

DIVERSITY, ABUNDANCE, AND TREND OF WATER BIRDS OUTSIDE THE PROTECTED AREA OF WESTERN LOWLANDS, NEPAL

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Abstract

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Waterbirds play a vital role in balancing aquatic ecosystems. Regular studies of their conservation status are crucial. Three major wetlands: Karnali River, Geruwa River, and Badhaiya Lake were surveyed from 2011 – 2016 and 2021 to assess the species and sites' long-term status. We counted all water birds in these areas using the point count method in Badhaiya Lake and the Line transect method for river transects of Karnali and Geruwa. Shannon- Weiner diversity index, Margalef richness index, and Pilou evenness index were calculated for each year and site to understand diversity and richness patterns over time and space. A total of 86 species were observed with an average number of species of 1027.02 per year. The relative abundance of the species showed fluctuations over the study period. The most abundant species was the Ruddy Shelduck (744.91 individuals/year), followed by the Lesser Whistling Duck (494.25). While the Ruddy Shelduck population increased, the Black Stork and Asian Wolly Neck species declined. Among the sites, Badhaiya Lake exhibited the highest Margalef richness index, Pilou evenness index, and Shannon- Weiner diversity index compared to Karnali and Geruwa Rivers. Due to its species richness and waterbird abundance, continuous monitoring and conservation efforts should be prioritized for the site.

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INTRODUCTION

Waterbirds represent a diverse group of birds with over 30 families that are ecologically dependent on wetland habitats (BirdLife International 2017). These birds can maintain the diversity of other organisms, control pests, and form the terminal links in many aquatic food chains and therefore are referred to as effective bio-indicators of ecological conditions, acting as sentinels of potential disease outbreaks (Custer and Osborne 1977, Green and Elmberg 2014). Although with such valuable functioning, waterbird populations are in danger (Wetlands International 2012), with Asia facing the most dramatic decline (BirdLife International 2017).

In the context of Nepal, waterbirds are the second most threatened group (Inskipp *et al.* 2016) fuelled by wetland contraction (Li *et al.* 2017). Nepal harbors a total of 195 wetland-dependent bird species, with the lowland wetlands supporting 187 species (Thapa 2006). Lies in the lowlands, Bardia National Park is an important bird and Biodiversity area (IBA) and its adjoining Badhaiya Lake is a potential IBA of Nepal. Bardia National Park alone holds a total of 513 species of birds 25 of which are globally threatened species (BCN and DNPWC 2019) Birds of Bardia. Bird Conservation Nepal and Department of National Parks and Wildlife Conservation, Kathmandu, Nepal. While Badhaiya Lake which lies east of the Bardia also harbors a large number of residents and wintering populations of waterfowl (ICIMOD 2007).

A study of the species' abundance in the long term is important to understand the fluctuation of bird species and identify their status (Rajpar and Zakaria 2011). Coordinated by Wetlands International, the international waterbird census (IWC) is organized in 143 countries to collect information on the numbers of waterbirds at different wetland sites annually. It is volunteered by thousands of birdwatchers and professionals making it one of the largest citizen sciences programs in the world (Wetland International 2020). National Trust for Nature Conservation, Bardia Conservation Program (BCP) coordinating with Bardia Nature Conservation Club (BNCC) and Nature Guide Association (NGA) conducts waterbird census in Bardia national park and adjoining Badhaiya Lake.

Although the overall report on IWC is regularly published by Wetlands International (e.g., Mundkar *et al.* 2017) site-based publications are lacking. Overall waterbird richness and abundance differ from local sites due to which population fluctuation at the site level will remain obscure enabling local extinction of species. Hence, it is extremely important to analyze the site-level fluctuation of waterbirds to align local conservation efforts. In addition, research and publication are quite abundant from the rest of Bardia such as Ghodaghodi Lake (Lamsal *et al.* 2014), Jagadishpur Lake (Bhusal *et al.* 2020), Chitwan National Park (Khadka *et al.* 2017), Pokhara Lake cluster (Khatri *et al.* 2019), Khaste lake complex (Dhakal *et al.* 2020) Koshi (Chhetri 2006) however, only structured survey in Bardia is dated back to 2005 Kunwar *et al.* 2005). Thus, there was a need for a meticulous look at water birds' status and trends from this site to drive future studies and management intervention. Therefore, this paper

aims to present the results of a long-term survey of waterbirds outside Bardia National Park and adjoining Badhaiya Lake.

MATERIALS AND METHODS

Study Area

The study was conducted in Badhaiya Lake, Geruwa River, and Karnali River of Bardia district (Fig. 1).

