GANDAK RIVER

Ecological status and trends









ASSESSMENT OF THE ECOLOGICAL STATUS OF **GANDAK RIVER** FOR CONSERVATION PLANNING

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GANDAK RIVER Ecological status and trends

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Preface

India being a megadiverse country, hosts a wide number of landscapes and ecosystems. A vital component of these are their riverine networks, which are in themselves a complete ecosystem. The nation's Ganga River is an internationally revered and recognised river that has been and continues to be a haven for a variety of animals and birds, making it an extremely important area with regard to biodiversity conservation. A number of tributaries make up the mighty Ganga River, of which the Gandak River is also a part. They also provide essential provisioning and regulating ecosystem services. The Wildlife Institute of India through the Biodiversity Conservation and Ganga Rejuvenation Project and National Mission for Clean Ganga funded by the Ministry of Water Resources, River Development and Ganga Rejuvenation has been working towards the conservation of Gandak River, along with all the other tributaries of Ganga River, so as to strengthen concerted efforts for restoration of its biodiversity value. For a complete scientific assessment of Gandak River, robust information on the diversity, abundance and distribution of aquatic vertebrate fauna of Gandak River, their major threats and the various drivers of these threats causing decline in their populations and habitat is collated in the present report.

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 Gandak 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 Gandak River through the Biodiversity Conservation and Ganga Rejuvenation Project and this report attempts to compile biodiversity of Gandak River through literature review and Rapid Biodiversity Assessment. This report aims to develop a thorough knowledge base for the priority species of Gandak River, aid in biological restoration, and assist policy planners and managers to judiciously use water from the Gandak River, in view of the needs of the aquatic species therein.

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CONTENTS

S. No	Title	Page No.
	Executive summary	i-ii
Chapter 1	Introduction	1
1.1	Course of the River	1
1.2	Geography and Geomorphology	2
1.3	Soil Type	3
1.4	Climate	3
1.5	Biogeography, Flora and Fauna	3
1.6	Demography	5
Chapter 2	Status of aqualife in the Gandak River	6
2.1	Methodological Framework	6
2.2	Mammals	7
2.3	Reptiles	9
2.4	Avifauna	16
2.5	Amphibians	19
2.6	Fishes	19
2.7	River stretches with High Biodiversity Value	20
Chapter 3	Threats to the biodiversity of Gandak River	26
3.1	River flow	26
3.2	Physiochemical parameters (water and sediments)	26
3.3	Alteration in habitat	26
3.4	Unsustainable resource use practices	26
Chapter 4	Conservation implications	28
	References	30-32
	Annexures	33-43



EXECUTIVE SUMMARY

Gandak, the second trans-boundary tributary of Ganga River encompasses intimidating wildlife in the exquisite landscapes. It originates at an altitude of 620 m above msl to the north of Dhaulagiri Mountain in Tibet near Nepal border. After flowing through Tibet it crosses Nepal, where it is also known as Narayani, to enter the Indian Territory. In India, it flows through West Champaran, East Champaran, Muzaffarpur, Gopalganj, Siwan, Saren and Vaishali districts of Bihar and Gorakhpur & Deoria district of Uttar Pradesh before joining Ganga at Hajipur in Bihar, after covering a course of 320 kms (FIMS). Due to steep slope and loose soil in the upper catchment, Gandak carries a lot of silt and other deposits to the Indian side, resulting in continuous shifting course of the river. Gandak River is also the home to threatened aquatic taxa including; Gangetic river dolphin, gharial, mugger, smooth-coated otter, freshwater turtles and water birds. This thriving ecosystem is subject to an array of anthropogenic pressures resulting in the physical modification, flow alteration, point source & diffuse pollution and sand mining.

Taking all the facts into consideration, a rapid biodiversity assessment was conducted in the India side of the river under the National Mission for Clean Ganga-Wildlife Institute of India project *Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga*. The assessment has been undertaken from Valmikinagar, West Champaran district (Bihar) to Hajipur, Vaishali district (Bihar) till the confluence with main stem Ganga in post-monsoon season of 2019-2020 and 2020-2021 covering a total stretch of 320 km. The entire length of the river four stretches, namely A) Upper Himalayan zone, (B) Lower Himalayan zone, (C) Middle zone and (D) Lower zone. The Upper Himalayan zone and Lower Himalayan zone fall in Nepal and the Middle zone from Gandak Barrage to Bansi confluence with and Lower zone from Bansi confluence to Ganga confluence fall in the Indian side.

The survey was conducted with the objectives of (a) Biodiversity assessment in terms of number of individuals and size classes of the species (b) Evaluation of habitat characteristics concerning bank features, shoreline features, water quality, and water depth (c) Evaluation of anthropogenic activities that had their influence on the River Ecosystem.

Boat based direct total count method was used for estimation of encounter rate. To assess water and habitat features, the survey stretch was divided into 65 equal segments of 5 kms each, and habitat variables were simultaneously recorded for each segments. River morphology data such as channel type, bank substratum, and water physical and chemical parameters namely; temperature and depth were recorded at the starting points of each segment.

Some of the major finding encountered during the study include, 152 individuals of Gangetic dolphins were recorded with an encounter rate of 0.47±0.07. Sixty-four percent of all sightings were recorded in lower zone with an encounter rate of 0.49±0.07 in 2019-2020. In the second rapid biodiversity in 2020-21, a total of 105 individuals of Gangetic dolphins with an encounter rate of 0.39±0.07 were recorded from Lavkush ghat, Valmikinagar, West Champaran to Hajipur, Vaishali. A total of 192 Gharials, including 05 adult males were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali with an encounter rate of 0.59±0.13 in the year 2019-2020. In the second assessment carried out in the year 2020-2021, a total of 206 individuals, including 09 adult male were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali with an encounter rate of 0.63±0.14. A total of 987 individuals of freshwater turtles were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali with an encounter rate of 3.04±0.87 in the year 2019-2020. During the second assessment in 2020-2021, 643 individuals were recorded from Lavkush Ghat, Valmikinagar to Hajipur, Vaishali with an encounter rate of 3.04±0.87 in the year 2019-2020. During the second assessment in 2020-2021, 643 individuals were recorded from Lavkush Ghat, Valmikinagar to Hajipur, Vaishali with an encounter rate of 1.98±0.64. The survey team also encountered a nesting site of *Morenia petersi* upstream of Dhanha Bridge in West Champaran district of Bihar. The study identifies a 115 km stretch from Dhanha, West Champaran to Dhekhwah, East Champaran districts with high biodiversity value with good presence of riverine islands and sandbanks.

Some of the major issues identified include flow alteration by the Gandak Barrage at Indo-Nepal border, habitat alteration and unsustainable resource. Other threats in the river include riverbed farming, sand mining, unsustainable fishing, feral dogs and open drains along river banks with close proximity to human settlement.

These threats need to be addressed with site specific conservation strategies developed with the support of an array of stakeholders for sustainable management of natural resources and conservation of the aquatic life.

