V)

During first post-monsoon survey, local fishermen who have been practicing fishing were interviewed on the spot, regarding the type of nets being used by them, type of fishing they practice and thespecies they get in their catch and simultaneously their catch was also identified. Five species belonging to four families were recorded from Hathinikund to Bareh.

During second post-monsoon survey, a total of 135 individuals of fish belonging to 11 species, 11 genera, 4 families and 3 orders were recorded. Of which, cyprinidae was the most dominant family with 8 species. Ten species are listed as the “Least Concern” and one species is listed as was “Near Threatened” as per the IUCN Red List of Threatened Species.

2.7 Vegetation

A total number of 94 plant species, representing 83 genera and 76 families has been recorded during first and second post-monsoon survey (Figure 2.17). The plants are classified according to their habit types into herbs,

shrubs, climbers, grasses, reeds and sedges. A checklist of the recorded plant species has given in Annexure VI. Among 38 families, Asteraceae found as the most dominant family with 11 species followed by Poaceae (10 species), Solanaceae and Amaranthaceae (6 species each),Fabaceae (5 species), Polygonaceae (4 species), Potamogetonaceae, Euphorbiaceae, Scrophulariaceae, Cyperaceae, Malvaceae and Chenopodiaceae (3 species each) (Figure 2.18). Majority of the plants along the Yamuna River were herbs (71), followed by grasses (10), shrubs (6), sedges and reeds (4), climber (3) (Figure 2.19). Plant habitat type classification of the recorded plants indicated that the majority of the plants along the Yamuna River were riparian (35), followed by moist (32), marshy (13), and aquatic (8) (Fig: 2.20).