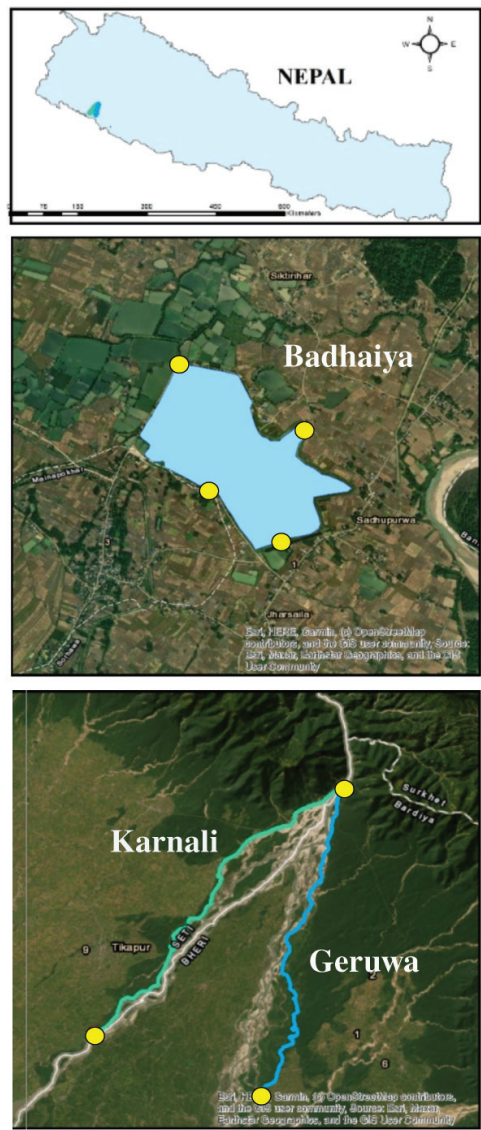


Fig. 1. Localities of the field observations at study areas: Badhaiya, Karnali and Geruwa

Badhaiya Lake: Badhaiya Lake (area 109 hectares; 28° 11' 45" N, 81° 30' 58" E) is a shallow, eutrophic rainfed lake managed by the local community. This is surrounded by agricultural lands where rice and wheat crops are planted seasonally. It holds a great diversity of invertebrates, herpetofauna, and waterbirds (Budha 2010). A total of 4 points were laid for surveying wetland birds in Badhaiya Lake.

Karnali River: Karnali, a perennial river is Nepal's longest river extending to India. Downstream, Karnali harbors fish diversity of around 74 species (Shrestha 2003) and is a functional habitat of the critically endangered Gangetic River dolphin *Platanista gangetica* (Smith 1993). In addition, this river basin has been an important habitat for the Bengal tiger *Panthera tigris tigris*, One-horned Rhinoceros *Rhinoceros unicornis*, and Smooth-coated otters *Lutrogale perspicillata*. We studied 40 km of this river that extends from Karnali Bridge to Daulatpur Ghat.

Geruwa River: Geruwa River channel is a fan out by Karnali downstream from Chisapani. It is further sub-divided into a number of channels making different islands forming mosaic habitats for wetland-dependent fauna such as Gharial (*Gavialis gangeticus*), Mugger crocodile (*Crocodylus palustris*), and various species of turtles (WWF 2006). We studied 27 km of this river that extends from Karnali Bridge to Hattisar.

METHODS

Bird Survey

A wetland bird survey was conducted in the second and third week of January, every year, from 2006 to 2016 and for the year 2021. The point count technique was followed for counting the birds, from 9hr to 15hr. Bushnell (8x42) binoculars and Svarovsky spotting scope (25-60x65) were used to observe the wetland birds which helped to count the birds from a distance without disturbing their activities. The count started in the late morning due to foggy weather.

Karnali and Geruwa river

The study of birds was conducted using a line transect method (Sutherland 2006), following the rivers as transects. The total length of the river surveyed was 67 km (Karnali 40 km and Geruwa 27 km) every year. Surveys on both rivers were conducted on the same day using a riverboat. All the wetland birds encountered or heard were recorded while birds flushing from backward were ignored to avoid double counting the same individuals.

Badhaiya Lake

Birds were surveyed following the point count method (Sutherland 2006). Altogether 4 points were laid to cover every part of the lake. The distance between each point was at least 500m to avoid the species' double count (Sirami *et al.* 2009). Each point was surveyed for 10 minutes, with 5 minutes of settling time. The study re-

corded all the wetland birds, seen, heard, or flushed around 500 meters from the point (Whited *et al.* 2000). The same method was applied for the whole study period from 2006 to 2016 and 2021.

Bird identification

The survey was conducted by a team of 8-10 bird-watching professionals, as well as bird experts (Grimmett *et al.* 2016), and was followed for the identification of confusing bird species and individuals.

Data analysis

Margalef richness index (S), Piloni evenness index (J), and Shannon wiener diversity index (H') were calculated for each year using the Past software. Finally, the average of each of these indexes, richness, and abundance was calculated to compare between sites. We used descriptive statistics, and bar and line graphs to interpret the results. A Map of the study area was prepared using ArcMap 10.8.

RESULTS

Species composition

The study revealed that 36977 bird individuals of 86 species belonging to 9 orders and 22 families were observed during the survey period (Table 1). *Charadriiformes* formed the most abundant order consisting of 26 species followed by *Anseriformes* having 19 species. On the other hand, *Podicipediformes* form the lowest species composition i.e., 2 species followed by *Suliformes* i.e., 3. Among families, *Anatidae* (19 species) was the most dominant family followed by *Scolopacidae* (10 species). At the same time, *Alaudidae*, *Burhinidae*, *Glareolidae*, *Gruidae*, *Hirundinidae*, *Recurvirostridae*, *Rostratulidae*, *Threskiornithidae*, *Anhingidae* were the least dominant family (each with 1 species).

