KOSI RIVER

Ecological status and trends

नमामि गंगे

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

ASSESSMENT OF THE ECOLOGICAL STATUS OF KOSI RIVER FOR CONSERVATION PLANNING

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Goura C. Das

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

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EXECUTIVE SUMMARY

The Kosi River is one of the major left bank tributaries of the Ganga River that contributes 1.32 % area of the Ganga basin and about 49 X 10^9 m^3 water flows annually into the Ganga River with an average discharge of 1564 m^3 s^{-1}. Kosi River system is known for the recurrent floods within the region which develop ecotones that act as a transition zone between terrestrial and aquatic environments. This riverine ecosystem is deeply influenced by annual precipitation, Himalayan glacial inputs, sedimentation rate, and sediment connectivity. The drainage system of the Kosi River is characterised by its migratory trend which results in flooding and sedimentation. Recurrent flooding and sedimentation lead to avulsions of active channels and constant shifting of the river course forming one of the biggest alluvial fans in the world extending up to 15,000 km^2, breaking into 12 distinct channels which are constantly shifting, especially during monsoons. The Kosi River flows through 8 districts of Bihar and is thus a lifeline to more than 21 million people. The biodiversity associated with this river system is unique in its features as the course of the river passes through 3 distinct biogeographic zones. Throughout its passage, there is a unique assemblage of biodiversity within the region ranging from faunal diversity of more than 340 bird species, critically endangered gharial and mugger, more than 12 turtle species, healthy population of Gangetic dolphin, and floral diversity ranging from tropical moist deciduous forests to tropical dry deciduous forests. However, this diverse and unique habitat is under constant pressure due to natural and anthropogenic drivers. Obstruction of the floodways, unscientific construction of embankments, sedimentation, riverbed agriculture, over-exploitation of aquatic resources, pollution due to sewage and solid wastes are some of the drivers of change for the Kosi River and its riparian habitats. This riverine ecosystem consists of a unique mosaic of habitats supporting distinct biodiversity and provides essential ecosystem services which call for conservation and restoration of the Kosi River System.

To identify biodiversity-rich habitats and devise an appropriate conservation and management plan, a vessel-based biodiversity survey was conducted during November 2020. Based on the geomorphology, channel types, landforms, confluences, aspects, and slope of the Kosi Basin the river was divided into three distinct zones. The survey was carried out in the Indian territory between Piprahi and Kursela, Bihar covering a stretch of 235 km in the Middle and Lower zone. During the survey 48 species of water-associated avifauna (1923 sightings), 180 sightings of Gangetic dolphins, and 326 sightings of turtles belonging to (*Pangshura spp*) were recorded. Based on preliminary findings, two river stretches with high biodiversity value along the surveyed stretch of the Kosi River were identified for future monitoring. The anthropogenic influences score were almost similar in the Middle and Lower Zones of the Kosi River. Extensive riverbed agriculture, human settlements, fishing activities were extensive throughout the study area.

1. INTRODUCTION

The Kosi River is a transboundary river spanning over 3 countries viz. Tibet, Nepal, and India. Its origin is in the Himalayas at a height of about 7000 m above mean sea level and is famous for being the highest originating river in the world (Rai, 2018). The Kosi River is also known as '*Kaushiki*' in Sanskrit (Meena, 2012). It is one of the major left bank tributaries of the Ganga River that contributes 1.32 % area of the Ganga basin (Chen et al., 2013). The river is known for its large avulsive shifts by over 100 km in a span of 200 years, the last being in 2008 (Gole & Chitale, 1966; Kale, 2003, Sinha 2009). The river covers six geographical and climatic belts from its origin to the confluence with the Ganga River at Kursela covering a total of 729 km (Wakode et al., 2013), of which 235 km lies in India (Srivastava et al., 2021). The Kosi River catchment expands from 7000 m elevation in Tibet, including Mount Everest and Kanchenjunga (Bajracharya et al., 2007; Bahadur, 2004) to 95 m elevation in Bihar. The Kosi alluvial fans, called mega-fans are one of the largest alluvial fans in the world (Mohindra et al., 1992) showing evidence of a lateral shift of nearly 150 km in the past 250 years (Owen, 1995; Bapalu & Sinha, 2005; Chakraborty et al., 2010; Sinha et al., 2014; Wells & Dorr, 1987; Mishra, 2008).

Due to its frequent course shifting and avulsive character, the river causes extensive flooding and hence has been called the "Sorrow of Bihar", annual floods in the Kosi River affect 21,000 km^2 of agricultural lands (Sinha, 2009). To control the devastating effect of floods in lower catchment areas of Kosi, Kosi Barrage (also known as Bhimnagar Barrage) was built upon the river in 1963 which acts as irrigation, flood control, and hydro-power generation project (India-WRIS, 2016). The river's basin drainage area amounts to 74,500 km^2, of the total 11,000 km^2 drainage area lies in the Indian Territory encompassing ten districts of Bihar (Jain et al., 2007; Dixit, 2009; Chen et al., 2013; Meena & Jha, 2017; Towheed & Roshni, 2021).

1.1 Course of the River

The Kosi River originates as Saptakosi at Triveni, Nepal after the confluence of seven streams namely the Sun Kosi, the Tama Kosi, the Dudh Kosi, the Likhu, the Indravati, the Arun Kosi, and the Tamar (Wells & Dorr, 1987; Shrestha et al., 2010; Pandey et al., 2017). Sapta Kosi enters into the Indian Territory as Kosi at Bhimnagar, Supaul district in North Bihar (Gole & Chitale, 1966). From Bhimnagar, the river flows in a south-westerly direction for about 100 km until it reaches Mahishi in the Saharsa district of Bihar. From Mahishi, it turns

southeast and, after going a further 33 km; it crosses the Saharsa-Mansi rail line, south of the Kopadia railway station, and joins the Ganges near Kursela in Katihar district (Figure 1.1) (Birol & Das, 2010). Its major tributaries are Bagmati, Kamala Balan, Bhutahi Balan, Trijuga, Fariani Dhar, and Dhemama Dhar (Rao, 1975; Vargehese, 1993).

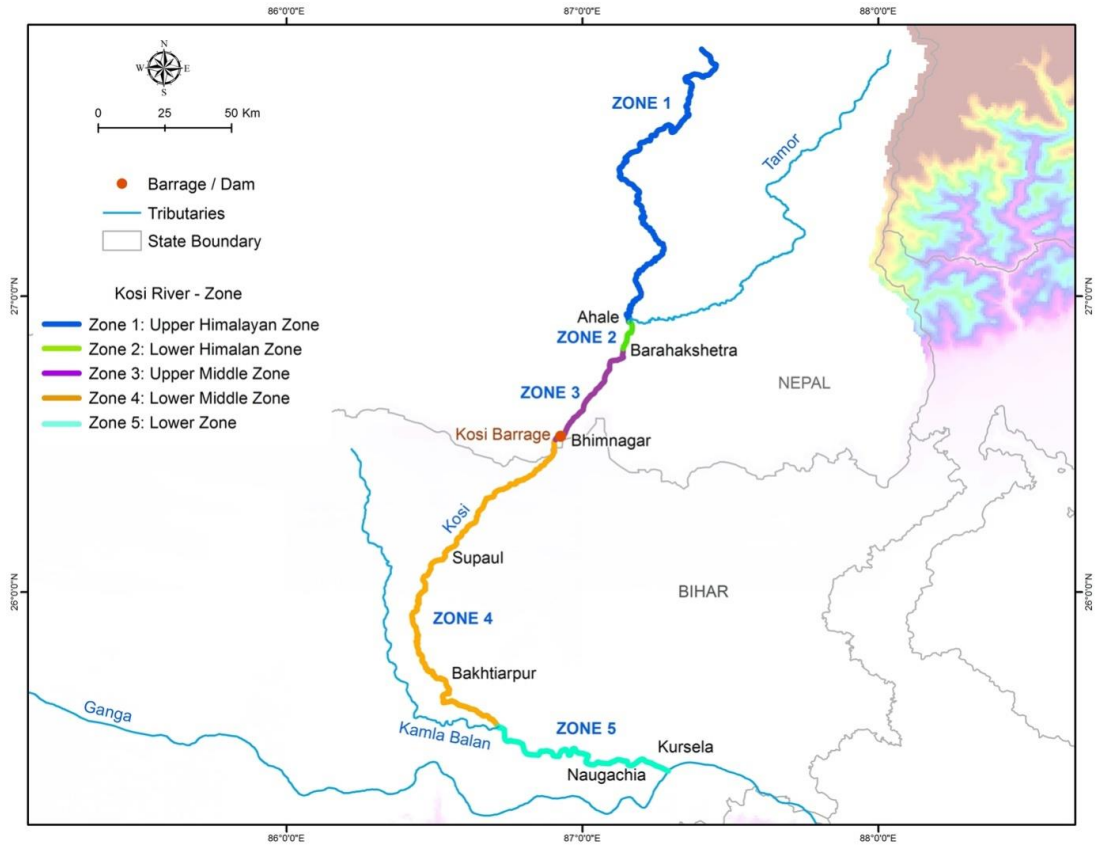

Figure 1.1 Zonation map of Kosi River

Based on the geomorphology, channel type, landforms, confluences, aspect, and slope of the Kosi basin the course of the river can be divided into five distinct zones, viz., Upper Himalayan Zone (UHZ), Lower Himalayan Zone (LHZ), Upper Middle Zone (UMZ), Lower Middle Zone (LMZ) and the Lower Zone (LZ) (Figure 1.1). Two zones, the Lower Middle Zone (LMZ) and the Lower Zone (LZ) fall within Indian Territory.

Table 1.1 Zone-wise characteristics of Kosi River

River Zone	Upper Himalayan Zone	Lower Himalayan Zone	Upper Middle Zone	Lower Middle Zone	Lower Zone
Length (km)	158	11	44	158	79
Stretches	Tamor confluence	Barahakshetra	Kosi barrage	Kamla Balan confluence	Kosi Confluence
Characteristics	Interlocking spur, Steep rock bench, Gorge, Stream terrace	Shivalik Himalaya, Terai region	Lower Shivalik region	Kosi Fan, Kosi Flood Plain	Gangetic flood plain

Upper Himalayan Zone: The Upper Himalayan zone (UHZ) lies in the upper catchment area of the Kosi basin, a158 km stretch of the Kosi River traversing through mountainous region between source of the Kosi River and Tamor confluences in Nepal represents. Steep rocky beds with boulders and deep gorges are the significant landforms that characterise Upper Himalayan Zone (Table 1.1).

Lower Himalayan Zone: The stretch between Tamor confluence downstream and Barahkshetra represents the Lower Himalayan zone (LHZ). Only 11 km of the stretch falling within the administrative boundary of Nepal represents LHZ. This zone represents upstream reach of the Shivalik foothills characterized with gorges and narrow channels (Bajracharya et al., 2007).

Upper Middle Zone: Lies between Barahkshetra to Kosi barrage at Bhimnagar defines the Upper middle zone (UMZ). This stretch spans across a length of 44 km and represents the transitional zone between Shivalik foothills and Terai landscape. The Kosi River flows through 10 km long gorge and enters into the eastern part of the Gangetic plain near Chatra in Nepal. Downstream of Chatra till Bhimnagar, the river forms narrow gravelly sandy braided channels and steep alluvial plains (Singh et al., 1993; Gohain & Parkash, 1990).

Lower Middle Zone: The Lower Middle Zone (LMZ) lies between Bhimnagar barrage and KamlaBalan confluence in the Indian state of Bihar. The channel width of the river increases as it enters Kosimegafan and traverse through western margin of the alluvial megafan (Singh et al., 1993) and is characterised by eroding and depositing banks, meanders, sandy braided channels, and mid-river sandy islands (Sinha et al., 2014).

Lower Zone: The Lower Zone (LZ) is a 79 km stretch between Kamla Balan confluence to the Ganga River confluence at Kursela. The zone is characterised by a wide meandering channel with silty mud and large alluvial fan formed out of vast sand deposits (Singh et al., 1993; Collinson, 1996; Parker et al., 1998, Kumar et al., 2014).