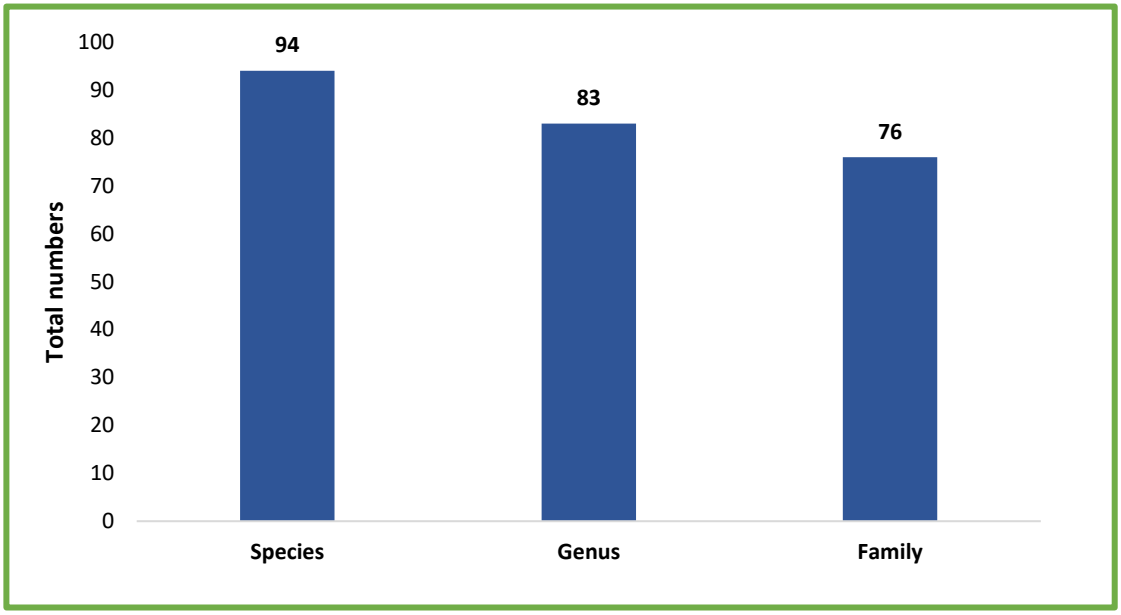

Figure 2.17 Floristic diversity recorded along the Yamuna River

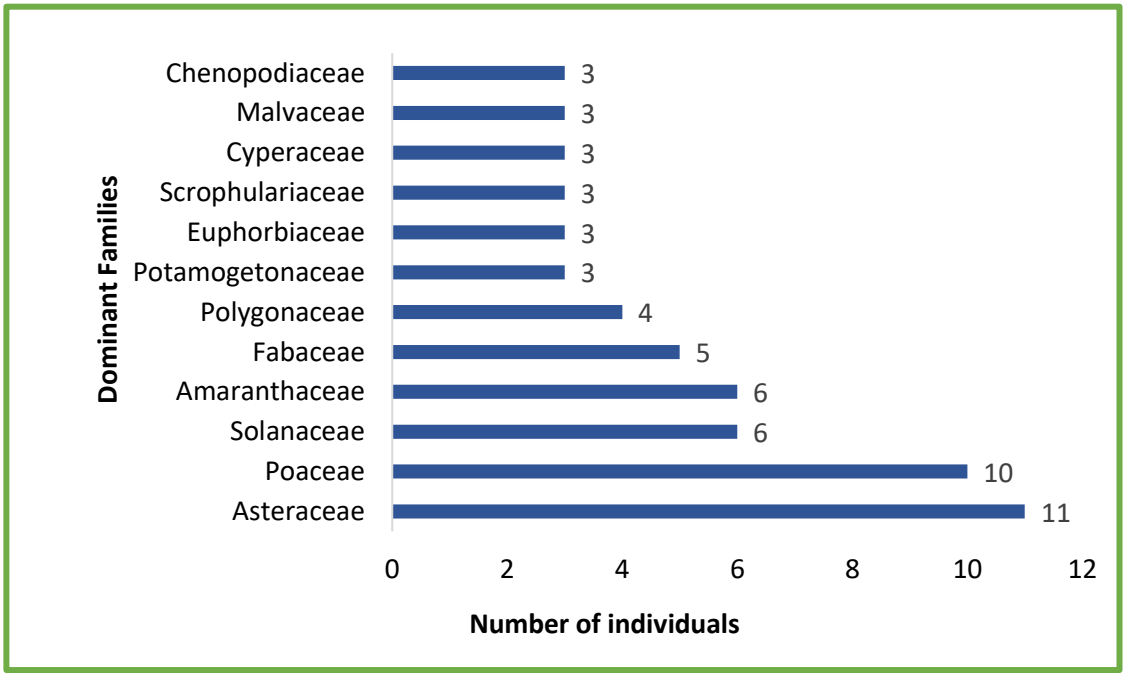

Figure 2.18 Dominant families recorded along the Yamuna River

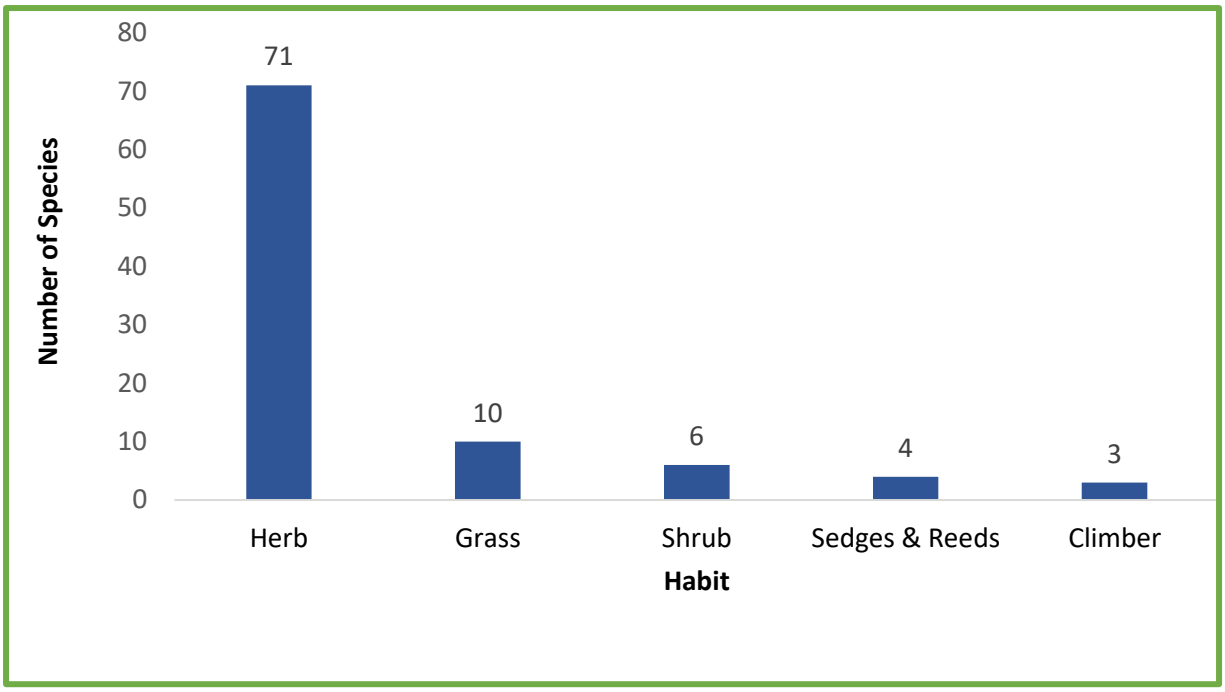

Figure 2.19 Plant habit type recorded along the Yamuna River

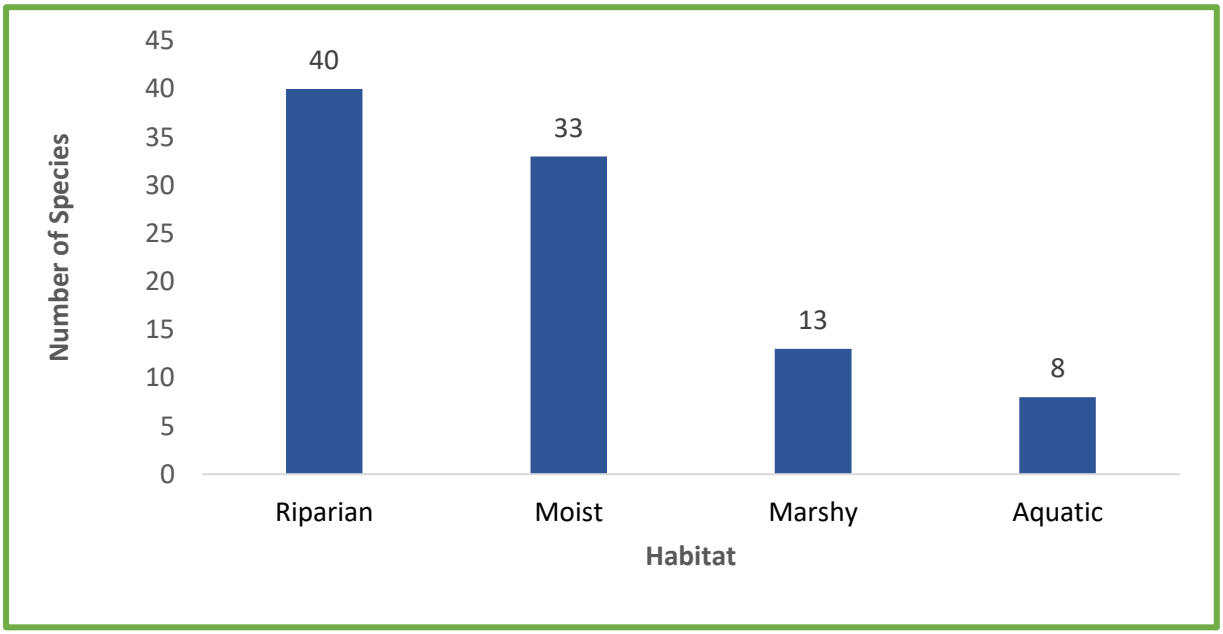

Figure 2.20 Plant habitat type recorded along the Yamuna River

2.8 Depth Profile of Yamuna River (Lower stretch, Bareh to Prayagraj)

During first post-monsoon survey, the channel depth (lower stretch) ranged from 0.1 m to 15.5 m (Average = 3.38 ± 0.26 (SE) m. During second post-monsoon survey, the channel depth (lower stretch) ranged from 0.7 m to 13.3 m (Average = 3.5 ± 0.25 (SE) m) (Figure 2.21). In the Lower zone, 46.51% of the surveyed stretch had depth between 1-3 m during first post-monsoon survey whereas water depth recorded in the second post-monsoon survey for 52.33% of the surveyed river stretch was between 1-3 m (Table 2.3).

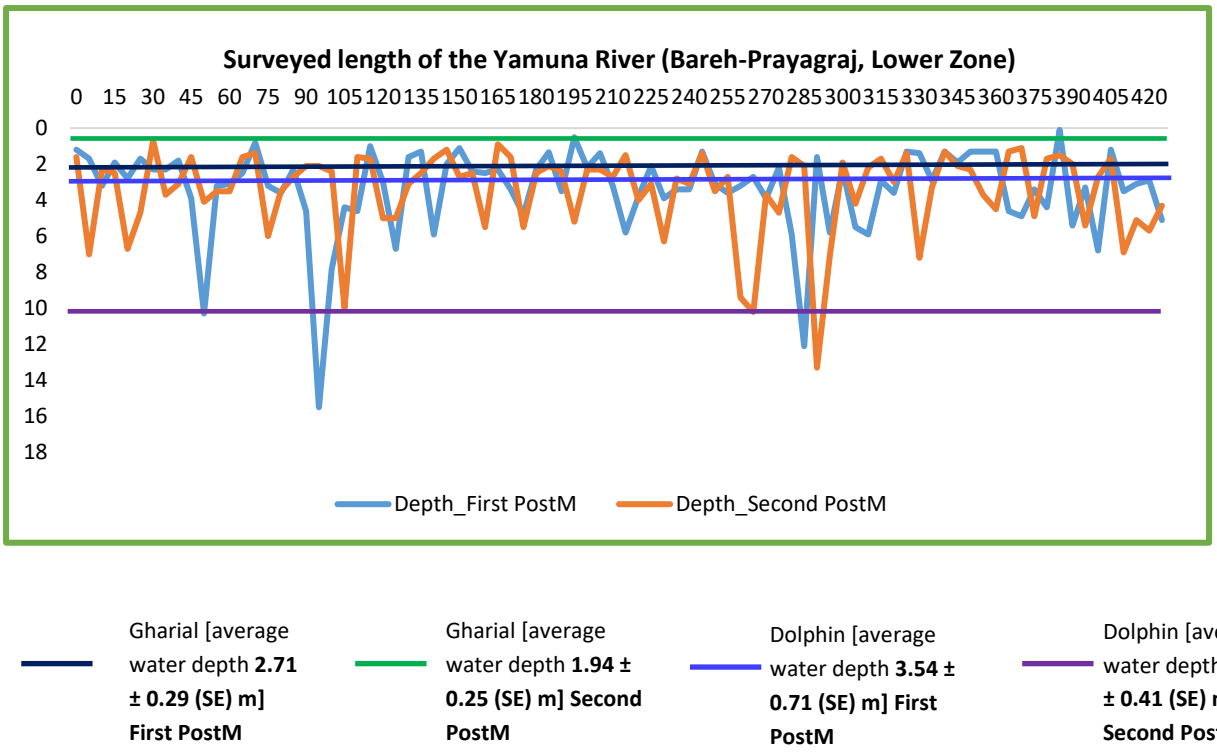

Figure 2.21 Depth profile of lower Yamuna River

Table 2.3 Depth class categories of Lower zone of Yamuna River

Depth Class	No. of River segment		% of stretch	
	First post-monsoon	Second post-monsoon	First post-monsoon	Second post-monsoon
<1 m	3	2	3.49	2.33
1-3 m	40	45	46.51	52.33
3-5 m	29	22	33.72	25.58
5-7 m	10	11	11.63	12.79
7-9 m	1	2	1.16	2.33
>9 m	3	4	3.49	4.65

2.9 River stretch with high species occurrence

- **Bareh to Prayagraj Ganga River Confluence (High)**
  This is a 436 km stretch between Bareh to Prayagraj in Uttar Pradesh. This stretch falls under the upper Gangetic plain (7A) biogeographic province and characterised by alluvial plain.

- **Biodiversity value and ecological significance**
  In first post-monsoon biodiversity assessment, 82 sightings of critically endangered gharial, 53 sightings of endangered Gangetic dolphin, 569 sightings of turtles which includes *Pangshura* sp (545), *Nilssonia* sp. (13), *Lissemys* sp. (10), *Batagur* sp. (1) and 83 waterbird and water associated species were recorded from this stretch.

- In second post-monsoon biodiversity assessment, 47sightings of critically endangered gharial, 13 sightings of endangered Gangetic dolphin, 202 sightings of turtles of *Pangshura* sp, 94 waterbird and water associated species were recorded from this stretch.

3. Threats to the biodiversity of Yamuna River

Yamuna River's flow is hindered by barrages and dams that divert its water for hydroelectric power generation, irrigation and for drinking water to nearby cities and other human settlements. In total, there are six major barrages on the river:

1. Dakpathar barrage in Uttarakhand
2. Hathnikund barrage near Yamuna Nagar, Haryana
3. Wazirabad barrage in North Delhi
4. ITO barrage or Indraprastha barrage in Central Delhi
5. Okhla barrage in South Delhi
6. Gokul barrage near Matura, Uttar Pradesh

3.1 Himalayan Zone

Due to low population density in the Himalayan stretch of the river, anthropogenic pressure is comparatively low. However, ongoing projects like the Vyashi hydroelectric power plant, Char Dham highway project and other upcoming dams and barrages on the river pose a threat to the integrity of the river. Deforestation due to these

projects is destabilising the slopes leading to increased soil erosion and more frequent landslides. The muck, debris and other solid waste generated in these projects have been reported to be dumped directly in the river which obstructs the flow, raises the river bed, increases water turbidity, fluctuates water temperature and thus affects aquatic biodiversity (SANDRP 2019).

