

GHAGHRA RIVER

Ecological status and trends





ASSESSMENT OF THE
ECOLOGICAL STATUS OF
GHAGHRA RIVER
FOR CONSERVATION
PLANNING

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Wildlife Institute of India, Dehra Dun**

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GHAGHRA RIVER

Ecological Status and Trend

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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 Ghaghra 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 Ghaghra 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 Ghaghra River, robust information on the diversity, abundance and distribution of aquatic vertebrate fauna of Ghaghra 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 Ghaghra 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 Ghaghra River through the support and involvement of stakeholders of all the Ghaghra states. The Wildlife Institute of India through the Biodiversity Conservation and Ganga Rejuvenation Project and this report attempts to compile biodiversity of Ghaghra River through literature review and Rapid Biodiversity Assessment. This report aims to develop a thorough knowledge base for the priority species of Ghaghra River, aid in biological restoration, and assist policy planners and managers to judiciously use water from the Ghaghra River, in view of the needs of the aquatic species therein.

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EXECUTIVE SUMMARY

Rivers and their floodplains are among the most important natural environments globally. Compared with other ecosystems, rivers support a disproportionately large number of plant and animal species. The concept of biodiversity, its conservation and restoration are central to maintaining the natural character of rivers.

Rivers are highly valued by humans for providing a wide range of essential goods and services, but the exploitation of rivers for fulfilling human needs – especially since the Industrial Revolution – has led to the widespread degradation of their natural character, resulting in a loss of habitat characteristics, biodiversity and other ecosystem services. This means river habitat is one of the most threatened habitat types.

Concerted efforts to tackle water pollution linked to industries began as early as the 20th century and have had considerable success in improving water quality. More recently, the recognition of physical damage caused by flow alteration, channelisation, flood embankment construction, dredging and impoundment by weirs or dams has led river restoration to reverse decades of physical change. Restoration actions aim to restore river biodiversity and the key ecosystem services that society depends on such as provision of clean drinking water and the natural management of flood risk.

Ghaghra is the first trans-boundary tributary of the Ganga River. The river originates in the Tibetan plateau near Lake Mansarovar. It then flows in southward direction from Nepal as Karnali River. Moving further southward across Shivalik hills, it splits into two branches, Girwa on left and Kauralia on right and re-joins south of the Indian border and forms main channel of Ghaghra. The Ghaghara (Karnali), with its average annual flow of about 2,991 m³/s (105,600 cu ft/s), is the largest tributary of the Ganga River by discharge.

Travelling a distance of about 615 km in southeast direction, through Uttar Pradesh and Bihar, the Ghaghra River joins Ganga River at Revelganj, Chhapra district of Bihar. It is home to many charismatic riverine fauna including: Gangetic river dolphin, gharial, mugger, smooth-coated otter, freshwater turtles and water dependent birds. However, the river is subject to a wide range of pressures including physical modification, flow alteration, point source and diffuse pollution, and sand mining.

Taking all the facts into consideration, a rapid biodiversity assessment was conducted in the Indian side of the river from Kailashpuri dam, Bahraich to its confluence with Ganga River at Revelganj, Chhapra during December and January 2020-2021. The entire length of Ghaghra River was divided into five stretches, namely Upper Himalayan zone, Lower Himalayan zone, Upper Middle zone, Lower Middle zone, and Lower zone based on the physical factors. A total length of 441 km of Upper Himalayan Zone lies between the source at Mapchachungo glaciers to Ghatgaun (confluence of Bheri River) in Nepal. The Lower Himalayan zone extends between Ghatgaun (confluence of Bheri River) in Nepal to Kailashpuri Dam near Katarniaghat Wildlife Sanctuary covering a length of 70 km. The present survey stretch falls under Upper Middle zone covering a length of 76 km from Kailashpuri Dam to its confluence with Sharda River near Mahsi, Uttar Pradesh, Lower Middle zone covers a length of 394 km from Mahsi to Rapti River confluence near Barhi and the Lower zone with a length of 142 km covers the stretch from Barhi to Ganga confluence at Revelganj.

The survey was conducted with the following objectives: (a) Biodiversity assessment in terms of number of individuals and size classes of the key aquatic species (b) Evaluation of habitat characteristics such as bank features, shoreline features, water quality, and water depth (c) Evaluation of anthropogenic activities that influence the riverine 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 128 equal segments of 5 km each, and habitat variables were simultaneously recorded for each segment. River morphology data such as channel type, bank substratum, and physical and chemical water parameters namely temperature and depth were recorded at the starting points of each segment.

During the study, a total of 338 individuals of dolphins were recorded in the 615 km stretch of the River. Gangetic dolphin sightings occurred throughout the river with an encounter rate of 0.54 ± 0.08 . Two direct sightings of smooth-coated otter were also recorded during the study. A total of 406 individuals of gharial including nine adults were recorded with an encounter rate of 0.66 ± 0.14 . All gharial sightings occurred from Kailashpuri Dam,

Bahraich to Tanda, Ambedkar Nagar. A total of 4534 individuals of freshwater turtles belonging to *Pangshura* genus and *Nilssonia gangetica* species were recorded. These sightings were frequently observed till Faizabad, Uttar Pradesh with an encounter rate of 7.37 ± 3.76 .

The survey also revealed that abundance and distribution of species was maximum in Lower Middle zone followed by Upper Middle and Lower zones. Suitable habitat with good presence of riverine islands, adequate water depth and sandbanks in the Lower Middle zone has resulted in good assemblage of key aquatic species.

Major issue was the flow alteration at Girija Barrage that causes lateral erosion and erodes nesting sites including riverine islands and sandbanks. A minimum flow should be maintained in the lean and monsoon seasons. Apart from this, all three zones have various issues viz., riverbed farming, sand mining, unsustainable fishing, feral dogs and open drain that intensifies in the Lower zone due to high dependency of local community. 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

Fragile and vulnerable freshwater ecosystems occupy a very small part of Earth, supporting a diverse group of aquatic fauna that includes threatened species of conservation concern. It has been noted that population of some of the key species including freshwater amphibians, reptiles and fishes have decreased by 84% and around 1/3rd of the wetlands have been lost since 1970 due to anthropogenic activities such as pollution or flow modification, overexploitation, and sand mining which deteriorates the quality of freshwater sources and leads to habitat degradation (WWF 2020, Dudgeon et al., 2006, Koehnken et al., 2020).

The situation becomes grave for the densely populated river basins that support large groups of economically & socially backward communities. Ganga River basin is one such region of the world, supporting more than 1/3rd of the country's population. This river basin with an area of 8,61,000 km², occupies approximately 26.3% of India's geographical area (Sanghi & Kaushal, 2014; Trivedi, 2010). It encompasses nine major river systems covering eleven states of the country viz., Himachal Pradesh, Uttarakhand, Uttar Pradesh, Delhi, Haryana, Rajasthan, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, and West Bengal comprising of a heterogeneous climate, geomorphology, soil, biogeography, culture, and socio-economic structure (NGRBA, 2011).

Ganga's tributaries have their origin in the Himalayas as well as Peninsular India. The Himalayan tributaries namely Alaknanda, Ramganga, Gomti, Ghaghra, Gandak and Kosi join the north bank of Ganga River except Yamuna that joins the south bank of Ganga along with Son River which originates in Peninsular India (Tandon & Sinha, 2018; NRC, 2009). Among these tributaries, Ghaghra River contributes the highest discharge (20%) in main stem Ganga followed by Yamuna River (16%) (Agrawal, 1994). After reaching West Bengal, Ganga River bifurcates into Hooghly that flows through the state forming the largest delta and Padma that enters Bangladesh. Hooghly here is rejuvenated by other peninsular rivers viz., Ajay, Rupnarayan and Kansai rivers.

The tributaries not only enhance the flow of main stem Ganga but are also significant breeding and feeding grounds for important aquatic floral and faunal species including the National Aquatic Animal of India the Gangetic dolphin (*Platanista gangetica*), gharial (*Gavialis gangeticus*), golden mahaseer (*Tor putitora*), freshwater turtles, water and water dependent birds, amphibians, that are of major conservation concern. Alterations in Land use/land cover, coupled with heavy pollution drained by tributaries such as Yamuna have an aggregated effect in normal functioning of the riverine ecosystem (Paul 2017). These changes have paved way for reduced flow, and have modified the hydrological regime which affects the aquatic biodiversity. Thus, the scientific community worldwide advocates that site level conservation goals for freshwater ecosystem will succeed if landscape level issues are addressed at catchment level (Bohn & Kershner, 2002; Lake et al., 2007). Hence, a basin level approach has been adopted to ensure the continuous and quality flow of the Ganga River.

Ghaghra, a left bank transboundary tributary of the Ganga River originates in the Tibetan plateau and flows through the two most densely populated states of the country i.e., Uttar Pradesh and Bihar. The entire length of the Ghaghra River is home to threatened freshwater species viz., Gangetic dolphin, gharial, mugger, smooth-coated otter, freshwater turtles and water dependent birds. Anthropogenic pressures such as physical modification, flow alteration, point source & diffuse pollution and sand mining are detrimental to these species' survival. To assess the rich biodiversity of Ghaghra River, its habitat characteristics and take account of the existing threats to the river ecosystem, a survey was undertaken under the NMCG-WII project "Planning and management for aquatic species conservation and maintenance of ecosystem services in the Ganga River basin for a clean Ganga" with an aim to intensify the conservation efforts in identified sites along the main stem Ganga River and upscale the conservation efforts to basin level for aquatic biodiversity conservation and maintenance of ecosystem services for a clean Ganga. Based on the physical factors, the entire length of the river was divided into five stretches that is Upper Himalayan zone, Lower Himalayan zone, Upper Middle zone, Lower Middle zone, and Lower zone covering a total length of 1,123 km in India and Nepal. The present study was taken up from Kailashpuri Dam in the Upper Middle zone to its confluence at Revelganj in the Lower zone covering a total length of 615 km.

A boat based direct count method was utilized to estimate the encounter rate. The survey stretch was divided into a total of 128 segments to assess the water and habitat characteristics. River morphological data was recorded at the initial points for each segment. The study recorded more than 300 individuals of the National Aquatic Animal- the Gangetic dolphin, >400 gharials including 9 adults, >4000 individuals of freshwater turtles and for the first time photographic records of smooth-coated otters in two different sites. Maximum assemblage

of key aquatic species was recorded in the Lower Middle zone followed by Upper Middle and Lower zones due to availability of the undisturbed habitat such as sandbanks, river islands and adequate water depth.

Alteration in the flow regime is one of the major threats to the aquatic diversity of this river ecosystem. Flow alteration is also responsible for lateral erosions further rescinding the riverine islands and sandy banks which are nesting sites for the threatened aquatic flora including gharial and freshwater turtles. The threats do not end here; riverbed farming, sand mining, unsustainable fishing, feral dogs and open drain are also a matter of concern across the length of the river. These factors intensify towards the lower zones with an increase of human habitation in close proximity to the river. Local communities are highly dependent on the river for their survival, further compounding the pressures on the River's ecosystem. Regular dialogue and consortium between various stakeholders including the local communities needs to be initiated to address these issues with site-specific conservation strategies for sustainable management of natural resources and conservation of the rich and vulnerable aquatic life.



Ghaghra, also known as Karnali in Nepal, is the largest tributary of the Ganga by volume and the second longest tributary by length after Yamuna (Jain et al., 2007; Tandon & Sinha, 2018). It is a trans-boundary perennial river that originates in the Tibetan plateau. It cuts through Himalayas in Nepal on its way to convergence with the Sharda River at Brahma Ghat in India beyond which it is known as Ghaghra. The Katarniaghat Wildlife Sanctuary (KLS), in Girwa river watershed of Ghaghra basin, is an important protected area and forms an integral part of the Dudhwa Tiger Reserve in Lakhimpur Kheri, Uttar Pradesh.

1.1 Course of the River

The source of Ghaghra River is Mapchachungo glaciers (3962 m asl) near Mansarovar lake in the Tibetan plateau (Singh & Awasthi, 2011). The river traverses the Himalayas, flowing in southward direction through Nepal, where it is known as 'Karnali'. While flowing through Shivalik hills, it splits into two branches, Girwa on the left and Kauralia on the right and re-joins south of the Indian border to form main channel of Ghaghra. It flows in North West-South East direction covering Uttar Pradesh and Bihar for a distance of about 615 km to join Ganga River at Revelganj, in Chapra district, Bihar (Jain et al., 2007).

The main tributaries of Ghaghra are Sharda, Saryu, Chauka, Kuwana, Rapti, Chhoti Gandak, Jharahi and Daha (Singh & Awasthi, 2011; Mohan, 2018). The Sharda River, an important tributary of Ghaghra, makes the international border between India and Nepal. Both these rivers nourish the landscapes of Dudhwa National Park and Katarniaghat Wildlife Sanctuary (Mathur & Midha, 2008).

1.2 Drainage and Hydrology

Ghaghra River has a catchment of 127,950 km², spread over India and Nepal, of which 45% or approximately 57,634 km² lies in India. Within India, 54,417 km² falls in Uttar Pradesh and 3,230 km² in Bihar (Rao, 1995; Jain et al., 2007; Gautam et al., 2021). Ghaghra contributes approximately 94,400 m³ of water to Ganga, making it its largest tributary by water volume (Rao, 1995; Jain et al., 2007; Lakra, 2010; Arya & Singh, 2021), but this also makes it highly susceptible to flash floods. Along with Yamuna, Son and Kosi, Ghaghra contributes half of the water of the Ganga River (CWC, 1988).

Monthly discharge in Ghaghra varies from 335 m³/s in lean season to 4370 m³/s in monsoon season with a mean discharge of 1410 m³/s (State Water Resource Agency, 2008) for the Ghaghra-Gomti basin, whereas the average discharge for Ghaghra has been reported as 2990 m³/s (Singh et al., 2017). A network of irrigation canals in Ghaghara basin in Uttar Pradesh, links Ghaghara with Sharda and Saryu rivers, and transfers water from one to another, making the discharge capacities of these rivers intricate (State Water Resource Agency, 2008).

Table 1.1 Diversion capacity of rivers (negative capacity indicates the diversion capacity into a river from a link canal)

River	Sharda		Ghaghra	Saryu
Barrage	Upper Sharda	Lower Sharda	Girija	Saryu
Capacity- Left (m ³ /s)	27	-480	360	450
Capacity- Right (m ³ /s)	326	650	480	-360



Ghaghra has a highly seasonal discharge regime, a common feature in the Ganga basin, with monsoon discharge being much greater than dry season. During summers, channel width reduces to as low as 100-200 m, however high flow period results in heavy flood, upto 60% of Ghaghra River basin falls under high flood hazard risk zone (Arya & Singh, 2021). Singh and Awasthi (2011) have described natural hazards for human population due to the regular flooding and erosion. Recently, Singh et al. (2020) sub-divided Ghaghra basin into 27 sub-basins and have described the quantitative morphometric properties of the drainage system. Large volume of water in Ghaghra river basin makes it one of the worst flood-affected areas in India, particularly during the southwestern monsoon season (Gautam et al., 2021). These waters are now being tamed through multiple hydro power projects either built or proposed on Karnali River through the Girija Barrage project near Katarniaghat Wildlife Sanctuary, due to which silt load has increased (Mital, 2016).

1.3 Land Use and Land Cover

Landuse and landcover (LULC) changes directly impact the biotic diversity and such changes may alter at ecosystem services (Sala et al., 2000; Vitousek et al., 1997). Spatial data analysis from the National Remote Sensing Centre (NRSC) indicates that the total area under agriculture and built up area has increased in the last 10 years (2006-06 to 2015-16) along the Ghaghra River, whereas open water bodies have reduced (Table 1.2 & Figure 1.2). These changes in agriculture land are more visible along the river stretch in Uttar Pradesh, whereas open water bodies have significantly reduced in Bihar (Table 1.3).

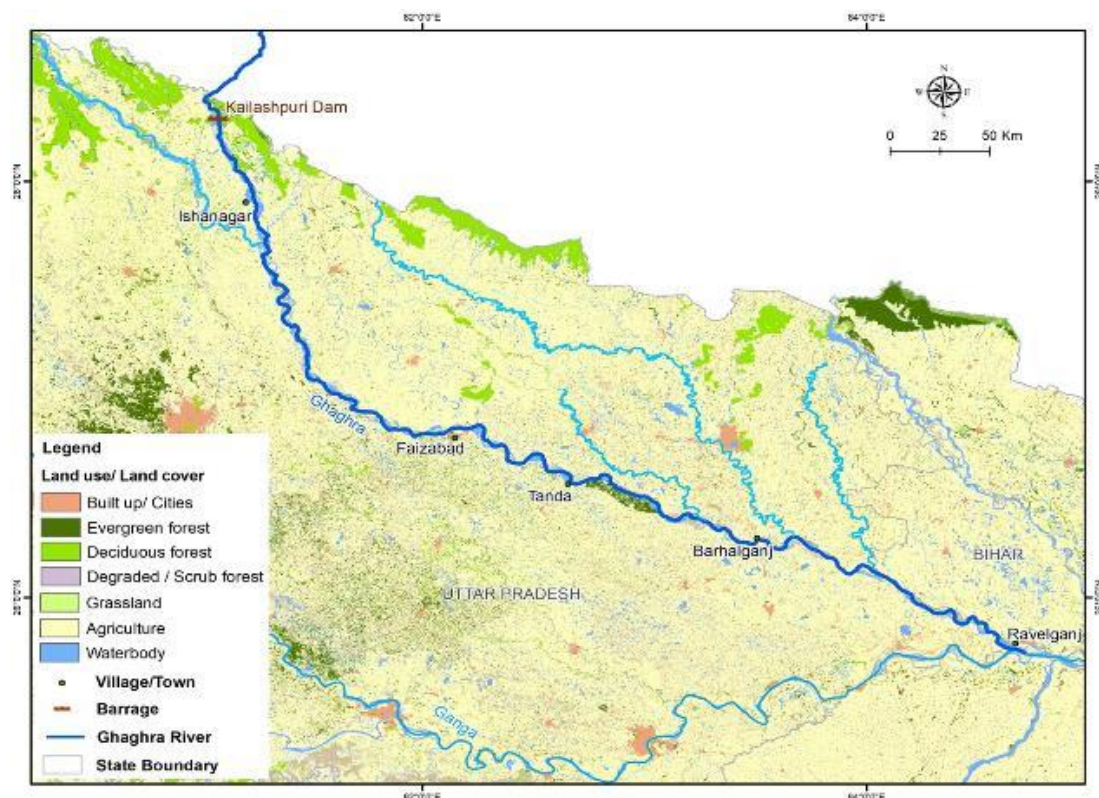


Figure 1.1
Land use Land cover of the Ghaghra River basin

Table 1.2: Decadal changes in land use land cover along Ghaghra River

Area (%)	2005-06	2015-16
Built up	4.08	5.65
Forest	4.32	4.31
Grassland	0.10	0.10
Agriculture	63.89	74.94
Fallow land	20.05	7.71
Waterbodies	7.57	7.29