1. INTRODUCTION

Gandak is the second transboundary left bank tributary of the Ganga River, it passes through two most densely populated states of India namely Uttar Pradesh and Bihar. Gandak River is regarded holy as per Hindu religion as it carries *Shaligrams*- an ammonite fossil, from devonion period; the representative of Lord Vishnu (DTH, 2018). Gandak not only supports the local communities but also an array of aquatic biodiversity including; mammals like Gangetic dolphin; reptiles like Gharial, freshwater turtles; amphibians; fishes and waterbirds. The lower zones of the basin are part of the Terai-arc landscape (Johnsingh et al., 2004). Two important protected areas, Chitwan National Park in Nepal and the adjacent Valmiki Tiger reserve in India have been established in the basin and are best known for conserving threatened terrestrial megafauna such as Indian Rhinoceros and the Tiger. The river also flows along the eastern flank of Nichlaul range of Sohagi-Barwa Wildlife Sanctuary, separating it from the Valmiki Tiger reserve.

The Gandak River is also known as Kali Gandaki and Narayani, after its confluence with Trisuli River in Nepal. Gandak rises at an altitude of approximately 7620 m asl in Tibet near the Nepal border. While flowing through the Nepal Himalayas, it forms the Kali Gandaki gorge, one of the deepest river gorges in the world.

In India, Gandak flows through the West Champaran, East Champaran, Muzaffarpur, Gopalganj, Siwan, Saran and Vaishali districts of Bihar; and Gorakhpur and Deoria districts of Uttar Pradesh.

The water of Gandak is utilized by one of the major irrigation cum hydroelectric power facility at the Indo-Nepal border in Valmikinagar of the West Champaran district in Bihar. The total catchment area of the river is 46,300 km² and has a drainage area of 7620 km² in India. The ancient Indian epic – the Mahabharata mentions Gandaki River (Jupiter infomedia ltd., 2015).

1.1 Course of the Gandak River

After originating at an altitude of 7620 m asl in Tibet, the Gandak River covers more than 700 km before its confluence with the Ganga River. The river enters India from Valmikinagar in West Champaran district of Bihar (Figure 1.1). The entry point of the river is at the Indo–Nepal border and is known as Triveni. In India, it covers a course of more than 300 km southeast, across the upper Gangetic plain in eastern Uttar Pradesh and northwestern Bihar. Gandak, joins Ganga near Patna just downstream of Hajipur at Sonepur in Vaishali district of Bihar (also known as Harihar Kshetra) (Kansal et. al., 2016).





Figure 1.1 The course of the Gandak River

1.2 Geology and Geomorphology

Originating in the Himalayas, snow-fed Gandak, enters India and gives rise to a 5-24 km wide alluvial fan also known as the mega fan in northern Bihar plains. The course of Gandak based on geomorphology and landforms can be divided into four zones from its source in Nepal to its confluence with Ganga River in India (Figure 1.2) i.e., (A) Upper Himalayan zone, (B) Lower Himalayan zone, (C) Middle zone and (D) Lower zone.



Figure 1.2 Zonation of Gandak River in India & Nepal

(A) Upper Himalayan zone: Upper Himalayan zone falls in Nepal covering 372 km stretch of the river from its source to Trisuli confluence. The geomorphological features of the stretch include steep slope and deep gorges. This stretch passes through upper Himalayas.

(B) Lower Himalayan zone: The lower Himalayan zone starts from Trisuli confluence to Gandak barrage in Nepal covering 85 km stretch. The stretch passes through the Shivalik Himalayas coupled with steep slope and deep gorges.

(C) Middle zone: Gandak enters India from this zone through Himalayan foothills crossing and entering Gangetic plain. The stretch cover 120 km stretch from Gandak Barrage, West Champaran, Bihar to Bansi confluence near Rakba jungli, Kushinagar, Uttar Pradesh with moderate slope. The width of the floodplain is approximately 18 km with only one major channel in middle zone (Mohindra et. al., 1992).

(D) Lower zone: The lower zone of Gandak river begins from the confluence of Bansi River near Rakba jungli, Kushinagar, Uttar Pradesh to the confluence of Gandak with Ganga River at Hajipur, Vaishali, Bihar covering 172 km stretch. This region is part of the Gangetic plain featured with gentle slopes and the widest floodplain with an approximate width of 24 km including two channels separated by two mid channel bars (Mohindra et. al., 1992).

Zone	Upper Himalayan zone	Lower Himalayan zone	Middle zone	Lower zone
Length (km)	372	85	120	172
Stretch	Trisuli confluence	Gandak barrage	Bansi confluence	Hajipur
Characteristic features	Upper Himalayas, steep slope and deep gorges	Shivalik Himalayas, steep slope and deep gorges	Himalayan foothills, moderate slope, wide floodplain	Gangetic plain, Gentle slope, widest floodplain

Table 1.1 Zonation of Gandak River in India & Nepal

Due to the steep slope and loose soil in the upper catchment, the river brings a lot of silt and other deposits in the Indian side, which is resulting in the shifting course of Gandak. The course of Gandak has moved 80 km eastwards over the past 5000 years, and the annual movement continues to occur (Mohindra & Prakash, 1990). The floodplains of Gandak are highly affected by this frequent channel migration or river avulsion making it one of the most flood prone areas in Bihar (Mahindra & Parkash, 1994; Sinha & Friend, 1994; Jain & Sinha, 2004).

1.3 Soil type

Srivastava et al (2015) identified five geomorphic units and described their properties from the Gandak megafan area. The oldest soils occur in the interfluve regions, are > 10,000 years old and show strong soil development. The youngest soils occur on the piedmonts and flood plains are < 500 years old and show poor soil development. Soil development is poorer in east and higher in the western parts. Dominant soil orders are represented by Entisols, Inceptisols and Alfisols. (Srivastava et al, 2015).

1.4 Climate

Climate of the Gandak basin ranges from sub-humid to humid-monsoon type. The annual rainfall ranges from 1000 mm to 1660 mm, with 80-85% the rainfall in the months July to September. Maximum downpour is received in plains than at the foothills of the Himalaya and decreases towards the south. Temperature in the Gandak basin shows an upward trend from February onwards till June with July bringing Monsoon rains and drop in temperature (Mohindra et al., 1992).

1.5 Biogeography, flora and fauna

Gandak River passes through the Gangetic plain in India, which is one of the largest biogeographic zones of India (Rogers et al., 2000). Vegetation type is mainly represented by tropical moist deciduous forests with small patches of semi-evergreen forests and grasslands (Choudhury, 2016). Singh et al. (2017) recorded a total of 233 plant species from the stretch of Gandak River (Appendix I). Out of these 84 species of algae were recorded, among angiosperms, 72 species of herbs, 20 species of Shrubs and 15 species of trees were identified.



Figure 1.3 Forest cover of Gandak River

The terrestrial fauna of the basin includes tiger, great one horned rhinoceros, gaur and fishing cat (Maurya & Borah, 2013). Major aquatic fauna recorded are Gangetic dolphin, smooth-coated otter, gharial and mugger. Greater and lesser adjutants and common shelduck are some of the representative birds found in the Gandak River (Choudhury, 2010). The Valmiki Tiger Reserve in India is located on right bank of the Gandak River. Across the border in Nepal, Chitwan National Park is adjacent to Valmiki Tiger Reserve and together they form an important Trans-boundary conservation unit of the Terai-arc landscape.



Figure 1.4 Land use and Land cover of Gandak River

1.6 Demography

Gandak river flows through the two most densely populated states of India, viz; Uttar Pradesh and Bihar covering two districts in Uttar Pradesh and six districts of Bihar with a total population of 5,42,58,914 (Figure 1.5). The average population density of the river is 1270 individual/km² (Table 1.2). Gandak River supports around 23% of the total population in the state of Bihar.