The trend of wetland birds

The number of species recorded in the Karnali River was 26 in 2006 and 23 in 2021. The research showed a slight species variation in all other years except for 2013 with 18 species.

On the other hand, data showed an increment in the species number on Geruwa River and Badhaiya Lake. At the beginning of the research period, both Geruwa River and Badhaiya Lake had 5 species recorded which increased to 36 and 29 species in the year 2021 respectively. It was low number of sightings in Badhaiya during 2006 due to impact using chemical fertilizer for fast growth of exotic carp fish species/. Actually, Badhaiya Lake was given to private business owner for income generation during 2004 and owner used chemical and artificial food for growth of exotic fish species like common carp, grass carp etc. And it was impacted on local fish in 2006 and after.

Table 1
Numbers of species by order and family

Order	Family	Species
Anseriformes	Anatidae	19
Coraciiformes	Alcedinidae	5
Gruiformes	Rallidae	6
	Gruidae	1
Charadriiformes	Scolopacidae	10
	Rostratulidae	1
	Jacanidae	2
	Recurvirostridae	1
	Charadriidae	7
	Glareolidae	1
	Laridae	3
	Burhinidae	1
Podicipediformes	Podicipedidae	2
Suliformes	Phalacrocoracidae	2
	Anhingidae	1
Pelecaniformes	Ardeidae	10
	Threskiornithidae	1
Ciconiiformes	Ciconiidae	5
Passeriformes	Muscicapidae	2
	Motacillidae	4
	Hirundinidae	1
	Alaudidae	1
Total		86

Later on, it was banned for tender business then after recovering the lake as preexisting condition by managing invasive plant etc.

Diversity, Evenness and Richness Indices

Species diversity (Shannon Weiner diversity index, H') and Pilou's evenness index (J) for Karnali was maximum in 2013 with ($H' = 2.21$) and $J = (0.50)$ while Margalef's Richness Index (S) was maximum in 2006 with ($S = 4.27$). For Geruwa H' was maximum in the year 2013 ($H' = 2.27$), J in the year 2006 with ($J = 0.37$), and S is maximum in the year 2015, ($S = 4.74$). In the case of Badhaiya, H' is the maximum in the year 2016 with ($H' = 0.86$), J is the maximum in 2021 with ($J = 0.55$) and S is higher in the year 2016 with ($S = 5.49$).

On average, the Margalef richness index (S), Pilou evenness index (J), and Shannon's Diversity Index (H') were found to be 3.64, 0.30, and 1.89 respectively for the study period. Over the study time, each of these indices has declined slightly in Karnali. While for Geruwa and Badhaiya, the and H' have increased considerably. J has decreased for Geruwa and increased for Badhaiya (Table 2).

Table 2
Diversity indices

Shannon's Diversity Index				Pilou Evenness Index			Margalef's Richness Index		
Years	Karnali	Geruwa	Badhaiya	Karnali	Geruwa	Badhaiya	Karnali	Geruwa	Badhaiya
2006	2.147	0.6168	0.7976	0.3162	0.3706	0.444	4.113	0.8298	1.134
2007	2.08	0.5064	2.153	0.3201	0.3318	0.2778	3.953	0.8543	4.26
2008	2.045	0.7256	2.228	0.2973	0.2066	0.2651	3.315	1.66	4.25
2009	2.025	0.7307	2.141	0.2705	0.1888	0.2744	3.583	1.836	3.766
2010	1.833	0.6857	2.185	0.2234	0.1985	0.2539	3.679	1.648	4.267
2011	1.844	1.77	2.841	0.2529	0.2551	0.476	3.521	3.618	5.129
2012	2.083	2.342	2.257	0.3087	0.2971	0.2987	4.069	5.149	4.513
2013	2.17	2.252	2.674	0.4866	0.3521	0.3919	3.243	3.968	4.992
2014	1.942	1.805	2.33	0.2681	0.2171	0.2936	4.139	4.215	4.455
2015	1.977	2.052	2.391	0.2674	0.2161	0.2801	4.233	4.744	5.186
2016	1.857	1.683	2.872	0.2783	0.207	0.4311	3.41	3.431	5.632
2021	1.935	1.744	2.778	0.3009	0.1635	0.5547	3.401	4.659	3.961

Abundance of notable species and their status

Ruddy Shelduck *Tadorna ferruginea* was the most abundant species with 744.91 individuals/ year followed by Lesser Whistling Duck *Dendrocygna javanica* (494.25 individuals/year). White-capped Water Redstart *Phoenicurus leucocephalus* (0.08 individuals/year), Common Snipe *Gallinago gallinago* (0.08 individuals/year), Brown-headed Gull *Chroicocephalus brunnicephalus* (0.08 individuals/year), Citrine Wagtail *Motacilla citreola* (0.08 individuals/year), and Stork-billed Kingfisher *Pelargopsis capensis* (0.08 individuals/year) were the least abundant bird with only one record during the survey period. Our study also found the presence of critically endangered Baer's Pochard *Aythya baeri* from Badhaiya Lake in 2015, a vulnerable Sarus Crane *Grus antigone* and a near-threatened Asian Woolly Neck *Ciconia episcopus*. Overall, we found a significant increase in the count of Ruddy Shelduck *Tadorna ferruginea* and a decline in the count of Black Stork *Ciconia nigra* and Asian Woolly Neck. The rest of the species were found to have fluctuating populations within years.