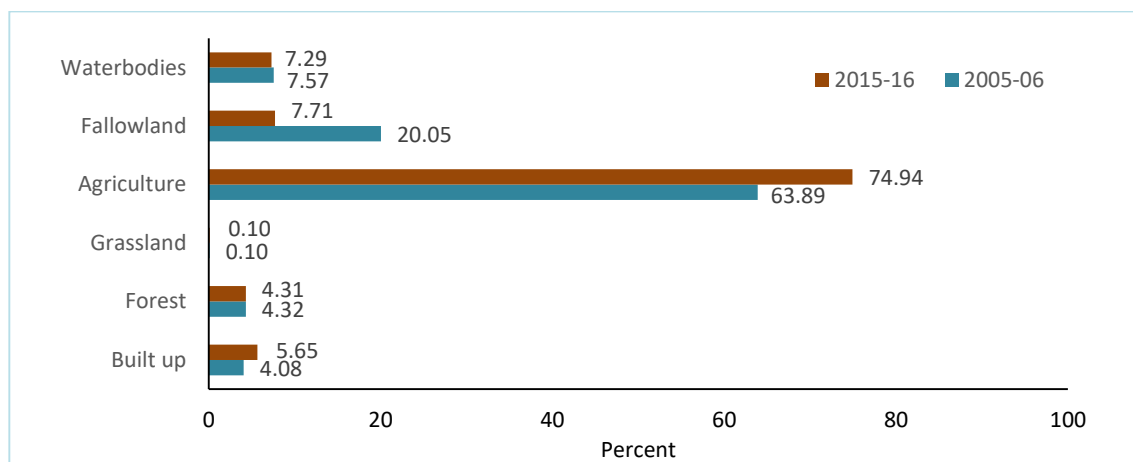


Figure 1.2 Comparative account of LULC along Ghaghra River

Table 1.3 District wise changes in LULC along Ghaghra River in Uttar Pradesh and Bihar

District/s	State	Built up (%)		Forest (%)		Grassland (%)		Agriculture (%)		Fallow land (%)		Waterbodies (%)	
		2005-06	2015-16	2005-06	2015-16	2005-06	2015-16	2005-06	2015-16	2005-06	2015-16	2005-06	2015-16
Ambedkar Nagar	Uttar Pradesh	2.55	4.27	9.74	9.78	0.00	0.00	66.84	71.34	14.08	7.24	6.79	7.37
Azamgarh		6.02	7.88	1.44	1.46	0.00	0.00	63.30	71.49	22.63	12.57	6.60	6.59
Bahraich		2.20	2.41	13.86	13.84	0.80	0.78	47.81	68.19	27.77	7.21	7.56	7.57
Ballia		5.06	6.61	1.29	1.30	0.00	0.01	63.31	71.84	20.79	11.46	9.55	8.79
Basti		3.99	6.59	2.48	2.47	0.00	0.00	56.37	74.10	29.14	8.10	8.02	8.75
Deoria		4.24	6.37	2.22	2.19	0.00	0.00	67.46	81.27	21.45	5.88	4.63	4.29
Gonda		1.22	1.34	4.26	4.25	0.00	0.00	69.76	85.66	20.06	3.90	4.71	4.85
Gorakhpur		6.17	10.50	3.71	3.69	0.00	0.00	68.83	72.92	15.99	7.07	5.30	5.83
Mau		5.05	6.37	1.14	1.16	0.00	0.00	74.12	79.45	12.59	6.02	7.10	7.01
Sant Kabir Nagar		2.62	7.02	2.57	2.60	0.00	0.00	67.86	75.20	18.84	6.64	8.10	8.53
Saran (Chhapra)	Bihar	5.24	5.28	3.03	3.04	0.00	0.00	63.49	71.47	13.49	8.10	14.74	12.11
Siwan		5.15	5.18	0.66	0.66	0.00	0.00	71.40	80.58	12.35	5.81	10.44	7.77

1.4 Geology and Geomorphology

Ghaghra river is part of the fertile Indo-Gangetic plains (Shah, 2017; Singh et al., 2020) with a heterogeneous landscape that includes denudating hills in the north followed by the micro and mega alluvial fans (Singh, 1996), since the river carries sediments and soils covering various stages of development thus the remaining area is covered by the alluvial deposits (Srivastava et al., 2016; Singh et al., 2020; Arya & Singh, 2021). Older sediments are characterized by yellow-brown colour whereas the river valley terrace located at an elevation of 5-10 m is formed by newer alluvium (Shah, 2017). Ghaghra River basin mostly falls in two-fold subdivisions, the Terai and central alluvial plains (Singh, 1996). As the river enters the alluvial plains, it braids over and meanders, and further its shifting course leads to the formation of oxbow lakes (Shukla & Singh, 2004; Shah, 2017). This river channel is coupled with giant mid channel and side bars (Singh & Awasthi, 2011). Varying width of the river in summer and monsoon seasons leaves an intricate pattern in the stream of Ghaghra river comprising of middle channel bars that may measure 5–10 km long and 1–5 km wide (locally known as “Diara”), sidebar, natural dike and flood plains (Singh et al., 2017).

1.5 Soil Type

Presence of large quantity of soil particles transported by the river makes the soil in Ghaghra extensively fertile. Soil in Terai region is mostly alluvial and the texture varies from fine to medium grain. As mentioned above, the geological structure of the region comprises of both old and new alluvium that consists of a mix of sand, clay, silt, gravels and coarse fragments that get renewed every day (Das & Das, 1981; Srivastava et al., 2016; Arya & Singh, 2021). Ghaghra River mainly flows through these old (Khadar) and new (Bangar) alluvial deposits. A deep loamy layer is the main soil type in the basin (Mohan, 2018). Reporting on idealized lithological profiles from boreholes, Singh (1996) gave the composition of Ghaghra-Terai as 5% gravel, 45% sand and 50% mud, while in the Ghaghra-Gomti interfluvium (Doab) these proportions were 50% mud-kanker, 20% mud, 20% sand and 10% gravel. Soil of the Ghaghra in north-eastern Uttar Pradesh is calcareous in nature (Singh et al., 2011). With the anthropogenic pressures such as deforestation, unsustainable agricultural practises have increased the adversities of natural calamities, such as frequent floods. This is happening because anthropogenic activities have created a permeable mixture of gravel, boulders and sand that is leading to detrimental consequences

such as lowering of water table, but at places where the soil layers consist of clay and fine sediments ground water rises washing away heavy sediments and accelerating flash floods during monsoons (Mital, 2016).

1.6 Climate

Climatic condition in Terai region where Ghaghra flows is generally characterised as tropical monsoon and has been divided into three seasons, namely summer (March to mid-June), monsoon (mid-June to mid-October) and winter (mid-October to February). Monsoon brings about 80% of the total annual rainfall. Overall, the annual rainfall in the basin ranges between 900-1400 mm (Mohan 2018; Srivastava et al., 1994, 1998; Mital, 2016; Arya & Singh, 2021). Relative humidity in the region ranges between 74 - 87%. (Shukla, 2009) and the temperature varies between a maximum of 47°C in summer to a minimum of 2°C in winters (Shah, 2017).

1.7 Demography

Ghaghra River flows through 16 districts of Uttar Pradesh and Bihar, with about 52.6 million people estimated to reside in these districts. Average human population density is 1042.1 persons/km², with districts in Bihar having higher density than Uttar Pradesh (Figure 1.3 & Table 1.4). Lower zone is densely populated as compared to the Upper zone (Figure 1.3).

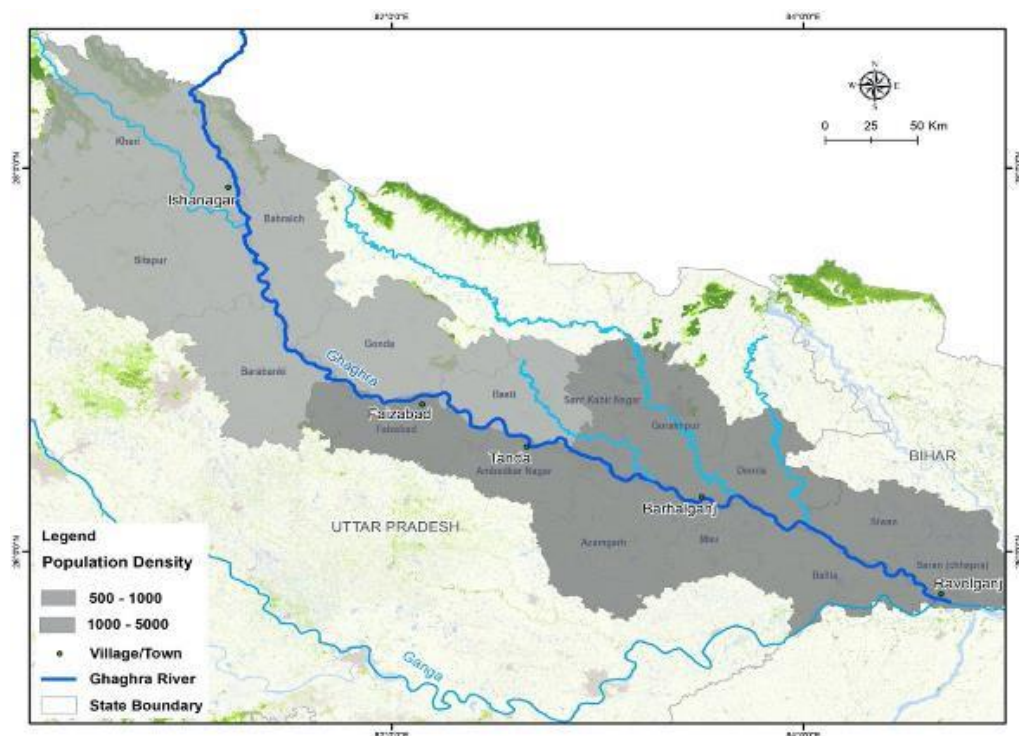


Figure 1.3
Human Population density along the Ghaghra River



Table 1.4 Human density along the Ghaghra River (Source: GOI, 2011)

States	Districts	Density (Persons/km ²)
Uttar Pradesh	Ambedkar Nagar	1020
	Azamgarh	1138
	Bahraich	666
	Ballia	1087
	BaraBanki	741
	Basti	917
	Deoria	1221
	Faizabad	1056
	Gonda	858
	Gorakhpur	1337
	Kheri	524
	Mau	1288
	SantKabir Nagar	1042
	Sitapur	781
Bihar	Saran (Chapra)	1496
	Siwan	1501

The administrative setup of Ghaghra basin includes one fully covered and 20 partially covered districts of Uttar Pradesh (Table 1.5). The percentage coverage of each district reflects that only Gonda district is fully covered under the Ghaghra basin followed by more than 90% area of Bahraich and Basti districts (Figure 1.4) (Ghaghra Basin Plan, 2020).

Table 1.5 Area wise districts coverage in Ghaghra River Basin (Source: GOI, 2011)

S. No.	District	Area in Basin (sq. km)	Total District Area (sq. km)
1	Ambedkar Nagar	1167.25	2357.85
2	Azamgarh	813.26	4222.46
3	Bahraich	4757.13	4855.25
4	Ballia	1404.32	2986.76
5	Balrampur	499.64	3343.84
6	Bara Banki	1115.43	3854.45
7	Basti	2533.28	2689.75
8	Deoria	1890.53	2561.84
9	Faizabad	724.5	2724.16
10	Gonda	3994.54	3994.54
11	Gorakhpur	419.17	3357.61
12	Kheri	5242.73	7683.98
13	Kushinagar	1741.75	2878.13
14	Maharajganj	620.29	2926.56
15	Mau	533.78	1711.98
16	Pilibhit	559.8	3498.18
17	Sant Kabir Nagar	711.41	1624.05
18	Shahjahanpur	26.92	4568.6
19	Shrawasti	262.01	2016.27
20	Siddharthnagar	103.53	2918.04
21	Sitapur	2381.74	5736.19
		31503.01	72510.49

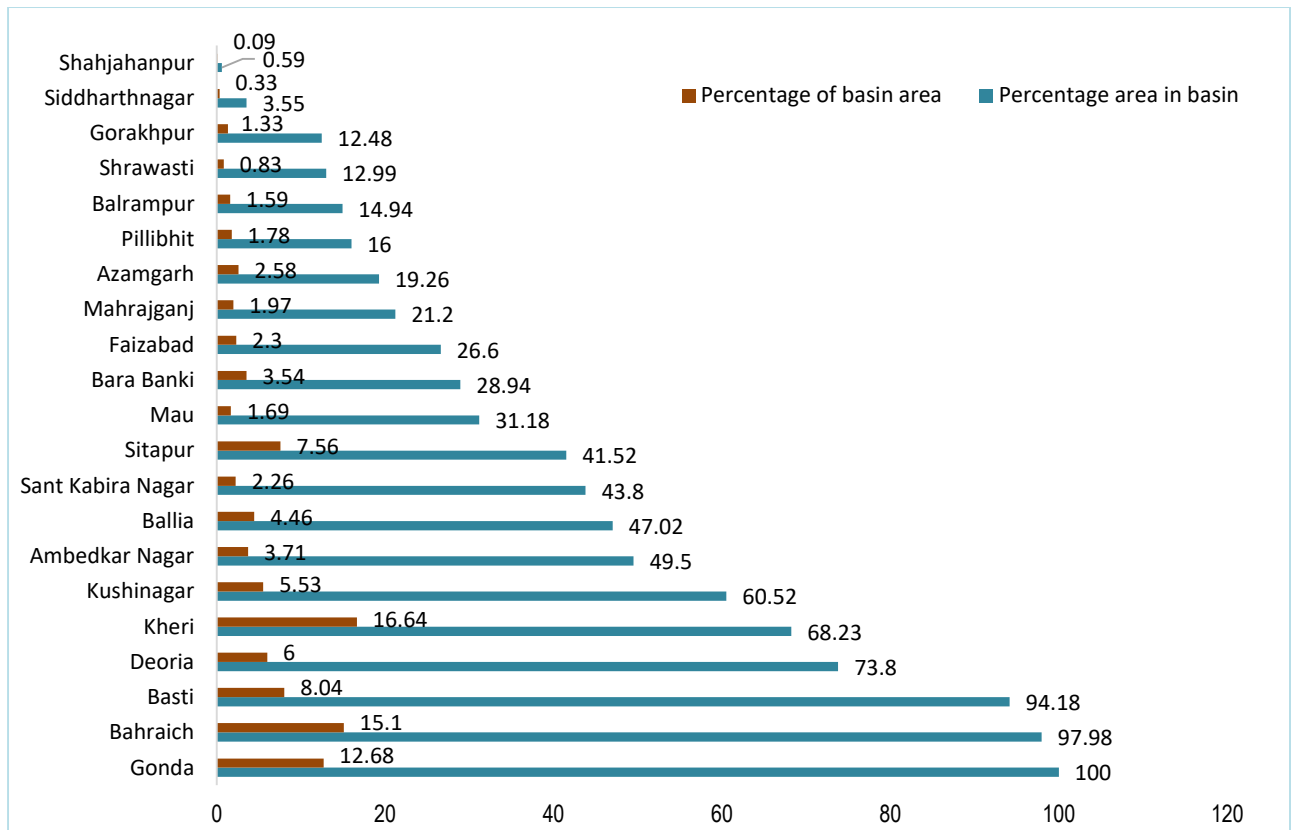


Figure 1.4 Percentage coverage of districts under the Ghaghra River Basin in Uttar Pradesh



1.8 Wetlands

Ghaghra river basin consists of 1164 wetlands covering 21 districts and 129 blocks of Uttar Pradesh (Table 1.6). Bahraich district has highest number of wetlands (N= 374) (Ghaghra Basin Plan, 2020). Wetlands in Saran and Siwan districts of Bihar cover a total area of 21170 ha and 7105 ha, respectively, covering 8.07% and 3.21% of total geographical area in two districts (Figure 1.5) (Jha et al., 2014).