Figure 1.5 Population density of Gandak River

State/s	District	Density (Person/km²)
Bihar	West Champaran	753
Littar Dradach	Maharajaganj	909
Ottar Pradesh	Kushinagar	1227
	Gopalganj	1260
	Muzaffarpur	1514
Bihar	East Champaran	1285
	Saran Chalta	1496
	Vaishali	1717

Table 1.2 Human density along the Gandak River (Census of India, 2011)

2. STATUS OF AQUATIC WILDLIFE IN THE GANDAK RIVER

Two species of aquatic mammals, Gangetic dolphin and smooth-coated otter, two crocodilian species gharial and mugger, and several species of turtles are recorded from Gandak (Table 2.1). A survey of a 10 km stretch from two sites of the River recorded 54 fish species (Srivastava, 2013). David (1963) and Jhingran et al (1964) have provided detailed observations on fishes prior to construction of the barrage.

Class	Representative species	IUCN status	CITES	IWPA status
Mammala	Gangetic dolphin	Endangered	Appendix I	Schedule I
Widmindis	Smooth-coated otter	Vulnerable	Appendix II	Schedule II
	Gharial	Critically Endangered	Appendix I	Schedule I
	Mugger	Vulnerable	Appendix I	Schedule I
Reptile	Red-crowned roofed turtle	Critically Endangered	Appendix II	Schedule I
	Indian narrow-headed softshell turtle	Endangered	Appendix II	Schedule I
Bird	Lesser adjutant	Vulnerable	Not listed	Not listed

Table 2.1 Representative aquatic fauna of the Gandak River

2.1 Methodological Framework

The entire stretch of 320 km which flows through India was surveyed from Valmikinagar, West Champaran district (Bihar) to Hajipur, Vaishali district (Bihar) till the confluence with mainstem Ganga in post-monsoon season of 2019-2020 and 2020-2021. The survey also covered the stretches which fall in Uttar Pradesh. This survey was completed in six days using a motorized inflatable boat with the capacity of eight persons. The boat travelled downstream at a constant speed of 8-10 km per hour with the observers recording the sightings of the key aquatic species.Boat based direct total count method was used (Smith & Reeves 2000b; Sinha & Sharma 2003) for estimation of encounter rate in the survey stretch.



To assess water and habitat features, the survey stretch was divided into 65 equal segments of 5 km each, and habitat variables were simultaneously recorded for the individual segments. River morphology data such as channel type, bank substratum, and water physical and chemical parameters namely; temperature and depth were recorded at the starting points of each segment.

Survey equipment included GPS (Garmin 30x eTrex) for recording coordinates of all significant sightings and observations, hondex handheld depth sounder for recording the channel depth, binoculars (Aculon A211 10x5), Nikon laser range finder for recording the channel width and sighting distance, kestrel 3000 pocket weather meter and Canon Powershot camera for photographic and video documentation.

2.2 Mammals

Gandak River is home to two mammalian species *viz.* Gangetic dolphin, an entirely aquatic mammal and smoothcoated otter, a semi-aquatic mammal. Both the species are habitat specialist and have special adaptive features for living in freshwater aquatic systems.

Gangetic dolphin (Platanista gangetica)

Gangetic dolphins have been known to be present in the Indian as well as the Nepal part of the river, which is now divided by the barrage (Shrestha, 1989; Smith et al. 1994; Sinha & Sharma, 2003; Chaudhary, 2010; Chaudhary et al., 2012). However, now in the Nepal section, upstream of the barrage, only 2-3 individuals survive (Paudel et al., 2015).

During the first rapid biodiversity assessment in 2019-2020, a total of 152 individuals of Gangetic dolphins were recorded between Lavkush ghat, Valmikinagar to Hajipur, Vaishali (Figure 2.1) with an encounter rate of 0.47 ± 0.07 . Sixty-four percent of all sightings were recorded in 172 km stretch of lower zone from Bansi river confluence near Rakba jungli, Kushinagar, Uttar Pradesh to its confluence with Ganga River at Hajipur, Vaishali, Bihar with an encounter rate of 0.49 ± 0.07 . Around thirty-six percent (35.52%) of the total sightings were recorded in the 120 km stretch of middle zone from Lavkush ghat, Valmikinagar, West Champaran, Bihar to Bansi confluence near Rakba jungli, Kushinagar, Uttar Pradesh with an encounter rate of 0.43 ± 0.14 .





 Figure 2.1

 Distribution map of Gangetic dolphin in Gandak River in 2019-2020

In the second rapid biodiversity assessment carried out in 2020-21, a total of 105 individuals of Gangetic dolphins were recorded from Lavkush ghat, Valmikinagar, West Champaran to Hajipur, Vaishali. Decrease in the number of sightings as compared to the previous survey may be due to excess release of waters from the Gandak barrage to counter the flood situation in Gandak River. However, a similar trend was observed in the present survey too. Seventy-four percent of the total sightings were recorded in lower zone from Bansi river confluence near Rakba jungli, Kushinagar, Uttar Pradesh to its confluence with Ganga River at Hajipur, Vaishali, Bihar with an encounter rate of 0.39 ± 0.07 (Figure 2.2). Remaining twenty-six percent (25.71%) of the total sightings were recorded in the middle zone from Lavkush ghat, Valmikinagar, West Champaran, Bihar to Bansi confluence near Rakba jungli, Kushinagar, Uttar Pradesh with an encounter rate of 0.22 ± 0.06 . The Gangetic dolphins were most frequently seen at water depths between 2 to 4 meters, indicating the specific depth requirements of the species (Figure 2.3) in both the surveys.



Figure 2.2 Distribution map of Gangetic dolphin in Gandak River in 2020-2021



Figure 2.3 Sighting record of Gangetic dolphin in different depth classes

Otters

Choudhary (2010) recorded indirect evidences of smooth-coated otter 172 km downstream from the Gandak barrage and 6 km downstream from Rajwahi Ghat. A report of sighting of the species by the locals during monsoon was also mentioned in the same study. These reports are based on the occasional sightings supplemented by the indirect evidence of their presence as the otters are elusive, largely nocturnal and live in low densities (Hussain, 2002).

No direct or indirect evidences of the smooth-coated otter's presence were recorded during both the rapid biodiversity assessments.

2.3 Reptiles

Crocodilians

Gandak is home to two species of crocodile, the mugger (*Crocodylus palustris*) and the gharial (*Gavialis gangeticus*) from Crocodylidae and Gavialidae families, respectively.



Gharial (*Gavialis gangeticus*)

Historically, Gharial has been known to be abundant in the Gandak River (or Narayani in Nepal) and was hunted for sport (Kennion, 1921). In Nepal, prior to the construction of Gandak Barrage in the year 1964, gharial population probably numbered in low hundreds, with 235 being counted in 1950's and similar numbers persisting at least till the construction of the Barrage (Maskey, 1999). In recent times Choudhary (2009), reported of 15 individuals and a nesting female, though this was likely an underestimate due to unsuitable weather conditions (Sinha, 2018). Subsequent conservation efforts and release of captive reared individuals has had a positive effect and a breeding population exists now (Chaudhury et al., 2016). In recent surveys 251 individuals have been reported all along the river with highest numbers being seen between the Paniahawa and Rewa Bridge (WTI, 2019).