Number dynamics of important species

A notable difference in the number of species was observed during the study period. The major cause of the fluctuating numbers is the subject of future studies as there may be underlying reasons for the change in the number of species. Among the seven species presented in the figure, Black-headed Ibis *Threskiornis melanocephalus* and Woolly Neck Storks were observed in all three sites over the years. Black Storks were observed from 2013- 2016 in Geruwa and Karnali. Painted Stork *Mycteria leucocephala* was only observed in Badhaiya from 2010. Sarus Crane and Bayer's Pochard *Aythia baeri* were only observed in Badhaiya Lake.

Twenty different species that are globally/nationally important were observed. Important observations about trends and patterns in bird count for each species over the years and across different sites are presented separately.

1. Bar-headed Goose *Anser indicus*. The counts for Bar-headed Goose are consistently low (mostly 0) across all years and sites, including a very low or no presence of this species in observed areas as its presence was observed only in Geruwa in the year 2006.
2. Ruddy Shelduck. Ruddy Shelduck counts vary over the years and sites. Karnali and Badhaiya in 2008 had significantly higher counts 502 and 310 respectively. The highest number i.e., 754 was observed in Geruwa in the year 2021.
3. Northern Pintail *Anas acuta*. Northern Pintail counts are generally low, with occasional higher counts in Badhaiya. The count was stable i.e., 350 in the years 2008, 2009 and 2010. While the highest count was 410 in the year 2015.
4. Great Cormorant *Phalacrocorax carbo*. Great Cormorant counts show a notable increase in Karnali in 2009 and 2010, especially compared to Geruwa and Badhaiya. After which the number decreased sharply in Karnali and there were fluctuations in number over other years and sites.
5. Common Pochard *Aythya ferina*, Baer's Pochard, Sarus Crane, Pheasant-tailed Jacana, *Hydrophasianus chirurgus*, Grear Thick-Knee *Esacus recurvirostris*, Northern Lapwing *Vanellus vanellus*, River Lapwing *Vanellus duvaucelii*, Small Pratincole *Glareola lactea*, Brown-headed Gull *Chroicocephalus brunnicephalus*, River Tern *Sterna aurantia*. These species have varying counts across years and sites. Some species show occasional spikes in counts indicating fluctuations in their population.

Number dynamics of common Species

Besides these species, the information about common species is also important to know the importance of the bird habitat as well. Some common species and their number dynamics are explained below.

1. Gadwall *Mareca strepera*. The highest number of Gadwall observed in the Karnali site occurred in 2021, with a substantial increase to 1708 individuals. In contrast, the species was absent in 2006. Their population remained low for a few years but started to increase in 2009 onwards, reaching 1708 individuals in 2021. Similarly,

their number remained low in 2006- 2009. However, in 2010, there was a significant surge, with 1708 individuals observed in 2021.

2. Mallard *Anas platyrhynchos*. The highest number of Mallards was recorded in 2007, with 153 individuals. They were not recorded in Karnali in 2006 while Mallards' numbers increased notably in 2007 in Geruwa similar to Badhaiya as the highest number of Mallards were observed there.
3. Little Cormorant *Microcarbo melanoleucos*. The highest number of Little Cormorants was recorded in 2007, with 105 individuals. The species was absent in 2006. The data suggests a substantial surge in Little Cormorants populations in 2007 across all sites, highlighting the sharp increase in their numbers.
4. Common Teal *Anas crecca*. The highest number of Common Teal was recorded in 2014, with 231 individuals. They were not seen during the year 2006 in Karnali. Their number increased significantly in 2014, with 257 individuals similar to Karnali with no individuals observed. The case is similar to Badhaiya Lake.
5. Common Merganser *Mergus merganser*. The highest number of Common Merganser was observed in 2011, with 2132 individuals. In 2006, there were 19 individuals in Karnali while the highest population in 2014 with 2132 individuals with no observation in 2006. Similarly, in 2011, we observed highest number in Badhaiya with the number 2132 individuals.
6. Common Greenshank *Tringa nebularia*. The highest number of Common Greenshanks was observed in 2013 in all three sites with 425 individuals. In 2006, there were only five individuals in Karnali, three in Badhaiya, and no individuals in Geruwa.
7. Green Sandpiper *Tringa ochropus*. The highest number of Green Sandpipers was recorded in 2013 in all three sites, with 126 individuals. There were only 3 in 2006 in Karnali, no records in Geruwa, and only four in Badhaiya in the year 2006.

Other common species found in the sites are Common Sandpiper *Actitis hypoleucos*, Little Stint *Calidris minuta*, Temminck's Stint *Calidris temminckii*, Little Ringed Plover *Charadrius dubius*, Grey-headed Lapwing *Vanellus cinereus*, Little Egret *Egretta garzetta*, Great Egret *Ardea alba*, Grey Heron *Ardea cinerea*, Intermediate Egret *Ardea intermedia*, Indian Pond Heron *Ardeola grayii* and Grey Wagtail *Motacilla cinerea*.