With the number of tourists coming to Uttarakhand increasing every year, hotels, lodges and other tourist facilities have mushroomed unchecked near the river. Rapid urbanization with increased tourist influx has also led to the issue of solid and liquid waste being dumped into the river and its tributaries. Many small Himalayan tributaries which used to contribute water to the Yamuna River round the year are drying up during the lean season.

Riverbed mining near Vikasnagar, Uttarakhand is another serious issue. Flouting all sustainable mining norms and rules, many miners have deliberately altered or blocked the river channel to mine the riverbed material and have built temporary bridges across these channels to transport the minerals, which was also observed by the survey team.

3.2 Middle Zone

In the Upper middle zone of the river, diversion of water at Dakpathar, Uttarakhand for irrigation and other purpose, extensive illegal sand mining, chemical intensive farming, industrial waste disposal, presence of feral dogs near waterbirds habitats are some major threats. The river stretches passing through the Yamuna Nagar and the Panipat districts is affected by rampant sand mining. At many sites the river channel has been altered by miners and heavy machinery is being used to collect sand and other minerals which has impacted the river habitat quality and in turn, its biodiversity as well.

Due to the diversion of most of the river water for irrigation at Hathnikund barrage, downstream of the barrage the flow of the river reduces drastically and it often goes dry during lean season. In this stretch, water is diverted at 4 barrages divert the remaining, water. What remains in the river after Wazirabad is mostly discharged wastewater from Delhi and downstream cities. Drains carrying domestic and industrial wastewater mainly from cities like Yamuna Nagar, Karnal, Panipat, Sonipat, Delhi, Agra flow directly into the river. Delhi is the biggest contributor of wastewater, generating 44% of the entire sewage generated in the basin and releasing 84% of it into the Yamuna River (Upadhay, 2012). About 60% of the total wastewater released into the Yamuna is untreated which has impacted the water quality as well (https://www.dnaindia.com/delhi/report-60-of-sewage-remains-untreated-in-delhi-2070947).

Riverbank agriculture is also a common practice in this zone. Majority of the crops grown are chemical and water intensive like wheat, paddy, and sugarcane. Many farmers extract groundwater through tube wells or directly from the river through pumps. Heavy groundwater extraction has led to the lowering of groundwater table which is another cause of reduced flow in the river in this zone.

3.3 Lower Zone

The river is heavily polluted once it crosses the national capital Delhi with hardly any flow until its confluence with the Chambal River at Pachnada in Etawah district of Uttar Pradesh. Sand mining continues in this zone. A large number of earth movers excavating the riverbanks and dumpers/lorries, were observed during the survey. Sand mining was observed at a higher rate beyond the Chambal confluence due to better quality of sand deposited by the river. Fishing and river bed farming/agriculture are other major anthropogenic activities seen along the lower zone. Use of poison and explosives for fishing is common and densely crowded gill nets were recorded mostly in deep pools. During interactions with the local communities of Shirawal village of Rajpur town, Kanpur Dehat district, community members reported capturing and killing of dolphins for its oil. Carcasses of dead *Nilssonia gangetica*, entangled in the fishing net were also recorded from Kanupur Dehat district of Uttar Pradesh by the survey team.

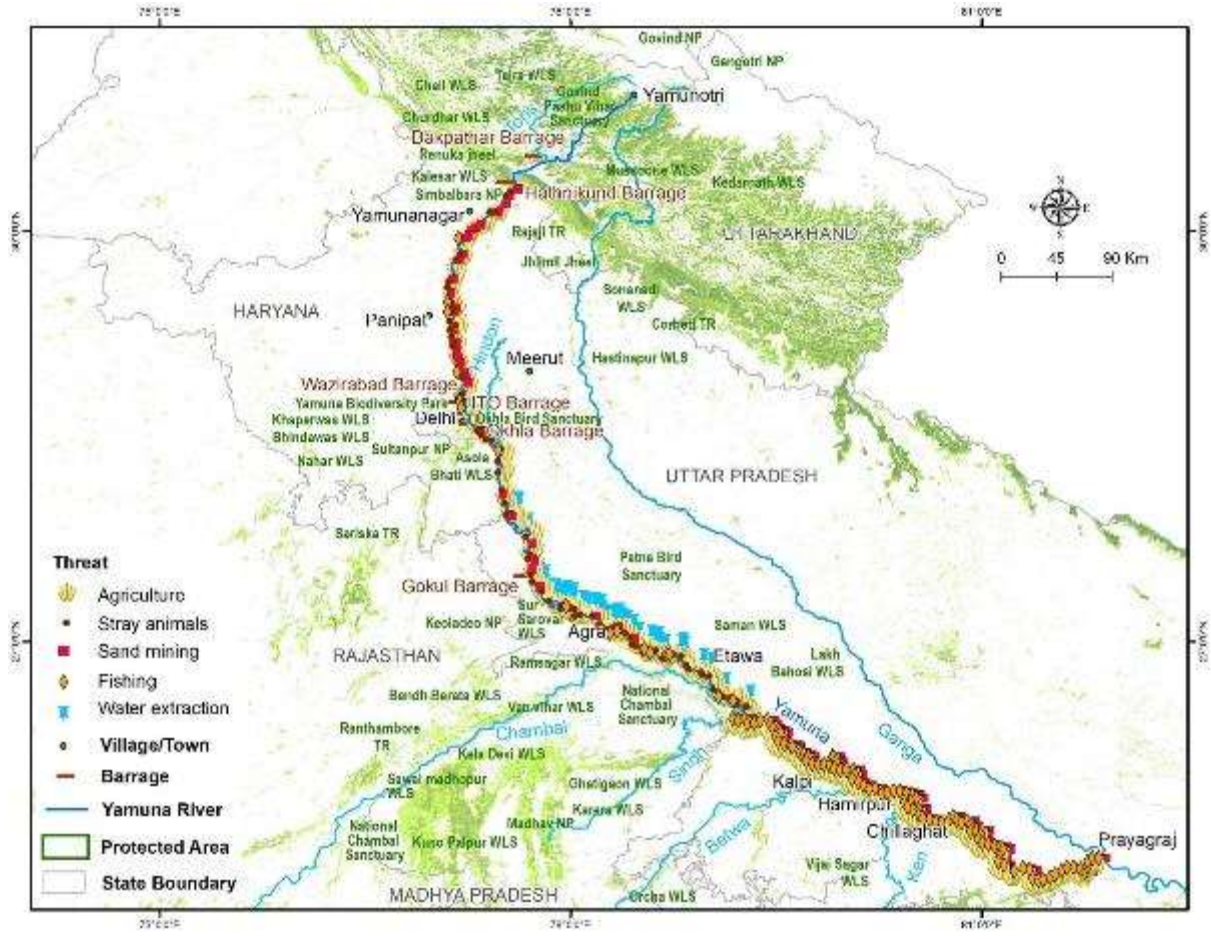

Figure 3.1 Threat map for Yamuna River during first post-monsoon biodiversity assessment