During the first rapid assessment in 2019-2020, a total of 192 individuals, including 05 adult males were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali (Figure 2.4) with an encounter rate of 0.59 ± 0.13 . These sightings comprise of 60adult, 60 sub-adult, 57 juvenile and 15 yearlings. Fifty-six percent (55.73%) sightings with the total number of 107 individuals were recorded in 172 km stretch of lower zone from Bansi river confluence near Rakba jungli, Kushinagar, Uttar Pradesh to its confluence with main stem Ganga River at Hajipur, Vaishali, Bihar with an encounter rate of 0.54 ± 0.18 including two individuals of full grown male. These included 14 yearlings, 28 juveniles, 35 sub-adults and 30 adult including 3 fully grown male. In the 120 km of middle zone 44.27% of the total individuals with an encounter rate of 0.68 ± 0.21 were recorded from Lavkush ghat, Valmikinagar, West Champaran, Bihar to Bansi confluence near Rakba jungli, Kushinagar, Uttar Pradesh. This zone comprised of 1 yearling, 29 juveniles, 25 sub-adult and 30 adult including 2 male.







In the second rapid biodiversity assessment undertaken in 2020-2021, a total of 206 individuals, including 09 adult male were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali (Figure 2.5) with an encounter rate of 0.63 ± 0.14 . These sightings include 78 adult, 43 sub-adults, 64 juvenile and 21 yearling. Unlike the previous survey in the present assessment 64.07% of the total sightings with an encounter rate of 1.06 ± 0.31 were recorded in the middle zone whereas the remaining 35.93% sightings with an encounter rate of 0.37 ± 0.10 were recorded in lower zone. Total number of 132 sightings recorded in the middle zone comprise of 14 yearlings, 45 juveniles, 33 sub-adult and 40 adult including 5 male. In the lower zone, a total of 74 individuals including 7 yearlings, 19 juveniles, 10 sub-adults and 38 adult including 4 male were recorded.



Most of these sighting have been on middle Channel Islands followed by the other islands formed by braiding channel of the river. Adult gharials were seen sighted in deeper water channel while yearlings on shallower water channel including middle island and channel banks in equal proportions, this pattern of habitat use is consistent with Hussain (2009).





Mugger (Crocodylus palustris)

Historically, Muggers were reported to be less abundant than Gharials in the Nepal part of the Gandak River (Kennion, 1921). In recent years, Chaudhary (2010), 05 individuals and 02 mugger spoors towards the Sohgi-Barwa Wildlife Sanctuary, 70 km downstream from the Gandak barrage. Later surveys in 2019, recorded a total of 14 individuals in the stretch from Gandak barrage to Paniahawa Bridge (WTI, 2019).



A total of 05 individuals were sighted during the first rapid biodiversity assessment carried out in 2019-2020 of which four sightings were recorded in the middle zone in a 40 km stretch along the Valmiki Tiger Reserve between Lavkush ghat to Mangalpur (Figure 2.6) followed by an individual sighting in the lower stretch near Bansi river confluence. No sightings were recorded beyond Mangalpur due to close proximity of sand banks to the human habitations.

In the second rapid biodiversity assessment undertaken in 2020-2021, the distribution pattern of mugger was similar and a total of 08 individuals were recorded in a 40 km stretch along the Valmiki Tiger Reserve in the middle zone.



Figure 2.6

Distribution of mugger in Gandak River in 2019-2020



Figure 2.7 Distribution of mugger in Gandak River in 2020-2021

Turtles

Gandak River basin being part of the Terai, falls within one of the five important Turtle Priority Area (TPA) in India (Singh & Hudson, 2010). Bhupathy et al. (1992) enlisted nine turtle species of which eight are freshwater turtles and one is land turtle in the upper stretch of Gandak River. These represent four softshell turtle species, *viz. Lissemys punctata, Nilssonia gangetica, Nilssonia hurum* and *Chitra indica*; three hardshell species, *viz. Pangshura tentoria, Pangshura tecta, Pangshura smithii* and a tortoise, *Melanochelys tricarinata*.



During the first rapid assessment in the year 2019-2020, a total of 987 individuals were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali (Figure 2.8) with an encounter rate of 3.04 ± 0.87 . These sightings comprised of 985 individuals of *Pangshura* genus and 02 individuals of *Nilssonia* genus. Seventy percent (70.22%) of the total sightings with 693 individuals were recorded in the 172 km stretch of lower zone from Bansi river confluence near Rakba jungli, Kushinagar, Uttar Pradesh to its confluence with main stem Ganga River at Hajipur, Vaishali, Bihar with an encounter rate of 3.47 ± 1.19 , all recorded sightings in the stretch were from *Pangshura* genus. In the 120 km stretch of the middle zone 29.78% of the remaining individuals of freshwater turtles were recorded with an encounter rate of 2.35 ± 1.24 from Lavkush ghat, Valmikinagar, West Champaran, Bihar to Bansi confluence near Rakba jungli, Kushinagar, Uttar Pradesh. Of the total individuals recorded, 292 belonged to *Pangshura* genus followed by two individuals of *Nilssonia* genus.



Figure 2.8 Distribution of freshwater turtles in Gandak River in 2019-2020

In the second rapid biodiversity assessment undertaken in 2020-2021, a total of 643 individuals were recorded from Lavkush ghat, Valmikinagar to Hajipur, Vaishali (Figure 2.9) with an encounter rate of 1.98 ± 0.64 . These sightings include 622 individuals of *Pangshura* genus, 19 individuals of *Nilssonia* genus and 02 individuals of *Lissemys* genus. This survey shows a similar trend as previous with 65.47% of the total sightings including 421 individuals with an encounter rate of 2.11 ± 0.93 recorded from the lower zone. These sightings include 415 individuals of *Pangshura* genus and six individuals of *Nilssonia* genus. Remaining, 34.53% individual were recorded in the middle zone with 222 individuals including 207 individuals of *Pangshura* genus, 13 individuals of *Nilssonia* genus and two individuals of *Lissemys* genus. In the present survey, a nesting site of *Morenia petersi* was also recorded at upstream of Dhanha bridge in West Champaran district of Bihar.





Individuals of *Pangshura* genus were observed basking on sand banks, wooden logs and bushes, whereas, individuals of *N. gangetica* were mostly observed basking on islands and high sand banks.



2.4 Avifauna

Shifting course of Gandak River from west to east over its megafan, gives rise to numerous channels, ponds, lakes and different types of bars in areas of impeded drainage, especially on the lower portion of the megafan. Gandak flows through its megafan and frequently shifts its course, the abandoned channels and meanders give rise to various wetlands (Mohindra, 1992), including some of the largest Oxbow lakes such as the Kanwar lake. The oxbow lakes are mainly distributed in Muzaffarpur, East Champaran West Champaran and Samastipur and Begusaral districts of North Bihar (Sinha & Jha, 1997) (Appendix II). These waterbodies serve as major habitat for winter migratory waterbirds.

A total of 83 species of waterbirds were recorded by Chaudhury (2010). Among these 24 were resident, 5 were resident migratory and 36 were migratory species of waterbirds (Appendix III). A subsequent survey, (Choudhury, 2016) listed 246 species of terrestrial and waterbirds from Valmiki Tiger Reserve along the banks of Gandak River, which included two Critically Endangered, four Vulnerable and five Near Threatened birds. There have been past records of sighting of the Bengal florican in grasslands from the undivided Champaran District (Mukherjee, 1986).