1.2 Drainage and Hydrology

The Kosi River is notorious for its unstable nature and constant shifting of its course due to heavy siltation from the upstream during monsoon season resulting in floods and avulsions of its active channels (Sinha, 2009). Joji et al is a study from south India, no relation to Kosi "Drainage basin delineation and quantitative analysis of Panamaram Watershed of Kabani River Basin, Kerala using remote sensing and GIS". One of the biggest alluvial fans of the world is built up by the Kosi River in the south of Shivaliks extending upto 15,000 km^2, breaking into 12 distinct channels which are constantly shifting, especially during monsoons (Dixit, 2009).

The annual rainfall in the Kosi plains varies between 1,000 to 1,600 mm/year and the average monthly discharge is between 500 m^3/sec and more than 6000 m^3/sec (Reddy et al., 2008; Chakraborthy, 2010). The average annual discharge of the river is 2,236 m^3/sec with an average monsoon discharge almost 5 times than the non-monsoonal discharge (5156 m^3/sec) (Sinha, 2008; Sinha et al., 2013). The mean annual flood discharge in the Kosi River Basin reaches up to 8000m^3/ sec (Sinha & Friend, 1994; Nayak, 1996).

The hydrology of the Kosi River system is is influenced by regional geological complexities, inputs of annual precipitation, Himalayan glacier melt, rate of sedimentation, and sediment connectivity (Bruijnzeel, 1990; Ives & Messerli, 1990). It was estimated that around 49 X 10^9 m^3 water flows annually into the Ganga River with an average discharge of 1564 m^3 s^{-1} (Chen et al., 2013). This river system is known for its migratory trends, resultant flooding, large detrital load of sediments, and avulsive nature of the river. The entire Kosi River fan belt is etched with paleo-channels that demarcate the East-to-West and backswing of the river from the geological past (Mishra et al., 2019).

1.3 Geology and Geomorphology

Geologically, the Kosi River basin is underlain by a highly uneven basement formed by the major tectonic features or "fore deeps" named as "Purnia Depression" (BAPEPS, 2015). The sediments are deposited in the Purnia depression or fore deeps into several meters of thickness forming the Eastern Gangetic Alluvial plains (Singh et al., 1993). The deposits of Eastern Gangetic alluvial plains consist of Older Alluvium (Middle-Pleistocene age) such as coarse gravels, calcareous nodules, etc (Gohain & Parkash, 1990). This layer is overlain by the Newer alluvium of Quaternary age comprising of carbonaceous and micaceous deposits in fine-grained sand particles derived from the process of erosion, sedimentation, aggradation, and deposition forming the mega alluvial fans (Gupta, 1997; Leier et al., 2005).

The geomorphology of the Kosi River basin is complex and is controlled by various factors like sedimentation, hydrological, and tectonic activities associated with the Himalayan mountain building activity (Valdiya, 1976; Dasgupta et al., 1987; Agarwal & Bhoj, 1992; Jain & Sinha, 2004) and allied iso-static adjustments as well as the response of basement structures to plate movements, regional slope, etc (Geddes, 1960). The various geomorphologic features that are conspicuously seen are active channels, inactive channels, oxbow-lakes,

channel bars, water-logged areas, braided streams, which have evolved out of hydrological and sedimentation processes. These geomorphological features are undergoing rapid changes because of channel avulsion and meander cut-offs (Hovius, 1996; Gupta, 1997; Ghosh et al., 2015). One of the most notable features of the basin is its alluvial fan, also called a mega fan due to its large size, it is 180 km long and 150 km wide, which is one of the largest mega fans in the world. The entire mega-fan is a complex network of interlocking channels (Sinha et al., 2005; Gohain & Parkash, 1990).

1.4 Land Use Land Cover

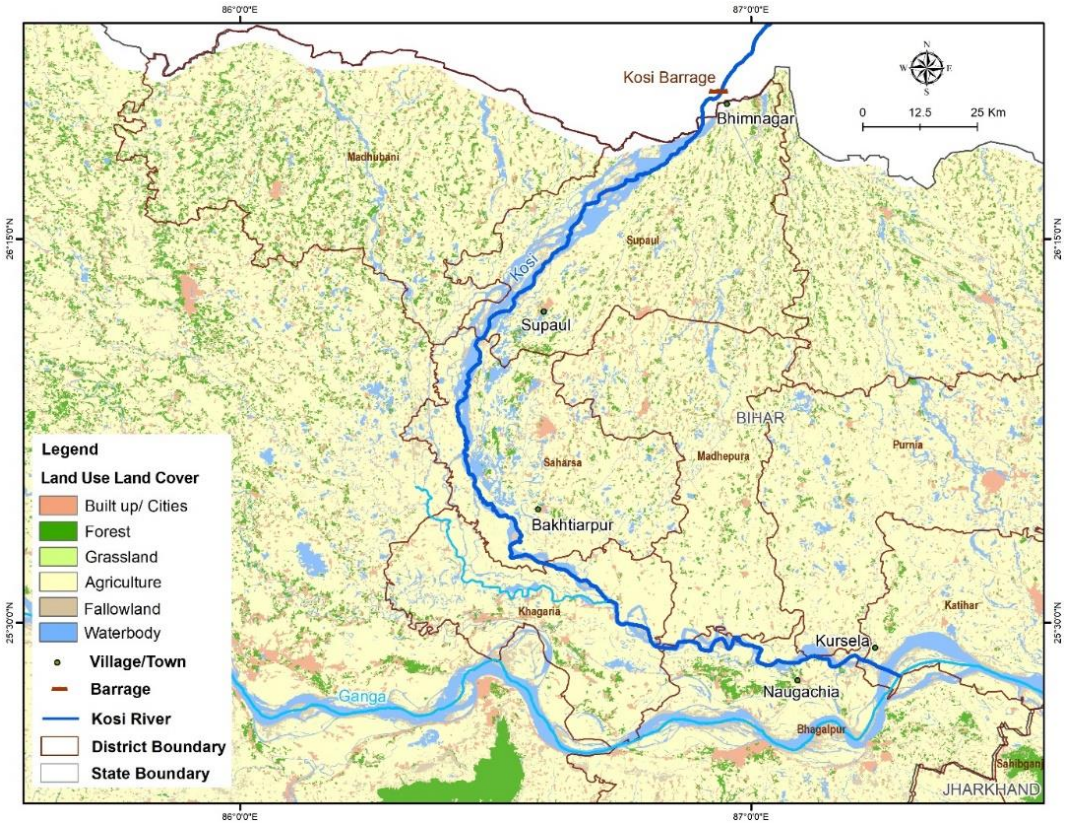

Figure 1.2 Land use Land cover map of the Kosi River basin

Major land use land cover types of Kosi River basin has been depicted in Figure 1.2. The data obtained from the Land Use Land Cover map of NRSC revealed that a significant change has occurred in the land use patterns of the Upper Middle Zone and Lower Zone of the Kosi River basin in 10 years, between the year 2005-2006 and 2015-2016 (Table 2 and 3). Agriculture is the major land use type of Kosi River basin (Figure 1.3). The agricultural land cover in the basin increased by ≈ 8.24% (1493.28 km^2, (Figure 1.3, Table 1.2 and 1.3), followed by ≈ 0.50% (87.88 km^2) increase in the built-up areas, and fallow lands, water bodies, and forest cover showed a decline of ≈ 6.71% (1209.45 km^2), ≈ 2.02% (368.84 km^2) and ≈ 0.02% (2.88 km^2) respectively.

Table 1.2 Area under land use land cover classes in the Kosi River Basin (2005-06)

State	District	Built up (%)		Forest (%)		Agriculture (%)		Fallow land (%)		Water bodies (%)	
		Area in sq km	% area	Area in sq km	% area	Area in sq km	% area	Area in sq km	% area	Area in sq km	% area
Bihar	Bhagalpur	146.40	5.99	128.34	5.25	1449.01	59.25	422.55	17.28	299.10	12.23
	Katihar	87.65	2.98	95.96	3.26	2038.57	69.30	329.19	11.19	390.25	13.27
	Khagaria	71.97	5.02	38.79	2.71	915.85	63.93	268.24	18.72	137.80	9.62
	Madhepura	91.92	5.20	76.14	4.31	1315.06	74.44	122.31	6.92	161.12	9.12
	Madhubani	221.74	6.70	376.02	11.35	2053.55	62.01	498.50	15.05	161.87	4.89
	Purnia	157.73	5.06	76.15	2.44	2344.27	75.16	234.44	7.52	306.64	9.83

	Saharsa	79.00	4.87	56.28	3.47	1012.50	62.38	214.59	13.22	260.70	16.06
	Supaul	115.65	5.01	158.36	6.86	1405.22	60.86	291.52	12.63	338.21	14.65
Total		972.06	5.10	1006.04	4.96	12534.04	65.92	2381.34	12.82	2055.69	11.21

Table 1.3 Area under land use land cover classes in the Kosi River Basin (2015-16)

State	District	Built up (%)		Forest (%)		Agriculture (%)		Fallow land (%)		Waterbodies (%)	
		Area in sq km	% area	Area in sq km	% area	Area in sq km	% area	Area in sq km	% area	Area in sq km	% area
Bihar	Bhagalpur	149.79	6.13	128.21	5.24	1661.08	67.93	255.05	10.43	251.27	10.28
	Katihar	104.01	3.54	95.90	3.26	2163.29	73.54	233.32	7.93	345.10	11.73
	Khagaria	80.44	5.61	38.89	2.71	1099.26	76.73	78.68	5.49	135.38	9.45
	Madhepura	110.93	6.28	74.88	4.24	1452.36	82.21	63.60	3.60	64.78	3.67
	Madhubani	224.04	6.77	376.23	11.36	2460.99	74.31	114.52	3.46	135.89	4.10
	Purnia	178.39	5.72	75.53	2.42	2466.05	79.06	173.14	5.55	226.12	7.25
	Saharsa	86.01	5.30	55.51	3.42	1177.04	72.52	77.89	4.80	226.62	13.96
	Supaul	126.33	5.47	158.01	6.84	1547.25	67.01	175.69	7.61	301.69	13.07
Total		1059.94	5.60	1003.16	4.94	14027.32	74.16	1171.89	6.11	1686.85	9.19

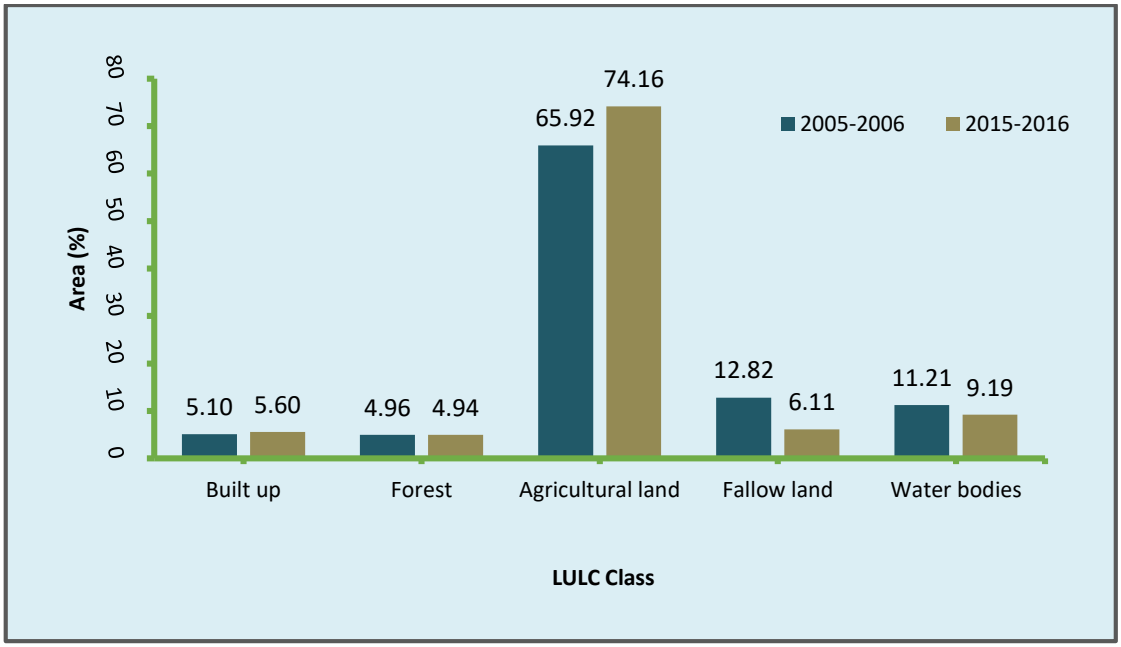

Figure 1.3 Extent of land use land cover change in the Kosi River Basin (2005-2016)

1.5 Soil Types

The Kosi River catchment is in the Himalayan region and is rich in acidic minerals. As a result, the soils of this zone are non-calcareous, there is an accumulation of sodium salts and the sodium adsorption ratio is on the higher side in the areas where the drainage is poor (Kumari, 2014).