Table 1.6 Area covered and total number of wetlands per district along Ghaghra River in Uttar Pradesh (Source: Ghaghra basin plan, 2020)

S. No.	District	No of Wetlands	Area (ha)
1	Ambedkar Nagar	37	973.46
2	Azamgarh	25	610.13
3	Bahraich	374	14141.78
4	Ballia	40	602.17
5	Balrampur	16	161.15
6	Bara Banki	50	1864.56
7	Basti	71	1555.78
8	Deoria	15	269.27
9	Faizabad	31	782.36
10	Gonda	180	3675.64
11	Gorakhpur	19	573.54
12	Kheri	87	3075
13	Kushinagar	50	2789.48
14	Maharajganj	12	303.09
15	Mau	8	236.72
16	Pilibhit	8	339.03
17	Sant Kabir Nagar	26	707.49
18	Shrawasti	18	481.67
19	Siddharthnagar	2	14.18
20	Sitapur	95	4985.46
	TOTAL	1164	38141.96

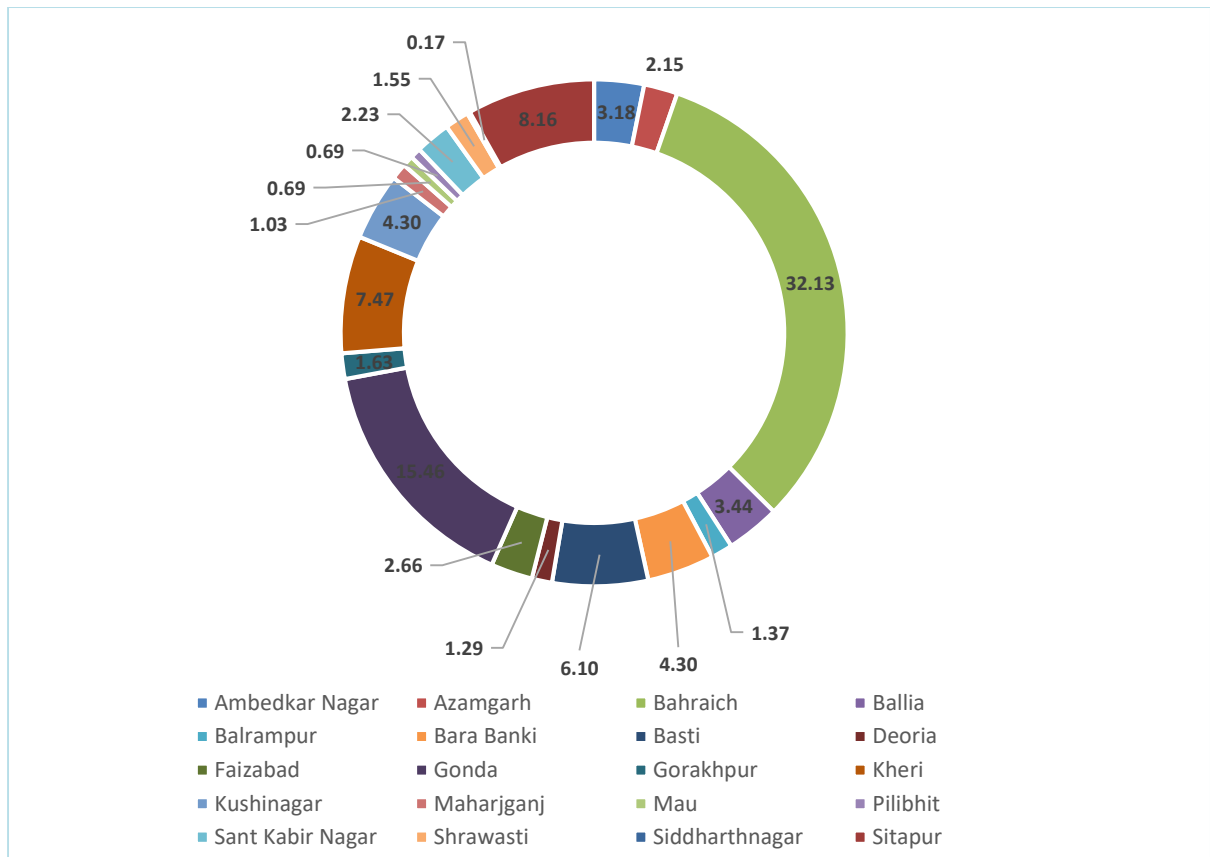


Figure 1.5 Percentage coverage of wetlands in districts of Uttar Pradesh in Ghaghra basin

1.9 Zonation of the River

Ghaghra river crosses high mountain ranges & deep gorges of primarily Nepal Himalayas whereas in India it passes through the Terai and fertile Gangetic plain in Uttar Pradesh and Bihar states. Based on the geomorphology and associated landforms, the river course can be broadly divided into: (A) Upper zone, (B) Middle zone, (C) Lower zone which are further subdivided into five sub-zones, namely (A.1) Upper Himalayan zone, (A.2) Lower Himalayan zone, (B.1) Upper Middle zone, (B.2) Lower Middle zone, (B.3) Lower zone (Figures 1.6 & 1.7).

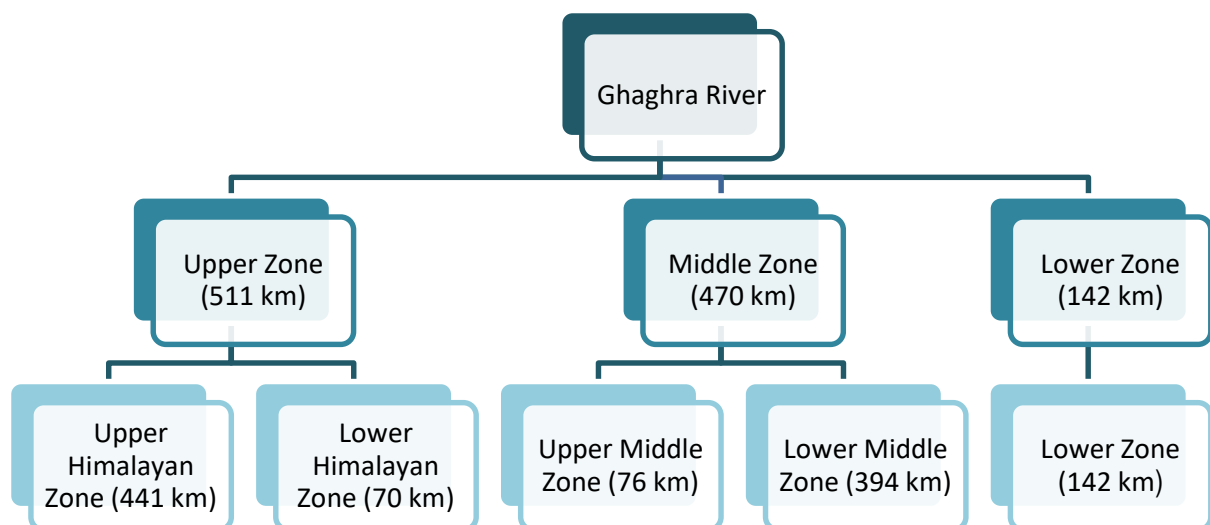


Figure 1.6 Zonation of Ghaghra river in India & Nepal

A. Upper Zone (511 km): Upper zone falls in Nepal covering 511 km stretch of the Karnali River. The geomorphological features of the stretch include steep slopes, faults and deep gorges. The Karnali River divides into Girwa and Kauriala rivers at Chisapani in Banke district of south-western Nepal before entering India. These rivers give rise to Ghaghra after their confluence at Kailashpuri Dam in Bahraich district of Uttar Pradesh (Table 1.7). The zone has been further divided into two sub zones:

A.1. Upper Himalayan zone (441 km): This zone lies between the source at Mapchachungo glaciers to Ghatgaun (confluence of Bheri River) in Nepal flowing through steep slopes, Himalayan faults and deep gorges.

A.2. Lower Himalayan zone (70 km): The Lower Himalayan zone starts from Ghatgaun (confluence of Bheri River) in Nepal to Kailashpuri Dam near Katarniaghat Wildlife Sanctuary in India. The river flows through Shivalik range and its two sub channels in this zone are Kauriala and Girwa.

B. Middle Zone (470 km): In India, Ghaghra covers a 615 km stretch covering the Middle and Lower zones. The middle zone has been further divided into two sub zones:

B.1. Upper Middle zone (76 km): The river is called Ghaghra from this area and flows through lower Shivalik range crossing the Terai landscape between Kailashpuri Dam and confluence of Sharda River near Mahsi, Uttar Pradesh.

B.2. Lower Middle zone (394 km): This zone starts from Sharda river confluence near Mahsi to Rapti confluence near Barhai, Uttar Pradesh. Here, the river travels through the upper Gangetic plain and is joined by the Sharda and rainfed Kuwana rivers, which contribute to its flow.

C. Lower zone (142 km): The lower zone of Ghaghra river extends from the confluence of Rapti River near Barhai, Uttar Pradesh to confluence of Ghaghra with mainstem Ganga at Revelganj, Bihar. This area is a part of the Gangetic plain featured with fertile alluvium deposition of Rapti and Choti Gandak rivers.

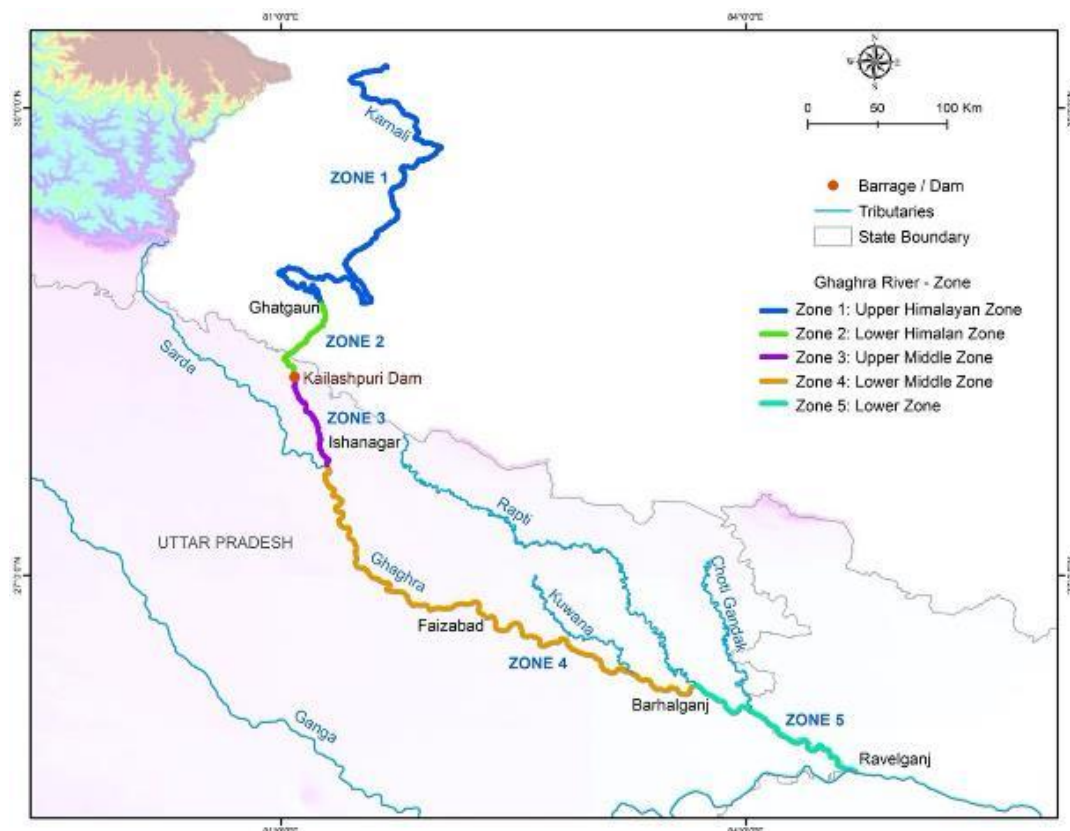


Figure 1.7
Zonation map of Ghaghra River

Table 1.7 Zone-wise characteristics of Ghaghra River

	Himalayan Zone (Nepal and India)		Middle Zone (India)		Lower Zone (India)
Sub-Zone	Upper Himalayan Zone (in Nepal)	Lower Himalayan Zone	Upper Middle Zone	Lower Middle Zone	Lower Zone
Length (km)	441	70	76	394	142
Stretches	Ghatgaun	Kailashpuri Dam	Sharda confluence	Rapti confluence	Ghaghra confluence at Revelganj
Characteristic features	Interlocking spur, Steep rocks, Gorge, Stream terrace	Shivalik Himalaya, Terai region	Narrow channel, Gravel and sand deposited region	Middle alluvial region	Gangetic flood plain



2. STATUS OF AQUALIFE IN THE GHAGHRA RIVER

Ghaghra River basin is home to diverse floral and faunal species encompassing many threatened aquatic species. Even though very few studies have been undertaken in mainstem Ghaghra River, historic records suggest the presence of 2 mammalian species belonging to 2 families, 10 amphibians belonging to 4 families, 16 reptiles belonging to 4 families, 111 fish species belonging to 4 families and 94 avian species belonging to 14 families (Figure. 2.1).

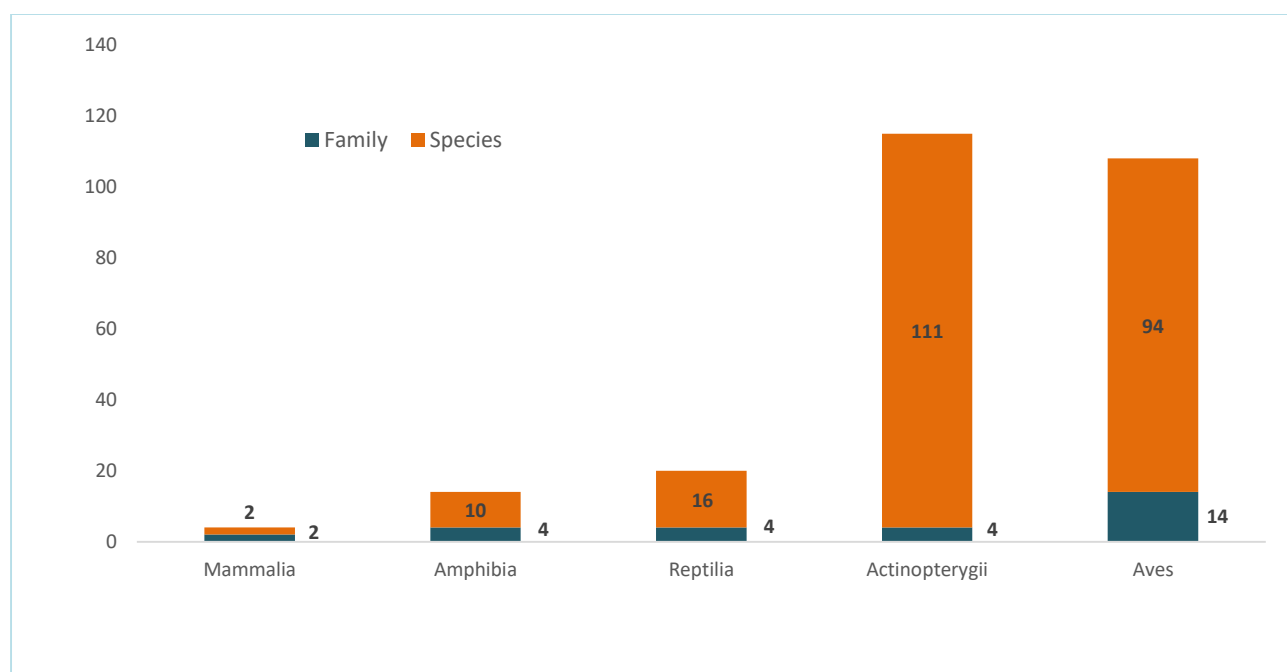


Figure 2.1 Biodiversity profile of the major species recorded from Ghaghra River

2.1 Methodological Framework

A multistage approach was used to assess the status of key aquatic species in Ghaghra River. In the first stage, a comprehensive literature review on distribution, abundance and threats to priority species was carried out. Information was collected and compiled using Google Scholar, Publish or Perish (Harzing, 2007) and other search engines. Mimeo reports, Fauna of British India, Fauna of India and other available literature from the British era were also consulted. Current abundance and distribution of the species in Ghaghra was estimated based on the post-monsoon ecological survey conducted in 2020-2021.

Survey and data collection

More than 600 km stretch was surveyed from Kailashpuri Dam, Bahraich to Revelganj, Saran district to its confluence with mainstem Ganga. The entire stretch was covered in 18 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 key aquatic species.

Boat based direct total count method was used (Smith & Reeves 2000b; Sinha & Sharma 2003) for estimation of encounter rate of Gangetic dolphin in the survey stretch.

To assess aquatic and bank habitat features, the survey stretch was divided into 123 equal segments of 5 km each and habitat variables were simultaneously recorded for individual segment. River morphology data such as channel type, bank characteristics, water temperature and depth were recorded at the starting point 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 channel depth, binoculars (Aculon A211 10x5), Nikon laser range finder for recording channel width and sighting distance, Kestrel 3000 pocket weather meter and Canon Powershot camera for photographic and videographic documentation.



2.2 Mammals

Gangetic dolphin (*Platanista gangetica*)

Historical Distribution

Scientific studies on the Gangetic dolphin in Karnali river dates back to early 80s, Shrestha (1989) reported presence of 12 and 20 dolphins, during two surveys conducted on September 1982 and January 1983, respectively. The surveys were conducted from Solta to Nepal-India border at Kotiaghat.

Smith (1993) recorded a total of 10 and 11 individuals of dolphins in January and April months of 1990, in a stretch of 20 km from Amba village, Katarniaghat WLS to Girijapuri. Later in 1993, in a 20 km stretch of Girwa River upstream and downstream between Kachali and Girijapuri barrage 25-30 dolphins were recorded (Smith et al., 1994). Basu & Sharma (2000) mentioned presence of 25 dolphins in Girwa River in a 20 km stretch from Amba village Katarniaghat WLS to Girijapuri. Surveys carried out by WWF-India in a 22 km stretch from Amba village Katarniaghat WLS to Girijapuri in the Girwa river observed 30, dolphins consecutively in December 2006, 2008, whereas in 2009 40 dolphins were recorded (Behera et al., 2014). In a survey undertaken in 18 km stretch of Girwa River from Amba village Katarniaghat WLS to Girijapuri, 18 dolphins were observed (Behera et al., 2014). 30 individuals of dolphin have been mentioned from the 18 km stretch of Katarniaghat WLS along Girwa during a survey undertaken in the year 2001, twelve years later survey undertaken in the same stretch observed presence of 35 dolphins (WWF-India unpublished report 2001; Singh & Behera, 2018).

Uttar Pradesh Forest Department (1992) reported presence of Gangetic dolphin throughout the stretch of Ghaghra River from Girija Barrage to its confluence with Ganga River, while conducting gharial (*Gavialis gangeticus*) survey.

A survey conducted in 532 km stretch from Kailashpuri Barrage to Ganga confluence near Chhapra in March, 1992 reports of 127-200 dolphins (Behera et al., 2014).

Basu & Sharma (2000) recorded 17 dolphins in a 60 km stretch in Ghaghra River from Ayodhya to Tanda in June 1999. Later in February/March 2001, an assessment undertaken in 505 km stretch of Ghaghra River from Kailashpuri Barrage to Dohrighat recorded 246 dolphins. A total of 295 dolphins were observed in a 505 km stretch of Ghaghra River from Kailashpuri Barrage to Deori Ghat, Uttar Pradesh (WWF-Nepal, 2006). Later, Behera et al. (2014) observed a total of 231 dolphins in the 445 km stretch from Kailashpuri Barrage to Deori Ghat, Uttar Pradesh. Singh et al. (2021), reported the presence of 107 dolphins in the 119 km stretch from Chahlari Ghat to Ayodhya based on the survey conducted in Ghaghra River in the year 2001. 115 dolphins were recorded from Mallapur – Barabanki Bahraich road bridge covering a 90 km stretch during a survey conducted in the year 2009 (Basu, 2012; Singh et al., 2021). In another survey carried out from Kailashpuri Bridge to Balia covering 518.72 km stretch, 317 dolphins were recorded in the month of October, 2015 (Singh et al., 2021). A survey conducted from Kailashpuri Bridge to Balia in the year 2012 covering 505 km stretch of the Ghaghra River, reported a total of 231 dolphins (WWF India, UPFD; Singh et al., 2021). Sinha et al. (2000) reported the presence of 1-3 dolphins at Revelganj, along Ghaghra River.