During the rapid biodiversity assessment in 2019-2020 & 2020-2021, a total of 49 species of waterbirds and water associated species were recorded in the Gandak River (Appendix IV). Forty-nine of the total species, Anatidae (24%) was the most abundant family, followed by Ardedidae (12%) and Scolopacidae (8%) (Figure 2.10).

Of the 49 bird species, 55% species were winter migratory, 25% species were resident with local movement, 18% species were resident and 2% includes migrant with summer visitor (Figure 2.11). Out of the 49 bird species, 41% were carnivores, 25% were omnivores, 20% were piscivores, 12% species were insectivores and 2% species were herbivores (Figure 2.12). Out of all the recorded species, one species was "Endangered", two species were "Near Threatened" and two species were "Vulnerable" (Table 2.2).





Figure 2.10 Family composition of waterbirds and wetland dependent birds recorded during the rapid biodiversity assessment



Figure 2.11 Residential status of waterbirds and water associated communities along the Gandak River



Figure 2.12 Feeding guilds composition of waterbirds and water associated communities along the Gandak River

Table 2.2 RET Species present across the Gandak River

Family	Bird Species	Scientific Name	Status
Accipitridae	Pallas's fish eagle	Haliaeetus leucoryphus	EN
Anatidae	Common Pochard	Aythya ferina	VU
Anatidae	Ferruginous duck	Aythya nyroca	NT
Anhingidae	Oriental darter	Anhinga melanogaster	NT
Ciconiidae	Woolly-necked stork	Ciconia episcopus	VU

2.5 Amphibians

Eleven amphibian species have been reported from parts of the Narayani River which forms western border of the Royal Chitwan National Park. Similar species richness and composition can be expected in the adjacent Indian zones. The taxa represent a subset of the herpetofauna of northern India. The distribution of amphibians was not studied during the assessments.

2.6 Fishes

Comprehensive records on the fisheries of river Gandak are scanty. David (1963) recorded 113 fish species in upper stretch of the Gandak River, 161 km above and 24 km below the Bhaisalota barrage, with the noted presence of *Hilsa ilisha* close to Bettiah, which hasn't been recorded thereafter. After a long gap, a study conducted by Srivastava (2013) recorded 54 fish species belonging to 18 families from two different sites *viz*. Chhitauni Bagaha Rail Bridge about 3 km away from the Valmiki National Park and Tiger Reserve to Chhitauni Ghat (Figure 2.13). One-third of the recorded species belonged to threatened category of the IUCN red list (Figure 2.14). The distribution of fishes was not studied during the assessments.



Figure 2.13 Family-wise percentage composition of fishes in Gandak River (Source: Srivastava, 2013)



Figure 2.14 Conservation status of fish fauna in the Gandak River (Source: Srivastava, 2013)

2.7 River Stretches with High Biodiversity Value

Stretches with high biodiversity values were identified using information obtained from the rapid biodiversity assessment. Habitat defining variables such as water depth were determined along the length of the Gandak River. Assessment of hydrology of the river revealed that channel depth was a major limiting factor for species distribution (Figure 2.15). The thematic diagram shows the depth profile of the Gandak River from Lavkush Ghat, Valmikinagar to Hajipur, near Patna during winter month of February (Figure 2.16).



Figure 2.15 Depth profile of Gandak River



Figure 2.16 Depth profile of Gandak River from Gandak barrage to Hajipur

An average depth of the river was 2.63 ± 0.17 m calculated using data collected during rapid biodiversity assessments in 2019-2020 & 2020-2021. Based on the average depth profile of Gandak River the river stretch was divided into three different zones (Figure 2.17).

Zone I Lavkush ghat, Gandak barrage, West Champaran, Bihar to Paniahwa, Kushinagar, Uttar Pradesh. Length of the stretch was 50 km and average depth recorded was 2.09 ± 0.19 m.

- Zone II Paniahwa, Kushinagar, Uttar Pradesh to Mangalpur, East Champaran, Bihar. The length of this stretch was 90 km with an average depth of 3.21 ± 0.48m.
- Zone III Mangalpur, East Champaran, Bihar to Hajipur, Vaishali, Bihar. The longest stretch covering a total length of 180 km, the average depth recorded was more than 2.50 ± 0.18 m.



Figure 2.17 Zonation of Gandak River based on average depth profile recorded in 2019-2020 & 2020-2021

Distribution of encountered species such as Gangetic dolphin, gharial, turtle and mugger were plotted together with the recorded average depth preference in Gandak River. Around 40-50 percent of the species preferred a depth of 2-4 m followed by a depth preference less than 2 m (Figure 2.18). Species presence in zone III was low even with an average depth of more than 3 m due to its close proximity to human habitation.



Figure 2.18 Average Sighting of the species recorded in different depth classes of Gandak River in 2019-2020 & 2020-2021

Priority stretches were identified based on presence of key aquatic species such as Gangetic dolphin, gharial, mugger and freshwater turtles. The presence location of key aquatic species, and habitat conditions were superimposed in the GIS domain. Three stretches covering the entire river were identified in the order of high, medium and low priority (Figure 2.19, 2.20). Table 4 summarizes these stretches in terms of location, length, river depth, presence of fauna of conservation significance and specific threats.



Figure 2.19 High, Medium and low biodiversity stretches and distribution of priority species in 2019-2020



Figure 2.20 High. Medium and low

biodiversity stretches and distribution of priority species in 2020-2021

High Biodiversity Value Stretch

Stretch: Dhanha to Dhekhwah

This is a 115 km stretch from Dhanha, West Champaran to Dhekhwah, East Champaran districts. Stretch's average depth ranged from 0.9 m to 5.2 m with a mean value of 2.76 ± 0.23 m. The stretch has good presence of riverine islands and sandbanks. This stretch is also free of immediate anthropogenic influence as the nearest village and the motorable road is at an approximate distance of 2-3 km from the banks. Anthropogenic activities such as riverbed farming, fishing and sand mining were observed only in few locations.

Biodiversity value and ecological significance

In 2019-2020, total number of 133 gharial including 2 adult males were observed indicating the presence of breeding groups in the stretch. In the stretch nurtures 79 individuals of Gangetic dolphin and 1 mugger were also recorded. Further, presence of more than 800 individuals of two turtle genera namely *Pangshura* and *Nilssonia* indicated a good stretch for these chelonians. Similar observations were made in the second assessment in 2020-2021 with 119 gharial including 8 adult males, 89 individuals of dolphin and 469 individuals of turtles belonging to *Pangshura* and *Nilssonia*.

Medium Biodiversity Value Stretch

Stretch: Lavkush ghat to Dhanha

This is a 90 km stretch between Lavkush ghat, Valmikinagar and Dhanha in West Champaran district. This is the point where Gandak River enters India. Average river depth in this stretch ranges from 0.9 m to 10.55 m with a mean depth of 2.74 \pm 0.46 m. About 40 km of this stretch marks the boundary of Valmiki Tiger Reserve. Small boulders and sandy banks characterize this stretch.

Biodiversity value and ecological significance

During 2019-2020 river assessment, 42 individuals of gharial, 22 individuals of Gangetic dolphin, 4 individuals of mugger and 44 individuals of two genera of freshwater turtles, Pangshura and *Nilssonia*. were recorded from this stretch. In 2020-2021 assessment, 74 individuals of gharial, 31 individuals of Gangetic dolphin, 8 muggers and 163 individuals of turtle belonging to *Pangshura* and *Nilssonia* species were recorded in the same stretch indicating medium biodiversity and ecological significance as before.