Table 1.4 Agro-climatic zones and Soil types of the districts of Kosi River (Source: BAPEPS, 2015)

S. No.	District	Agro-Climatic Zone	Soil Type	Soil pH Range
1	Madhubani	Zone I	Sandy Loam, Loam	6.5 – 8.4
2	Sapaul	Zone II	Sandy Loam, Clay Loam	6.5-84
3	Saharsa	Zone II	Sandy Loam, Clay Loam	6.5-7.8
4	Khagaria	Zone II	Sandy Loam, Clay Loam	6.5-7.8
5	Purnia	Zone II	Sandy Loam, Clay Loam	6.5-7.8
6	Katihar	Zone II	Sandy Loam, Clay Loam	6.5-7.8

7	Madhepura	Zone II	Sandy Loam, Clay Loam	6.5-7.8
8	Bhagalpur	Zone IIIA	Sandy Loam, Clay Loam, Clay	6.8-8.0

Salinity and alkalinity increase in the permanently waterlogged areas. Results of soil testing indicate that the soil is in the neutral range, the Electrical Conductivity (EC) values indicate low salinity levels in the area, and the organic carbon indicates moderate to high soil productivity (Table 1.4 and 1.5) (BAPEPS, 2015).

Table 1.5 Classification and Characteristics of the soil types found in the Agro-climatic Zones (Source: BAPEPS, 2015)

S. No.	Zone	Soil Classification	Abundant Nutrients	Deficient Nutrients	Other Characteristics	Drainage
1	**Zone I**	Sub-Himalayan Forest Soil Alluvial Tarai Soil Alluvial Calcareous Soil Alluvial Calcareous Saline Soil Alluvial Non-Calcareous Non –Saline Soil	Calcium, Nitrogen, Potash	Zinc, Iron, Phosphorous	Light to Medium Light Texture Soil,	Good to Moderate
2	**Zone II**	Alluvial Tarai Soil Alluvial Calcareous Soil Alluvial Non-Calcareous Soil	Manganese, Sodium, Acidic Minerals, Potash	Zinc, Boron, Nitrogen, Calcium, Phosphorous	Very Light Texture Soil	Poor
3	**Zone IIIA**	Alluvial Calcareous Soil Tal Land Soil Alluvial Yellow Soil Alluvial Yellow Non-Calcareous Soil Alluvial Red-Yellow Soil Alluvial Saline Alkali Soil	Phosphorous, Potash	Nitrogen	Medium to Heavy Textured Soil, Moderate Acidic to Slight Alkaline	Moderate to Poor

1.6 Climate

The Kosi river basin includes five climatic zones determined mainly by elevation (Agarwal et al., 2014), with nine distinct ecoregions. The climate in the basin varies from humid tropical in the south, through subtropical and temperate, to cold and arid in the north (Anders et al., 2006; Barros et al., 2006; Bookhagen & Burbank, 2006). The climate in the southern part of the basin and the central Himalayas is strongly influenced by the South Asian monsoon, while the Tibetan plateau to the north lies in a rain shadow area (Chen et. al., 2013). The average annual precipitation ranges from 207 mm in the trans-Himalaya to more than 3,000 mm in the eastern mountains and mid-mountains of Nepal (Neupane et al., 2015). Subsequently, the basin in the Indian territory receives a mean annual rainfall of around 1200 mm with the most precipitation received between June and September months of the year (Srivastava et al., 2021). Owing to the great variation in topography, the spatial and temporal complexity of rainfall is large over short distances, about 75% of the annual rainfall in the region occurs during the four monsoon months from June to September (Barros et al., 2006; Bookhagen & Burbank, 2006), and temperatures range from a mean minimum in December and January of 10 to 11°C to an annual mean maximum in May around 41°C (Chakraborty et al., 2010; IPCC, 2007).

1.7 Biogeography, Flora, and Fauna

The Kosi Basin in the Indian part falls within the Lower Gangetic Plain (7B) biogegraphic province of Rodgers and Panwar (1988) and represents two broad types of forest viz. Tropical moist deciduous covering the hills and the tropical dry deciduous vegetation occurring in the alluvial plains (Dutta et al., 2004) (Figure 1.4).

A preliminary survey conducted by ZSI in the year 1992 reported the presence of mugger crocodile (*Crocodylus palustris*), 340 bird species including terrestrial as well as water-associated species, 12 species of turtles, and 10 species of Frogs (ZSI, 1992). Sinha and Sharma (2003) reported 87 individuals of Gangetic dolphin in discrete segments in the Kosi River between the Kosi Barrage at the India-Nepal border till Kursela (Kosi and Ganga River confluence). Choudhary (2016) observed that dolphins tend to migrate from the Ganga River to the Kosi River during monsoon seasons. In the recent past no sightings of Smooth-coated Otters (*Lutrogale perspicillata*) was

obtained (Sinha et al. 2014). Once gharials (*Gavialis gangeticus*) as well as Mugger (*Crocodylus palustris*) were abundant in the Kosi River (Shortt, 1921) however there is no recent available information on the occurrence of gharial (Saikia, 2013).

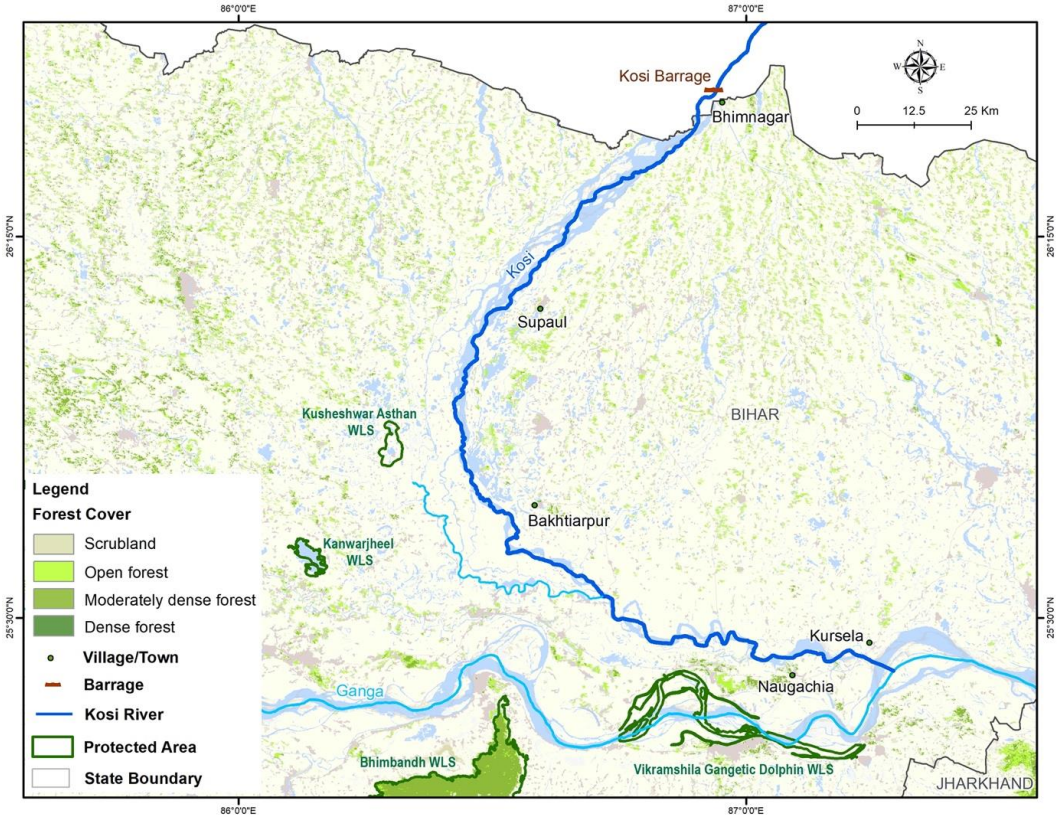

Figure 1.4 Forest cover map of the Kosi River basin

Table 1.6 Biogeographical provinces, floral and faunal assemblages of the Kosi River Basin

River segment	Bio-geographic Provinces	Length (km)	Characteristics	Forest cover (km^2)	Species Richness						No. of Protected Areas
					Mammals	Bird	Turtle	Gharial	Mugger	Fish	
Zone 4 (Bhimnagar barrage to Kamla Balan River Confluence at Usraha)	Lower Gangetic Plain (7B)	158	Wide braided channel with high deposition of sediments and river islands	395.92	✓	44	✓	NA	✓	25	Nil
Zone 5 (Kamla Balan River confluence to Ganga confluence at Kursela)	Lower Gangetic Plain (7B)	79	Braided channel with sandy bars, oxbows, meanders, and huge deposition of sand, formed a large inland delta	258.71	✓	28	✓	NA	✓	✓	Nil

1.8 Demography

The Kosi River flows through 8 districts of the Bihar state (Figure 1.5), with about 21,659,178 people estimated to reside in these districts (GOI, 2011). The average population density of the Indian Kosi River basin is 1097.11 individuals/km^2. Table 1.7 shows the district-wise human population density.

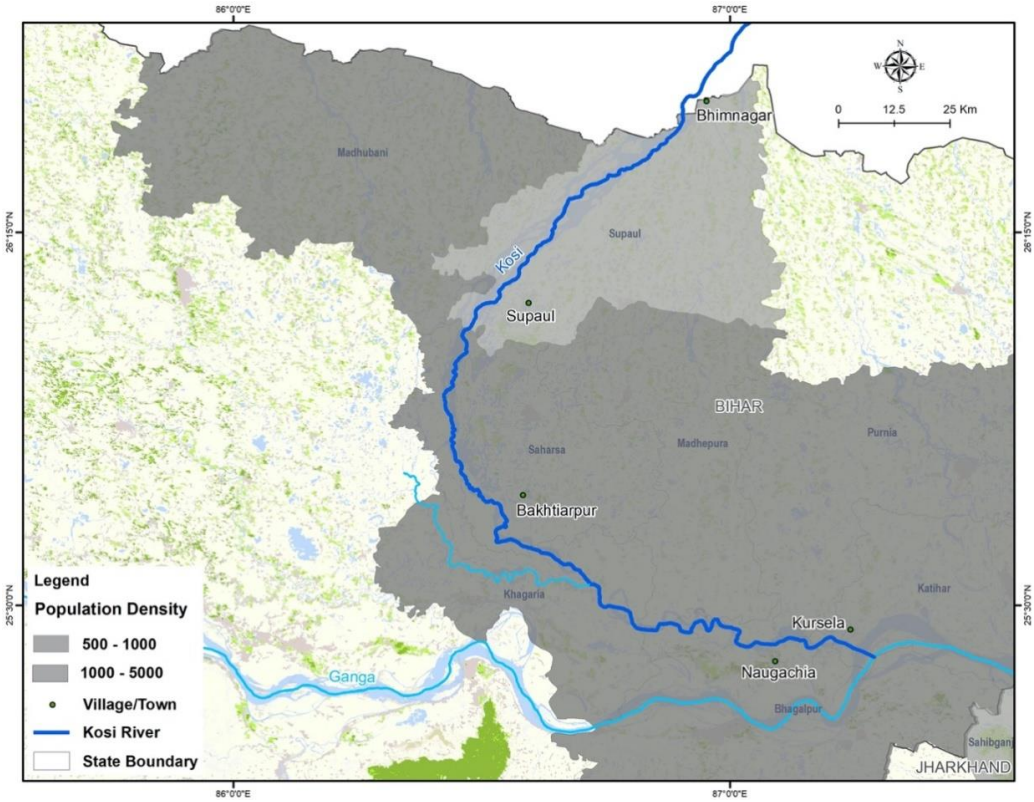

Figure 1.5 Density map of the Kosi River Basin

Table1.7 Human density along the Kosi River (Source: GOI, 2011)