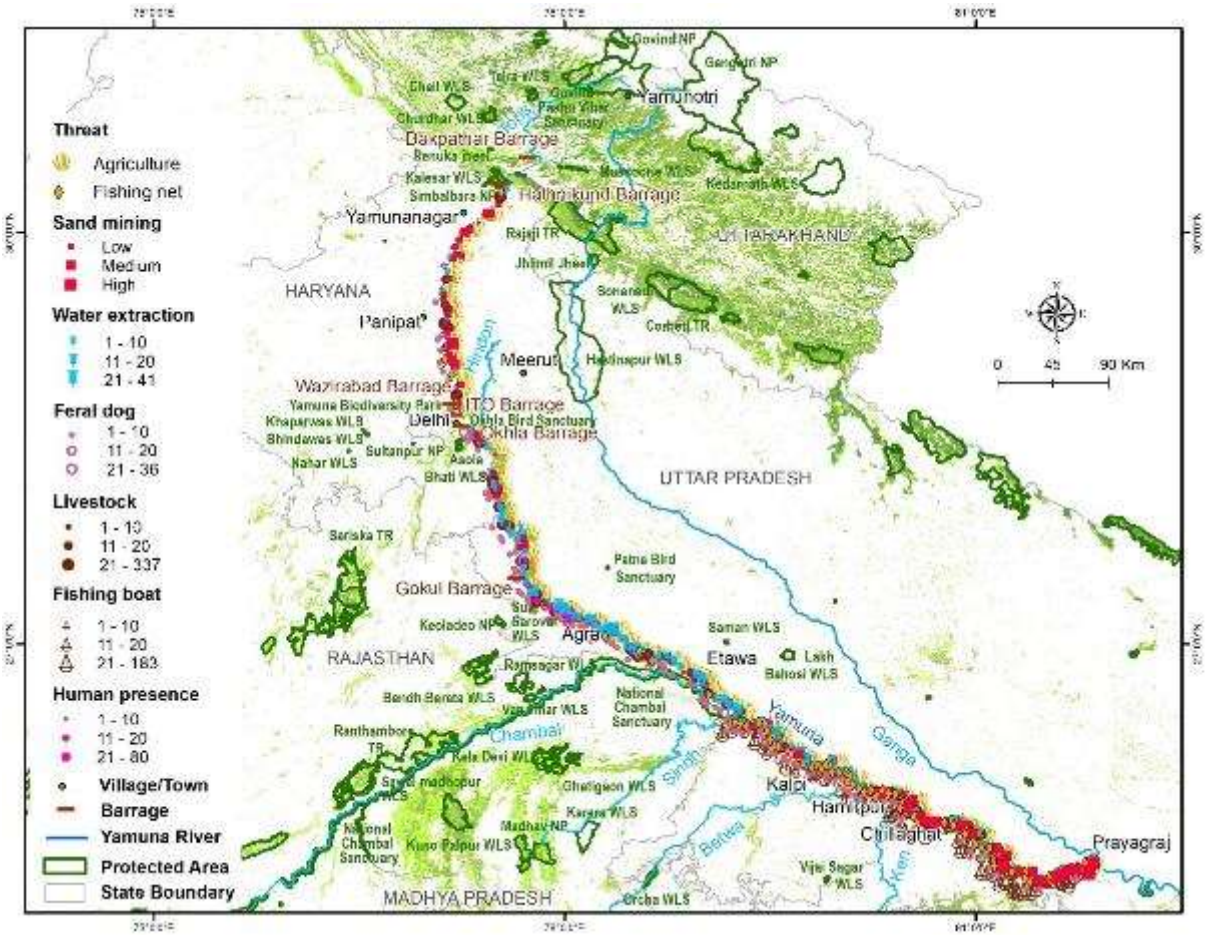

Figure 3.2 Threat map for Yamuna River during second post-monsoon biodiversity assessment

4. Conservation Implications

- The Himalayan and Middle zones of the Yamuna River are undergoing structural changes because of the intensive anthropogenic activities. Constructions of tourist facilities, upcoming dam, highway projects and riverbed mining activities need to be regulated for long-term sustainability so as to maintain the river's hydrological and ecological integrity.

- Water quality in the Middle and Lower zones of the Yamuna River has deteriorated due to unregulated discharge of urban and industrial wastes, agricultural run-off consisting of harmful pesticides. Intensive farming, river-bed mining, urban drainage has altered the habitat for nesting bird species. It is necessary to focus conservation action on the natural habitats and protected areas along the river which are preferred by the migratory birds.

- Rapid biodiversity assessment revealed that key aquatic species like Gangetic dolphin, gharial still exists in the lower zone of the Yamuna River. These species are highly sensitive to anthropogenic habitat alterations. Therefore, they are conservation-dependent. The areas of high biodiversity value need to be conserved on priority basis.

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ANNEXURE I

List of Mammalian species of the Yamuna River (N=3)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	First PostM	Second PostM	Biogeographic zones
Cetacea	Gangetic dolphin	*Platanista gangetica* (Roxburgh, 1801)	EN	Sch I	a, c, d, e, f, g	+	+	7A
Carnivora	Smooth-coated otter	*Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire, 1826)	VU	Sch II	b			2B, 7A
	Eurasian otter	*Lutra lutra* (Linnaeus, 1758)	NT	Sch II	b			2B

[a]Anderson (1878); [b]Atkinson (1882); [c]Singh& Sharma (1985); [d]Sinha et al. (2000); [e]Sinha& Sharma (2003); [f]Behera et al. (2013); [g]Sinha& Kannan (2014)

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ANNEXURE II

List of Water and water associated bird species of the Yamuna River (N=156)

Species	Scientific Name	IUCN Status	IWPA Status	Previous Studies*	First PostM	Second PostM	Biogeographic Zones
Order: Anseriformes Family: Anatidae							
Baikal Teal	*Sibirionetta formosa* (Georgi, 1775)	LC	Sch IV	c			4A
Bar-headed Goose	*Anser indicus* (Latham, 1790)	LC	Sch IV	a, b, c, d	+	+	2B, 4A
Common Goldeneye	*Bucephala clangula* (Linnaeus, 1758)	LC	Sch IV	c			4A
Common Pochard	*Aythya ferina* (Linnaeus, 1758)	VU	Sch IV	a, b, c, d	+	+	2B, 4A
Common Shelduck	*Tadorna tadorna* (Linnaeus, 1758)	LC	Sch IV	c			4A
Common Teal	*Anas crecca* (Linnaeus, 1758)	LC	Sch IV	a, c	+	+	2B, 4A
Cotton Pygmy-goose	*Nettapus coromandelianus* (Gmelin, 1789)	LC	Sch IV	c			4A
Eurasian Wigeon	*Mareca penelope* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+		2B, 4A, 7A
Falcated Duck	*Mareca falcata* (Georgi, 1775)	NT	Sch IV	c			4A, 7A
Ferruginous Duck	*Aythya nyroca* (Güldenstädt, 1770)	NT	Sch IV	c, d	+		4A
Gadwall	*Mareca strepera* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Garganey	*Spatula querquedula* (Linnaeus, 1758)	LC	Sch IV	a, c, d			2B, 4A
Goosander	*Mergus merganser* (Linnaeus, 1758)	LC	Sch IV	c	+	+	4A
Greater Scaup	*Aythya marila* (Linnaeus, 1761)	LC	Sch IV	c			4A
Greater White-fronted Goose	*Anser albifrons* (Scopoli, 1769)	LC	Sch IV	c			4A
Greylag Goose	*Anser anser* (Linnaeus, 1758)	LC	Sch IV	a, c	+	+	2B, 4A
Indian Spot-billed Duck	*Anas poecilorhyncha* (Forster, 1781)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Knob-billed Duck	*Sarkidiornis melanotos* (Pennant, 1769)	LC	Sch IV	c	+	+	4A, 7A

Lesser Whistling Duck	*Dendrocygna javanica* (Horsfield, 1821)	LC	Sch IV	c, d		+	4A
Mallard	*Anas platyrhynchos* (Linnaeus, 1758)	LC	Sch IV	a, b, c			2B, 4A
Northern Pintail	*Anas acuta* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A
Northern Shoveler	*Spatula clypeata* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A
Red-crested Pochard	*Netta rufina* (Pallas, 1773)	LC	Sch IV	a, b, c	+	+	2B, 4A
Ruddy Shelduck	*Tadorna ferruginea* (Pallas, 1764)	LC	Sch IV	a, b, c, d	+	+	2B, 4A
Smew	*Mergellus albellus* (Linnaeus, 1758)	LC	Sch IV	c			4A
Tufted Duck	*Aythya fuligula* (Linnaeus, 1758)	LC	Sch IV	a, c, d		+	2B, 4A, 7A
Order:Podicipediformes **Family: Podicipedidae**							
Great Crested Grebe	*Podiceps cristatus* (Linnaeus, 1758)	LC	Sch IV	a, c, d		+	2B, 4A
Little Grebe	*Tachybaptaus rufficollis* (Pallas, 1764)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Order: Phoenicopteriformes **Family: Phoenicopteridae**							
Greater Flamingo	*Phoenicopterus roseus* (Pallas, 1811)	LC	Sch IV	c, d	+	+	4A, 7A
Order:Gruiformes **Family: Rallidae**							
Baillon's Crake	*Porzana pusilla* (Pallas, 1776)	LC	Sch IV	c, d			4A
Brown Crake	*Zapornia akool* (Sykes, 1832)	LC	Sch IV	c			4A
Common Coot	*Fulica atra* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Common Moorhen	*Gallinula chloropus* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Purple Swamphen	*Porphyrio porphyrio* (Linnaeus, 1758)	LC	Sch IV	a, c, d	+	+	2B, 4A, 7A
Ruddy-breasted Crake	*Zapornia fusca* (Linnaeus, 1766)	LC	Sch IV	c			4A
White-breasted Waterhen	*Amaurornis phoenicurus* (Pennant, 1769)	LC	Sch IV	a, c, d	+	+	2B, 4A, 7A
Family: Gruidae							
Common Crane	*Grus grus* (Linnaeus, 1758)	LC	Sch IV	c		+	4A