Low Biodiversity Value Stretch

Stretch: Dhekhwah to Hajipur

This is a 115 km stretch of Gandak River that extends from Dhekhwah to Hajipur where it confluences with mainstem Ganga River. Average river depth in this stretch ranges from 0.9 m to 5.2 m with a mean value of 2.40±0.22m. Presence of human habitation along the riverbanks is a common feature throughout this stretch. Local communities are highly dependent on the river for fishing, riverbed farming and religious rituals including cremations. During survey more than 80 instances of cremation were observed. Presence of around 700 wooden boats in this stretch indicates extensive fishing activity.

Biodiversity value and ecological significance

In the assessment of 2019-2020, about 17 individuals of gharial, 51 individual of Gangetic dolphin and 16 individuals of freshwater turtles were sighted in this stretch. During the second assessment carried out in the year, 13 individuals of gharial, 55 individuals of Gangetic dolphin and 6 individuals of *Pangshura* turtles were recorded.

Biodiversity Value Location (km) River characteristic	River characteristics	Mean River depth (2019- 2020 & 2020-2021) (m)	Gan Dol	getic phin	Gha	rial	Mu	gger	Fresh tur	water tles	Threats		
				(average)	2019- 2020	2020- 2021	2019- 2020	2020- 2021	2019- 2020	2020- 2021	2019- 2020	2020- 2021	
High	Dhanha to Dhekhwah	115	Sandy banks with extensive alluvium	0.9 to 5.2 (2.76 ± 0.23)	79	89	133	119	1	0	812	469	Riverbed farming, fishing and sand mining
Medium	Lavkush ghat to Dhanha	90	Boulder and sandy banks	0.9 to 10.55 (2.74 ± 0.46)	22	31	42	74	4	8	44	163	Low fishing and agriculture practice
Low	Dhekhwah to Hajipur	115	Sandy banks with extensive alluvium and wide channel	0.9 to 5.2 (2.40 ± 0.22)	51	55	17	13	-0	0	16	6	Unsustainable fishing and agricultural practice, extensive religious practices

Table 2.2 Description of the High, Medium and low biodiversity stretches along the Gandak River

3. THREATS TO THE BIODIVERSITY OF GANDAK RIVER



3.1 River Flow

Gandak River is fully regulated by the Gandak Barrage at Indo-Nepal border. Water here gets diverted into the Nepal West Gandak Canal (8.5 m³/s) and Nepal East Canal (24.1 m³/s) causing flow alteration in India (Dixit & Shukla, 2017). Chaudhury et al (2012) have emphasized the negative impacts of dry season flow reduction in the Gandak on Gangetic dolphins.

3.2 Physicochemical parameters (Water and Sediments)

A study conducted by Singh et al. (2017), assessed the river water quality variables at 5 different sampling sites, the values of the Physico-chemical parameters of Gandak River water obtained were low compared to the permissible limit prescribed in the Indian standards indicating less industrial activities and a healthy floristic assemblage.

3.3 Alteration in Habitat

Being in close proximity to the human habitation, the banks of the Gandak River clearly show bank feature alteration due to agricultural practise and sand mining.

3.4 Unsustainable resource use practices

Extensive farming has made the nesting sites of reptiles and island nesting birds vulnerable towards predation by wild animals and poaching by humans. Missing eggs from gharial nest in the river bank a few km downstream of Gandak barrage have been reported (Choudhary, 2010). Choudhary (2010) also reported poaching of turtle

species for meat and over fishing by the local communities. These unsustainable biological resource extractions are wide spread along the river.



For long term survival of the aquatic species, it is crucial to address the structural changes in its morphology which in turn alters the natural flow regime. Limiting further river bank alteration for agriculture and sand mining would ensure the availability of suitable habitat for the species to thrive. Promoting sustainable resource practices and aligning livelihoods of communities with the conservation goals are some of the steps that can be taken up. Thus, in order to maintain the ecological integrity of the river, it is crucial to address these threats at the earliest. The major focus today, should be on providing natural condition by maintaining the minimum ecological flow with the collaborative effort of the two countries; India and Nepal.



Figure 3.1 Anthropogenic pressures recorded during rapid biodiversity assessment

4 CONSERVATION IMPLICATIONS

Current status of Gandak River, as evident from the rapid biodiversity assessment along with an extensive review of secondary literature, highlights the need for its ecological restoration while considering its geomorphology, climate, ecological features and social aspects. In view of the foregoing discussion, the following points need to be considered for the conservation of aquatic biodiversity of Gandak River.



General implications

- The flow of Gandak River is highly modified by the trans-boundary Gandak barrage, leading to flow alteration causing change in the species assemblage.
- Sand mining, riverbed farming and agricultural practices along the river that intensifies towards its lower stretch, have altered the habitat for island nesting birds and freshwater turtles.
- These issues are not purely ecological but also social with respect to the dependency of riverside communities of Gandak.
- Maintaining of a minimum ecological flow suitable for sustaining a healthy ecosystem for the aquatic biodiversity in lean and monsoon seasons.
- Aquatic reptiles are highly sensitive to any change in their habitat thus it is necessary to protect their habitat with strong law enforcement.
- Aquatic reptiles such as Crocodilian and freshwater turtles lay their eggs and bask on the sandy banks and mid-Channel Islands, thus bank alteration induced by human activities are threat to the survival of these species.

- Gandak River falls within one of the five Turtle Priority Areas of the country but there hasn't been a dedicated study on turtles. Therefore, an intensive study is required to be under taken for better conservation planning.
- Paucity of information on amphibians along the Gandak River makes them the least studied group. Thus, more studies are required to assess their population for better understanding of the ecosystem.

Recommendations

Based on the preliminary rapid biodiversity assessment the following recommendations are suggested:

Detailed surveys during lean and monsoon seasons

- Continuous assessment to study the diversity pattern of higher freshwater vertebrates along with habitat assessment from Valmikinagar to Hajipur/Sonepur is required in the lean and post-monsoon periods.
- Estimation of water discharge is required to assess the minimum discharge that is required for the species for their survival during the lean and Post-monsoon periods. Collaboration with irrigation and barrage maintaining authorities is needed for access to discharge data and planned changes in discharge for effective management of nesting habitats of endangered species.

Involvement of multiple stake holders

- Baseline community survey is needed to identify the river dependent villages within 2-3 km periphery
 of the river.
- Participation of local community especially women in conservation efforts needs to be ensured.
- Skill development of the dependent communities is required so as to reduce their dependency on the river.
- Local volunteers and schools need to be identified and a conservation education plan built, to ensure sustainability of conservation efforts.

Establishment of Interpretation Centre and base camp

- Muzaffarnagar district has been identified for establishment of an Interpretation Centre to create awareness among the local community. The location has been selected due of its close proximity to Stretch III that has been found to be a biodiversity rich area with a moderate anthropogenic pressure that increases downstream towards Patna city.
- Bettiah in West Champaran district may be selected for the establishment of base camp. The selected location is the administrative headquarter of the district and will ensure regular and quick interaction with the Forest Department and other Administrative setups.

Collaboration with Nepal for Conservation and Management

• Regular dialogue and exchange programme with the concerned conservation authorities in Nepal is essential for better management of the Gandak River.