River	State	Zones	Districts	Geographical Area (Km^2)	Population	Density (Persons/km^2)
Kosi	Bihar	4	Supaul	2425	2229076	919
			Madhubani	3501	4487379	1282
			Saharsa	1687	1900661	1127
			Khagaria	1486	1666886	1122
		5	Khagaria	1486	1666886	1122
			Madhepura	1788	2001762	1120
			Purnia	3229	3264619	1011
			Katihar	3057	3071029	1005
			Bhagalpur	2569	3037766	1182

2. STATUS OF AQUATIC WILDLIFE IN THE KOSI RIVER

2.1 Methodological Framework

Evaluation of the species distribution and occurrence patterns, habitat profile, and location of major settlements along the Kosi River was done with the help of published literature and a survey protocol along with a species-specific assessment method was developed. A rapid biodiversity survey was conducted to assess the local distribution of higher vertebrate fauna viz. mammals, water birds, gharial, mugger, and freshwater turtles in the Kosi River. The survey was carried out during the month of November 2020 (from 21st – 25th November) covering a stretch of 235 km from Piprahi (N 26° 26' 44.35", E 86° 53' 37.9") to Kursela (N 25° 25' 10.81", E 87° 14' 5.25") in the state of Bihar.

Gangetic Dolphin

Formal interviews with river-dependent communities and the available literature revealed that during the dry season (October to April), dolphins tend to leave the Kosi and congregate in the Ganga River and return to the Kosi in the following wet season (Reeves and Brownell, 1989). A decrease in the abundance of dolphins in the Kosi River, during the summer season, confirms a seasonal pattern of migration (Shrestha, 1989). This migration seems to be associated with the dispersal of fish, which are their main prey (Kasuya & Haque, 1972). According to the literature the last survey was done in the year 2003 (Sinha & Sharma 2003)

During the present survey, a vessel-based visual count method (Perrin and Brownell, 1989; Sinha, 1997; Smith and Reeves, 2000; Smith et al., 2006; Behera et al., 2013) was adopted to enumerate the sighting occurrence and distribution patterns of Gangetic dolphins (*Platanista gangetica*), in the Kosi River. Sightings of dolphin were recorded between 8:00 hrs to 12:00 hrs in the morning and 16:00 hrs to 18:00 hrs in the afternoon with the help of three independent observers that were stationed at the motorboat in three different directions (right, left, and front) to obtain concurrent records of dolphin sightings.

Avifauna

During the present study, the abundance of waterbirds was obtained using the Total Count Method (Sutherland et al., 2004; Sutherland, 2006). Field recordings of waterbirds were done with the naked eye and using 50×10 Nikon binoculars followed by a comparison with a field guide (Grimmett et al., 2016; Gopi & Hussain, 2014).

Gharial, Mugger, and Turtles

A boat-based visual encounter survey was conducted to document baseline information on the current status and occurrences of gharials, muggers and turtles (Singh, 1985; Hussain, 2009). The surveys were made during the peak basking time and it was assumed that all individuals come out from the water for basking (Choudhary & Roy 1982, Rodgers 1991). Critical habitats including sandy shoreline, exposed islands, dry logs near the shoreline, and surfacing plant materials were thoroughly scanned using Nikon Binoculars (8X40) to record all possible sightings. GPS location and associated habitat parameters were also noted down whenever a sighting was made (WII-NMCG, 2019).

Habitat Parameters

During the survey, indices for habitat quality were noted down at each 5 km interval. The parameters such as water current (slow, medium, fast), channel depth and channel width (m), bank characteristics (right & left), shoreline vegetation (right & left), GPS coordinates, confluences, meanders, sandbars, physicochemical parameters as well as anthropogenic factors were recorded. Channel depth (m) and width (m) were recorded with the help of a GARMIN Striker Plus fish finder and a YUKON laser range finder, respectively. YSI Pro DSS multi-parameter water quality meter was used to measure physicochemical parameters such as dissolved oxygen, pH, conductivity, salinity, TDS and water temperature. These parameters were monitored through in situ measurement techniques following standard procedures of APHA (1998). Bank characteristics were broadly classified into five categories viz., 1. Pebbles and boulders; 2. Sandy; 3. Loamy; 4. Clayey and 5. Rocky embankment; is based on geomorphic features and substrate types of the river. Shoreline vegetation was grouped into three major classes i.e., fully covered (> 90% bank surface covered with riparian vegetation); partially covered (< 50% green cover), and exposed (< 10% green cover). As a measure of indices of the quality

of riverbank a series of river bank scenarios was assessed, based on bank slopes ranging from vertical (90° from horizontal) to an angle of < 30° from horizontal. Slopes of the bank were then classified into three categories viz. low slope (< 30°), medium slope (30-60°), and high slope (> 60°) (Doble et al., 2012).

2.2 Mammals

Gangetic Dolphin (*Platanista gangetica*)

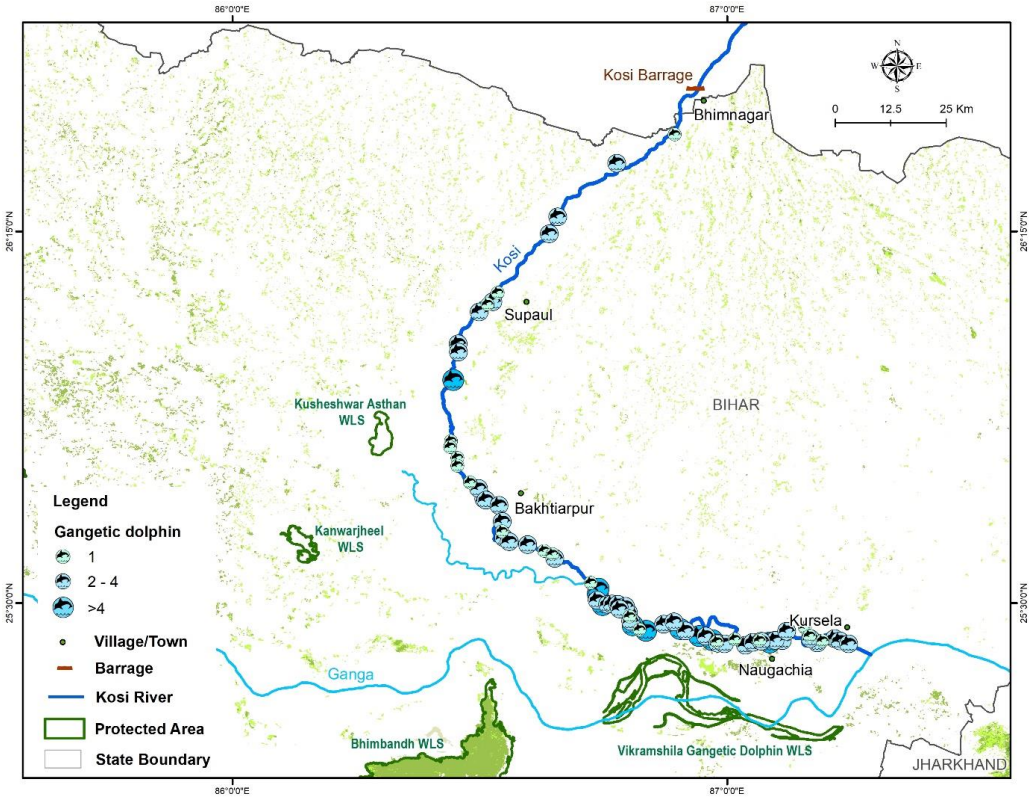

Figure 2.1 Occurrence map of Gangetic Dolphin in the Kosi River

A total of 180 individuals of surfacing dolphins in 71 sighting occasions were recorded during the survey (Figure 2.1, Table 2.1). The encounter rate of the dolphins along the surveyed stretch was found to be 0.78 sightings km^{-1}. Of the total sightings sub-adults (54.19%) were highest followed by adults (36.87%) and neonates (8.94%). All the sightings occurred between the channel depths of 1.2 m to 12 m, with an average depth of 5.22 ± 2.34 m, and the channel widths ranging from 190m to 1290 m, with an average width of 624.86 ± 236.93 m (Table 2.1).

Table 2.1 Sighting occurrences and Encounter Rate of Gangetic dolphin (*Platanista gangetica*) in the Kosi River observed during the Post-monsoon biodiversity survey

River Zones	Stretch	Stretch Length (Km)	No. of dolphin sightings	ER (Sightings/Km) ± SE	Average Channel depth ± SD	Average Channel width ± SD
Zone IV	Piprahi to Itahari	40	10	0.25 ± 0.11	1.18 ± 0.56	361.86 ± 114.6
	Itahari to Baluaha	48	17	0.35 ± 0.14	1.47 ± 0.51	822.27 ± 373.59
	Baluaha to Usraha	60	29	0.48 ± 0.11	2.77 ± 1.58	690.83 ± 282.58
Zone V	Usraha to Pratapnagar	47	90	1.91 ± 0.37	5.68 ± 1.02	526.49 ± 154.53
	Pratapnagar to Kursela	35	34	0.97 ± 0.23	4.16 ± 1.51	528 ± 141.95

According to data, 69.02% of dolphin sightings were recorded in the channel depth of above 4 m followed by 23.94% sightings in channel depths between 2 m to 4 m and 7.04% sightings were observed below channel depth of 2 m (Figure 2.2).

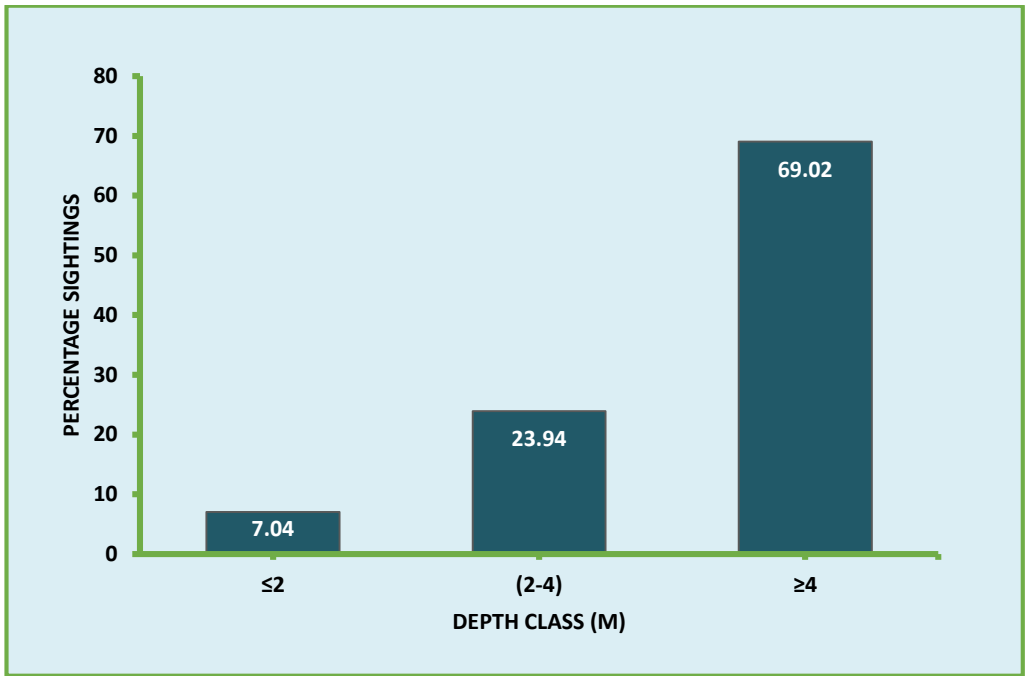

Figure 2.2 Occurrences of Gangetic dolphin in different depth classes of the Kosi River observed during the Post-monsoon biodiversity survey