Table 2.1 Historic record of the dolphin surveys undertaken in the Ghaghra River basin

River	Location/Stretch	length (km)	Dolphin number	Survey	Reference
Karnali River	Solta to Nepal-India border at Kotiaghat	-	12	September 1982	Shrestha, 1989
	Solta to Nepal-India border at Kotiaghat		20	January 1983	
Girwa River	Amba village Katarniaghat WLS to Girijapuri	20	10	January 1990	Smith, 1993
		20	11	April 1990	
Girwa river	Upstream and downstream between Kachali and Girijapuri Barrage	20	23-30	1993	Smith et al., 1994
Girwa river	Amba village Katarniaghat WLS to Girijapuri	20	25		Basu & Sharma, 2000
Girwa River	Amba village Katarniaghat WLS to Girijapuri	22	39	WWF India Dec 2006	Choudhury et al., 2010
		22	49	WWF India Dec 2009	
Girwa river	Amba village Katarniaghat WLS to Girijapuri	22	30	WWF India 2008	Behera et al., 2014
Girwa River	Amba village Katarniaghat WLS to Girijapuri	18	39	2012	Behera et al., 2014
Girwa River	Katarniaghat WLS	18	35	2013	Singh & Behera, 2018
Girwa River	Katarniaghat WLS	18	30	2001	WWF 2001, Singh & Behera, 2018
Ghaghra River	Girija Barrage to confluence		Throughout the River	1992	Uttar Pradesh Forest Department, 1992
Ghaghra River	Kailashpuri Barrage to Deori Ghat, Uttar Pradesh	505	295		WWF Nepal, 2006
Ghaghra River	Kailashpuri Barrage to Deori Ghat, Uttar Pradesh	445	231		Behera et al., 2014
Ghaghra River	Kailashpuri Barrage to Ganga confluence near Chhapra	532	127-200	March 1992	Behera et al., 2014

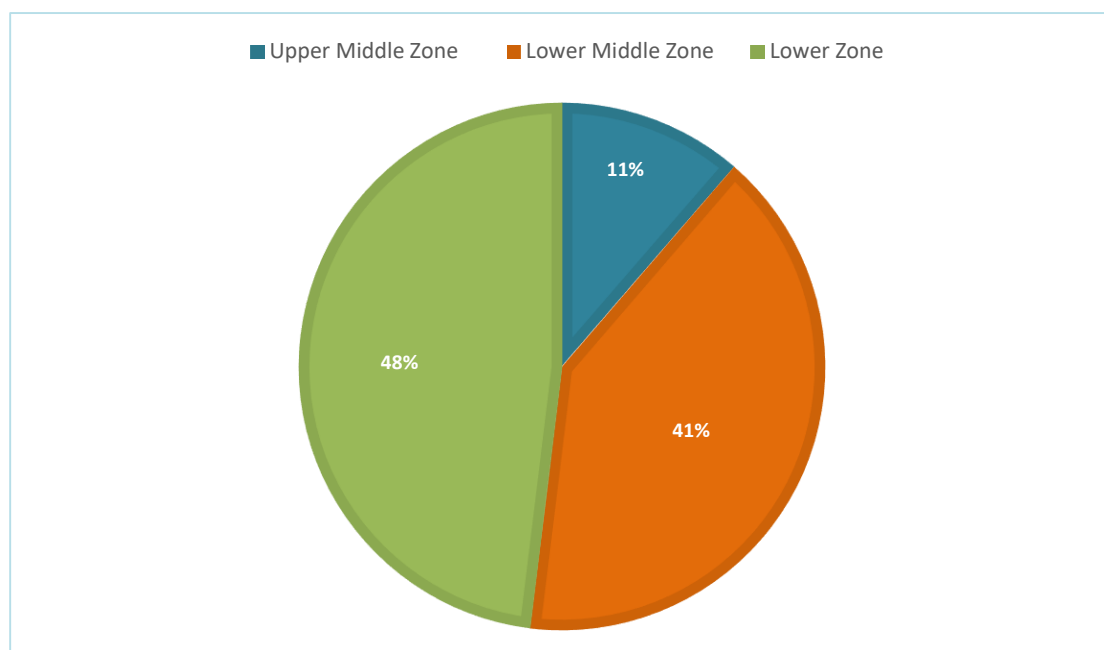


Figure 2.3 Zone-wise distribution (%) of Gangetic River dolphin in Ghaghra River

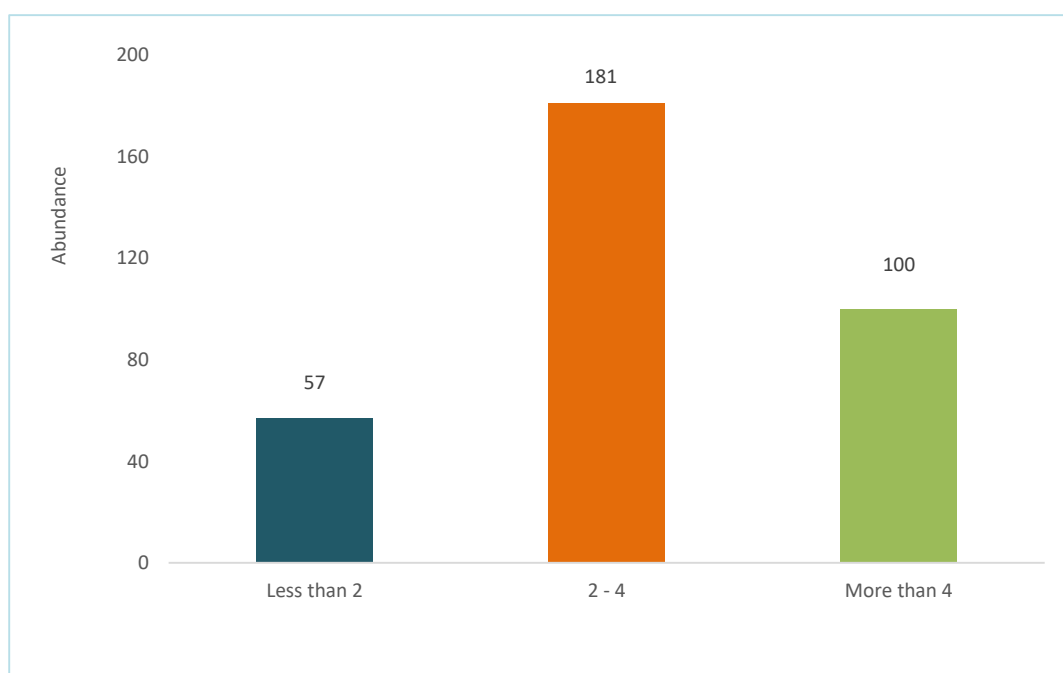


Figure 2.4 Sighting record of Gangetic dolphin in different depth classes of Ghaghra

Table 2.2 Zone wise abundance and encounter rate of dolphin in Ghaghra River

Stretches	Length	Segment	Abundance	ER $\pm$ SE
Upper Middle Zone	76	15	38	0.51 $\pm$ 0.12
Lower Middle Zone	394	79	136	0.34 $\pm$ 0.05
Lower Zone	142	29	161	1.11 $\pm$ 0.30

Otters

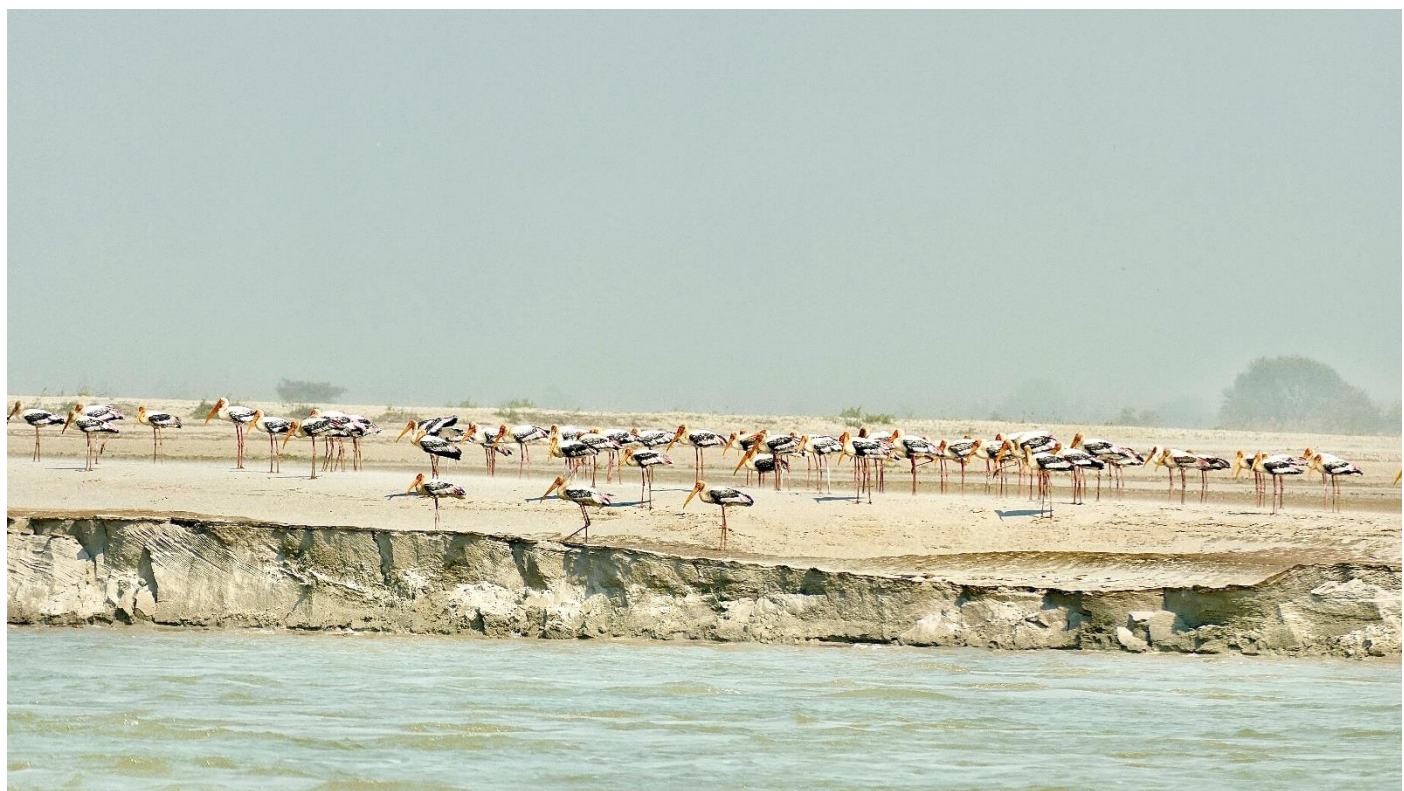
Presence of smooth-coated otter (*Lutrogale perspicillata*) in Bahraich district of Uttar Pradesh in Girwa River, one of the main tributaries of Ghaghra River has been mentioned earlier (Behera et al., 2013; Singh & Behera, 2018).

During the present rapid biodiversity assessment, direct photographic sightings of smooth-coated otter were recorded for the first time from the middle stretch of Ghaghra River and near its confluence with Ganga River.





2.3 Avifauna



Historical Distribution

Most of the studies on avifauna in Ghaghra River basin were undertaken in and around wetlands. A total of 31 waterbirds have been reported from wetlands in Bahraich district of Uttar Pradesh (Varghese et al., 2008), few individuals of Sarus crane were recorded in patches along the grasslands in middle zone (Maheswaran et al., 2010), 200 species of birds including 57 species of waterbirds have been recorded in the Katarniaghat WLS (Sethy & Chauhan, 2011). Mital (2016) reported 43 species of waterbirds in mainstem Ghaghra and Saryu rivers, whereas Singh & Behera (2018) reported presence of 63 species of waterbirds from Girwa River, tributary of Ghaghra river. A recent study by Turtle Survival Alliance (2021) reported presence of 42 species of waterbirds from Chahlari Ghat to Ayodhya Ghat covering a total distance of 119 km along mainstem Ghaghra River. These studies suggest that the information available on distribution of waterbirds is scarce, and this knowledge gap needs to be filled for effective planning of site-specific conservation strategies.

Present Distribution

During the present rapid biodiversity assessment, a total of 93 individuals of 50 species of water and water associated birds were recorded (Annexure II). Anatidae (28%) was the most abundant family, followed by Ciconiidae (10%) (Figure 2.6). Of the 50 bird species, 42% were winter migratory, 36% were resident with local movement and 22% were resident (Figure 2.7). Feeding guild of these species includes 44% carnivores, 30% omnivores, 20% piscivores, 4% scavengers and 2% herbivores (Figure 2.8). Out of all the total species recorded, three species fall under the “Endangered” category of the IUCN, followed by seven species being “Near Threatened” and three species coming under “Vulnerable” category (Table 2.3).

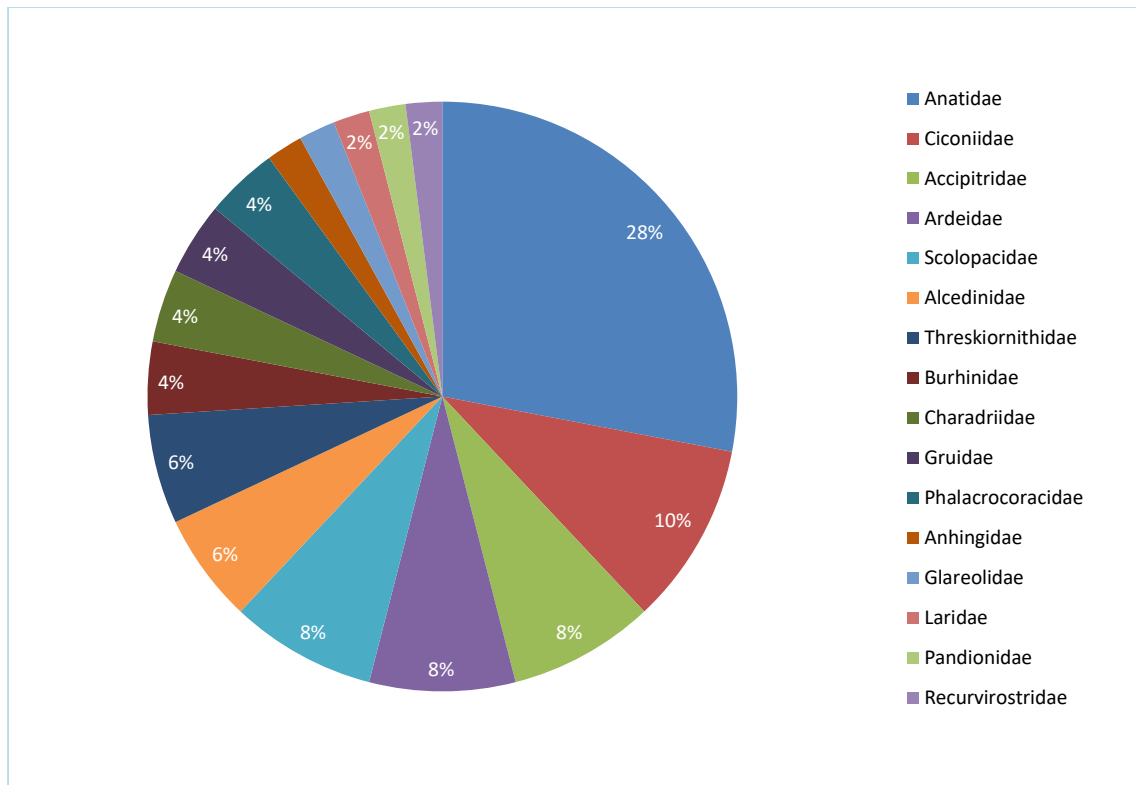


Figure 2.6 Family wise composition of waterbirds and water associated communities along the Ghaghra River

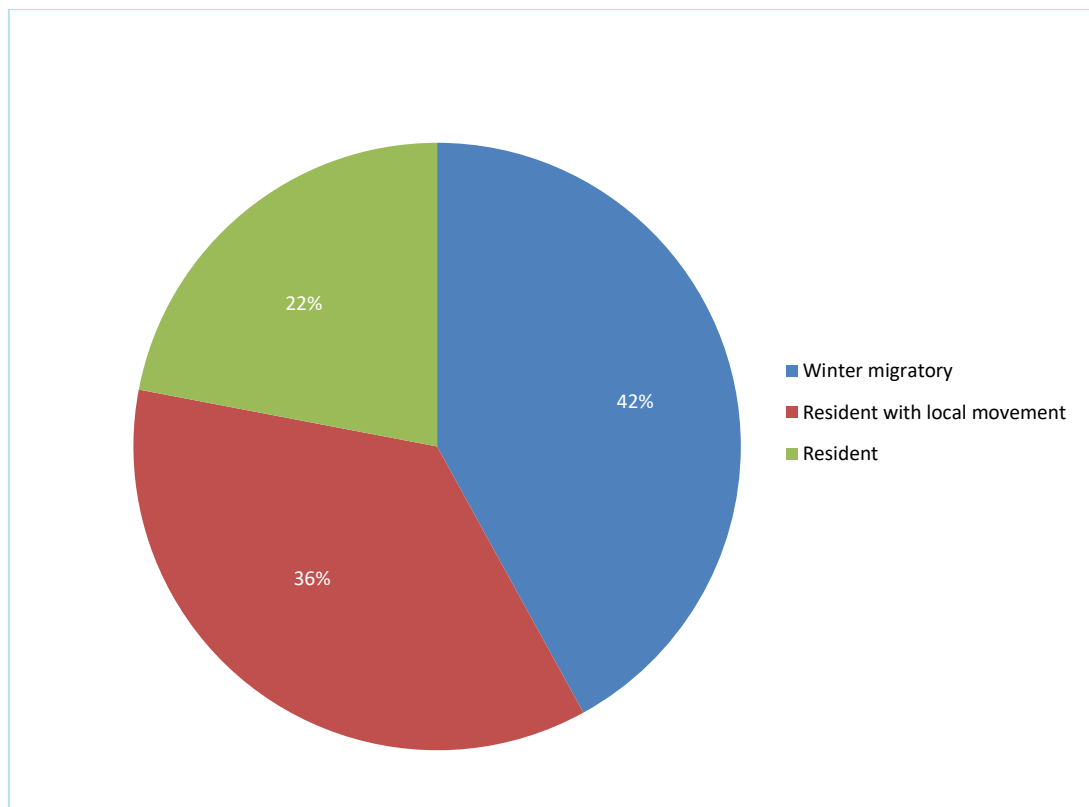


Figure 2.7 Residential status of waterbirds and water associated communities along the Ghaghra River