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ANNEXURE I

Occurrence and distribution of aquatic macrophytes, marginal plants and riparian vegetation on the banks of Gandak River (Source: Singh *et al.* 2017)

Group	Plant species
	Cynanophyceae
	Anabaena sp.
	Anabaenopsis sp.
	Anacystis sp.
	Aphanothece sp.
	Arthrospira sp.
	Aulosira sp.
	Calothrix sp.
	Chroococcus sp.
	Gloeocapsa sp.
	Gloeotrichia sp.
	Lyngbya sp.
	Mastigocladus sp.
	Microcoleussp.
	Microcystis aeruginosa
	Mixosarsina sp.
	Nodularia sp.
Algae	Nostoc sp.
	Oscillatoria sp.
	Phormidium calcicola
	Pseudanabaena sp.
	Raphidiopsis curvata
	Rivularia aquatica
	Spirulina gigantea
	Spirulina sp.
	Synechococcus elongatus
	Tolypothrix sp.
	Trichodesmium sp.
	Chlorophyceae
	Aphanochaete sp.
	Bulbochaete sp.
	Chaetophora sp.
	Chara sp.
	Chlamydomonas ehrenbergii
	Chlorella sp.

Chlorococcum sp.
Cladophora glomerata
Coelastrum sp.
Cosmarium auriculatum
Cylindrocapsa sp.
Dictyosphaerium pulchellum
Dimorphococcus sp.
Draparnaldia sp.
Draparnaldiopsis sp.
Enteromorpha sp.
Golenkinia sp.
Gonium sp.
Hormidium sp.
Hydrodictyon reticulatum
Microspora sp.
Netrium sp.
Nitella sp.
Pandorina morum
Pediastrum sp.
Pithophora sp.
Pleurodiscus sp.
Scenedesmus abundans
Schizomeris sp.
Selenastrum sp.
Sirogonium sp.
Spirogyra sp.
Stigeoclonium sp.
Ulothrix zonata
Ulothrix sp.
Voucheria sp.
Volvox sp.
Zygnema sp.
Bacillariophyceae
Amphora ovalis
Asterionella japonica
Caloneis sp.
Ceratoneis sp.
Cyclotella sp.
Cymbella sp.

	Cymbellamicrocephala
	Diatomata elongatus
	Eunotiasp.
	Gomphonemasp.
	Gyrosigmasp.
	Melosiraambigua
	Navicula sancta
	Navicula gracilis
	Pinnularia sp.
	Pleurosigma sp.
	Surirella sp.
	Xanthophyceae
	Tribonema sp.
	Pistia stratiotes (ChotaJalkumbhi)
	Lemna paucicostata (Duckweed)
	Spirodela polyrhiza (Titali)
	Ranunculus sceleratus
	Ceratophyllum demersum
	Potamogeton crispus
	Eichhornia crassipes
	Potamogeton pectinatus
Aquatic angiosperms	Eleocharis palustris
	Hydrilla verticillata
	Aponogeton natans
	Scirpus articulatus
	Trapa bispinosa(Singhara)
	Najas graminea
	Typha angustata
	Sagittaria guyanensis
	Jussiaea repens
	Marsilea minuta
	Equisetum sp.
Aquatic pteridophytes	Azolla sp.
	Salvinia sp.
	Nephrolepis sp.
	Cyperus rotundus
Codgos	Scirpus articulatus
Sedges	Kyllinga brevifolia
	Scirpus maritimus

GrassesSaccharum spontaneumGrassesPanicum repensSetaria verticillataPaspalum distichumAconus calamusAchyranthes asperaAchyranthes asperaAsclepias sp.Boerhavia sp.Celosia argenteaCatharanthus roseus (Sadabahar)Centella asiaticaCostus speciosusCynoalassum lanceolatum
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Centella asiatica Costus speciosus Cynoalassum lanceolatum
Costus speciosus Cynoalassum lanceolatum
Cynoalassum lanceolatum
cynograddun fanccolatan
Desmodium gangeticum
Eclipta prostrate (Bhangrya)
Ocimum sanctum (Tulsi)
Pedalium murex (Gokhru)
Sida cordata (Bariar)
S. cordifolia
Solanum surretens
Herbs Trianthema portulacastrum
Croton sp.
Portulaca quadrifida
Malva parviflora
Malvastrum sp.
Crotalaria medicagenia
Desmodium triflorum
Indigofera linnaei
Indigofera linifolia
Lathyrus sativus
Medicago polymorpha
Phaseolus trilobus
Vicia sativa
Ageratum conyzoides
Echinopsechinatus
Tridax procumbens
Primula umbellata

	Heliotropium indicum
	Nicotiana plumbaginifolia
	Physalis minima (Makao)
	Solanum nigrum
	Lindernia crustacea
	Scoparia dulcis
	Leucas aspera
	Ocimum canum (Bantulsi)
	Salvia plebeia
	Amaranthus spinosus (Katylasag)
	A.viridis (Jangali sag)
	Polygonum glabrum
	Rumex dentatus
	Acalypha indica
	Cannabis sativa (Bhang)
	Croton bonplandianum (Mirchaini)
	Asphodelus tenuifolius (angalipyaj)
	Commelina benghalensis
	Argemone mexicana
	Euphorbia thymifolia (Chotadudhi)
	Phyllanthus fraternus (Bhuiamla)
	Convolvulus arvensis
	Lindenbergia indica
	Ricinus communis (Arandi)
	Xanthium strumarium
	Scirpus articulatus
	Cleome viscose (Peela hurhur)
	Cleome gynandra (hurhur)
	Portulaca oleracea
	Sida acuta
	Corchorus acutangulus
	Oxalis corniculata (Tinpatia)
	Scoparia dulcis
	Parthenium hysterophorus (Safedtopi)
	Amaranthus spinosus
	Euphorbia rosea
	Phylanthus simplex
	Hibiscus virtifolius
Shrubs	Adhatoda zeylanica

	Adhatodavasica
	Cassia sophera
	Calotropis gigantea
	Cannabis sativa
	Hibiscus rosa-sinensis
	Plumbago zeylanica
	Rauvolfia serpentina
	Solanum khasianum
	S. indicum
	Vernonia anthelmintica
	Cassia occidentalis
	Calotropis procera (Ak)
	Withania somnifera (Asgandh)
	Lantana indica
	Jatropha curcas (Bagandhi)
	J. gossypifolia
	Datura sp.
	Abuliton indicum (Kanghi)
	Polyalthia suberosa
	Asparagus sp. (Satawar)
	Dioscoria bulbifera
	Hemidesmus indicus
	Ichnocarpus frutescens (Dudhi lata)
	Leptadenia reticulate
	Tylophora indica
	Cuscuta reflexa
	Tinospora cordifolia
	Dalbergia spinosa
Clinchen	Derris trifoliate
Climbers	Ipomoea cairica
	Acacia nilotica
	Aegle marmelos
	Azadirachta indica
	Acacia fistula
	Emblica officinalis
	Ficus glomerata
	Morus alba
	Mangifera indica
	Moringa oleifera

	Pongamia pinnata	
	Syzygium (Jamun)	
	Terminalia arjuna (Arjun)	
	Tamarix dioica (Jhahua)	
	Oroxylum indicum	
	Dalbergia sissoo	