2.3 Avifauna

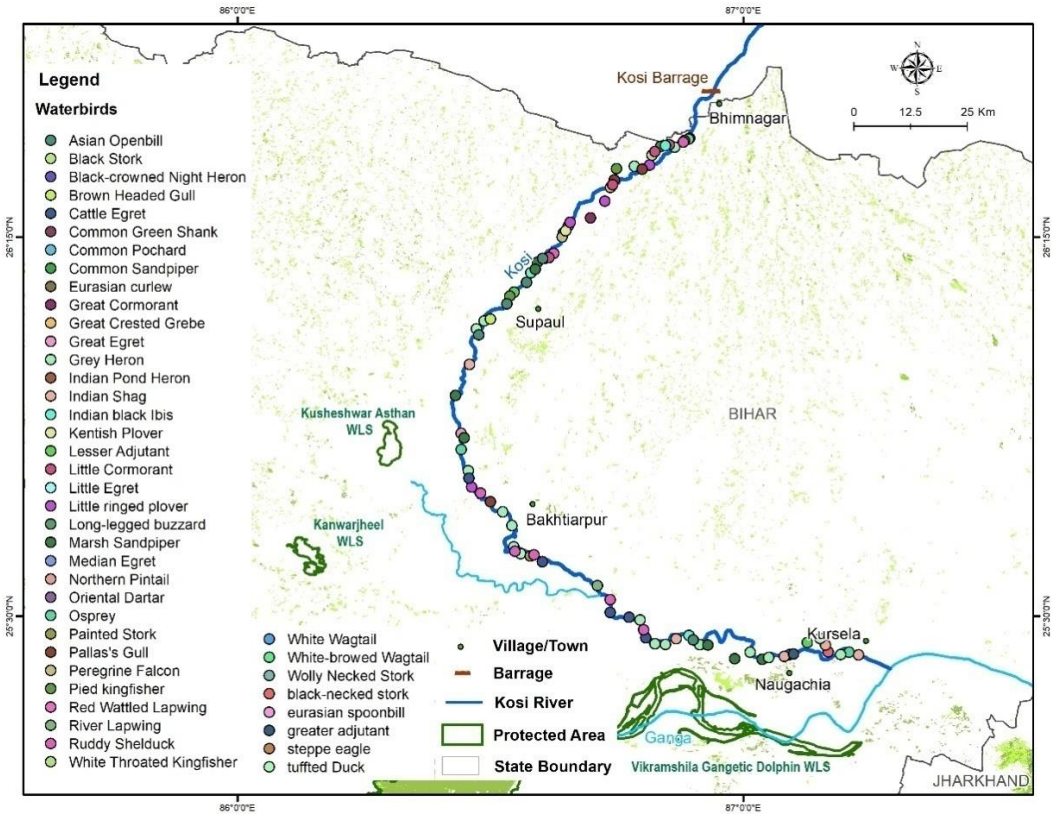

Figure 2.3 Location of waterbird recorded during the post-monsoon biodiversity survey of the Kosi River

During the survey, 1923 individuals of 48 waterbird species belonging to 16 families were recorded (Figure 2.3). The encounter rate of these species was 8.36 sightings km^{-1} (Table 2.2). Among them, 11 species are of global importance, with two species listed as Endangered, two species as Vulnerable, and seven species as Near-threatened as per the IUCN red list of Threatened Species (IUCN, 2021) (Annexure 3). Of the total recorded species, 8 species belonged to the Anatidae family, 7 species each in Coconiidae and Ardeidae, followed by 4 species each in Charadriidae and Scolopacidae. Accipitridae, Threskiornihidae and Phalacrocoracidae accounted for 3 species in each family, Laridae, Alcedinidae and Motacillidae had 2 species each and 1 species each in Pandionidae, Glareolidae, Falconidae, Podicipedidae and Anhingidae (Figure 2.4).

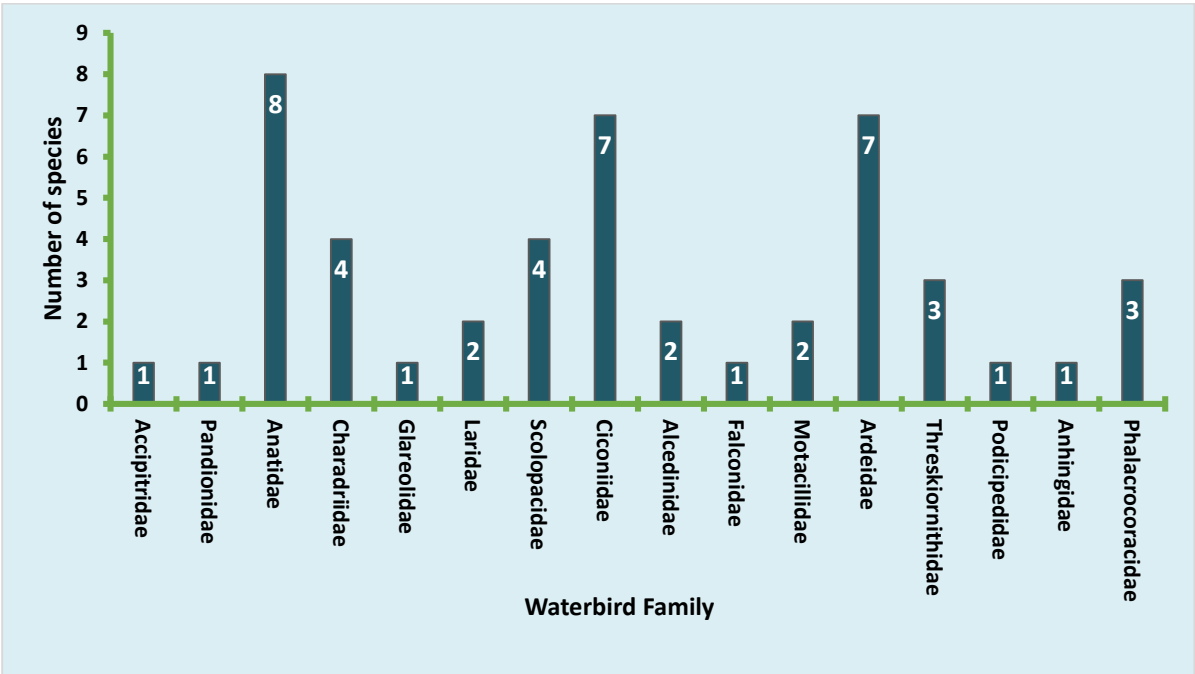

Figure 2.4 Family-wise composition of waterbird communities across the Kosi River observed during the post-monsoon biodiversity survey

Of the all recorded waterbird species 19 species were Resident followed by 12 species were Winter Migrant, 10 species were Resident with local movement, 6 species were Resident with winter influx with, and only one species represented Largely winter migrant and partly resident (Figure 2.5). According to the feeding guilds, recorded species were categorized into 9 groups. In these feeding groups, 14 species belonged to Carnivore group, followed by 10 species in Piscivore/Carnivore, 8 species in Piscivore /Insectivore, 4 species each in Omnivore and Insectivore group, 3 species each in Herbivore and Piscivore, and 1 species in Piscivore/Omnivore and 1 species Carnivore/Insectivore groups (Figure 2.6).

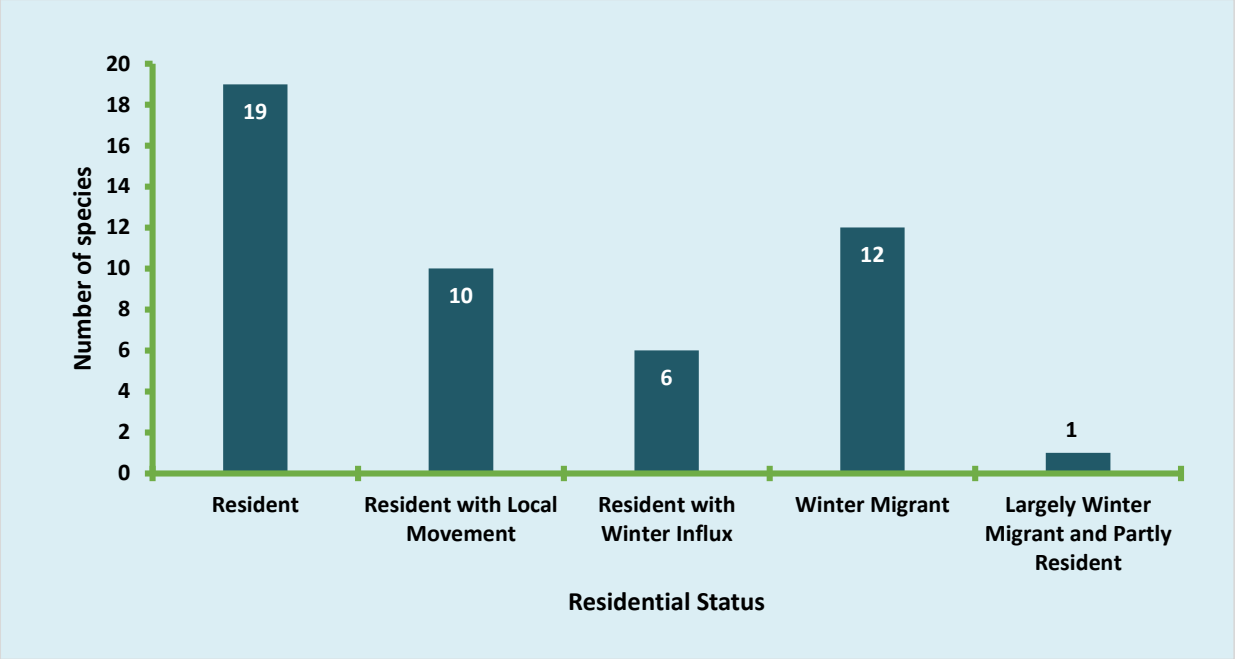

Figure 2.5 Residential status of water birds communities across the Kosi River observed during the post-monsoon biodiversity survey

Figure 2.6 Feeding guilds composition of water birds communities across the Kosi River observed during the post-monsoon biodiversity survey

During the survey, 1927 individuals of 50 waterbird species were recorded on 284 sighting occasions. The encounter rate of waterbirds ranged from 2.9 to 12.4 individuals km^{-1} (Table 2.2).

Table 2.2 Encounter rate of waterbird species observed during the Post-monsoon Biodiversity survey of the Kosi River

Zones	Stretch	Stretch Length (Km)	No. of species recorded	No. of Individuals Sighted	ER (indioviduals/Km) ± SE
Zone IV	Piprahi to Itahari	40	28	332	8.3 ± 2.39
	Itahari to Baluaha	48	30	382	7.56 ± 2.49
	Baluaha to Usraha	60	25	746	12.43 ± 6.08
Zone V	Usraha to Pratapnagar	47	22	361	7.68 ± 2.2
	Pratapnagar to Kursela	35	16	102	2.91 ± 1.92

2.4 Reptiles

Turtles

A total of 326 visual detections of freshwater turtles (*Pangshura* spp.) were recorded within 14 sighting occasions (Table 2.3). Maximum turtle sightings occurred between Baluaha and Usraha with an encounter rate of 1.05 sightings km^{-1}. The recorded sightings occurred between the river depths of 0.77m to 6.23m, with an average depth of 2.54 ± 1.74 m, and the river widths ranging from 255m to 967m, with an average width of 574.50 ± 204.32 m. Turtle sightings occurred with water temperature ranging from 17.6 ˚C to 21.5 ˚C and air temperature from 20.2 ˚C to 29.1 ˚C, dissolved oxygen (DO) values ranged from 1.12 mg/l to 6.5 mg/l. The maximum sightings of turtles (46.63%) were recorded between 12 pm and 3 pm followed by 44.48% between 9 am and 12 pm. Lowest number of sightings (8.89%) were recorded between 3 pm and 6 pm.