Comparison between sites

Diversity and richness indices have declined in Karnali and increased in both Geruwa and Badhaiya. While there are fluctuations in all three studied sites regarding the evenness index.

Among three surveyed sites, Badhaiya Lake has a higher average Margalef's richness index ($S = 4.33$, Species richness = 32.2 per year) followed by Karnali ($S = 3.68$, Average Species richness = 24.7 per year) and lowest at Geruwa ($S = 3.07$, Species richness = 21 per year). Similarly, the average Pilou evenness index (J) was maximum in Badhaiya (0.35) followed by Karnali (0.30), and least at Geruwa ($P = 0.25$). Finally, average species diversity was maximum at Badhaiya (Shannon-Weiner index, $H' = 2.25$) followed by Karnali ($H' = 2$) and least at Geruwa ($H' = 1.48$). Similarly, an

abundance of wetland birds was maximum in Badhaiya Lake (1594.5 birds per year) followed by Geruwa (662.08) and least in Karnali (824.91).

Brown-headed gulls *Chroicocephalus brunnicephalus* and Oriental Darters *Anhinga melanogaster* were only recorded in Karnali. Common Pochard, Brown crane (*Zapornia akool*), Dunlin *Calidris alpina*, and River Tern *Sterna aurantia* were exclusively recorded in Geruwa. Badhaiya Lake comprised 15 species that were not found in the other two sites. They were Gadwall, Northern Pintail, Northern Shoveler, Common Teal, Ferruginous Pochard *Aythya nyroca*, Baer's Pochard, Stork-billed Kingfisher, Sarus Crane, Spotted Redshank, Purple Swampphen *Porphyrio porphyrio*, Painted Stork, Common coot *Fulica atra*, Northern Lapwing, Citrine Wagtail *Motacilla citreola*, and Black-winged Stilt *Himantopus himantopus*.

Conservation status of important bird species

The table presents the conservation status of various bird species, both at the global and national levels, as assessed by the International Union for Conservation of Nature (IUCN) along with their sighting years in our study sites: Karnali, Geruwa and Badhaiya. This data provides the species' conservation status and local presence within the study area. The IUCN categories are used to evaluate the extinction risk of species, with designations ranging from "Least Concerned" (LC) for species at lower extinction risk to "Critically Endangered" (CR) for those at the highest risk of extinction (Table 3).

1. **Global Conservation Status.** We noticed a diversity of conservation statuses among the species recorded. Among them, some important species are presented in the table. While some species like Bar-headed Goose and Pheasant-tailed Jacana are categorized as "Least Concern" globally, others face more significant conservation concerns. Two species, the Baer's Pochard and the Great Thick-Knee *Esacus recurvirostris* are classified as "Critically Endangered" on a global scale, indicating an urgent need for conservation efforts to prevent their extinction. Many species fall into the "Vulnerable" category, including the Common Pochard, Sarus Crane, and River Tern, signifying a high risk of extinction if threats are not addressed.
2. **National Conservation Status.** At the national level, the conservation statuses of these species may vary, reflecting regional differences in threats and population trends. Here, for instance, while the Great Cormorant is "Least Concern" (LC) globally, its national status is "Near Threatened" (NT), highlighting potential regional challenges to its conservation. The Black Bittern *Ixobrychus flavicollis* listed as "Least Concern" globally, is categorized as "Endangered" (EN) at the national level, underscoring the importance of considering local factors in conservation planning.

This assessment of conservation status provides a valuable baseline for understanding the current vulnerability of bird species within the study area. It underscores the need for targeted conservation efforts particularly for species facing higher extinction risks, to safeguard avian biodiversity in the region. These findings contribute to our broader understanding of ecological dynamics and support evidence-based conservation decision-making.

Table 3
Table showing the Conservation status of important birds observed

Name of species	Scientific name	IUCN status Global/ National
Bar-headed Goose	<i>Anser indicus</i>	LC/NT
Ruddy Shelduck	<i>Tadoma ferruginea</i>	LC/NT
Northern Pintail	<i>Anas acuta</i>	LC/EN
Common Pochard	<i>Aythya ferina</i>	VU/NT
Baer’s Pochard	<i>Aythya baeri</i>	CR/CR
Sarus Crane	<i>Grus antigone</i>	VU/VU
Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	LC/VU
Great Thick-Knee	<i>Esacus recurvirostris</i>	NT/CR
Northern Lapwing	<i>Vanellus vanellus</i>	NT/NT
River Lapwing	<i>Vanellus duvaucelii</i>	NT/NT
Small Pranticole	<i>Glareola lacteal</i>	LC/NT
Brown- headed Gull	<i>Larus brunnicephalus</i>	LC/VU
River Tern	<i>Sterna aurantia</i>	VU/CR
Great Cormorant	<i>Phalacrocorax carbo</i>	LC/NT
Black Bittern	<i>Ixobrychus flavicoliis</i>	LC/EN
Black-headed Ibis	<i>Threskiornis melanocephalus</i>	NT/NT
Painted Stork	<i>Mycteria leucocephala</i>	NT/EN
Asian Openbill	<i>Anastomus oscitans</i>	LC/VU
Black Stork	<i>Ciconia nigra</i>	LC/VU
Wolly- neck Stork	<i>Ciconia episcopus</i>	NT/NT