ANNEXURE II

Districts	Name of lakes	Area in ha.
Muzaffarpur	Brahampura	45.5
	Manika	105.5
	Motipur	110
	Jhapaha	140
	Kanti	100
	Murra	15
	Rahuwa	30
	Bhoosra	45
	Bachaha	30
	Semera	16
	Matiha	20
	Rajwara	12
	Morsandi	60
	Ghosod	50
	Motijheel	100
	Kararia	120
	Basmanpur	50
	Sirsa	80
	Sajhi	40
	Rulhi	80
	Majharia	60
	Chilraon	80
	Turkaulia	100
	Sonbarsa	40
	Phulwari	80
	Sugaon	80
	Paswaw	20
East Champaran	Chakin	20
&	Pipra	70
West Champaran	Matwalia	90
	Barwalialzamali	8
	Narmaida	20
	Sonwalia	40
	Karekatti	40
	Sirha Chorwa	70
	Chaknaha	400
	Rajpur	80
	Bakya	160
	Piprao	164
	Rohna	20
	Samanjia	40
	Mati	40
	Piprapakri	400

Distribution and area of existing of ox-bow lakes in Gandak basin (Source: Sinha & Jha, 1997)

	Gobni	40
	Lal Sariya	230
	Jaganathpur	40
	Amwa	60
	Bhawanipur	20
	Saraya	400
	Gahri	70
	Hardia	48
	Bhakubar	4
	Vaishali	40
	Piprasi	8
	Bishambharpur	45
	Tateria	130
	Muktapur	60
	Dholi	8
Samastipur and Begusarai Districts	Bamanpura	15
	Poaram	30
	limasnagar	27
	Manjhol	11

ANNEXURE III

List of Waterbirds of Gandak river

Group	Family Name	Common Name	Scientific Name	IUCN Status	Residential Status	Feeding	IWPA
Ducks, Geese	Anatidae	Lesser Whistling-duck	Dendrocygna javanica	LC	R/LM	Omnivore	IV
Ducks, Geese	Anatidae	Bar-headed Goose	Anser indicus	LC	WM	Herbivore	IV
Ducks, Geese	Anatidae	Goosander	Mergus merganser	LC	WM	Piscivore	IV
Ducks, Geese	Anatidae	Common Shelduck	Tadorna tadorna	LC	WM	Omnivore	IV
Ducks, Geese	Anatidae	Ruddy Shelduck	Tadorna ferruginea	LC	WM	Omnivore	IV
Ducks, Geese	Anatidae	Common Pochard	Aythya ferina	VU	WM	Omnivore	IV
Ducks, Geese	Anatidae	Ferruginous Duck	Aythya nyroca	NT	WM	Omnivore	IV
Ducks, Geese	Anatidae	Northern Shoveler	Spatula clypeata	LC	WM	Omnivore	IV
Ducks, Geese	Anatidae	Gadwall	Mareca strepera	LC	WM	Omnivore	IV
Ducks, Geese	Anatidae	Indian Spot-billed Duck	Anas poecilorhyncha	LC	R/LM	Omnivore	IV
Ducks, Geese	Anatidae	Northern Pintail	Anas acuta	LC	WM	Omnivore	IV
Ducks, Geese	Anatidae	Common Teal	Anas crecca	LC	WM	Herbivore	IV
Grebes	Podicipedidae	Great Crested Grebe	Podiceps cristatus	LC	WM	Carnivore	IV
Cranes	Gruidae	Demoiselle Crane	Anthropoides virgo	LC	WM	Herbivore	IV
Cranes	Gruidae	Common Crane	Grus grus	LC	WM	Omnivore	IV
Storks	Ciconiidae	Black Stork	Ciconia nigra	LC	WM	Carnivore	IV
Storks	Ciconiidae	Asian Woollyneck	Ciconia episcopus	VU	R	Carnivore	IV
Herons	Ardeidae	Black Bittern	Ixobrychus flavicollis	LC	R	Carnivore	IV
Herons	Ardeidae	Indian Pond-heron	Ardeola grayii	LC	R	Carnivore	IV
Herons	Ardeidae	Cattle Egret	Bubulcus ibis	LC	R	Carnivore	IV
Herons	Ardeidae	Grey Heron	Ardea cinerea	LC	R	Carnivore	IV
Herons	Ardeidae	Great White Egret	Ardea alba	LC	R	Carnivore	IV
Herons	Ardeidae	Intermediate Egret	Ardea intermedia	LC	R	Carnivore	IV
Cormorants	Phalacrocoracidae	Great Cormorant	Phalacrocorax carbo	LC	R	Piscivore	IV
Cormorants	Phalacrocoracidae	Indian Cormorant	Phalacrocorax fuscicollis	LC	R	Piscivore	IV
Darters	Anhigidae	Oriental Darter	Anhinga melanogaster	NT	R	Piscivore	IV
Plovers	Charadriidae	Little Ringed Plover	Charadrius dubius	LC	R	Carnivore	IV
Plovers	Charadriidae	Kentish Plover	Charadrius alexandrinus	LC	R	Carnivore	IV
Sandpiper	Scolopacidae	Little Stint	Calidris minuta	LC	WM	Carnivore	IV
Sandpiper	Scolopacidae	Common Sandpiper	Actitis hypoleucos	LC	WM	Carnivore	IV
Sandpiper	Scolopacidae	Common Greenshank	Tringa nebularia	LC	WM	Carnivore	IV
Sandpiper	Scolopacidae	Marsh Sandpiper	Tringa stagnatilis	LC	WM	Carnivore	IV
Pratincoles	Glareolidae	Little Pratincole	Glareola lactea	LC	R/LM	Insectivore	NL

Gulls, Terns	Laridae	Brown-headed Gull	Larus brunnicephalus	LC	WM	Carnivore	IV
Gulls, Terns	Laridae	Pallas's Gull	Larus ichthyaetus	LC	WM	Carnivore	IV
Osprey	Pandionidae	Osprey	Pandion haliaetus	LC	WMR	Piscivore	I
Hawks, Eagles	Accipitridae	Western Marsh- harrier	Circus aeruginosus	LC	WM	Carnivore	I
Hawks, Eagles	Accipitridae	Pallas's Fish-eagle	Haliaeetus leucoryphus	EN	R/WM	Carnivore	Ι
Hawks, Eagles	Accipitridae	Brahminy Kite	Haliastur indus	LC	R/LM	Carnivore	I
Kingfishers	Alcedinidae	Common Kingfisher	Alcedo atthis	LC	R/WM/SW	Carnivore	IV
Kingfishers	Alcedinidae	Pied Kingfisher	Ceryle rudis	LC	R	Carnivore	IV
Kingfishers	Alcedinidae	White-breasted throated Kingfisher	Halcyon smyrnensis	LC	R/LM	Carnivore	IV
Falcons	Falconidae	Peregrine Falcon	Falco peregrinus	LC	R/WM	Carnivore	I
Swallows, Martins	Hirundinidae	Barn Swallow	Hirundo rustica	LC	R/WM	Insectivore	NL
Swallows, Martins	Hirundinidae	Asian Plain Martin	Riparia chinesis	LC	R/LM	Insectivore	NL
Swallows, Martins	Hirundinidae	Collared Sand Martin	Riparia riparia	LC	R/LM	Insectivore	NL
Wagtails	Motacillidae	Grey Wagtail	Motacilla cinerera	LC	R/AM/WM	Insectivore	IV
Wagtails	Motacillidae	White-browed Wagtail	Motacilla maderaspatensis	LC	R	Insectivore	IV
Wagtails	Motacillidae	White Wagtail	Motacilla alba	LC	R/WM/PM	Insectivore	IV



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