Table 2.3 Sighting occurrences and Encounter Rate of Freshwater turtles (*Pangshura spp.*) in the Kosi River observed during the Post-monsoon biodiversity survey

Zones	Stretch	Stretch Length (Km)	No. of sightings	ER (Sightings/Km) ± SE	Substrate Type (%)			Anthropogenic Pressure (%)
					Sandy	Loamy	Floating Log	
Zone IV	Piprahi to Itahari	40	233	5.18 ± 2.44	93.99	1.29	4.72	9.1
	Itahari to Baluaha	48	11	0.22 ± 0.24	72.73	27.27	0.00	39.02
	Baluaha to Usraha	60	63	1.05 ± 0.24	82.54	0.00	17.46	25.45
Zone V	Usraha to Pratapnagar	47	19	0.38 ± 0.20	36.84	63.16	0.00	20.66

2.5 Habitat Parameters

Channel width and Channel depth

The width and depth of the surveyed river stretch varied radically throughout its length. During the post-monsoon season, the channel width ranged from 120m to 1800m (Average = 598.83 ± 300.44) (Figure 2.7) and the channel depth ranged from 0.4m to 7.2m (Average = 2.83 ± 2.07) (Figure 2.8). The majority of the sampled river stretch (52.17%) had depths ranging between 1m to 3m (Table 2.4).

Table 2.4 **Depth Class of Kosi River sampled during post-monsoon, 2020**

Depth Class (m)	No. of Segments	% of Stretch
< 1	5	10.86 %
1- 3	24	52.17 %
3- 5	9	19.56 %
5- 7	8	17.39 %
7- 9	1	2.17 %

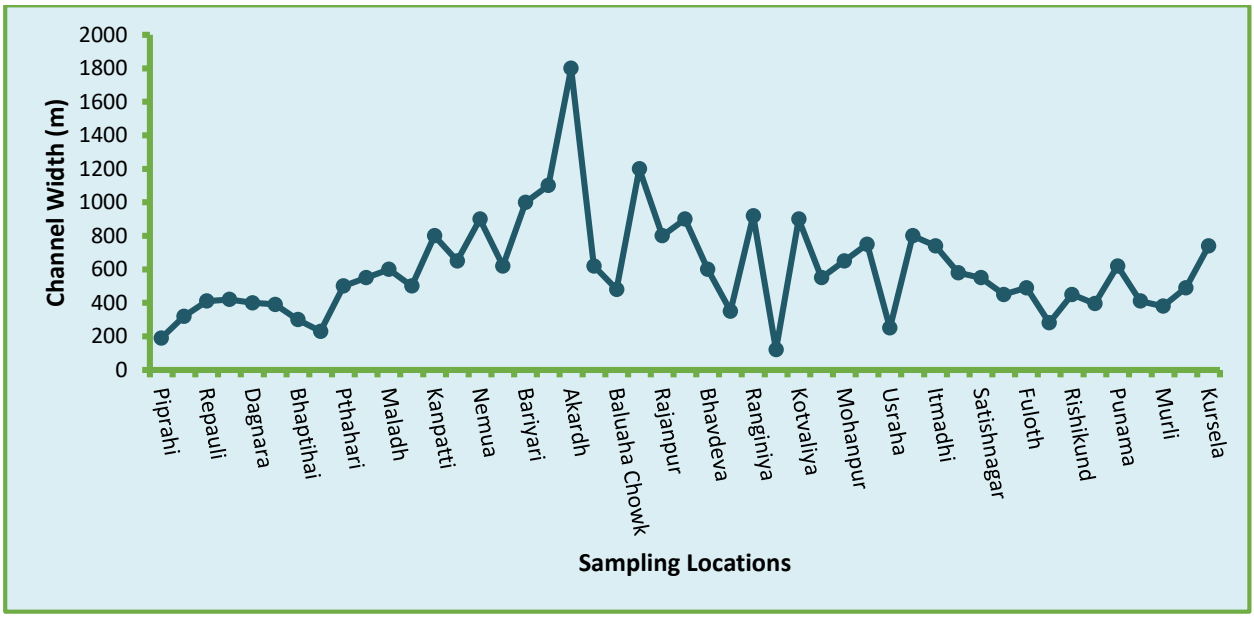

Figure 2.7 Channel width profile of each river segment of the Kosi River during the study period

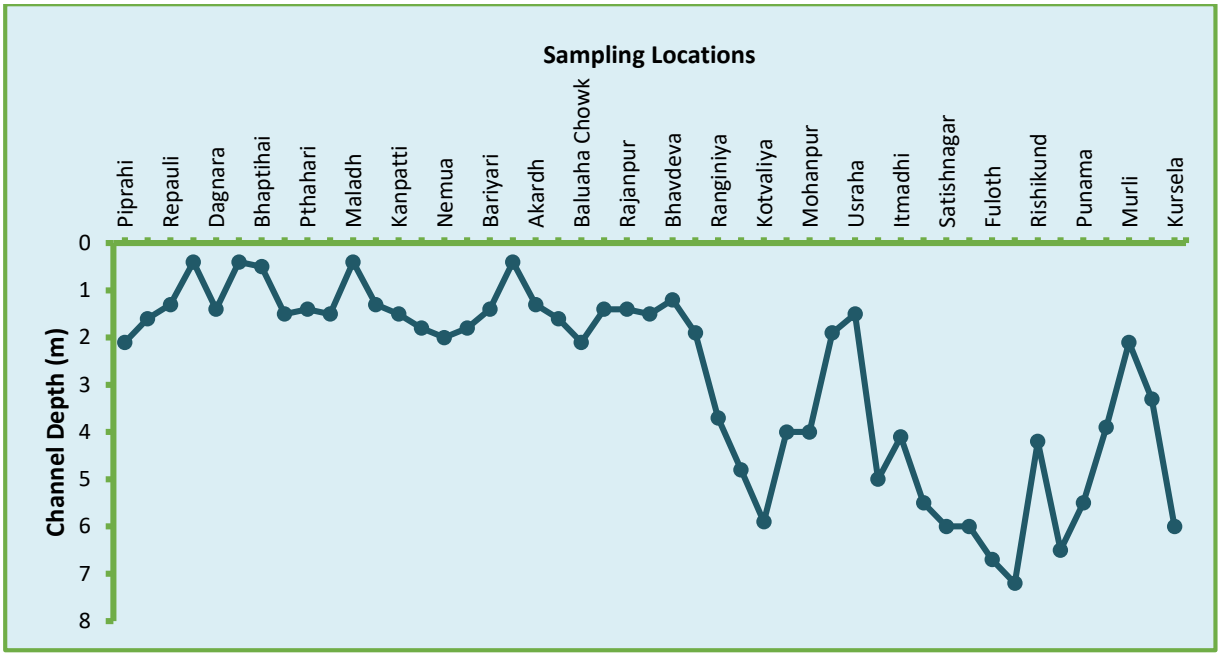

Figure 2.8 **Channel depth profile of each river segment of the Kosi River during the study period**

Bank features

In the Lower Middle Zone (LMZ) of the Kosi River more than fifty percent **(**54.55%) of the left bank substrate was loamy followed by rocky (30.30%) and 15.15% sandy substrate, while on the right bank almost 93.94% of the river segment had loamy soil and 6.06% of the river segment had sandy substrate. 51.52% of the left bank was partially covered by vegetation, 6.06% had fully covered vegetation, and the remaining was devoid of any vegetation (42.42%), whereas on the right bank, 54.55% area was partially covered, 27.27% was fully covered and the remaining 18.18% area was devoid of vegetation. Overall the the banks slopes were characterised as medium gradient, left banks were mostly medium slope (57.58%) followed by low 39.39% and 3.03% high slopes respectively, the right bank, 69.70% had a medium slope, 24.24% low slope, and 6.06% was under high slope category.

In the Lower Zone (LZ) of the Kosi River more than ninety percent (92.86%) of the left bank substrate was found to be loamy, 7.14% was sandy, whereas on the right bank, 57.14% was Loamy and 21.43% each was attributed to the rocky and sandy substrate. 71.43% of the left and right banks were found to be partially covered by vegetation and the remaining 21.43% of the banks on both sides were devoid of any vegetation. About 78.57% of the left bank had a medium slope, followed by 14.29% of low slope and high slope accounted for 7.14%, whereas on the right bank 42.86% had low slope followed by 35.71% of high slope and 21.43% was under medium slope category.

Water quality parameters

Dissolved Oxygen (DO) of Lower Middle Zone (LMZ) of the Kosi River was found in the range between 1.1 mg/l to 6.5 mg/l and in Lower Zone (LZ) it was 1.09 mg/l to 1.79 mg/l. In LMZ, conductivity range was between 95.8 µS/cm to 136.2 µS/cm and in LZ conductivity range was 136.8 µS/cm to 206.5 µS/cm. Total Dissolved Solids (TDS) in LMZ varied from 72.15 mg/l to 99.08 mg/l and in LZ, from 98.45 mg/l to 146.25 mg/l. Salinity of LMZ ranged between 0.04 ppt to 0.07 ppt followed by 0.07 ppt to 0.11 ppt in LZ. pH ranged from 7.96 to 9.52 in LMZ and 8.42 to 8.63 in LZ (Table 2.5).

Table 2.5 Water quality parameters observed during post-monsoon survey of Kosi River, 2020

River Zones	DO (mg/l)	Conductivity (µS/cm)	TDS (mg/l)	Salinity (ppt)	pH
Zone IV (LMZ)	1.1 - 6.5	95.8 - 136.2	72.15 - 99.08	0.04 - 0.07	7.96 - 9.52
Zone V (LZ)	1.09 - 1.79	136.8 - 206.5	98.45 - 146.25	0.07 - 0.11	8.42 - 8.63

As per the standards set by CPCB for the propagation of wildlife, the value of Dissolved Oxygen (DO) was set at >4mg/l, and for pH, the value was 6.5 to 8.5 (CPCB, 2016). During the Post-monsoon biodiversity survey, we recorded that the range of pH was from 7.96 to 9.52 (Figure 2.9) and for Dissolved Oxygen, the values ranged from 1.09mg/l to 10.79mg/l (Figure 2.10).

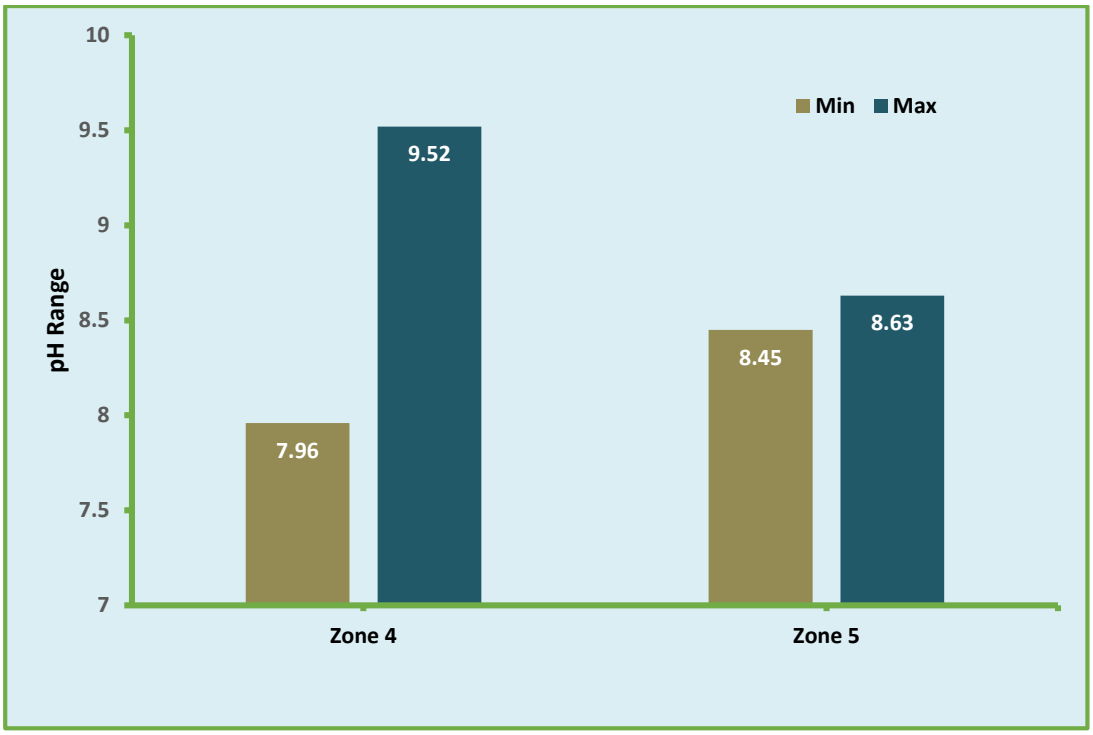

Figure 2.9 pH Range recorded during the post-monsoon biodiversity survey in the Kosi River

The pH values recorded by us ranged from 8.45 to 8.63 (Figure 2.9) and the dissolved oxygen value ranged from 1.17mg/l to 1.79mg/l (Figure 2.10).