*IUCN: International Union for Nature Conservation, LC: Least Concerned, NT: Near Threatened, EN: Endangered, VU: Vulnerable, CR: Critically Endangered

Abundance category of the species

The study recorded 86 species of waterbirds in the study sites. According to frequency of occurrence over the years the species were categorized into five different categories. Since we have long-term data, we categorized the species as follows:

- Rare: Species that have not occurred in the site.
- Occasional: Species that were observed for 1-3 years in the site.
- Uncommon: Species that were observed for 4-6 years in the site.
- Fairly common: Species that were observed for 6-9 years in the site.
- Very Common: Species that were observed for 9-12 years in the site.

The abundance category of birds recorded for all three species is presented in the stacked diagram below (Fig. 4). There is high human activities in Karnali but the flow of water is regular. Geruwa flow via core area of National Park so that no any human activities. But, Badhaiya is highly disturbed in human domesticated landscape. Water is stagnant like pond or lake.

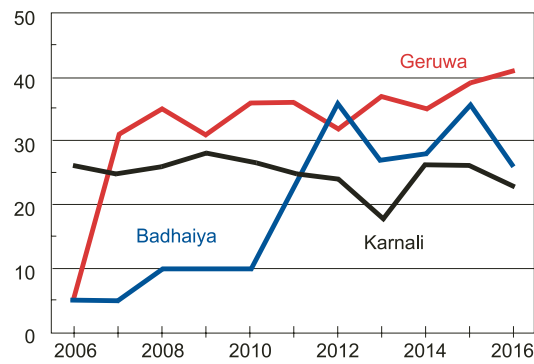


Fig. 2. Numbers of observed species at study areas

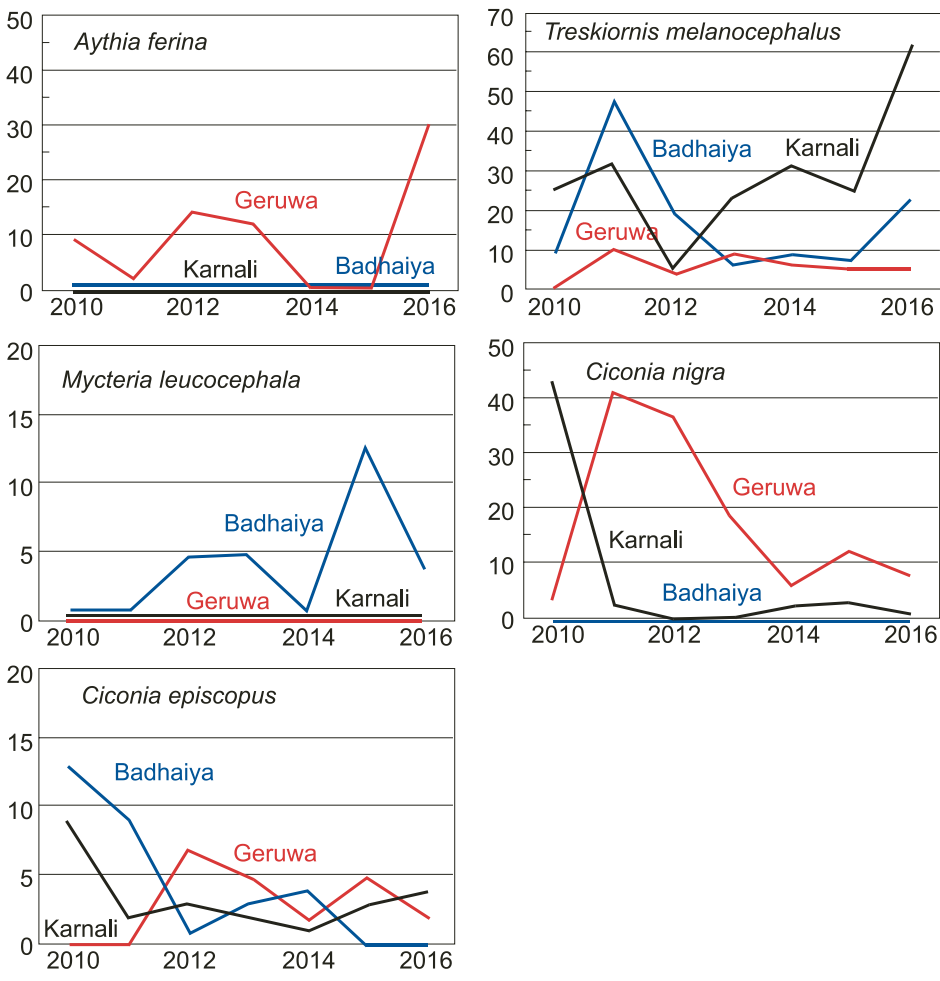


Fig. 3. Numbers of observed birds of some the most common species

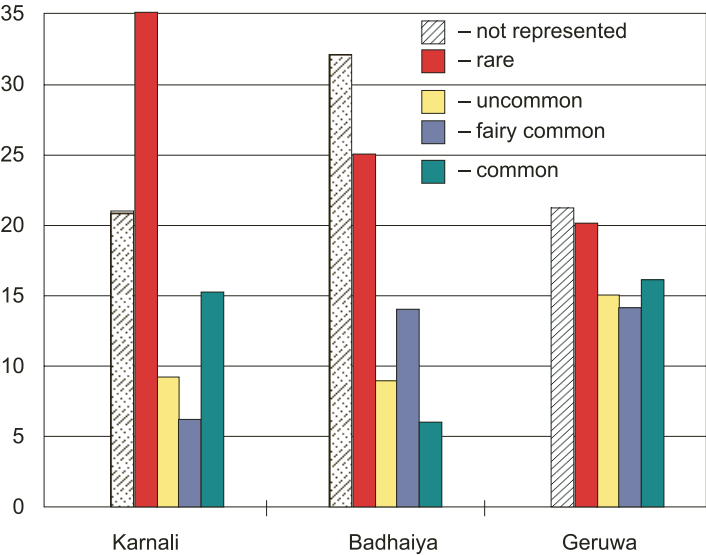


Fig. 2. Numbers of observed species at study areas

DISCUSSION

A national update on the waterbird survey by Nepal and Thapa (2018) reported 1379 individuals of 87 species of waterbirds. Our study site has 86 species, which shows that Karnali River, Geruwa River, and adjoining Badhaiya Lake hold more than two-thirds of waterbird species found in Nepal, a high-value wetland bird habitat. In line with this result Geruwa, - Karnali is taken as a healthy habitat for the bird population (Chaudhari *et al.* 2009). Similarly, Badhai Lake is regarded as the most important wetlands supporting various globally and nationally threatened species (Nepal and Thapa 2020). *Anatidae* was the most dominant, and *Anhingidae*, *Glareolidae*, *Gruidae*, *Recurvirostridae*, *Rostratulidae*, and *Threskiornithidae* were the least dominant families in overall Nepal (Nepal and Thapa 2018). Our study shows somewhat similar results as *Anatidae* comprises the most dominant family while *Alaudidae*, *Burhinidae*, *Glareolidae*, *Gruidae*, *Hirundinidae*, *Recurvirostridae*, *Rostratulidae*, *Threskiornithidae*, *Anhingidae* were found to be the least dominant families.