Demoiselle Crane	*Anthropoides virgo* (Linnaeus, 1758)	LC	Sch IV	c			4A
Sarus Crane	*Antigone antigone* (Linnaeus, 1758)	VU	Sch IV	c		+	4A
Watercock	*Gallicrex cinerea* (Gmelin, 1789)	LC	Sch IV	c			4A
Order:Ciconiiformes Family: Ciconiidae							
Asian Openbill	*Anastomus oscitans* (Boddaert, 1783)	LC	Sch IV	a, c, d	+	+	2B, 4A
Asian Woollyneck	*Ciconia episcopus* (Boddaert, 1783)	VU	Sch IV	a, c, d	+	+	2B, 4A, 7A
Black Stork	*Ciconia nigra* (Linnaeus, 1758)	LC	Sch IV	b, d	+		2B, 4A
Black-necked Stork	*Ephippiorhynchus asiaticus* (Latham, 1790)	NT	Sch IV	a, c, d	+	+	2B, 4A
Greater Adjutant	*Leptoptilos dubius* (Gmelin, 1789)	EN	Sch IV	c			4A
Lesser Adjutant	*Leptoptilos javanicus* (Horsfield, 1821)	EN	Sch IV	c			4A
Painted Stork	*Mycteria leucocephala* (Pennant, 1769)	NT	Sch IV	a, c, d	+	+	2B, 4A, 7A
Order:Pelecaniformes Family: Threskiornithidae							
Black-headed Ibis	*Threskiornis melanocephalus* (Latham, 1790)	NT	Sch IV	a, c, d		+	2B, 4A
Eurasian Spoonbill	*Platalea leucorodia* (Linnaeus, 1758)	LC	Sch IV	a, c, d	+	+	2B, 4A
Red-naped Ibis	*Pseudibis papillosa* (Temminck, 1824)	LC	Sch IV	a, c	+	+	2B, 4A, 7A
Glossy Ibis	*Plegadis falcinellus*(Linnaeus, 1766)	LC	Sch IV		+		7A
Family: Ardeidae							
Black Bittern	*Ixobrychus flavicollis* (Latham, 1790)	LC	Sch IV	c			4A
Black-crowned Night-heron	*Nycticoraxn ycticorax* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d			2B, 4A
Cattle Egret	*Bubulcus ibis* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Cinnamon Bittern	*Ixobrychus cinnamomeus* (Gmelin, 1789)	LC	Sch IV	a, c, d			2B, 4A
Great White Egret	*Ardea alba* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Green-backed Heron	*Butorides striata* (Linnaeus, 1758)	LC	Sch IV	c	+	+	4A

Grey Heron	*Ardea cinerea* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Indian Pond Heron	*Ardeola grayii* (Sykes, 1832)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Intermediate Egret	*Ardea intermedia* (Wagler, 1829)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Little Egret	*Egretta garzetta* (Linnaeus, 1766)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Purple Heron	*Ardea purpurea* (Linnaeus, 1766)	LC	Sch IV	a, c, d	+	+	2B, 4A, 7A
Western Reef Egret	*Egretta gularis* (Bosc, 1792)	LC	Sch IV	c			4A
Yellow Bittern	*Ixobrychus sinensis* (Gmelin, 1789)	LC	Sch IV	c			4A
Family: Pelecanidae							
Dalmatian Pelican	*Pelecanus crispus* (Bruch, 1832)	NT	Sch IV	c	+	+	4A
Great White Pelican	*Pelecanus onocrotalus* (Linnaeus, 1758)	LC	Sch IV	c	+	+	4A
Order:Suliformes **Family: Phalacrocoracidae**							
Great Cormorant	*Phalacrocorax carbo* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Indian Cormorant	*Phalacrocorax fuscicollis* (Stephens, 1826)	LC	Sch IV	c, d	+	+	4A, 7A
Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Order:Suliformes **Family: Anhingidae**							
Oriental Darter	*Anhinga melanogaster* (Pennant, 1769)	NT	Sch IV	a, c, d	+	+	2B, 4A, 7A
Order: Charadriiformes **Family: Burhinidae**							
Great Thick-knee	*Esacus recurvirostris* (Cuvier, 1829)	NT	Sch IV	c	+	+	4A
Eurasian Thick-knee	*Burhinus oedicnemus* (Linnaeus, 1758)	LC	NL	c			4A
Indian Thick-knee	*Burhinus indicus* (Salvadori, 1865)	LC	Sch IV			+	2B
Family: Recurvirostridae							
Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Pied Avocet	*Recurivirostra avosetta* (Linnaeus, 1758)	LC	Sch IV	a, c	+	+	2B, 4A

Family: Charadriidae							
Common Ringed Plover	*Charadrius hiaticula* (Linnaeus, 1758)	LC	Sch IV	c			4A
Grey Plover	*Pluvialis squatarola*(Linnaeus, 1758)	LC	Sch IV			+	7A
Kentish Plover	*Charadrius alexandrinus* (Linnaeus, 1758)	LC	Sch IV	a, c	+	+	2B, 4A
Lesser Sandplover	*Charadrius mongolus*(Pallas, 1776)	LC	Sch IV			+	4A, 7A
Little Ringed Plover	*Charadrius dubius* (Scopoli, 1786)	LC	Sch IV	a, c	+	+	2B, 4A
Northern Lapwing	*Vanellus vanellus* (Linnaeus, 1758)	NT	Sch IV	c			4A
Red-wattled Lapwing	*Vanellus indicus* (Boddaert, 1783)	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
River Lapwing	*Vanellus duvaucelii* (Lesson, 1826)	NT	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Sociable Lapwing	*Vanellus gregarius* (Pallas, 1771)	CR	Sch IV	c			4A
White-tailed Lapwing	*Vanellus leucurus* (Lichtenstein, 1823)	LC	Sch IV	a, c			2B, 4A
Yellow-wattled Lapwing	*Vanellus malabaricus* (Boddaert, 1783)	LC	Sch IV	a, c			2B, 4A, 7A
Family: Rostratulidae							
Greater Painted Snipe	*Rostratula benghalensis* (Linnaeus, 1758)	LC	Sch IV	c	+		4A
Family: Jacanidae							
Bronze-winged Jacana	*Metopidius indicus (Latham, 1790)*	LC	Sch IV	a, c, d	+		2B, 4A, 7A
Pheasant-tailed Jacana	*Hydrophasianus chirurgus (Scopoli, 1786)*	LC	Sch IV	a, c, d			2B, 4A
Family: Scolopacidae							
Black-tailed Godwit	*Limosa limosa (Linnaeus, 1758)*	NT	Sch IV	c, d			4A
Common Greenshank	*Tringa nebularia (Gunnerus, 1767)*	LC	Sch IV	a, b, c	+	+	2B, 4A
Common Redshank	*Tringa totanus (Linnaeus, 1758)*	LC	Sch IV	a, c, d	+	+	2B, 4A, 7A
Common Sandpiper	*Actitis hypoleucos (Linnaeus, 1758)*	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Common Snipe	*Gallinago gallinago (Linnaeus, 1758)*	LC	Sch IV	a, c, d	+	+	2B, 4A
Curlew Sandpiper	*Calidris ferruginea (Pontoppidan 1763)*	NT	Sch IV	c	+	+	4A

Dunlin	*Calidris alpina (Linnaeus, 1758)*	LC	Sch IV	c			4A
Eurasian Curlew	*Numenius arquata (Linnaeus, 1758)*	NT	Sch IV	c, d	+	+	4A
Green Sandpiper	*Tringa ochropus (Linnaeus, 1758)*	LC	Sch IV	b, c	+	+	2B, 4A
Little Stint	*Calidris minuta (Leisler, 1812)*	LC	Sch IV	c	+	+	4A
Marsh Sandpiper	*Tringa stagnatilis (Bechstein, 1803)*	LC	Sch IV	a, c	+	+	2B, 4A
Pintail Snipe	*Gallinago stenura (Bonaparte, 1831)*	LC	Sch IV	c, d			4A
Ruff	*Calidris pugnax (Linnaeus, 1758)*	LC	Sch IV	c, d	+	+	4A, 7A
Spotted Redshank	*Tringa erythropus (Pallas, 1764)*	LC	Sch IV	a, c	+		2B, 4A
Temminck's Stint	*Calidris temminckii (Leisler, 1812)*	LC	Sch IV	c	+	+	4A
Terek Sandpiper	*Xenus cinereus (Güldenstädt, 1775)*	LC	Sch IV	c			4A
Wood Sandpiper	*Tringa glareola (Linnaeus, 1758)*	LC	Sch IV	c, d	+	+	4A, 7A
Family: Glareolidae							
Oriental Pratincole	*Glareola maldivarum (Forster, 1795)*	LC	NL	c			4A
Little Pratincole	*Glareola lactea (Temminck, 1820)*	LC	NL	c	+	+	4A
Family: Laridae							
Black Tern	*Chlidonias niger (Linnaeus, 1758)*	LC	Sch IV	c			4A
Black-bellied Tern	*Sterna acuticauda (Gray, 1831)*	EN	NL	a, c	+	+	2B, 4A
Black-headed Gull	*Larus ridibundus (Linnaeus, 1766)*	LC	Sch IV	a, c, d	+	+	2B, 4A, 7A
Brown-headed Gull	*Larus brunnicephalus (Jerdon, 1840)*	LC	Sch IV	a, b, c, d	+	+	2B, 4A, 7A
Caspian Tern	*Hydroprogne caspia (Pallas, 1770)*	LC	NL	c			4A
Common Tern	*Sterna hirundo (Linnaeus, 1758)*	LC	NL	c, d			4A
Common Gull-billed Tern	*Gelochelidon nilotica (Gmelin, 1789)*	LC	NL	c, d	+	+	4A
Indian Skimmer	*Rynchops albicollis (Swainson, 1838)*	Vu	NL	c		+	4A
Little Gull	*Hydrocoloeus minutus (Pallas, 1776)*	LC	NL	c			4A