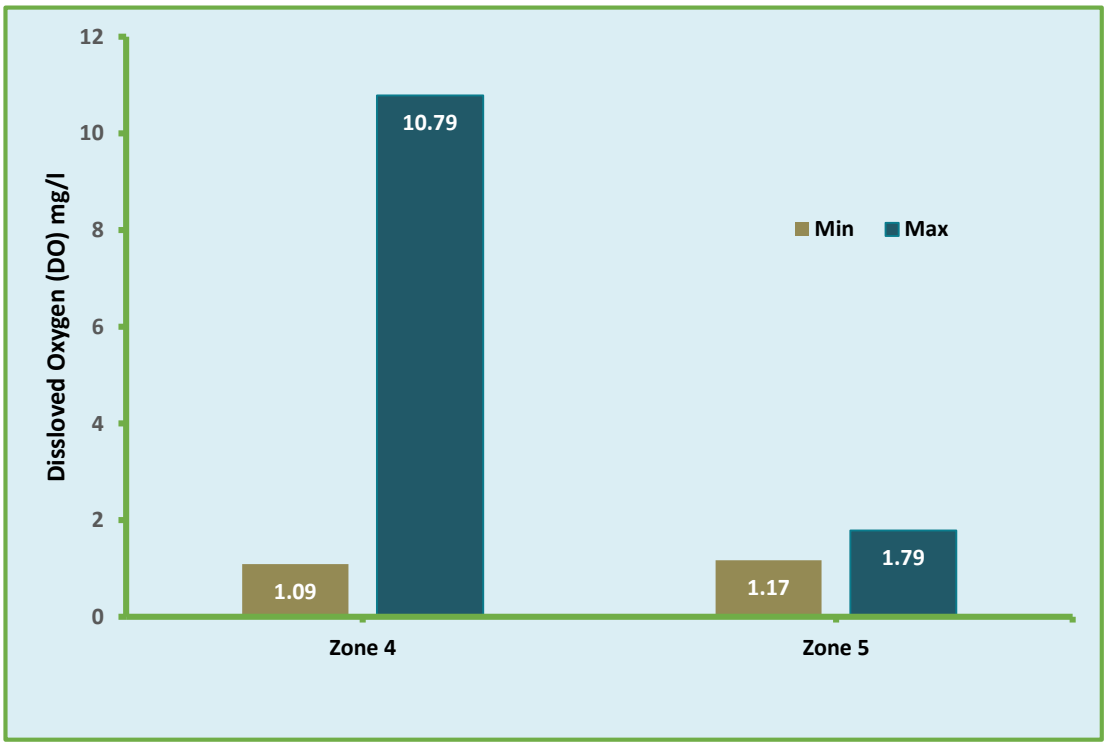

Figure 2.10 Dissolved oxygen (DO) recorded during the post-monsoon biodiversity survey in the Kosi River

2.6 River Stretches with High Biodiversity Value

Based on the encounter rate of Gangetic dolphin, water birds, freshwater turtle and degree of anthropogenic pressure, we identified two stretches of high biodiversity importance.

Baluaha to Usraha (Lower Middle Zone) –This stretch is about 60 km. Twenty-five water associated bird species (744 individuals) were recorded. Species of high conservation significance, such as lesser adjutant, classified as Vulnerable by the IUCN was sighted in this river stretch. Near Threatened species, viz. Painted stork and river lapwing were also sighted here. Six winter migrant waterbird species (black stork, gadwall, painted stork, tufted duck, common greenshank, ruddy shelduck), with the highest encounter rate for gadwall (5.03 sightings km^{-1}) were also recorded from this stretch. A total of 29 sightings of Gangetic dolphins were recorded in this stretch, with an encounter rate of 0.48 sightings km^{-1}. Freshwater turtle (*Pangshura* spp., 63 detections) were also recorded in this stretch.

Table 2.6 Stretch wise overall species encounter rate observed in Kosi River

River Zones	Stretch	No. of BEU (5 km)	Gangetic Dolphin ER (sightings/km) ± SE	Waterbirds ER (sightings/km) ± SE	Freshwater Turtle ER (sightings/km) ± SE	Species of Global concern	Anthropogenic Pressure (%)
Zone IV (LMZ)	Piprahi to Itahari	9	0.25 ± 0.11	8.3 ± 2.39	5.18 ± 2.44	2	9.1
	Itahari to Baluaha	10	0.35 ± 0.14	7.56 ± 2.49	0.22 ± 0.24	6	39.02
	Baluaha to Usraha	12	0.48 ± 0.11	12.43 ± 6.08	1.05 ± 0.24	4	25.45
Zone V (LZ)	Usraha to Pratapnagar	10	1.91 ± 0.37	7.68 ± 2.2	0.38 ± 0.20	7	20.66
	Pratapnagar to Kursela	5	0.97 ± 0.23	2.91 ± 1.92	*	5	5.76

- **Usraha to Pratapnagar (Lower Zone) –** This stretch is 47 km long, 23 water-associated bird (368 individuals) were recorded Species with high conservation significance, . Lesser Adjutant, classified as Vulnerable by the IUCN red list was recorded, Near Threatened species, viz. Black-headed Ibis, Black-necked Stork, Eurasian Curlew, Oriental Darter, and Wolly-necked Stork were also recorded here. Four winter migrant waterbird species (Eurasian Curlew, Gadwall, Marsh Sandpiper, & Ruddy Shelduck) were recorded from this stretch and Grey Herons (2.51 sightings km^{-1}) had the highest encounter rate. Gangetic Dolphins occured in high numbers with an encounter rate of 1.94 sightings km^{-1} in 91 detections in 11 sighting occasions The group size for these dolphins was more than 4 individuals. A total of 19 sightings of freshwater turtles (*Pangshura spp.)* were documented in this stretch.

3. THREATS TO THE BIODIVERSITY OF KOSI RIVER

Zone IV (LMZ): The Lower Middle Zone of the Kosi River is subjected to extensive riverbed agriculture and inland water movement through ferryboats. The resultant impact on the river includes over-extraction of water, runoffs rich in fertilisers into the river stream, and hindrance in the movement of aquatic wildlife within the river. Obstruction of floodways by the unscientific constructions within the floodplain in the zone has resulted in aggravation of flood intensity in the region (Valdiya, 2011). In this stretch, extensive sand mining is one of the factors which cause the deterioration of riverbed morphology and create obstruction for aquatic species movements (Figure 3.1, Table 3.1).

Table 3.1 Occurrence of various anthropogenic factors in the Kosi River

Anthropogenic Factors	Occurrence of Anthropogenic Influences in the Kosi River (%)	
	Zone IV	Zone V
Ferry Intensity	59.57	25.53
Fishing Intensity	68.09	29.79
Riverbed Agriculture	59.57	25.53
Sand Mining	55.32	12.77
Water Extraction	10.64	12.77
Built-up	68.09	23.40
Stray Dog	29.79	14.89
Livestock	65.96	27.66

Zone V (LZ): The Lower Zone of the Kosi River is subjected to high intensity of fishing from the river, river-fed ponds, and water-logged reservoirs near the river floodplains. Over-fishing within the region results in by-catch of dolphins in the fishing nets. Construction of embankments within the lower stretch of the river to control the flow of the river leads to sediment deposition in the river channels rising the riverbed levels above floodplains (Valdiya, 2011).

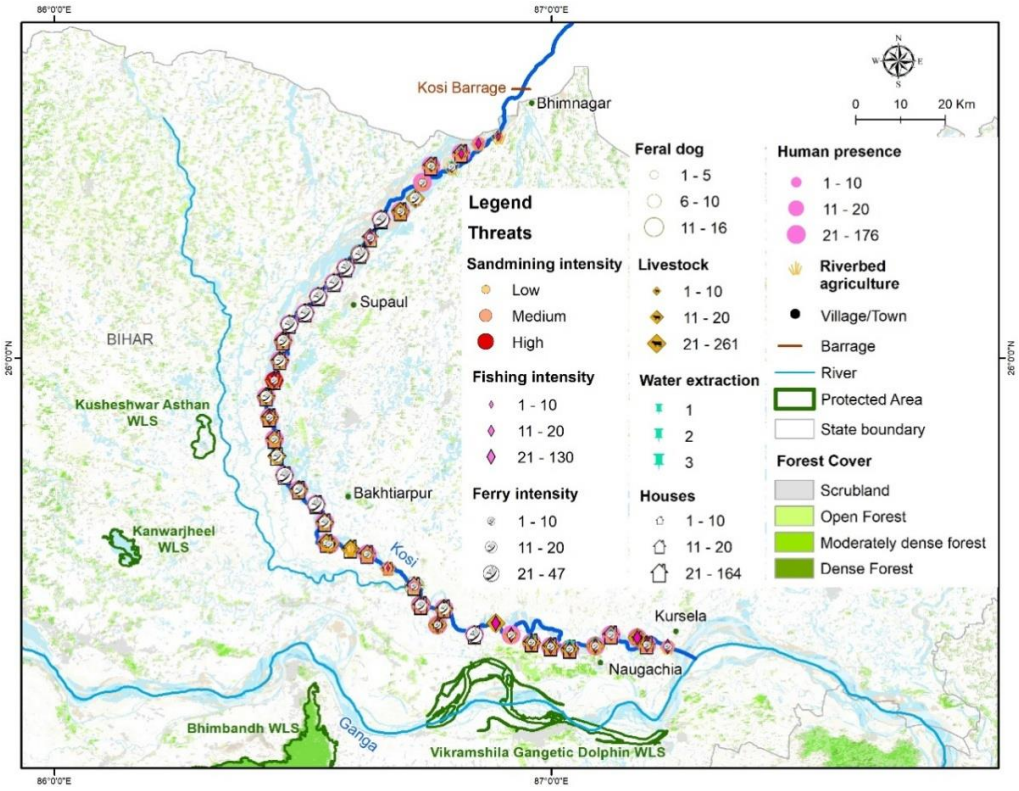

Figure 3.1 Drivers identified during the Post-Monsoon Biodiversity survey in Kosi River

4. CONSERVATION IMPLICATIONS

Rivers are the most endangered ecosystem on the Earth and their biodiversity is declining faster than their terrestrial or marine counterparts (Dudgeon, 2013). The Kosi River sustains a wide variety of aquatic flora and fauna. A well-defined conservation plan is essential for maintaining biodiversity, ecosystem functioning, and reduction of human disstress due to recurrent flooding within the region (Nayak, 1996). From the preliminary study it was concluded that the Kosi River supports rich biodiversity due its varied geomorphological features. The Kosi River in the Indian Territory passes through two distinct zones viz, Lower Middle Zone (LMZ) and Lower Zone (LZ). The river in the LMZ emerges into Kosi megafan and forms braided, wide channels characterised by eroding and depositing banks, meanders and mid-river sandy islands. Howerver, the Lower Zone (LZ) is less braided with wide meandering channel characterised with deep pools and muddy banks.