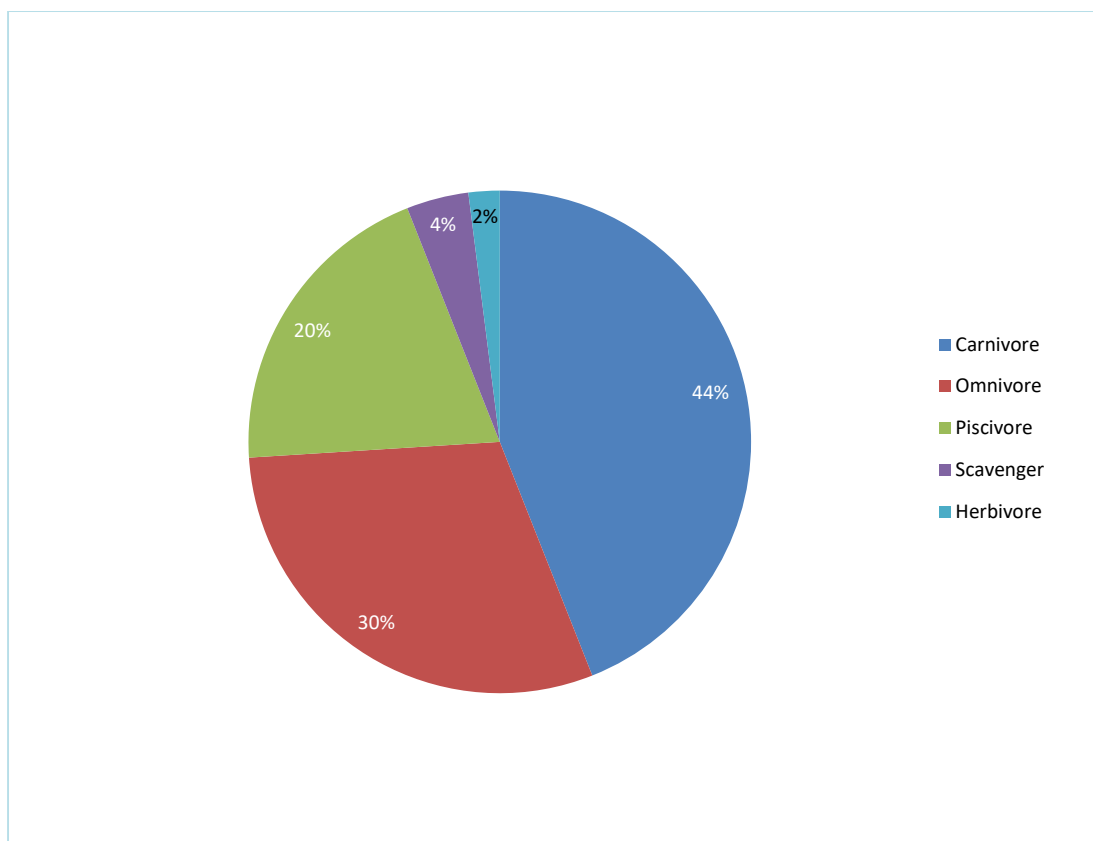


Figure 2.8 Feeding guilds composition of waterbirds and water associated communities along the Ghaghra River

Table 2.3 RET Species present across the Ghaghra River

Family	Bird Species	Scientific Name	Status
Accipitridae	Egyptian vulture	<i>Neophron percnopterus</i>	EN
Accipitridae	Pallas's fish eagle	<i>Haliaeetus leucoryphus</i>	EN
Accipitridae	Steppe eagle	<i>Aquila nipalensis</i>	EN
Anatidae	Common Pochard	<i>Aythya ferina</i>	VU
Anhingidae	Oriental darter	<i>Anhinga melanogaster</i>	NT
Burhinidae	Great thick-knee	<i>Esacus recurvirostris</i>	NT
Charadriidae	River lapwing	<i>Vanellus duvaucelii</i>	NT
Ciconiidae	Painted Stork	<i>Mycteria leucocephala</i>	NT
Ciconiidae	Woolly-necked stork	<i>Ciconia episcopus</i>	VU
Ciconiidae	Black-necked stork	<i>Ephippiorhynchus asiaticus</i>	NT
Gruidae	Sarus Crane	<i>Grus antigone</i>	VU
Scolopacidae	Eurasian curlew	<i>Numenius arquata</i>	NT
Threskiornithidae	Black-headed ibis	<i>Threskiornis melanocephalus</i>	NT

2.4 Reptiles

Gharial (*Gavialis gangeticus*)

Historical Distribution

A part of Girwa River in Katarniaghat WLS, in the Ghaghra basin is a healthy breeding habitat for the Critically Endangered gharial (*Gavialis gangeticus*) and mugger (*Crocodylus palustris*) populations. The first ever estimation of gharial population in Ghaghra basin was carried out at Katarniaghat in 1975 and 1976 by Singh (1978) who recorded a total of 14 (one male) and 25 (seven male) individuals of gharial. Further downstream of the Kailashpuri Barrage, Singh (1978) recorded only five individuals of gharial in the entire stretch of Ghaghra River. Later, this subpopulation was studied by Srivastava (1981) in Girwa River from 1976 to 1980. They recorded 28 gharial including two male in 1976-77, followed by 33 individuals including 3 males in 1977-78, 39 individuals including 2 males in 1978-79 and 32 individuals including 2 males in 1979-80. From March 2001 to April 2002, Singh (2003) reported the presence of 75 individuals including 6 males in Girwa River from Indo-Nepal border to Kailashpuri Barrage.

Basu (2001) recorded a single gharial in 505 km stretch from Kailashpuri Barrage to Road bridge Dohrighat. WWF-India recorded 49 gharial individuals in 2006, 65 gharial individuals in 2009 and then again 65 individuals in 2013 (Singh & Behera, 2018). Das et al. (2012) recorded 105 gharial (five male) during a survey conducted in December 2008 in Girwa River. Basu & Singh (2009) recorded 16 individuals of gharial from Mallapur to Barabanki Bahraich road bridge covering a 90 km stretch. Later, a team of researchers from TSA India, GCA and Uttar Pradesh Forest Department undertook a survey in 2013 in the 150 km stretch of Ghaghra River from Mallapur to Ayodhya and recorded the presence of 43 individuals. More recently, a boat survey conducted in Ghaghra River reported 174 individuals of gharial in the 119 km stretch from Chahlarighat to Ayodhya Ghat that included 47 adults, 54 sub-adults, 71 juveniles and 2 yearlings (Singh et al., 2021).

Apart from the survey records, 310 individuals of gharial have been released into the Saryu River between March 2014 to December 2020 from the Kukrail Gharial Rehabilitation Center, Lucknow (Singh et al., 2021).



Present Distribution

During the present rapid biodiversity assessment, a total of 406 individuals of gharial, including 8 adult males were sighted. The encounter rate of 0.66 ± 0.14 was observed (Figure 2.9). These sightings make Ghaghra River the single largest colony of gharial outside any protected area and the second largest in the world after the Chambal River. These sightings comprise of 125 adult, 147 sub-adult, 128 juvenile, 4 yearlings and 2 hatchlings (Figure 2.10). Maximum sightings with 324 individuals including all 8 males (78%) were recorded in 394 km stretch of Lower Middle zone from Ghaghra-Sharda confluence in Mahsi, Bahraich district to Ghaghra-Rapti confluence at Kaparwar, Deori district in Uttar Pradesh with the encounter rate of 0.81 ± 0.19 . The zone comprises of 110 adults, 123 sub adults, 85 juveniles, 4 yearlings and 2 hatchlings. In the 76 km stretch of Upper Middle Zone, 82 individuals (22%) with encounter rate of 1.17 ± 0.38 from Kailashpuri Dam to Sharda River confluence at Mahsi, Mahasi Tehsil in Bahraich district, Uttar Pradesh were recorded. This zone comprises of 15 adults, 24 sub adults and 43 juveniles. No sighting was recorded from the Lower zone starting from its confluence with Rapti River near Kaparwar village, Barhaj Tehsil in Deoria district, Uttar Pradesh to its confluence with main stem Ganga River at Revelganj in Saran (Chhapra) district, Bihar.

Table 2.4 Historic record of Gharial surveys undertaken in Ghaghra River basin

River	Stretch	Length	No of Gharial	Survey period	Reference
Girwa	Indo-Nepal border to Kailashpuri barrage		14	1975	Singh, 1978
			25	1976	
Girwa River	Indo-Nepal border to Kailashpuri Barrage		28	1976-77	Srivastava, 1981
			33	1977-78	
			39	1978-79	
			32	1979-80	
Girwa River	Indo-Nepal border to Kailashpuri Barrage		75	March 2001 to April 2002	Singh, 2003
Girwa River	-		105	December 2008	Das <i>et al.</i> , 2012
Girwa River	Bhawanipur to Girijapuri Barrage & Girwa-Kauriala confluence		49	2006	Singh & Behera, 2018
Girwa River	Katarniaghat to Girija Barrage & Girwa-Kauriala confluence		65	2009	
Girwa River	Indo-Nepal border to Girija Barrage & Girwa-Kauriala confluence		65	2013	
Ghaghra	Kailashpuri Barrage to Dohrighat road bridge		5	1975-76	
Ghaghra River	Kailashpuri Barrage to Dohrighat road bridge	505	1	February/March 2001	Basu, 2001
Ghaghra River	Mallapur-Barabanki Bahraich road bridge	90	16	December 2009	Basu and Singh, 2009
Ghaghra River	Mallapur to Ayodhya Ghat	150	43	March 2013	Singh et al., 2021
Ghaghra River	Chehlarighat to Ayodhya ghat	119	174	18 to 22 February 2021	
Ghaghra River	Kailashpuri Barrage to Ganga confluence at Revelganj, Bihar	615	406	December 2020	Current Study

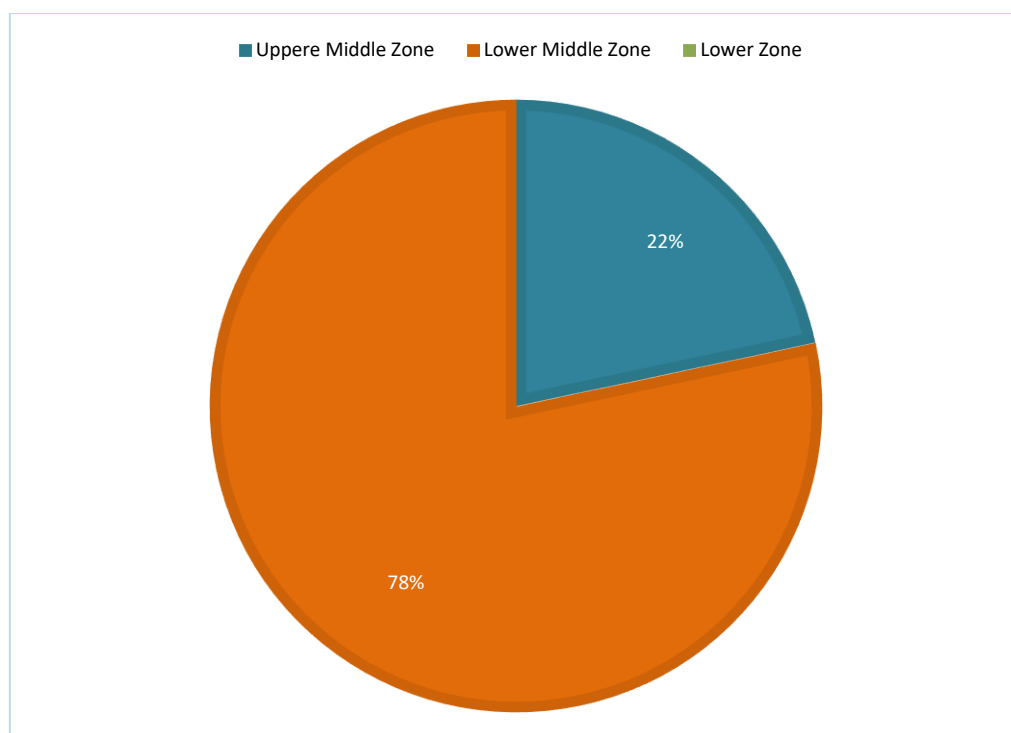


Figure 2.11 Zone-wise percentage of Gharial sighting in Ghaghra River recorded during Ecological assessment

Table 2.5 Zone-wise abundance of Gharial recorded during present ecological assessment

Stretches	Length	Segment	Abundance	ER $\pm$ SE
Upper Middle Zone	76	15	88	1.17 $\pm$ 0.38
Lower Middle Zone	394	79	318	0.81 $\pm$ 0.19
Lower Zone	142	29	0	0

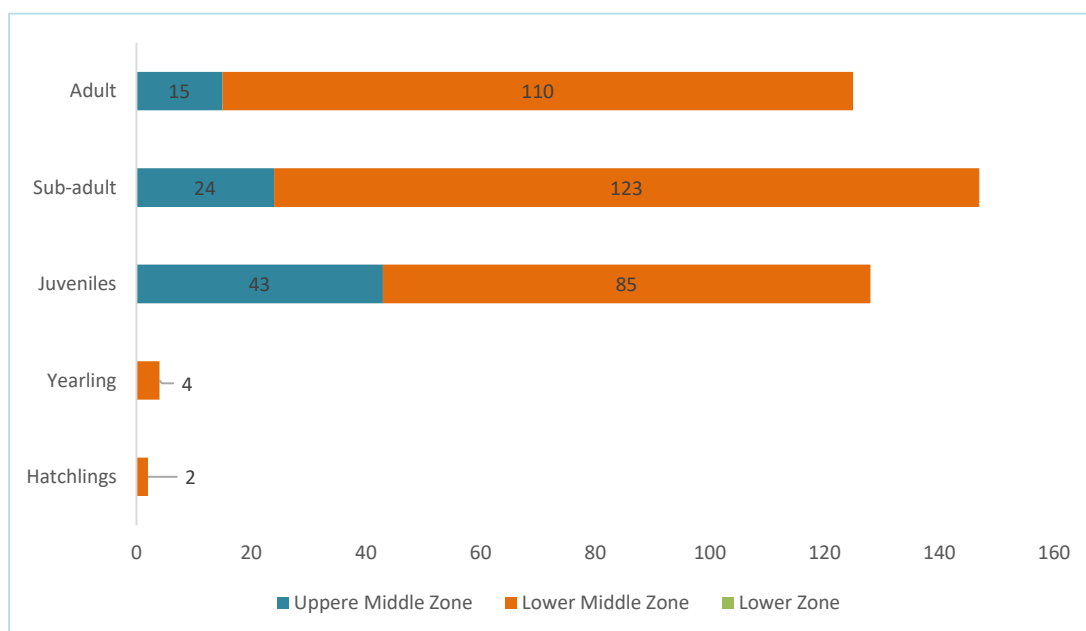


Figure 2.12 Zone-wise classes of Individuals of Gharial recorded during Ecological assessment

Mugger (*Crocodylus palustris*)

Historical Distribution

Presence of mugger has been mentioned previously from the Girwa River (Singh, 1978). Singh and Behera (2018) recorded 14 muggers in 2006, 16 in 2009 and 20 in 2013 from the Girwa River. Survey undertaken by Das et al. (2012) mentions mugger feeding on the hatchling of gharial along the Girwa River. Mital (2016) recorded the presence of mugger crocodile in Bahraich district along the Ghaghra River. More recently, Singh et al. (2021) recorded one individual in 2001 and two muggers in 2013 in the 119 km stretch between Chehlari Ghat and Ayodhya Ghat in the Ghaghra River. Apart from the population estimation mentioned above, two muggers were released in Katarniaghat WLS along the Girwa River.

Present Distribution

During the rapid biodiversity assessment three muggers were sighted, just, downstream of the confluence of Sharda and Ghaghra rivers. All sightings were made in the Lower Middle zone.



Historical Distribution

Das (1995) reported an individual of one species from Girwa River inside the Katarniaghat WLS. Fritz et al. (2018) reported of a female sub-adult of *Cyclemys gemelli* five km downstream of the Indo-Nepal border at Nishangada, Bahraich, Uttar Pradesh. A study by Singh et al. (2009) reported the presence of six species of freshwater turtles in Ghaghra River near Bahraich district. Das et al. (2012) later reported 12 species of freshwater turtles and one land turtle from Katarniaghat WLS. Mital (2016) reported the presence of 5 species of freshwater turtles from Ghaghra River and 7 species from Saryu River based on the subsequent surveys conducted in 2015 and 2016, in Bahraich and Gonda districts of Uttar Pradesh. More recently, 9 species of freshwater turtles have been reported from the lower stretch of Saryu River (Singh et al., 2021). *Pangshura smithii* and *P. tentoria* were recorded with a likely interspecific hybridization in the Ghaghra River (Praschag et al., 2007). In the survey covering 119 km stretch from Chehlari Ghat to Ayodhya Ghat, Pangshura genus along with individuals of *Lissemys punctata* and *Nilssonia gangetica* were frequently recorded, with an additional record of two unidentified species of freshwater turtles (Singh et al., 2021). Among the 11 species of freshwater turtles recorded so far, 72% are threatened followed by 14% each in the Near Threatened and Least Concern categories of the IUCN.