Ruddy Shelduck is the most dominant species in our study similar to the study done in Chitwan National Park (Khadka *et al.* 2017). Our study has similar results and is mainly focused on the riverine habitat which is the prime habitat preference for these species by Kear (2005) and Namgail *et al.* 2013. An increase in Ruddy Shelduck indicates that Karnali and Geruwa have been great functions for their ecological requirement. Another possible reason could be the lack of human disturbance within the national parks. However, a decline in Asian Woolly Neck and Black Storks couldn't be interpreted. Asian Woolly Neck breeds within the national park while the

Black Stork is a winter visitor. This declining trend could be an aspect of future research.

Species such as Brown-headed Gull and Stork-billed Kingfisher are occasionally observed which are among the least dominant species. The presence of globally threatened species within the study site demands conservation attention.

It is not surprising that Badhaiya Lake has high species abundance, richness, and diversity. This is because the lakes of Nepal are known to provide a habitat for wintering waterbirds (e.g., Ghodaghodi Lake, Jagadishpur Lake, Phewa Lake; Nepal and Thapa 2018; Khatri *et al.* 2019; Bhusal *et al.* 2020). Badhaiya supports many globally threatened species and is home to the largest population of visiting Painted Storks (Ghimire *et al.* 2021). This lake is sandwiched between agricultural fields making diverse habitats for wetland-dependent species. This is different in the case of Geruwa and Karnali which mainly run through the forest. These three sites also support a considerable number of important bird species. This provides another compelling reason why each site should be taken into consideration for the conservation of important bird habitats in the Western lowlands of the country.

CONCLUSION

All three sites are important for the avian population. However, the higher Shannon's Diversity Index, Pielou's Evenness Index, and Margalef's Richness Index in Badhaiya show that it is an important bird hub among other studied sites. Badhaiya has also been home to many waterbirds. Regular monitoring should be conducted and additional conservation attention should be given to these sites to conserve the integrity of the sound waterbird habitat. Ruddy Shelduck is the most dominant species which has increased during our study period. The decrease in Asian Woolly Neck and Black Storks demands grave attention. The fluctuating number of bird species over time should be taken seriously and the underlying threats should be studied cum mitigated. Furthermore, conservation awareness campaigns would be beneficial to conserve the birds present in the study site.