Little Tern	*Sternula albifrons (Pallas, 1764)*	LC	NL	c	+	+	4A
Mew Gull	*Larus canus (Linnaeus, 1758)*	LC	NL	c			4A
Pallas's Gull	*Larus ichthyaetus (Pallas, 1773)*	LC	NL	a, c		+	2B, 4A
River Tern	*Sterna aurantia (Gray, 1831)*	VU	NL	a, b, c, d	+	+	2B, 4A
Slender-Billed Gull	*Larus genei (Breme, 1839)*	LC	NL	c			4A
Whiskered Tern	*Chlidonias hybridus (Pallas, 1811)*	LC	NL	c, d			4A
White-winged Tern	*Chlidonias leucopterus (Temminck, 1815)*	LC	NL	c			4A
Caspian Gull	*Larus cachinnans (Pallas, 1811)*	LC	NL	c			4A
Order:Strigiformes **Family: Strigidae**							
Brown Fish-owl	*Ketupa zeylonensis (Gmelin, 1788)*	LC	Sch IV	c			4A
Tawny Fish-owl	*Ketupa flavipes(Hodgson, 1836)*	LC	Sch IV			+	2B
Order:Accipitriformes **Family: Pandionidae**							
Osprey	*Pandion haliaetus (Linnaeus, 1758)*	LC	Sch I	c		+	4A
Order:Accipitriformes **Family: Accipitridae**							
Brahminy Kite	*Haliastur indus (Boddaert, 1783)*	LC	Sch I	c			4A
Greater Spotted Eagle	*Clanga clanga (Pallas, 1811)*	VU	Sch I	c			4A
Grey-headed Fish Eagle	*Icthyophaga ichthyaetus (Horsfield, 1821)*	NT	Sch I	c			4A
Pallas's Fish-eagle	*Haliaeetus leucoryphus (Pallas, 1771)*	EN	Sch I	c			4A
Order:Coraciiformes **Family: Meropidae**							
Blue-cheeked Bee-eater	*Merops persicus* (Pallas, 1773)	LC	NL	c			4A
Blue-tailed Bee-eater	*Merops philippinus* (Linnaeus, 1766)	LC	NL	c, d			4A
Family: Alcedinidae							

Common Kingfisher	*Alcedo atthis (Linnaeus, 1758)*	LC	Sch IV	c, d		+	4A
Crested Kingfisher	*Megaceryle lugubris (Linnaeus, 1758)*	LC	Sch IV		+	+	2B
Pied Kingfisher	*Ceryle rudis (Linnaeus, 1758)*	LC	Sch IV	c, d	+	+	4A
Stork-billed Kingfisher	*Pelargopsis capensis (Linnaeus, 1766)*	LC	Sch IV	d			4A
White-breasted Kingfisher	*Halcyon gularis (Kuhl, 1820)*	LC	Sch IV	c, d	+	+	4A, 7A
Order: Falconiformes **Family: Falconidae**							
Peregrine Falcon	*Falco peregrinus* (Tunstall, 1771)	LC	Sch I	-		+	4A
Order: Passeriformes **Family: Hirundinidae**							
African Plain Martin	*Riparia paludicola (Vieillot, 1817)*	LC	NL	c	+	+	4A
Barn Swallow	*Hirundo rustica (Linnaeus, 1758)*	LC	NL	c, d	+	+	4A, 7A
Red-rumped Swallow	*Cecropis daurica (Linnaeus, 1771)*	LC	NL	c			4A
Streak-Throated Swallow	*Petrochelidon fluvicola (Blyth, 1855)*	LC	NL	c			4A
Wire-tailed Swallow	*Hirundo smithii (Leach, 1818)*	LC	NL	c		+	4A
Family: Cinclidae							
Brown dipper	*Cinclus pallasii(Temminck, 1820)*	LC	Sch IV			+	
Family: Muscicapidae							
Little Forktail	*Enicurus scouleri (Vigors, 1832)*	LC	Sch IV			+	2B
Plumbeous Water Redstart	*Phoenicurus fuliginosus (Vigors, 1831)*	LC	Sch IV	c		+	4A
White-capped Redstart	*Phoenicurus leucocephalus (Vigors, 1831)*	LC	Sch IV			+	2B
White-tailed Stonechat	*Saxicola leucura (Blyth, 1847)*	LC	Sch IV	c			4A
Family: Motacillidae							
Citrine Wagtail	*Motacilla citreola* (Pallas, 1776)	LC	Sch IV	c, d	+	+	4A, 7A
Grey Wagtail	*Motacilla cinerea* (Tunstall, 1771)	LC	Sch IV	c, d	+	+	4A, 7A

Western Yellow Wagtail	*Motacilla flava* (Linnaeus, 1758)	LC	Sch IV	c, d	+	+	4A, 7A
White Wagtail	*Motacilla alba* (Linnaeus, 1758)	LC	Sch IV	c	+	+	4A, 7A
White-browed Wagtail	*Motacilla maderaspatensis* (Gmelin, 1789)	LC	Sch IV	c	+	+	4A, 7A

*[a]Kaushik et al. (2013); [b]Tak et al. (2010); [c]Urfi (2003); [d]Mazumdar (2017)

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ANNEXURE III

List of Reptilian species of the Yamuna River (N=11)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	First PostM	Second PostM	Biogeographic zones
Gavialidae	Gharial	*Gavialis gangeticus* (Gmelin, 1789)	CR	Sch I	c, f, i, j, k, l	+	+	4B, 7A
Crocodylidae	Mugger	*Crocodylus palustris* (Lesson, 1831)	VU	Sch I	l	-	-	7A
Geoemyididae	Red-crowned roofed turtle	*Batagur kachuga,* (Gray, 1830)	CR	Sch I	a, g	-	-	7A
	Three-striped roofed turtle	*Batagur dhongoka*(Gray, 1832)	CR	NL	g	+	-	7A
	Crowned river turtle	*Hardella thurjii*(Gray, 1831)	EN	NL	e	-	-	7A
	Indian roofed turtle	*Pangshura tecta* (Gray, 1830)	VU	Sch I	a,e	-	-	7A
	Indian tent turtle	*Pangshura tentoria* (Gray, 1834)	LC	NL	a, b, d, f	+	-	7A
Triyonichidae	Indian narrow-headed softshell turtle	*Chitra indica* (Gray, 1830)	EN	Sch IV	d,c,e	-	-	7A
	Indian softshell turtle	*Nilssonia gangetica*(Cuvier, 1825)	EN	Sch I	e,g	+	-	7A
	Indian peacock softshell turtle	*Nilssonia hurum*(Gray, 1830)	EN	Sch I	c	+	-	7A
	Indian flapshell turtle	*Lissemys punctata* (Lacépède, 1788)	VU	Sch I	c	-	-	7A

[a]Anderson (1871), [b]Baruah et al., (2016); [c]Bhaskar and Mohindra (2016); [d]Günther (1864), [e]Iverson (1992), [f]Moll (1987), [g]Tiwari (2003)

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ANNEXURE IV

List of Amphibians Species of the Yamuna River basin (N=6)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	Present study	Biogeographic zones
Dicroglossidae	Asian Grass Frog	*Fejervarya limnocharis*	LC	NL	a, b	-	2B
Dicroglossidae	Common Skittering Frog	*Euphlyctis cyanophlyctis*	LC	NL	a, b	-	2B
Dicroglossidae	Indian Bullfrog	*Hoplobatrachus tigrinus*	LC	Sche IV	a	-	7A
Microhylidae	Ornamented Pygmy Frog	*Microhyla ornata*	LC	NL	a	-	7A
Pyxicephalidae	Burrowing Frog	*Tomopterna* sp.			a	-	7A
Bufonidae	Indian Common Toad	*Duttaphrynus melanostictus*	LC	NL	b	-	2B

[a]Poddar et al. (1998); [b]Rizvi et al. (2010)

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ANNEXURE V

List of Fish Species of the Yamuna River (N= 79)