Table 2.6 Historic record of freshwater turtle studies in Ghaghra basin

S. No.	River	Sampling location/Stretch	No. of Species	Reference
1	Saryu River	Near Colonelganj in Gonda district	6	Singh et al., 2009
2	Ghaghra River	Down Ghaghra Ghat and Bahraich	6	
3	Saryu River	Bahraich, Gonda	7	Mital, 2016
4	Ghaghra River	Bahraich, Gonda	5	
5	Ghaghra River	Chehlari Ghat to Ayodhya Ghat	3*	Singh et al., 2021
6	Lower Saryu	Gandarwa Taal close to Nanpara town, Bahraich Uttar Pradesh to Chandapur, Gonda, Uttar Pradesh	9	Singh et al., 2021
7	Girwa River	Katarniaghat WLS	12	Das et al., 2012
8	-	Bahraich	1	Fritz et al., 2008
9	Girwa River	Katarniaghat WLS	1	Das, 1995

*two species were unidentified

Table 2.7 Freshwater turtle species recorded in the Ghaghra River basin

S. No.	Species	Family	IUCN Status	CITES	IWPA
1	<i>Batagur dhongoka</i>	Geoemydidae	CR	Appendix II	Schedule I
2	<i>Geoclemys hamiltonii</i>		EN	Appendix I	Schedule I
3	<i>Hardella thurjii</i>		EN	Not listed	Schedule IV
4	<i>Morenia petersi</i>		EN	Not listed	Not listed
5	<i>Melancholys tricarinata</i>		EN	Appendix I	Schedule I
6	<i>Pangshura tecta</i>		VU	Appendix II	Schedule I
7	<i>Cyclemys gemeli</i>		NT	Appendix II	Not listed
8	<i>Pangshura smithii</i>		NT	Appendix II	Schedule IV

9	<i>Pangshura tentoria</i>		LC	Appendix II	Schedule I
10	<i>Melanochelys trijuga</i>		LC	Appendix II	Schedule IV
11	<i>Chitra indica</i>	Trionychidae	EN	Appendix II	Schedule IV
12	<i>Nilssonia gangetica</i>		EN	Appendix I	Schedule I
13	<i>Nilssonia hurum</i>		EN	Appendix I	Schedule I
14	<i>Lissemys punctata</i>		VU	Appendix II	Schedule I

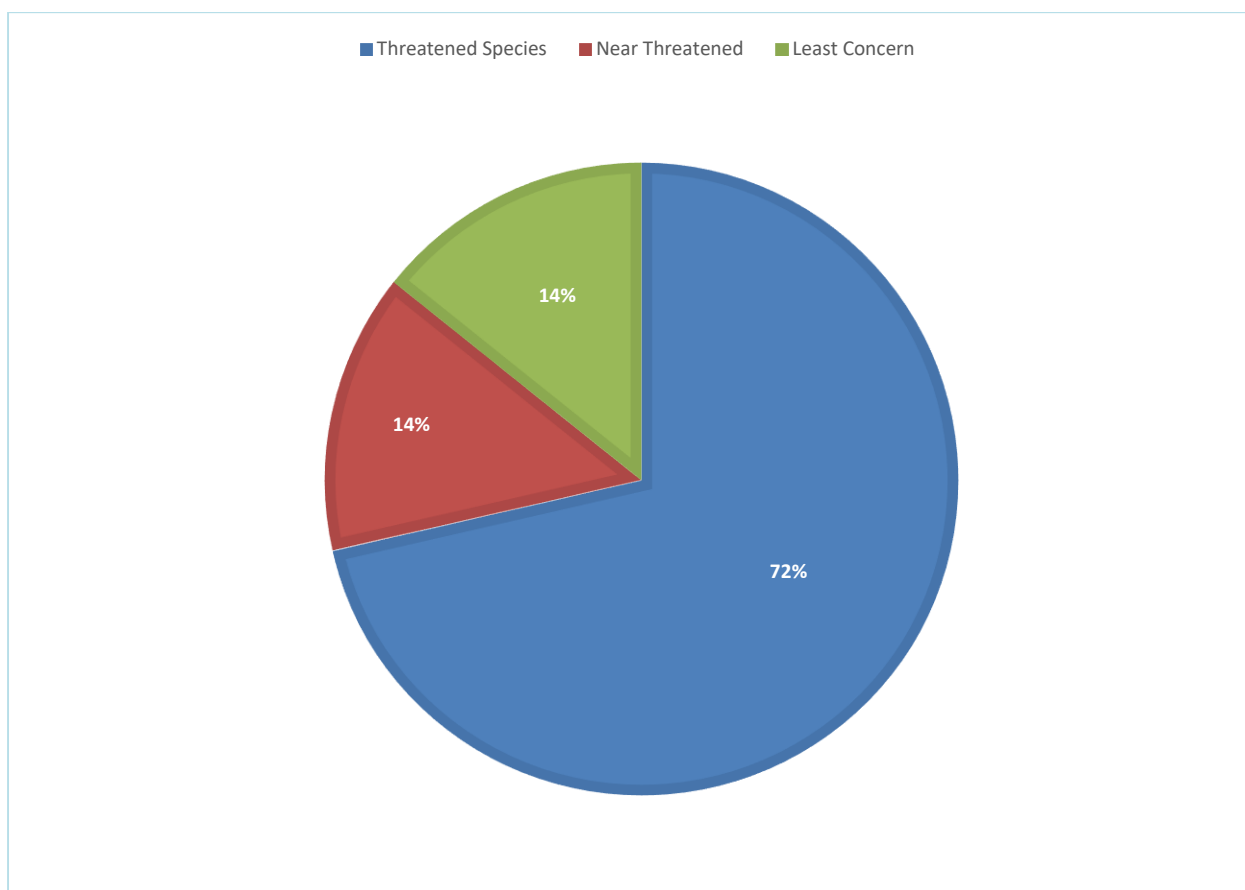


Figure 2.14 Threatened species (%) under IUCN category recorded in Ghaghra River basin

Present Distribution

During the present survey, 4,534 individuals of freshwater turtles with an encounter rate of 7.37 ± 3.76 were sighted, all belonged to *Pangshura* genus except for one, the Indian softshell turtle (*Nilssonia gangetica*). More than 70% of the sightings occurred in 76 km stretch of Upper Middle zone from Kailashpuri Dam to Sharda River confluence at Mahsi, Mahasi tehsil in Bahraich district, Uttar Pradesh with an encounter rate of 42.28 ± 29.80 . The Indian softshell turtle individual was the only species of softshell turtle recorded from the lower stretch of the Ghaghra River near Barhalganj, Gorakhpur district, Uttar Pradesh. Twenty-eight percent (28%) sightings with 1286 individuals was recorded in 394 km stretch of Lower Middle zone from Ghaghra-Sharda confluence at Mahsi, Bahraich district to Ghaghra-Rapti confluence at Kaparwar, Deori district in Uttar Pradesh; with an encounter rate of 3.26 ± 0.80 . Only 1% turtles were recorded from the Lower zone starting from its confluence with Rapti River near Kaparwar village, Barhaj Tehsil in Deoria district, Uttar Pradesh to its confluence with main stem Ganga at Revelganj in Saran (Chhapra) district, Bihar with an encounter rate of 0.24 ± 0.17 .

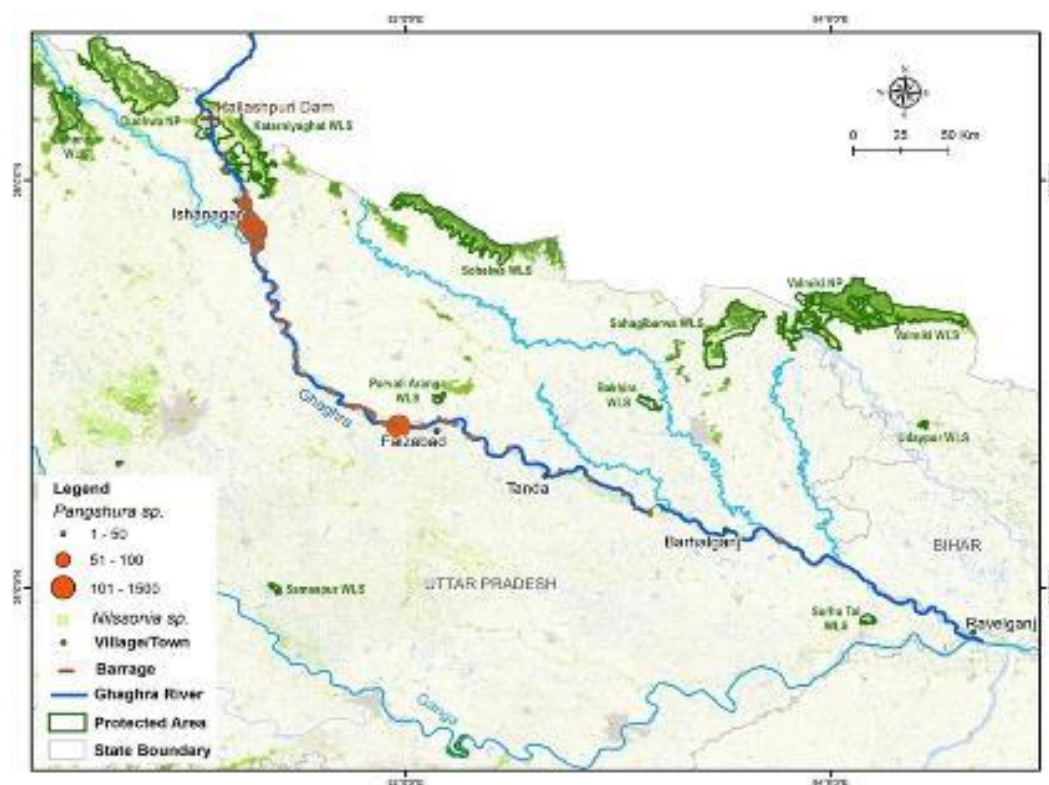


Figure 2.15
Distribution map of Freshwater turtle in Ghaghra River recorded during present ecological assessment

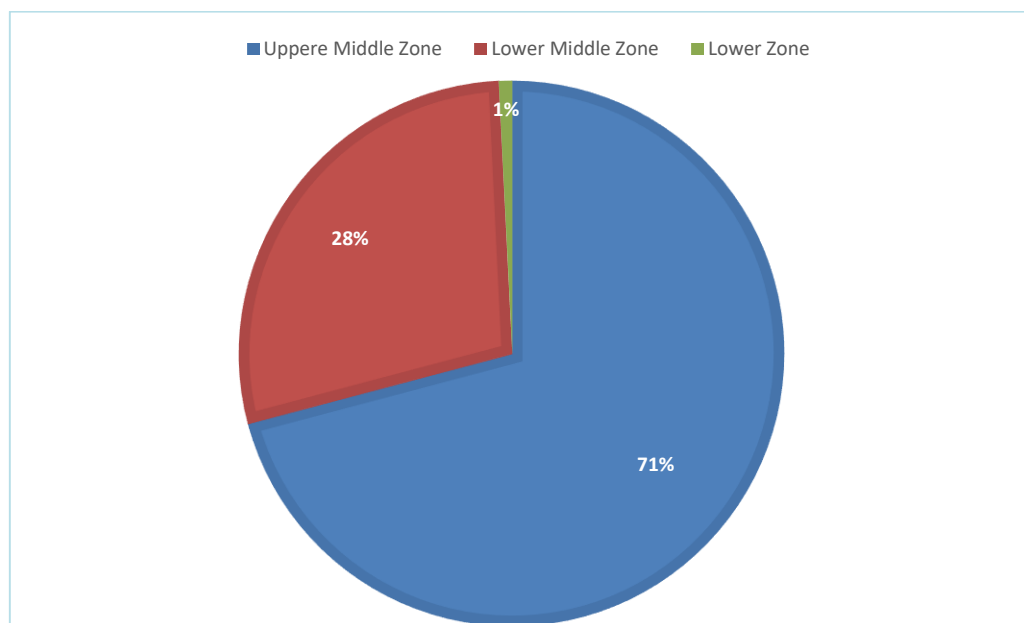


Figure 2.16 Zone-wise (%) distribution of freshwater turtle recorded during present study in Ghaghra River

Table 2.8 Zone-wise abundance of freshwater turtle recorded during present ecological assessment

Zone	Length	Segment	Abundance	ER $\pm$ SE
Upper Middle Zone	76	15	3213	42.28 $\pm$ 29.80
Lower Middle Zone	394	79	1286	3.26 $\pm$ 0.80
Lower Zone	142	29	35	0.24 $\pm$ 0.17

2.5 Amphibians

Amphibians are one of the least studied taxa from the Ghaghra River. The studies undertaken by Hegde & Roy (2011) and Das et al. (2012) in Katarniaghat WLS recorded 10 species belonging to 4 families in and around the Girwa River (Figure 2.17). However, two unidentified species belonging to the families *Dicroglossidae* Anderson, 1871 and *Microhylidae* Günther, 1858 have also been recorded (Das et al., 2012). All recorded species come under the Least Concern category of the IUCN.

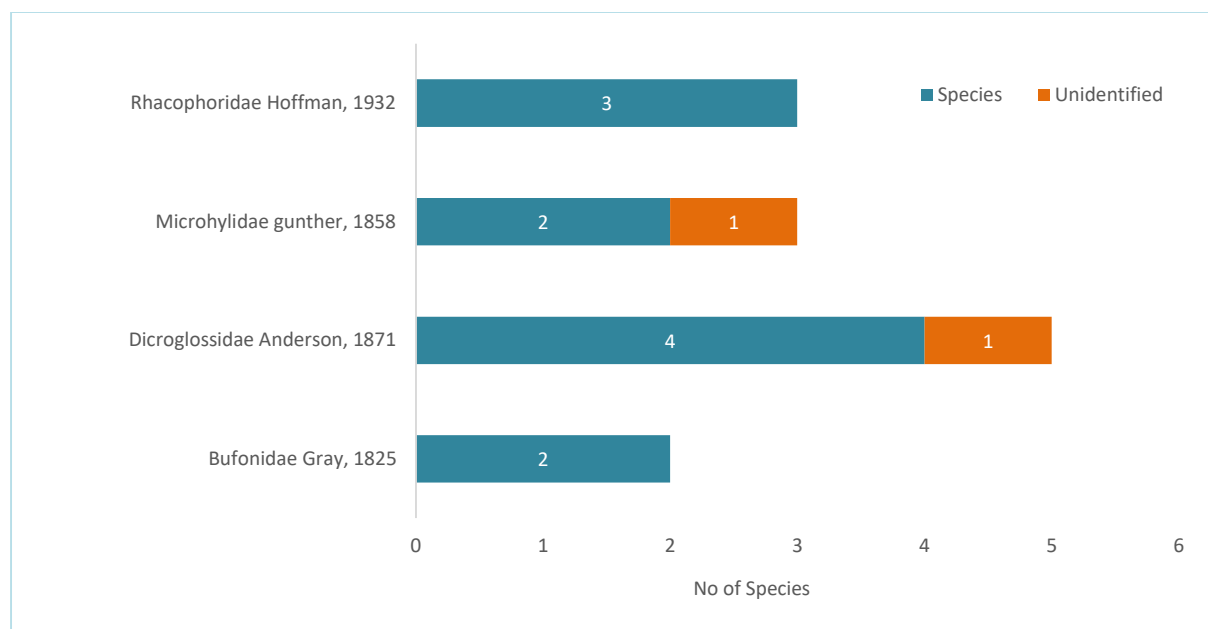


Figure 2.17 Amphibians species recorded from Ghaghra River basin based on previous studies

The assessment for amphibian distribution was not undertaken during the present study.

2.6 Fishes

Pioneering study by Srivastava (1988) documented 111 fish species from Ghaghra River in Uttar Pradesh and Bihar. However, Mishra et al., (2011) comparatively reported a lesser number (n=62) of fish species from the five sampling sights in Uttar Pradesh using four different types of gill nets. Their study summarised Cyprinidae as the most abundant family (30.6%), followed by Bagridae (9.7%), Siluridae (6.5%) and Schilbeidae (6.5%). They also documented that carnivore fishes dominated the Ghaghra River (61.3%), followed by omnivores (25.8%). Further, out of the 62 fish species recorded, 4 species were endangered, 10 vulnerable and remaining 48 species were not evaluated as per categories of the IUCN Red List. Sarkar et al. (2012) recorded four exotic species, including Common carp (*Cyprinus carpio*), Grass carp (*Ctenopharyngodon idellus*), Silver carp (*Hypophthalmichthys molitrix*) and *Pangasius pangasius* in low abundance from the Ghaghra River. Fish assessments undertaken later indicate that Ghaghra River harbours the richest fish diversities in terms of families and genera throughout its length as compared to other major tributaries of the Ganga River with presence of 85 species (Sarkar et al., 2014). Intensive studies carried out on the growth and age of *Labeo calbasu* and *Catla catla* have also been carried out in the Ghaghra River (Dwivedi et al., 2009; Dwivedi and Tripathi, 2019).

The distribution of fishes was not studied during the present assessment, but will be undertaken later.

2.7 River Stretches with High Biodiversity Value

Based on the field observations, stretches with high biodiversity value were identified. Variables such as water depth were used to define habitat along the length of the Ghaghra River. Ecological assessment of the River indicates that the presence of riverine islands, suitable water depth and low anthropogenic pressures are

responsible for wide distribution of aquatic species of conservation concern. Figures 2.18 and 2.19 depict the depth profile of Ghaghra River from Kailashpuri Barrage, Bahraich district of Uttar Pradesh to Revelganj, Saran (Chhapra) district of Bihar during the winter months of December 2020- January 2021.

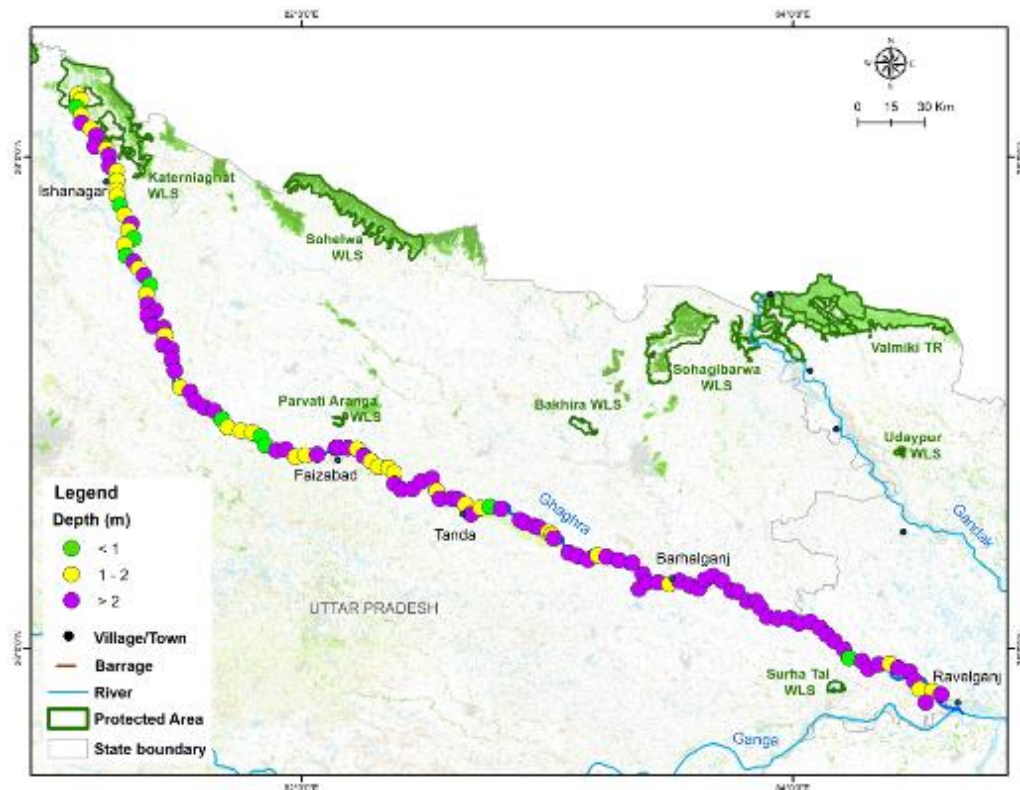


Figure 2.18
Depth profile of Ghaghra River

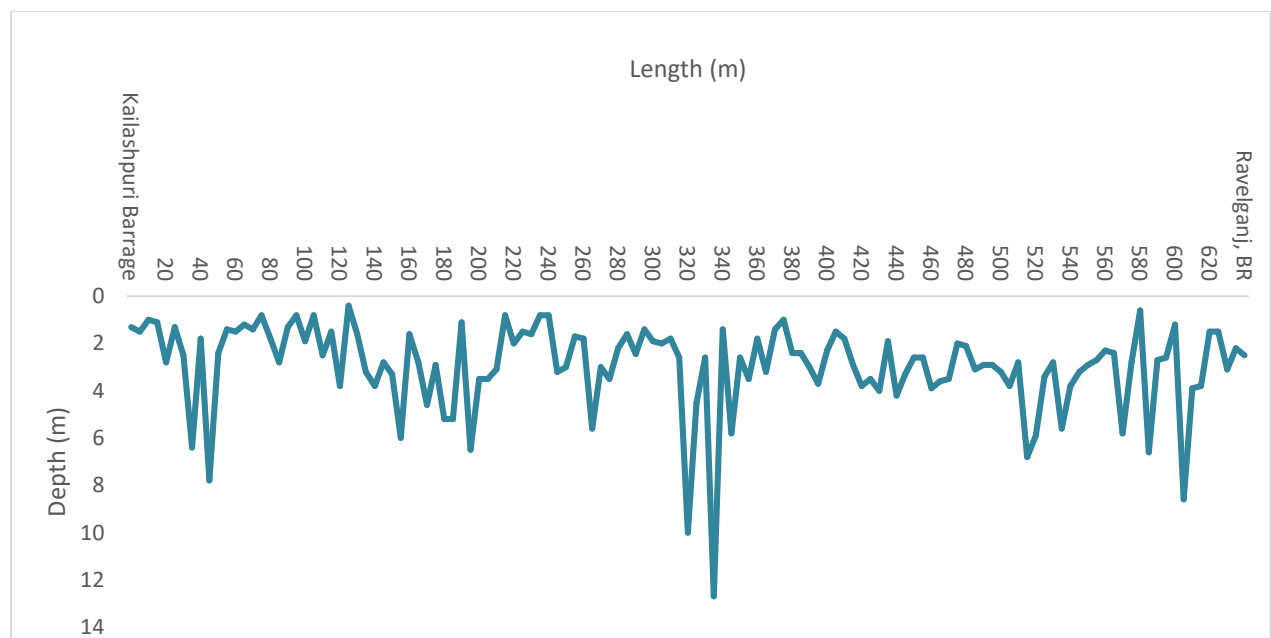


Figure 2.19 Depth profile of Ghaghra River from Kailashpuri Barrage, Uttar Pradesh to Revelganj, Bihar