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REFERENCES

- Bhuju U.R., Shakya P.R., Basnet B. and Shrestha S. 2007. *Nepal biodiversity resource book: protected areas, Ramsar sites, and World Heritage sites*. International Centre for Integrated Mountain Development (ICIMOD).
- Bhusal K.P., Rana D.B., Joshi A.B., Chaudhary I.P., Ghimire P. and Pandey M. 2020. Diversity and abundance of winter wetland birds in Jagdishpur Reservoir Ramsar Site, Kapilvastu, Nepal. *Danphe Q. Newsl*, 29: 1-13.
- BirdLife International 2017. Waterbirds are showing widespread declines, particularly in Asia.
- Budha P.B. 2010. Inventory of wetland fauna and sustainable resource utilization of Bahraiya Lake, Bardiya, mid-Western Nepal: issues and future prospects. *TIGERPAPER, Regional Quarterly Bulletin on Wildlife and National Park Management* 37: 10-20.
- Chhetry D.T. 2006. Diversity of wetland birds around the Koshi Barrage area. *Our Nature* 4(1): 91-95.
- Custer T.W., Osborn R.G. 1977. *Wading birds as biological indicators: 1975 colony survey* (Vol. 206). Department of the Interior, Fish and Wildlife Service.
- Dhakal H., Ghimire M., Poudel A.K., Ghimire P. and Bhusal K.P. 2020. Avian Diversity of Khaste Lake Complex, Pokhara Valley, Nepal. *Minivet* 3: 17-25.
- Green A.J. and Elmberg J. 2014. Ecosystem services provided by waterbirds. *Biological reviews* 89(1): 105-122.
- Inskipp C., Baral H.S., Phuyal S., Bhatt T.R., Khatiwada M., Inskipp T., Khatiwada A., Gurung S., Singh P.B., Murray L. and Poudyal L. 2016. The Status of Nepal's Birds: The National Red List Series. Zoological Society of London. Accessed online 19 May 2016.
- Kear J. ed. 2005. *Ducks, Geese, and Swans: Species accounts (Cairina to Mergus)* (Vol. 2). Oxford University Press.
- Khadka B.B., Acharya P.M. and Rajbhandari S.L. 2017. Population status and species diversity of wetland birds in the Rapti and Narayani rivers and associated wetlands of Chitwan National Park, Nepal. *Journal of Threatened Taxa*, 9(6): 10297-10306.
- Khatri N.D., Neupane B., Timilsina Y.P. and Ghimire S., 2019. Assessment of avifaunal diversity and threats to them in Phewa wetland, Nepal. *Forestry: Journal of Institute of Forestry, Nepal* 16: 31-47.
- Lamsal P., Atreya K., Pant K.P. and Kumar L. 2017. People's dependency on wetlands: South Asia perspective with emphasis on Nepal. *Wetland Science: Perspectives From South Asia*: 407-419.
- Lamsal P., Pant K.P., Kumar L. and Atreya K. 2014. Diversity, uses, and threats in the Ghodaghodi Lake complex, a Ramsar site in western lowland Nepal. *International Scholarly Research Notices* 2014.
- Li A., Lei G., Cao X., Zhao W., Deng W. and Koirala H.L. 2017. Land cover change and its driving forces in Nepal since 1990. *Land cover change and its eco-environmental responses in Nepal*: 41-65.
- McInnes R.J., Davidson N.C., Rostron C.P., Simpson M. and Finlayson C.M. 2020. A citizen science state of the world's wetlands survey. *Wetlands*, 40(5): 1577-1593.
- Mundkur T. and Nagy S. eds. 2012. *Waterbird Population Estimates: Summary Report*. Wetlands International.
- Namgail T., Takekawa J.Y., Sivananthaperumal B., Sathiyaselvam P., Areendran G., Mundkur T., Mcracken T. and Newman S. 2013. Ruddy Shelduck Tadorna ferruginea home range and habitat use during the non-breeding season in Assam, India. *Wildfowl*, 61(61): 182-193.
- Nepal K. and Thapa I. 2018. Water bird count 2017 in wetlands of nepal. *Danphe Q. Newsl*, 27: 1-8.

- Nepal W.W.F., 2006. Status, Distribution and Conservation Threats of Ganges River Dolphin in Karnali River, Nepal. *WWF-Nepal, Kathmandu*. [11].
- Rajpar M.N. and Zakaria M., 2011. Bird species abundance and their correlation with microclimate and habitat variables at Natural Wetland Reserve, Peninsular Malaysia. *International Journal of Zoology* 2011.
- Shrestha T.K. 2003 February. Conservation and management of fishes in the large Himalayan rivers of Nepal. In *Second International Symposium on the Management of large rivers for fisheries*: 1-19.
- Sirami C., Seymour C., Midgley G. and Barnard P. 2009. The impact of shrub encroachment on savanna bird diversity from local to regional scale. *Diversity and Distributions*, 15(6): 948-957.
- Smith B.D. 1993. 1990 Status and conservation of the Ganges River dolphin *Platanista gangetica* in the Karnali River, Nepal. *Biological Conservation*, 66(3): 159-169.
- Sutherland W.J. ed. 2006. *Ecological census techniques: a handbook*. Cambridge university press.
- Whited D., Galatowitsch S., Tester J.R., Schik K., Lehtinen R. and Husveth J. 2000. The importance of local and regional factors in predicting effective conservation: Planning strategies for wetland bird communities in agricultural and urban landscapes. *Landscape and Urban Planning*, 49(1-2): 49-65.