Family	Common name	Scientific name	IUCN Status	First PostM	Second PostM	Biogeographic zones
Ambassidae	Elongate glass perchlet	*Chanda nama* (Hamilton, 1822)	LC	-	+	4A,7A
	Highfin glassy perchlet	*Parambassis lala*(Hamilton,1822)	NT	-	-	4A,7A
	Indian glassy fish	*Parambassis ranga* (Hamilton,1822)	LC	-		4A,7A
Bagridae	Day's mystus	*Mystus bleekri*(Day,1877)	LC	-	-	4A,7A
	Gangetic mystus	*Mystus cavasius* (Hamilton, 1822)	LC	+	-	4A,7A
	Striped dwarf catfish	*Mystus vittatus* (Bloch, 1794)	LC	-	+	4A,7A
	Rita	*Rita rita* (Hamliton, 1822)	LC	+	-	4A,7A
	Long-whiskered catfish	*Sperata aor* (Hamilton, 1822)	LC	-	-	4A,7A
	Giant river-catfish	*Sperata seenghala* (Sykes, 1839)	LC	-	-	4A,7A
Balitoridae	Mottled loach, Sand loach	*Aborichthys elongatus* (Hora, 1921)	LC	-	-	4A, 7A
	Striped loach	*Acanthocobitis botia*(Hamilton,1822)	LC	-	-	4A, 7A
Channidae	Bull's eye snakehead, Great snakehead	*Channa marulius* (Hamilton, 1822)	LC	-	-	4A,7A
	Spotted snakehead, Goroi	*Channa punctata* (Bloch, 1793)	LC	-	-	4A,7A
	Snakehead murrel, Shoal	*Channa striata* (Bloch, 1793)	LC		-	4A,7A
Clariidae	Clarias catfish	*Clarias batrachus* (Linnaeus, 1758)	LC	+	-	4A,7A
Clupeidae	The Ganges River sprat	*Corica soborna* (Hamilton, 1822)	LC	-	-	4A,7A
	Ganges river gizzard shad	*Gonialosa manmina* (Hamilton, 1822)	LC	-	-	4A,7A
	Indian river shad	*Gudusia chapra* (Hamilton, 1822)	LC	-	-	4A,7A
	Hilsa	*Tenualosa ilisha* (Hamilton, 1822)	LC	-	-	4A,7B

Cobitdae	Y- loach	*Botia lohachata*(Chaudhuri, 1912)	NL	-	-	4A,7A
	Peppered loach, Guntea loach	*Lepidocehalichthys guntea* (Hamilton, 1822)	NL	-	-	4A,7A
Cyprinidae	Molacarplet, Pale carplet	*Amblypharyngodon mola* (Hamilton, 1822)	LC	-	+	4A,7A
	Jaya, Choto-piali	*Aspidoparia jaya* (Hamilton, 1822)	LC	-	-	4A,7A
	Kalabans	*Bangana dero* (Hamilton, 1822)	LC	-	-	4A,7A
	Barred baril	*Barilius barila* (Hamilton, 1822)	LC	-	+	4A,7A
	Hamilton's barila Dudhnea, Gheur	*Barilius bendelisis* (Hamilton, 1807)	LC	-	-	4A,7A
	Vagrabaril	*Barilius vagra* (Hamilton, 1822)	LC	-	-	4A
	Morari	*Cabdio morar* (Hamilton,1822)	LC	-	-	4A
	Chaguni, lalputi	*Chagunius chagunio* (Hamilton, 1822)	LC	-	+	4A
	Silver hatchet	*Chela cachius* (Hamilton, 1822)	LC	-	-	4A
	Mrigal, Mirka	*Cirrhinus mrigala* (Hamilton, 1822)	LC	-	-	4A
	Reba carp	*Cirrhinus reba* (Hamilton, 1822)	LC	-	-	4A,7A
	Gangetic latia	*Crossocheilus latius* (Hamilton, 1822)	LC	+	-	4A,7A
	Grass carp	*Ctenopharyngodon idella* (Valenciennes, 1844)	NL	-	-	4A,7A
	Debari, Devario	*Danio devario* (Hamilton. 1822)	LC	-	-	4A,7A
	Lamta garra	*Garra lamta* (Hamilton, 1822)	LC	-	+	4A,7A
	Catla	*Gibelion catla* (Hamilton, 1822)	LC	-	-	4A,7A
	Angralabeo	*Labeo angra* (Hamilton, 1822)	LC	-	-	4A,7A
	Minor carp	*Labeo bata* (Hamilton, 1822)	LC	-	-	4A,7A
	Boga labeo	*Labeo boga* (Hamilton, 1822)	LC	-	-	4A,7A
	Orange-fin labeo	*Labeo calbasu* (Hamilton, 1822)	LC	-	-	4A,7A
	Kali, Boalla	*Labeo dyocheilus* (McClelland, 1839)	LC	-	-	4A,7A
	Fringed-lipped peninsula carp	*Labeo fimbriatus* (Bloch, 1795)	LC	-	-	4A,7A

	Kuria labeo	*Labeo gonius* (Hamilton, 1822)	LC	-	+	4A
	Rohu	*Labeo rohita* (Hamilton, 1822)	LC	-	-	4A
	Indian hatchet fish Gilakhani, Cotio	*Labeo laubuca* (Hamilton, 1822) *Osteobrama cotio*(Hamilton, 1822)	LC LC	- -	- +	4A 4A,7A
	Rosy barb, Red barb	*Pethia conchonius* (Hamilton, 1822)	LC	-	-	4A
	Ticto barb, Firefin barb	*Pethia ticto* (Hamilton, 1822)	LC	-	-	4A,7A
	Spot fin swamp barb	*Puntius sophore* (Hamilton, 1822)	LC	-	-	4A,7A
	Indian trout	*Raiamas bola* (Hamilton, 1822)	LC	-	+	4A,7A
	Slender barb, Blackline rasbora	*Rasbora daniconius* (Hamilton, 1822)	LC	-	-	4A,7A
	Gora-chela	*Securicula gora* (Hamilton, 1822)	LC	-	-	4A,7A
	Olive barb	*Systomus sarana* (Hamilton, 1822)	LC	-	+	4A,7A
	Putitor mahseer, Golden mahseer	*Tor putitora* (Hamilton, 1822)	EN	-	-	4A
Engraulidae	Gangetic anchovy	*Setipinna phasa* (Hamilton, 1822)	LC	-	-	4A
Gobiidae	Bareye Goby, Belay	*Glossogobius giuris* (Hamilton, 1822)	LC	-	+	4A,7A
Heteropneustidae	Stinging catfish	*Heteropneustes fossilis* (Bloch, 1794)	LC	-	-	4A,7A
Mastacembelidae	Spiny Eel	*Macrognathus aral* (Bloch & Schneider, 1801)	LC	-	-	4A,7A
	Barred spiny eel or Indian spiny-eel	*Macrognathus pancalus* (Hamilton, 1822)	LC	-	-	4A,7A
	Spiny eel	*Mastacembelus armatus* (Lacepede, 1800)	LC	-	-	4A,7A
Mugilidae	Corsula mullet	*Rhinomugil corsula* (Hamilton, 1822)	LC	-	-	4A,7A
	Yellowtail mullet	*Minimugil cascasia*(Hamilton, 1822)	LC	-	-	4A,7A
Nandidae	Gangetic leaf fish, Nanda, Mottled nandus	*Nandus nandus* (Hamilton, 1822)	LC	-	-	4A,7A
Notopteridae	Indian featherback, Kandla	*Chitala chitala* (Hamilton, 1822)	NT	-	-	4A,7A
	Bronze featherback	*Notopterus notopterus* (Pallas, 1769)	LC	-	-	4A,7A
Pristigasteridae	Bigeye ilisha, Indian ilisha	*Ilisha megaloptera* (Swainson, 1839)	LC	-	-	4A

Schilbeidae	Gangetic ailia	*Ailia coila* (Hamilton, 1822)	NT	-	-	4A,7A
	Muriusvacha	*Eutropiichthys murius* (Hamilton, 1822)	LC	-	-	4A,7A
	Vacha, tunti	*Eutropiichthys vacha* (Hamilton, 1822)	LC	-	-	4A,7A
	Silond catfish, Silong catfish	*Silonia silondia* (Hamilton, 1822)	LC	-	-	4A,7A
Sciaenidae	Big-eyed jewfish, Coitor croacker,Ganges croacker	*Johnius coitor* (Hamilton, 1822)	LC	-	-	4A,7A
	Gangetic bola	*Johnius gangeticus* (Talwar, 1991)	NL	-	-	4A,7A
Siluridae	Indian butter-catfish	*Ompok bimaculatus* (Bloch, 1794)	NT	-	-	4A,7A
	Pabdah catfish	*Ompok pabda* (Hamilton, 1822)	NT	-	-	4A,7A
	Parhin, Helicopter catfish	*Wallago attu* (Bloch & Schneider, 1801)	NT	+	+	4A,7A
Sisoridae	Devil catfish, Dwarf goonch	*Bagarius bagarius* (Hamilton, 1822)	NT	-	-	4A,7A
	Telchitta, Dhal magur	*Glyptothorax telchitta* (Hamilton, 1822)	LC	-	-	4A
	Kosi nangra	*Nangra nangra*(Hamilton, 1822)	LC	-	-	4A