Depth of the Ghaghra River recorded during the present ecological assessment varies from the minimum of 0.4 m to a maximum of 12.7 m with an average of 2.96 ± 1.88 m. Depth of 1 to 3m was recorded in 57.03% of the total survey stretch from Kailashpuri Dam, Bahraich, Uttar Pradesh to Revelganj, Bihar.

Table 2.9 Stretch-wise depth classes recorded in Ghaghra River

Depth Classes	Stretch (%)
Less than 1m	6.25
1m to 3m	57.03
3m to 5m	24.22
5m to 7m	9.38
More than 7m	3.13

Priority stretches were identified based on presence of key aquatic species such as Gangetic dolphin, gharial, mugger and freshwater turtles. The geographical location of key aquatic species, and habitat conditions were superimposed in the GIS domain (Figure 2.21). Three stretches covering the entire river were identified in the order of high, medium and low priority. Table 2.10 summarizes these stretches in terms of location, length, river depth, presence of fauna of conservation significance and specific threats.

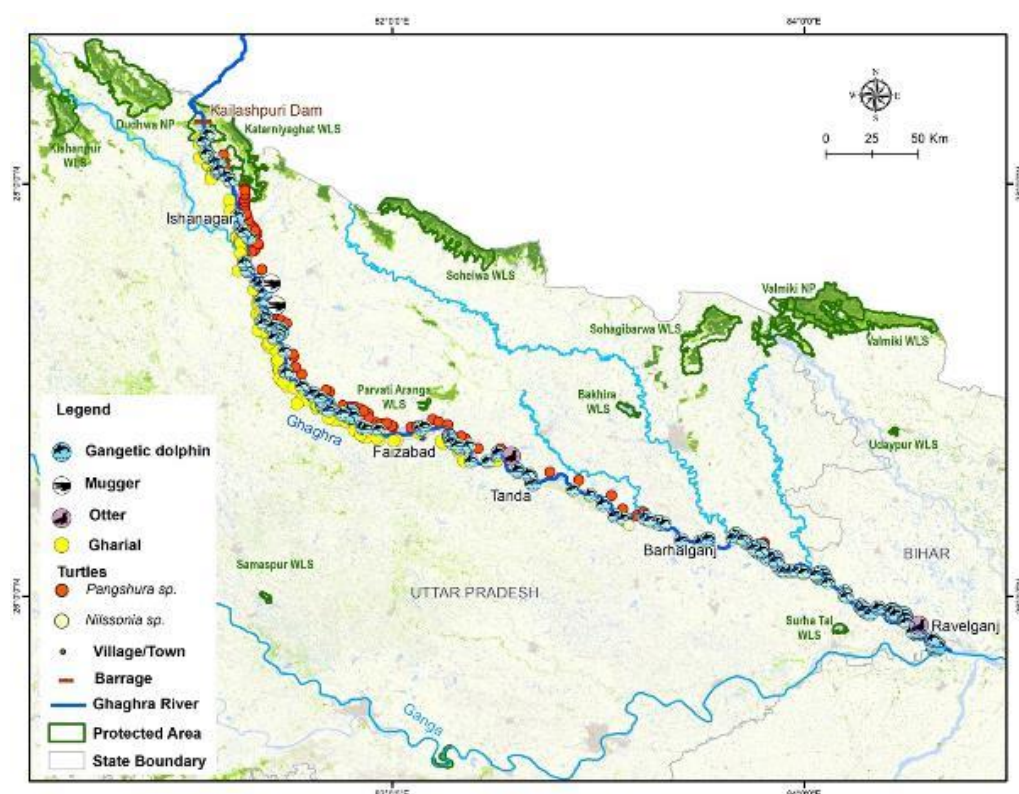


Figure 2.21
Distribution of key aquatic species in the Ghaghra River

High Biodiversity Value Stretch

Stretch: Lower Middle Zone

This is a 394 km stretch from the Ghaghra-Sharda confluence at Mahsi, Bahraich district to Ghaghra-Rapti confluence at Kaparwar, Deori district in Uttar Pradesh. The depth here ranges from 0.4 m to 12.7 m with a mean value of 2.91 m. The stretch has low anthropogenic pressure till Ayodhya district with presence of large sandbanks and riverine islands. The nearest human habitation is approximately 1-2 km away from the River. However, human dependency in terms of riverbed farming was recorded throughout the stretch. Beyond

Ayodhya, the anthropogenic activities were prominently visible with large presence of active drains, cremation activities, fishing, sand mining and domestic livestock waddling along the river.

Biodiversity value and ecological significance

A total of 318 individuals of gharial including breeding groups were recorded from this stretch. These sightings abruptly stopped from Ayodhya district till Ghaghra's confluence with the Ganga River. A total of 136 individuals of Gangetic dolphin, three mugger, 1286 individuals of freshwater turtle including one individual of Indian softshell turtle were recorded throughout this stretch. First photographic sighting of the smooth-coated otter from Ghaghra River was recorded from Bhatiha village, Harraiya Tehsil in Basti district of Uttar Pradesh. Presence of these individuals indicates good healthy habitat for species of conservation concern.

Medium Biodiversity Value Stretch

Stretch: Upper Middle Zone

This is a 76 km stretch of the river from Kailashpuri Dam to Sharda River confluence at Mahsi, Mahasi Tehsil in Bahraich district, Uttar Pradesh. The depth ranges from 0.8 m to 7.8 m with a mean value of 2.3 m. The stretch is in close proximity to the Katarniaghat Wildlife Sanctuary. The habitat includes presence of small boulders, sandy banks and riverine islands. Human habitation is 1-3 km away from the river. Anthropogenic pressures in the stretch include livestock waddling, riverbed farming, and fishing.

Biodiversity value and ecological significance

A total of 38 individuals of Gangetic dolphin, 88 individuals of gharial and 3213 individuals of *Pangshura* genus were recorded in the stretch indicating its high significance for freshwater turtle species.

Low Biodiversity Value Stretch

Stretch: Lower Zone

The length of the stretch is 142 km from its confluence with Rapti River near Kaparwar village, Barhaj Tehsil in Deoria district, Uttar Pradesh to its confluence with the Ganga River at Revelganj in Saran (Chhapra) district, Bihar. A decreasing trend was observed in the surface water of the Ghaghra-Gandak zone (Ghose et al., 2004). The depth ranges from 0.6 m to 8.6 m with an average value of 3.5m. Anthropogenic pressures in the stretch increased many folds with human settlements right on the river banks, along with presence of numerous infrastructures like crematoriums and bathing ghats. High human traffic was recorded in the stretch. Floating carcasses of domestic animals, river bed farming, extensive fishing and livestock waddling were among the other anthropogenic pressures in the stretch. The stretch has presence of riverine islands and sandbank as one approaches near the confluence of Ghaghra with Ganga River.

Biodiversity value and ecological significance

A total of 161 individuals of Gangetic dolphins and 35 freshwater turtles of *Pangshura* genus were recorded in the stretch. Towards the confluence of Ghaghra River with Ganga, the second photographic sighting of smooth-coated otter was recorded at Raja Tengaraha village, Bairia Tehsil in Ballia district of Uttar Pradesh. This individual count indicates the high significance and conservation potential of the stretch not only for Gangetic dolphins but otters too.

Table 2.10 Description of the high biodiversity stretches along the Ghaghra River

Biodiversity value	Location	Length (km)	River characteristics	River depth (2019-2020 & 2020-2021) (mean depth) in m	Dolphin	Otter	Gharial	Mugger	Freshwater turtles	Threats
High	Mahsi to Kaparwar	394	Sandy banks and riverine islands with extensive alluvium	0.4 to 12.7 (2.91)	136	1	318	3	1286	Active drains, Riverbed farming, fishing and sand mining
Medium	Kailashpuri Dam to Mahsi	76	Boulder and sandy banks	0.8 to 7.8 (2.3)	38	0	88	0	3213	Cattle waddling, fishing, riverbed farming and burning of dead bodies
Low	Kaparwar to Revelganj	142	High clay bank, riverine islands near confluence with Ganga	0.6 to 8.6 (3.5)	161	1	0	0	35	Riverbed farming, extensive fishing, animal carcasses, cattle waddling and extensive religious practices



3. THREATS TO THE BIODIVERSITY OF GHAGHRA RIVER



3.1 River Flow

Water development projects often fragment population and alter environmental conditions that are preferred by the aquatic species (Smith et al., 2000). The construction of Girija Barrage in 1976 for irrigation flood control measures has significantly fragmented the dolphin population upstream of the barrage in Nepal. In the 1990's, a population of 21-30 dolphins were reported upstream of the barrage (Reeves et al., 1993; Smith et al., 1994; Sinha et al., 2000), by 2011 it had decreased to 11 and to six in 2015 (Khanal et al., 2016). Low discharge of water during summers may be a factor for high value of Chemical Oxygen Demand (COD) in the River (Singh et al., 2017). Alkalinity and water temperature is attributed to seasonal variation in water quality (Nipunika et al., 2010).

3.2 Alteration in Habitat

Human settlements near or on the banks of the Ghaghra River, construction of ghats, agricultural practices and sand mining further lead to habitat alteration. Tanda, Ayodhya, Golabazar, Barhaj, and Bansdih are some of the critical points where large-scale sand mining is a major cause for the shifting course of Ghaghra River (Singh et al. 2017). Moreover, lateral erosion during low discharge period in the river is another reason for loss of habitat (Singh & Awasthi, 2011). Seasonal cultivation of Cucurbitaceae crops on the sandy banks of the river (Pandey & Karmakar, 2015) disturb key nesting and roosting habitats of different avian and reptilian species. Remnants of swampy grassland patches in Katarniaghat WLS are the critical habitats of Swamp Deer (*Rucervus duvaucelii duvaucelii*) (Paul et al., 2020).

3.3 Development of the river for inland navigation

About 350 km stretch of Ghaghra River, from Ayodhya (Faizabad) to Saran (Chhapra) has been declared National Waterway (NW-40). Detailed hydrographic surveys have been completed and the Inland Waterways Authority of India (IWAI) has categorized the stretch as a category "A" waterway, i.e. suitable for navigation with cargo.

Several river modification activities such as dredging and river training are proposed. Regular disturbance due to vessel traffic and habitat modifications may potentially negatively impact the aquatic biodiversity including Gangetic dolphin (Aggarwal et al., 2020). Proactive impact studies, decision making systems and mitigation plans are required for sustainable development.

3.4 Unsustainable resource use practices

Unsustainable resource extraction, such as intensive fishing practices across the stretch of the Ghaghra River may reduce fish diversity and have negative impact on other dependent species, such as dolphins, otters or freshwater turtles. This situation becomes grave as one approaches the Ghaghra-Ganga confluence near Revelganj, Bihar.

3.5 Physio-chemical Properties

Previous studies in the Ghaghra River basin indicate depleting water quality over the years due to inflow of industrial waste, plants, unsustainable agriculture and domestic waste (Singh, 2004; Kushwaha & Agrahari, 2016). River water monitoring has been carried out in different segments of the Ghaghra River. A recent study on ground water quality of Saran district in Bihar indicated high concentration of coliforms (Kumar et al., 2021), and high level pollutants in Dhobi Ghats along Rapti River recorded especially near townships (Kushwaha & Agrahari, 2016). Industries along the Ghaghra River produce a large amount of liquid and solid waste degrading the physiochemical qualities (Singh, 2004; Yadav & Pandey, 2021). In a comparative study of tributaries of the Ganga, a high concentration of heavy metals (Lead and Cadmium) was recorded from the Ghaghra River (Siddiqui et al., 2019). Several studies have highlighted an alarming concentration of Arsenic in the waters of Ghaghra river basin (Srivastava & Sharma, 2013; Mehrotra et al., 2018, Sahu & Saha, 2019).

Habitat alteration, regulated flow of the river, unplanned settlements and unsustainable resource extraction are some of the major threats concerning the Ghaghra River. Further, climate change poses a serious challenge to crocodilians and freshwater turtles who have temperature-dependent sex determination (TSD), which might shift the habitat of these species. To maintain the ecological integrity, we need to address these threats with site specific solutions.

River quality as reflected in physico-chemical properties and distribution of aquatic plants have been studied in 2011-2012 by Singh et al. (2017), who provides an important benchmark for five sites from Bahraich, Uttar Pradesh to Saran (Chhapra). Increasing salinity and water logging for irrigation pose additional threat to both, river and agriculture (Kumar, 2009).



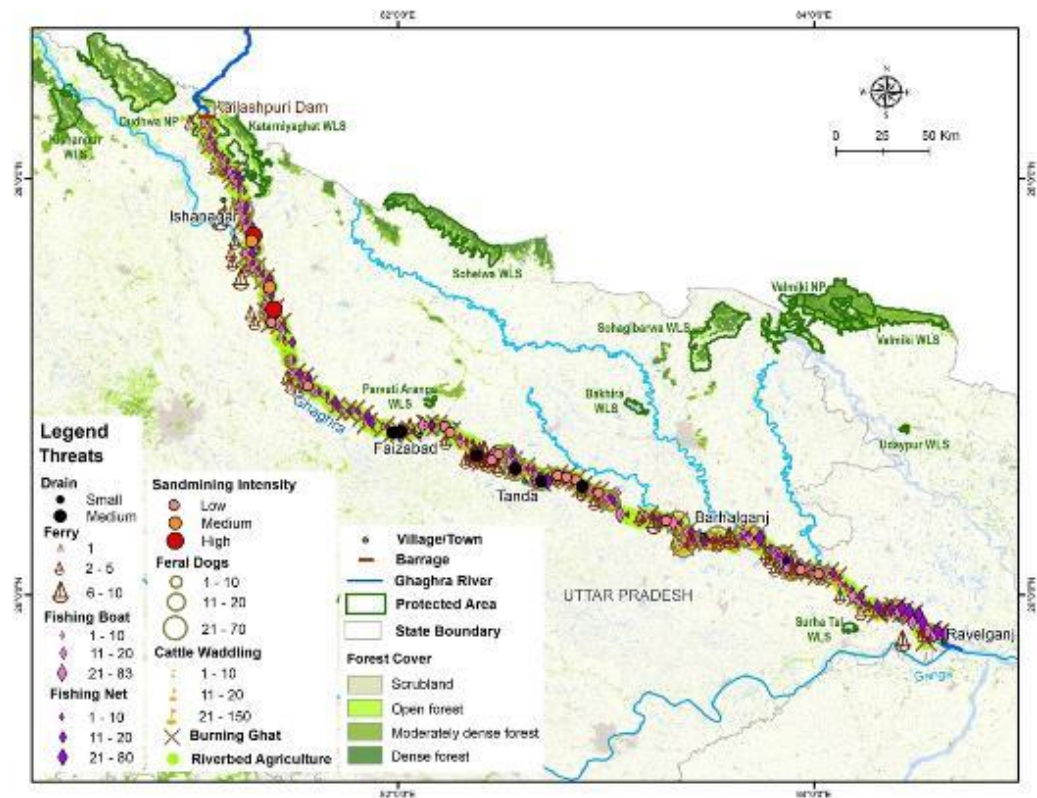


Figure 3.1
Anthropogenic pressures recorded during present survey of Ghaghra River



4. CONSERVATION IMPLICATIONS



Rivers are the most fragile ecosystem on the earth and its biodiversity is declining faster than of its terrestrial or marine counterparts (Dudgeon, 2013). Being one of the largest tributaries of the Ganga, Ghaghra River sustains a wide variety of aquatic flora and fauna, which needs intensive as well as extensive documentation. Apart from the studies around the Katarniaghat WLS, there is dearth of information on key aquatic species. Hydrological alteration, invasive species, unsustainable fishing practices and waste-water discharge are major causes of concern in Ghaghra River.

4.1 General implications

- ◆ Anthropogenic activities such as illegal sand mining, extension of human settlement closer to the river, riverbed farming and other unsustainable agricultural practices along the river are high especially towards its lower stretch, which have altered the habitat for island nesting avifauna and reptiles and needs to be regulated.
- ◆ Minimum environmental flow needs to be maintained to ensure a healthy ecosystem for the aquatic biodiversity through transboundary management between Nepal and India.
- ◆ Reptilian species are highly sensitive to any alteration in their habitat therefore, it is crucial to protect their habitat with strict law enforcement.
- ◆ Reptiles like crocodilians and freshwater turtles lay eggs and bask on the sandy banks and mid-channel islands, thus anthropogenic alteration pose a serious threat to the survival of these species.
- ◆ Ghaghra River is recognized as one of the five Turtle Priority Areas in India but there is an information gap on these species. Thus, an intensive research work is required to develop an effective conservation action plan.
- ◆ Amphibians have poorly been studied in the basin, and require intensive survey to know about their distribution.