The occurrence of umbrella species such as Gangetic Dolphin was recorded throughout the survey stretch. However, higher abundance of dolphins were recorded in the LZ (1.51 ± 0.25 sightings km^{-1}) than LMZ (0.38 ± 0.07 sightings km^{-1}). Water bird encounter rate in the LMZ was 9.86 ± 2.43 sightings km^{-1} whereas in the LZ it was found to be 3.37 ± 1.64 sightings km^{-1}. Encounter rate of turtles were higher in LMZ (2.07 ±1.03 sightings km^{-1} than in the LZ (0.23 ± 0.16 sightings km^{-1}).

Thus Gangetic dolphins were more abundant in the lower part of the river, whereas turtles were more abundant in the upper part, emphasising the need for taking into account of the entire geomorphological diversity of the river for holistic biodiversity conservation.

Stretch-specific implications

The two river stretches identified in the Indian Territory of the Kosi River with high biodiversity value need to be studied extensively to formulate a stretch-specific management and river restoration plan. As evident from the literature, the Kosi River in the lower stretch faces extensive sedimentation resulting in a drastic lateral shift in the river course resulting in a rapidly shifting riverscape. This highly dynamic nature of the river has to be taken into account in any management initiative, natural connections of the river with flood plains, lakes and wetlands need to be considered for successful conservation of biodiversity and ecosystem services in the basin.

River hydrology

The preliminary assessment study of the river hydrology and current drainage profile revealed that the average depth of Lower Middle Zone was lower (1.90m ± 1.26) than the Lower Zone (5.16m ± 1.39) of the river.In LMZ river was more braided and in LZ its mostly single channel with variable sinuosity. In Lower Zone, tributaries like Kamla Balan, Bagmati join the Kosi Due to reduction in silt carrying capacity in the flood plains, silts are deposited into the river bed, resulting into rise of river bed, bank erosion and floods. Channel depth plays a crucial role in retaining the distribution of species in the entire stretch and controlling the spillage of excess floodwaters during monsoon season. Kosi basin has a large number of flood control embankments, confining the channel, the long-term impact of these embankments on river-flood plain connectivity and riverine biodiversity is a matter of concern.

Anthropogenic activities

The socio-economic profile of the region needs to be assessed to successful community engagement in biodiversity conservation. Setting up rescue-cum-rehabilitation centers and capacity building of the frontline staff of the forest department, local communities, and the stakeholders along the entire stretch of the Kosi River can help the recovery of threatened species, awareness and engagement may also help reduce the accidental mortality of endangered species such as Gangetic dolphins in fishing nets.

Involvement of local communities

Community participation can play a key role in the conservation of the aquatic ecosystem of the Kosi River. Local communities, those residing near the banks of the river need to be enriched with the knowledge of the role of water-associated species for humankind to make them less dependent on river to improve the river health conditions. Stakeholders like forest departments, local communities, environmental NGOs, or other stakeholders (school, college students) could play a positive role towards aquatic ecosystem conservation. Increased social engagement and sharing of different types of rescue and conservation knowledge could be a game-changer for the restoration and conservation of degraded habitat and endangered aquatic species of the Kosi River.

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ANNEXURE I

Gangetic dolphin (Source: ZSI 1992)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	Biogeographic Province/s
Cetacea	Gangetic dolphin	*Platanista ganagetica* (Roxburgh, 1801)	EN	Schedule I	a	7B,6B
[a]ZSI (1992). Fauna of Bihar including Jharkhand, Part 2. State Fauna Series 11. Calcutta: Zoological Survey of India.						

ANNEXURE II

Crocodilian species of Kosi River (Source: ZSI 1992)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	Biogeographic Province/s
Crocodylidae	Mugger crocodile	*Crocodylus palustris*(Lesson, 1831)	VU	Schedule I	a	7B,6B
[a]ZSI (1992). Fauna of Bihar including Jharkhand, Part 2. State Fauna Series 11. Calcutta: Zoological Survey of India.						

ANNEXURE III

Avifauna of Kosi River

Order	Family	Species	Scientific Name	IUCN Status	IWPA Status	Residential Status	Feeding Guild
Accipitriformes	Accipitridae	Steppe Eagle	*Aquila nipalensis*	EN	I	WM	C
	Pandionidae	Osprey	*Pandion haliaetus*	LC	I	WM/R	P
Anseriformes	Anatidae	Bar-headed Goose	*Anser indicus*	LC	IV	R/WM	H
		Common Merganser	*Mergus merganser*	LC	IV	R/WM	P/C
		Common Pochard	*Aythya ferina*	VU	IV	WM	O
		Gadwall	*Mareca strepera*	LC	IV	WM	H
		Northern Pintail	*Anas acuta*	LC	IV	WM	O
		Red-crested Pochard	*Netta rufina*	LC	IV	WM	H
		Ruddy Shelduck	*Tadorna ferruginea*	LC	IV	WM	O
		Tufted Duck	*Aythya fuligula*	LC	IV	WM	O
Charadriiformes	Charadriidae	Kentish Plover	*Charadrius alexzandrinus*	LC	IV	R/LM	C

		Little-ringed Plover	*Charadrius dubius*	LC	IV	R	C
		Red-wattled Lapwing	*Vanellus indicus*	LC	IV	R	C
		River Lapwing	*Vanellus duvaucelli*	NT	IV	R	C
	Glareolidae	Small Pratincole	*Glareola lactea*	LC	IV	R	I
	Laridae	Brown-headed Gull	*Larus brunnicephalus*	LC	IV	R/WM	C
		Pallas's Gull	*Larus ichthyaetus*	LC	IV	WM	C
	Scolopacidae	Common Greenshank	*Tringa nebularia*	LC	IV	WM	C
		Common Sandpiper	*Actitis hypoleucos*	LC	IV	R/WM	I
		Eurasian Curlew	*Numenius arquata*	NT	IV	WM	C
		Marsh Sandpiper	*Tringa stagnatilis*	LC	IV	WM	C
Ciconiiformes	Ciconiidae	Asian Openbill	*Anastomus oscitans*	LC	IV	R	C
		Black Stork	*Ciconia nigra*	LC	I	WM	C
		Black-necked Stork	*Ephippiorhynchus asiaticus*	NT	IV	R	P/I
		Greater Adjutant	*Leptoptilos dubius*	EN	IV	R/LM	P/O

		Lesser Adjutant	*Leptoptilos javanicus*	VU	IV	R/LM	P/C
		Painted Stork	*Mycteria leucocephala*	NT	IV	R/LM	P/C
		Woolly-necked Stork	*Ciconia episcopus*	NT	IV	R	P/C
Coraciiformes	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	LC	IV	R	P/I
		White-throated Kingfisher	*Halcyon gularis*	LC	IV	R	P/C
Falconiformes	Falconidae	Peregrine Falcon	*Falco peregrinus*	LC	IV	R/WM	P/C
Passeriformes	Motacillidae	White Wagtail	*Motacilla alba*	LC	IV	R	I
		White-browed Wagtail	*Motacilla maderaspatensis*	LC	IV	R	I
Pelecaniformes	Ardeidae	Black crowned Night Heron	*Nycticorax nycticorax*	LC	IV	R/LM	C
		Cattle Egret	*Bubulcus ibis*	LC	IV	R	C/I
		Great Egret	*Ardea alba*	LC	IV	R/LM	P/I
		Grey Heron	*Ardea cinerea*	LC	IV	R	P/I
		Indian Pond Heron	*Ardeola grayii*	LC	IV	R/LM	P/I
		Intermediate Egret	*Ardea intermedia*	LC	IV	R/LM	P/I

		Little Egret	*Egretta garzetta*	LC	IV	R/LM	P/I
	Threskiornithidae	Eurasian Spoonbill	*Platalea leucorodia*	LC	I	R	P/C
		Red-naped Ibis	*Pseudibis papillosa*	LC	IV	R	C
		Black-headed Ibis	*Threskiornis melanocephalus*	NT	IV	R	P/I
Podicipediformes	Podicipedidae	Great Crested Grebe	*Podiceps cristatus*	LC	IV	R/WM	P/C
Suliformes	Anhingidae	Oriental Darter	*Anhinga melanogaster*	NT	IV	R/LM	P
	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	LC	IV	R	P/C
		Indian Cormorant	*Phalacrocorax fuscicollis*	LC	IV	R	P
		Little Cormorant	*Microcarbo niger*	LC	IV	R	P/C

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Abbreviation

EN-Endangered, Vu-Vulnerable, NT-Near threatened, LC-Least Concern

R- Resident, R/LM, Resident with local movement, R/WM, Resident with winter influx, WM-Winter migratory

C-Carnivore, H-Herbivore, O-Omnivore, P-Piscivore, I-Insectivore, P/I-Piscivore/Insectivore, I/H- Insectivore/Herbivore, P/C-Piscivore/Carnivore

ANNEXURE IV

Turtles of Kosi River (Source. ZSI 1992)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	Biogeographic Province/s
Geoemyididae	Red-crowned roofed turtle	*Batagur kachuga* (Gray, 1830)	CR	Schedule I	a	7B,6B
	Three-striped roofed turtle	*Batagur dhongoka* (Gray, 1832)	EN	NL	a	7B,6B
	Crowned river turtle	*Hardella thurjii* (Gray, 1831)	VU	NL	a	7B,6B
	Indian roofed turtle	*Pangshura tecta* (Gray, 1830)	LC	Schedule I	a	7B,6B
	Indian tent turtle	*Pangshura tentoria* (Gray, 1834)	LC	NL	a	7B,6B
	Indian black turtle	*Melanochelys trijuga* (Schweigger, 1812)	LC	NL	a	7B,6B
	Indian eyed turtle	*Moreniapetersi* (Anderson, 1879)	VU	NL	a	7B,6B
Triyonichidae	Indian narrow-headed softshell turtle	*Chitra indica* (Gray, 1830)	EN	Schedule IV	a	7B,6B
	Indian softshell turtle	*Nilssonia gangetica* (Cuvier, 1825)	VU	Schedule I	a	7B,6B
	Indian peacock softshell turtle	*Nilssonia hurum* (Gray, 1830)	VU	Schedule I	a	7B,6B
	Indian flapshell turtle	*Lissemys punctata* (Lacepede, 1788)	LC	Schedule I	a	7B,6B
Testudinidae	Elongated tortoise	*Indotestudo elongate*	CR	Schedule I	a	7B,6B

		(Blyth, 1853)				
ZSI (1992). Fauna of Bihar including Jharkhand, Part 2. State Fauna Series 11. Calcutta: Zoological Survey of India.						

ANNEXURE V

Amphibians of Kosi River (Source: ZSI 1992)

Family	Common Name	Scientific Name	IUCN Status	IWPA Status	Previous studies	Biogeographic Province/s
Dicroglossidae	Asian Grass Frog	*Fejerva ryalimnocharis*	LC	NL	a	7B, 6B
	Common Skittering Frog	*Euphlyctis cyanophlyctis*	LC	NL	a	7B,6B
	Indian Bullfrog	*Hoplobatrachus tigrinus*	LC	Schedule IV	a	7B,6B
Microhylidae	Ornamented Pygmy Frog	*Microhyla ornata*	LC	NL	a	7B,6B
	Banded bullfrog	*Kaloula pulchra* (Gray,1831)	LC	-	a	7B,6B
	White-bellied Pug-snout frog	*Uperodon variegatus* (Stoliczka,1872)	LC	-	a	7B,6B
	Narrow-mouthed frog	*Uperodon systoma* (Schneider,1799)	LC	-	a	7B,6B
Pyxicephalidae	Burrowing Frog	*Tomopterna sp.*	-	-	a	7B,6B
Bufonidae	Indian Common Toad	*Duttaphrynus melanostictus*	LC	NL	a	7B,6B
	Indus marbled toad	*Duttaaphrynus stomaticus*	LC	NL	a	7B,6B
ZSI (1992). Fauna of Bihar including Jharkhand, Part 2. State Fauna Series 11. Calcutta: Zoological Survey of India.						

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