[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) [l]Gunther (1864);

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ANNEXURE VI

List of Plant species along the Yamuna River (N=94)

Family	Species name	Habit	Habitat	IUCN Status
Acanthaceae	*Justicia adhatoda* L.	Herb	Riparian	-
Amaranthaceae	*Achyranthes aspera* L.	Herb	Moist	-
Amaranthaceae	*Alternanthera paronychioides* A.St.-Hil.	Herb	Moist	-
Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb.	Herb	Aquatic	-
Amaranthaceae	*Alternanthera sessilis* (L.) R. Br. ex DC.	Herb	Marshy	LC
Amaranthaceae	*Amaranthus spinosus* L.	Herb	Riparian	-
Araceae	*Pistia stratiotes* L.	Herb	Aquatic	LC
Asclepiadaceae	*Calotropis procera* (Ait.) R.Br.	Herb	Riparian	-
Asteraceae	*Ageratina adenophora* (Spreng.) R.M.King & H.Rob.	Herb	Riparian	-
Asteraceae	*Ageratum houstonianum* Mill.	Herb	Riparian	-
Asteraceae	*Cirsium arvense* (L.) Scop.	Herb	Riparian	-
Asteraceae	*Eclipta alba* (L.) Hassk.	Herb	Marshy	LC
Asteraceae	*Grangea maderaspatana* (L.) Poir.	Herb	Moist	LC
Asteraceae	*Lactuca sativa* L.	Herb	Moist	-
Asteraceae	*Parthenium hysterophorus* L.	Herb	Riparian	-
Asteraceae	*Sonchus wightianus* DC.	Herb	Riparian	-
Asteraceae	*Synedrella nodiflora* (L.) Gaertn.	Herb	Riparian	-
Asteraceae	*Tridax procumbens* L.	Herb	Moist	-
Asteraceae	*Xanthium strumarium* L.	Herb	Riparian	-
Basellaceae	*Basella alba* L.	Climber	Riparian	-
Boraginaceae	*Arnebia hispidissima* (Lehm.) A.DC.	Herb	Riparian	-
Boraginaceae	*Heliotropium europaeum* L.	Herb	Riparian	-
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.	Herb	Riparian	-
Cannabaceae	*Cannabis sativa* L.	Herb	Riparian	-
Caryophyllaceae	*Stellaria media* (L.) Vill.	Herb	Moist	-
Chenopodiaceae	*Chenopodium album* L.	Herb	Riparian	-
Chenopodiaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Herb	Riparian	-
Chenopodiaceae	*Suaeda fruticosa* (L.) Forsk.	Herb	Moist	-
Amaranthaceae	*Suaeda maritima* (L.) Dumort.	Herb	Riparian	-
Convolvulaceae	*Ipomoea carnea* Jacq.	Shrub	Riparian	-
Cucurbitaceae	*Coccinia grandis* (L.) Voigt	Climber	Marshy	-
Cucurbitaceae	*Cucurbita moschata* Duchesne	Climber	Riparian	-

Cyperaceae	*Schoenoplectus mucronatus* (L.) Palla	Sedges & Reeds	Marshy	-
Cyperaceae	*Cyperus rotundus* L.	Grass	Moist	LC
Cyperaceae	*Kyllinga brevifolia* Rottb.	Sedges & Reeds	Moist	LC
Euphorbiaceae	*Croton bonplandianus* Baill.	Herb	Riparian	-
Euphorbiaceae	*Euphorbia hirta* L.	Herb	Moist	-
Euphorbiaceae	*Ricinus communis* L.	Shrub	Riparian	-
Fabaceae	*Alhagi maurorum* Medik.	Herb	Riparian	-
Fabaceae	*Cicer arietinum* L.	Herb	Riparian	-
Fabaceae	*Crotalaria spectabilis* Roth	Shrub	Riparian	-
Fabaceae	*Medicago monantha* (C.A.Mey.) Trautv.	Herb	Riparian	-
Fabaceae	*Tephrosia purpurea* (L.) Pers.	Herb	Riparian	-
Fumariaceae	*Fumaria indica* (Hausskn.) Pugsley	Herb	Moist	-
Hydrocharitaceae	*Hydrilla verticillata* (L. f.)	Herb	Aquatic	LC
Hydrocharitaceae	*Vallisneria natans* (Lour.) H. Hara	Herb	Aquatic	LC
Lamiaceae	*Anisomeles indica* (L.) Kuntze	Herb	Riparian	-
Lamiaceae	*Leucas aspera* (Willd.) Link	Herb	Moist	-
Lythraceae	*Ammanniabaccifera* L.	Herb	Marshy	LC
Malvaceae	*Abutilon indicum* (L.) Sweet	Herb	Riparian	-
Malvaceae	*Gossypium arboreum* L.	Shrub	Riparian	-
Malvaceae	*Sida acuta* Burm.f.	Herb	Riparian	-
Onagraceae	*Ludwigia adscendens* (L.) H.Hara	Herb	Marshy	-
Orobanchaceae	*Orobanchecernua* Loefl.	Herb	Moist	-
Papaveraceae	*Argemone mexicana*L.	Herb	Riparian	-
Plantaginaceae	*Veronica anagallis-aquatica* L.	Herb	Marshy	LC
Plantaginaceae	*Veronica arvensis* L.	Herb	Moist	-
Poaceae	*Coix lacryma-jobi* L.	Grass	Marshy	-
Poaceae	*Cynodon dactylon* (L.) Pers.	Grass	Moist	-
Poaceae	*Eleusine indica* (L.) Gaertn.	Grass	Moist	LC
Poaceae	*Eragrostis amabilis* (L.) Wight &Arn.	Grass	Moist	-
Poaceae	*Phragmites karka* (Retz.) Trin. ex Steud.	Sedges & Reeds	Moist	LC
Poaceae	*Saccharum officinarum* L.	Grass	Moist	-
Poaceae	*Saccharum ravennae* (L.) L.	Grass	Moist	LC
Poaceae	*Saccharum spontaneum* L.	Grass	Moist	LC
Poaceae	*Setaria verticillata* (L.) P. Beauv.	Grass	Moist	-
Poaceae	*Setaria viridis* (L.) P.Beauv.	Grass	Moist	-
Polygonaceae	*Persicaria glabra* (Willd.) M.Gómez	Herb	Moist	-

Polygonaceae	*Polygonum plebeium* R.Br.	Herb	Moist	-
Polygonaceae	*Polygonum barbatum* L.	Herb	Marshy	-
Polygonaceae	*Rumex dentatus* L.	Herb	Moist	-
Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms	Herb	Aquatic	-
Pontederiaceae	*Monochoria hastata* (L.) Solms	Herb	Marshy	LC
Potamogetonaceae	*Potamogeton crispus* L.	Herb	Aquatic	-
Potamogetonaceae	*Potamogeton nodosus* Poir.	Herb	Aquatic	-
Potamogetonaceae	*Stuckenia pectinata* (L.)	Herb	Aquatic	-
Primulaceae	*Anagallis arvensis* L.	Herb	Moist	-
Ranunculaceae	*Ranunculus sceleratus* L.	Herb	Moist	-
Rhamnaceae	*Ziziphus nummularia* (Burm. f.) Wight &Arn.	Shrub	Riparian	-
Rubiaceae	*Galium aparine* L.	Herb	Moist	-
Scrophulariaceae	*Bacopa monnieri* (L.) Wettst.	Herb	Marshy	-
Scrophulariaceae	*Scoparia dulcis* L.	Herb	Moist	-
Scrophulariaceae	*Verbascum thapsus* L.	Herb	Riparian	-
Solanaceae	*Datura stramonium* L.	Herb	Riparian	-
Solanaceae	*Nicotiana plumbaginifolia* Willd.	Herb	Marshy	-
Solanaceae	*Physalis minima* L.	Herb	Moist	-
Solanaceae	*Solanum nigrum* L.	Herb	Moist	-
Solanaceae	*Solanum sisymbriifolium* Lam.	Herb	Riparian	-
Solanaceae	*Withania somnifera* (L.) Dunal	Herb	Riparian	-
Tamaricaceae	*Tamarix indica* Willd.	Herb	Riparian	-
Tamaricaceae	*Tamarix ramosissima* Ledeb.	Herb	Riparian	LC
Typhaceae	*Typha angustata* Bory. & Choub. = *Typha domingensis* Pers.	Sedges & Reeds	Marshy	LC
Verbenaceae	*Lantana camara* L.	Shrub	Riparian	-
Verbenaceae	*Phyla nodiflora* (L.) Greene	Herb	Moist	LC

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