4.2 Recommendations

Based on the preliminary rapid biodiversity assessment, the following is suggested to further enhance ecological information and improve the conservation status of the aquatic biodiversity:

Detailed surveys during lean and monsoon seasons

- ◆ Regular surveys during lean and monsoon seasons are required to understand the dynamics of habitats and distribution of key biodiversity elements. These surveys should cover the river from Kailashpuri Dam, Bahraich, Uttar Pradesh to Revelganj, Saran (Chhapra), Bihar.
- ◆ Studies are required to assess the minimum environmental flows necessary for key species.

Involvement of multiple stakeholders

- ◆ Socio-economic surveys for local community need to be done to identify resource dependency along the width of 2-3 km from the river.
- ◆ Community participation, especially from women need to be ensured for sustainable conservation efforts.
- ◆ Alternate skill development trainings based on the locally available economic resource material needs to be imparted to reduce dependency of local community on the river.
- ◆ Enhanced conservation education programmes, identification of local volunteers and schools are needed to ensure long-term sustainability of conservation efforts.

Establishment of Interpretation Centre and base camp

- ◆ Ayodhya district has been identified as the key site under the NMCG-WII project for carrying forward the project activities with the establishment of rescue and rehabilitation centre along with Interpretation Centre for mass conservation education.

Collaboration with Nepal for Conservation and Management

As Ghaghra is one the trans-boundary tributaries of the mighty Ganga River; regular dialogues and exchange programme with the concerned authorities in Nepal needs to be undertaken for better management of the river from its source to its confluence.

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ANNEXURE I

Aquatic mammals of Ghaghra Basin

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	Biogeographic zones
Platanistidae	Gangetic dolphin	<i>Platanista gangetica</i>	EN	Schedule I	a, b	7A
Mustelidae	Smooth-coated Otter	<i>Lutrogale perspicillata</i>	VU	Schedule II	a, b	7A

^aBehera *et al.* (2013); ^bSingh&Behra (2018)

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ANNEXURE II

Avifauna of Ghaghra Basin

Family	Bird Species	Scientific Name	IUCN	Previous studies	Present studies
Accipitridae	Steppe eagle	<i>Aquila nipalensis</i> (Hodgson, 1833)	EN	b, c, e	P
	Eurasian griffon	<i>Gyps fulvus</i> (Hablizl, 1783)	LC		P
	Pallas's fish eagle	<i>Haliaeetus leucoryphus</i> (Pallas, 1771)	EN	e	P
	Brahminey kite	<i>Haliastur indus</i> (Boddaert, 1783)	LC	d	
	Egyptian Vulture	<i>Neophron percnopterus</i> (Linnaeus, 1809)	EN	b, c, d, e	P
Alcedinidae	Common kingfisher	<i>Alcedo atthis</i> (Linnaeus, 1758)	LC	b, c, d	
	Pied Kingfisher	<i>Ceryle rudis</i> (Linnaeus, 1758)	LC	b, c, d, e, f	P
	White-breasted kingfisher	<i>Halcyon smyrnensis</i> (Kuhl, 1820)	LC	b, c, d, e, f	P
	Crested Kingfisher	<i>Megaceryle lugubris</i> (Linnaeus, 1758)	LC		P
	Stork-billed kingfisher	<i>Pelargopsis capensis</i> (Linnaeus, 1766)	LC	c, d	
Anatidae	Northern pintail	<i>Anas acuta</i> (Linnaeus, 1758)	LC	b, c, d, e	P
	Common teal	<i>Anas crecca</i> (Linnaeus, 1758)	LC	c, d, e, f	P
	Mallard	<i>Anas platyrhynchos</i> (Linnaeus, 1758)	LC	d, e	P
	Indian spot-billed duck	<i>Anas poecilorhyncha</i> (Forster, 1781)	LC	b, d, e	P
	Greylag goose	<i>Anser anser</i> (Linnaeus, 1758)	LC	b	
	Bar-headed goose	<i>Anser indicus</i> (Latham, 1790)	LC	b, e	P
	Common pochard	<i>Aythya farina</i> (Linnaeus, 1758)	VU	c, d, e, f	P
	Tufted duck	<i>Aythya fuligula</i> (Linnaeus, 1758)	LC	c, d, e	P

	Ferruginous duck	<i>Aythya nyroca</i> (Güldenstädt, 1770)	NT	b, d, f	
	Lesser whistling duck	<i>Dendrocygna javanic a</i> (Horsfield, 1821)	LC	b, c, e, f	P
	Eurasian wigeon	<i>Mareca Penelope</i> (Linnaeus, 1758)	LC	d, e	P
	Gadwall	<i>Mareca strepera</i> (Linnaeus, 1758)	LC	c, d, e, f	P
	Red crested pochard	<i>Netta rufina</i> (Pallas, 1773)	LC	b, c, d	P
	Cotton pygmy goose	<i>Nettapus coromandelianus</i> (Gmelin, 1789)	LC	b, d	
	Comb duck	<i>Sarkidiornis melanotos</i> (Pennant, 1769)	LC	d	
	Northern shoveller	<i>Spatula clypeata</i> (Linnaeus, 1758)	LC	c, d, e	P
	Garganey	<i>Spatula querquedula</i> (Linnaeus, 1758)	LC	d, e	P
	Ruddy Shelduck	<i>Tadorna ferruginea</i> (Pallas, 1764)	LC	b, c, d, e	P
	Common shelduck	<i>Tadorna tadorna</i> (Linnaeus, 1758)	LC	c	
Anhingidae	Oriental darter	<i>Anhinga melanogaster</i> (Pennant, 1769)	NT	b, c, d, e, f	P
Ardeidae	Great white egret	<i>Ardea alba</i> (Linnaeus, 1758)	LC	b, c, d, f	
	Grey heron	<i>Ardea cinerea</i> (Linnaeus, 1758)	LC	b, c, d, e, f	P
	Intermediate egret	<i>Ardea intermedia</i> (Wagler, 1829)	LC	d, e, f	P
	Purple heron	<i>Ardea purpurea</i> (Linnaeus, 1766)	LC	c, f	
	Black-crowned night heron	<i>Nycticorax nycticorax</i> (Linnaeus, 1758)	LC	f	
	Indian pond heron	<i>Ardeola grayii</i> (Sykes, 1832)	LC	b, c, f	
	Cattle Egret	<i>Bubulcus ibis</i> (Linnaeus, 1758)	LC	b, c	P
	Little Egret	<i>Egretta garzetta</i> (Linnaeus, 1766)	LC	b, c, d, f	P

Burhinidae	Eurasian thick-knee	<i>Burhinus oedicnemus</i> (Linnaeus, 1758)	LC	e	P
	Great thick-knee	<i>Esacus recurvirostris</i> (Cuvier, 1829)	NT	d	P
Charadriidae	Kentish plover	<i>Charadrius alexandrinus</i> (Linnaeus, 1758)	LC	b, d	
	Little-ringed plover	<i>Charadrius dubius</i> (Scopoli, 1786)	LC	b, c, d	
	Common ringed plover	<i>Charadrius hiaticula</i> (Linnaeus, 1758)	LC	c	
	River lapwing	<i>Vanellus duvaucelii</i> (Lesson, 1826)	NT	b, c, d, e	P
	White-tailed lapwing	<i>Vanellus leucurus</i> (Lichtenstein, 1823)	LC	f	
	Red-wattled lapwing	<i>Vanellus indicus</i> (Boddaert, 1783)	LC	b, c, d, e, f	P
Ciconiidae	Asian openbill	<i>Anastomus oscitans</i> (Boddaert, 1783)	LC	b, c, d, e, f	P
	White stork	<i>Ciconia ciconia</i> (Linnaeus, 1758)	LC	c	
	Woolly-necked stork	<i>Ciconia episcopus</i> (Boddaert, 1783)	VU	b, c, d, e	P
	Black stork	<i>Ciconia nigra</i> (Linnaeus, 1758)	LC	d	P
	Black-necked stork	<i>Ephippiorhynchus asiaticus</i> (Latham, 1790)	NT	d, e	P
	Painted Stork	<i>Mycteria leucocephala</i> (Pennant, 1769)	NT	b, c, d, e	P
Glareolidae	Small pratincole	<i>Glareola lactea</i> (Temminck, 1820)	LC	b, c, d, e	P
Gruidae	Sarus crane	<i>Antigone Antigone</i> (Linnaeus, 1758)	VU	a, b, c, d, e, f	P
	Common crane	<i>Grus grus</i> (Linnaeus, 1758)	LC	b, e	P
Hirundinidae	Barn swallow	<i>Hirundo rustica</i> (Linnaeus, 1758)	LC	c	
	Wire-tailed swallow	<i>Hirundo smithii</i> (Leach, 1818)	LC	c	
	Streak-throated swallow	<i>Petrochelidonf luvicola</i> (Blyth, 1855)	LC	c	
Jacaniidae	Pheasant-tailed jacana	<i>Hydrophasianus chirurgus</i> (Scopoli, 1786)	LC	b, d, f	

	Bronze-winged jacana	<i>Metopidius indicus</i> (Latham, 1790)	LC	b, d, f	
Laridae	Whiskered tern	<i>Chlidonias hybridus</i> (Pallas, 1811)	LC	d	
	Caspian tern	<i>Hydroprogne caspia</i> (Pallas, 1770)	LC	c	
	Brown-headed gull	<i>Larus brunnicephalus</i> (Jerdon, 1840)	LC	d	
	Pallas's gull	<i>Larus ichthyæetus</i> (Pallas, 1773)	LC	d, e	P
	Indian skimmer	<i>Rynchops albicollis</i> (Swainson, 1838)	EN	d	
	Black-bellied tern	<i>Sterna acuticauda</i> (Gray, 1831)	EN	c, d	
	River tern	<i>Sterna aurantia</i> (Gray, 1831)	VU	c, d	
Motacillidae	White wagtail	<i>Motacilla alba</i> (Linnaeus, 1758)	LC	b, c	
	Grey wagtail	<i>Motacilla cinerea</i> (Tunstall, 1771)	LC	c	
	Yellow wagtail	<i>Motacilla flava</i> (Linnaeus, 1758)	LC	c, f	
	White-browed wagtail	<i>Motacilla maderaspatensis</i> (Gmelin, 1789)	LC	b, c, f	
Pandionidae	Osprey	<i>Pandion haliaetus</i> (Linnaeus, 1758)	LC	b, d, e, f	P
Pelecanidae	White pelican	<i>Pelecanus nocrotalus</i> (Linnaeus, 1758)	LC	c	
Phalacrocoracidae	Little cormorant	<i>Microcarbo niger</i> (Vieillot, 1817)	LC	b, c, d, e, f	P
	Great cormorant	<i>Phalacrocorax carbo</i> (Linnaeus, 1758)	LC	b, c, d, e	P
	Indian cormorant	<i>Phalacrocorax fuscicollis</i> (Stephens, 1826)	LC	c	
Podicipedidae	Great crested grebe	<i>Podiceps cristatus</i> (Linnaeus, 1758)	LC	c	
	Little grebe	<i>Tachybaptus rufficollis</i> (Pallas, 1764)	LC	b, c	
Rallidae	White-breasted waterhen	<i>Amaurornis phoenicurus</i> Pennant, 1769)	LC	c, d, f	
	Common coot	<i>Fulica atra</i> (Linnaeus, 1758)	LC	c, d, f	

	Common moorhen	<i>Gallinula chloropus</i> (Linnaeus, 1758)	LC	c, d, f	
	Purple swampphen	<i>Porphyrio porphyrio</i> (Linnaeus, 1758)	LC	b, c, f	
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i> (Linnaeus, 1758)	LC	d, e	P
	Pied avocet	<i>Recurvirostra avosetta</i> (Linnaeus, 1758)	LC	d	
Scolopacidae	Common sandpiper	<i>Actitis hypoleucos</i> (Linnaeus, 1758)	LC	b, c, d	P
	Little stint	<i>Calidris minuta</i> (Leisler, 1812)	LC	e	P
	Black-tailed godwit	<i>Limosa limosa</i> (Linnaeus, 1758)	NT	d	
	Eurasian curlew	<i>Numenius arquata</i> (Linnaeus, 1758)	NT	b, d, e	P
	Common greenshank	<i>Tringanebularia</i> (Gunnerus, 1767)	LC	c, d, e	P
	Green sandpiper	<i>Tringao chropus</i> (Linnaeus, 1758)	LC	d	
	Marsh sandpiper	<i>Tringa stagnatilis</i> (Bechstein, 1803)	LC	d	
	Common redshank	<i>Tringa totanus</i> (Linnaeus, 1758)	LC	d	
Threskiornithidae	Eurasian spoonbill	<i>Platalea leucorodia</i> (Linnaeus, 1758)	LC	b, c, d, e	P
	Red-naped ibis	<i>Pseudibis papillosa</i> (Temminck, 1824)	LC	b, c, e	P
	Black-headed ibis	<i>Threskiornis melanocephalus</i> (Latham, 1790)	NT	d, e	P

^aMaheswaran *et al.*, 2010; ^bMital, A. 2016; ^cSethy & Chauhan, 2011; ^dSingh & Behera, 2018; ^eSingh *et al.*, 2021; ^fVarghese *et al.*, 2007

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ANNEXURE III

Crocodilian species of Ghaghra basin

Family	Common Name	Scientific Name	IUCN status	IWPA status	Previous studies	Biogeographic zone
Crocodylidae	Marsh (Mugger) crocodile	<i>Crocodylus palustris</i>	VU	Schedule I	1,2,3	7A
Gavialidae	Gharial	<i>Gavialis gangeticus</i>	CR	Schedule I	1,2,3	7A

¹Singh (1978); ²Srivastava (1981); ³Das *et al.* (2012)

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ANNEXURE IV

Anurans of Ghaghra basin

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies
Bufonidae	Indian Common Toad	<i>Duttaphrynus melanostictus</i>	LC	NL	a,b
	Marbled Toad	<i>Duttaphrynus stomaticus</i>	LC	NL	a, b
Dicroglossidae	Indian Bull Frog	<i>Hoplobatrachus tigerinus</i>	LC	Schedule IV	a, b
	Terai Cricket Frog	<i>Fejervarya teraiensis</i>	LC	NL	a, b
	Asian Grass Frog	<i>Fejervarya limnocharis</i>	LC	NL	a, b
	Common Skittering Frog	<i>Euphlyctis cyanophlyctis</i>	LC	NL	a, b
	Indian Burrowing Frog	<i>Sphaerotheca breviceps</i>	LC	NL	a
Microhylidae		<i>Kaloula</i> sp.			b
	Ornamented Pgymy Frog	<i>Microhyla ornata</i>	LC	NL	a, b
	Marbled Balloon Frog	<i>Uperodon systoma</i>	LC	NL	a
Rhacophoridae	Terai Tree Frog	<i>Polypedates teraiensis</i>	LC	NL	b
	Common Tree Frog	<i>Polypedates maculatus</i>	LC	NL	a
	Dudhwa Tree Frog	<i>Chiromantis dudhwaensis</i>	DD	NL	b

^aHegde& Roy (2011); ^bDas *et al.* (2012)

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ANNEXURE V

Fish species of Ghaghra basin (Source: Mishra *et al* 2011)

Family	Common name	Scientific name	IUCN Status
Ambassidae	Elongate glass perchlet	<i>Chanda nama</i>	LC
Bagridae	Striped dwarf fish	<i>Mystus vittatus</i>	LC
	Tengaramystus	<i>Mystus tengara</i>	LC
	Gangetic mystus	<i>Mystus cavasius</i>	LC
	Rita	<i>Rita rita</i>	LC
	Long-whiskered catfish	<i>Sperata aor</i>	LC
	Giant river catfish	<i>Sperata seenghala</i>	LC
Balitoridae	Mottled loach	<i>Acanthocobitis botia</i>	LC
	Giant snakehead	<i>Channa marulius</i>	LC
Clupeidae	Ganges river gizzard shad	<i>Gudusia chapra</i>	LC
Cobitidae	Bengal loach	<i>Botia dario</i>	LC
Cyprinidae	Chaguni	<i>Chagunius chagunio</i>	LC
	Grass carp	<i>Ctenopharyngodon idella</i>	NL
	Wild common carp	<i>Cyprinus carpio</i>	VU
	Mrigal	<i>Cirrhinus mrigala</i>	LC
	Catla	<i>Gibelion catla</i>	LC
	Silver carp	<i>Hypophthalmichthys molitrix</i>	LC
	Minor carp	<i>Labeo bata</i>	LC
	Rohu	<i>Labeo rohita</i>	NT
	Orange-fin labeo	<i>Labeo calbasu</i>	LC
	Gilakhani, Cotio	<i>Osteobrama cotio</i>	LC
	Ticto barb	<i>Pethia ticto</i>	LC
	Slender barb, Blackline rasbora	<i>Rasbora daniconius</i>	LC
	Large razorbelly minnow	<i>Salmophasia bacaila</i>	LC
	Olive barb	<i>Systomus sarana</i>	LC
Heteropneustidae	Stinging catfish	<i>Heteropneustes fossilis</i>	LC
Mastacembelidae	Spiny eel	<i>Macrognathus aral</i>	LC
	Barred spiny eel	<i>Macrognathus pancalus</i>	LC
Nandidae	Gangetic leaf fish	<i>Nandus nandus</i>	LC
Notopteridae	Indian featherback	<i>Chitala chitala</i>	NT
	Bronze featherback	<i>Notopterus notopterus</i>	LC
Pangasidae	Pungas	<i>Pangasius pangasius</i>	LC

Schilbeidae	Garua, Bachcha	<i>Clupisoma garua</i>	LC
	Vacha, tunti	<i>Eutropichthys vacha</i>	LC
	Silond catfish	<i>Silonia silondia</i>	LC
Siluridae	Indian butter-catfish	<i>Ompok bimaculatus</i>	NT
	Pabdah catfish	<i>Ompok pabda</i>	NT
	Pabo catfish	<i>Ompok pabo</i>	NT
	Parhin	<i>Wallago attu</i>	NT
Sisoridae	Kosinangra	<i>Nangara nangara</i>	LC
Tetraodontidae	Ocellated pufferfish	<i>Leiodon cutcutia</i>	LC

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