Evaluation of Water Birds Population Trends, Threats, and Conservation Status in Selected Wetlands of Pakistan

Inam Ullah[1,2], Sun Xue-Ying[1], Wu Qing-Ming[1]*, Deng Wen-You[1], Tauheed Ullah Khan[3], Muhammad Nawaz Rajpar[4], Tariq Ahmad[1] and Muhammad Suliman[1]

[1]*College of Wildlife and Protected Areas, Northeast Forestry University, No 26, Hexing Road, Harbin 150040, P. R. China*

[2]*Department of Zoology, Sub-Campus Gomal University Tank. Khyber Pakhtunkhwa, Pakistan*

[3]*Guangdong Key Laboratory of Animal Conservation and Resource Utilization, Guangdong Public Laboratory of Wild Animal Conservation and Utilization. Institute of Zoology, Guangdong Academy of Sciences, Guangzhou, China*

[4]*Department of Forestry, Faculty of Life Sciences, Shaheed Benazir Bhutto University Sheringal, Dir (Upper), Khyber Pakhtunkhwa, 18051, Pakistan*

Inam Ullah and Sun Xue-Ying are co-first author.

ABSTRACT

Water birds are considered to be important biological indicators for measuring the quality and significance of wetlands. We conducted field surveys at the six wetlands from each September to March 2017-2022. Data were collected using point count methods at one to fifteen vantage points in each sub-lake using binoculars, monocular, and Nikon D7200 (150-600 lens). A community-based survey including questionnaires and interviews with local hunters, shepherds, farmers, shopkeepers, and students at local schools, colleges, and universities. A total of 450 questionnaires were filled. Exclusively, 73 water birds from 11 orders were observed. Results showed the species composition of Charadriiformes exceptionally high (20 spp., 27.39%), while the lowest order was Accipitriformes (1 spp., 1.36%). Population trends for 73 water bird species, 16 (11.19%) birds species exhibited an increasing trend, 27 species (36.98%) declined, 6 species (8.21%) remained stable, while population trends for 24 species (32.87%) were unknown. 13 species (17.8% of the total) have been listed as threatened species, including 8 species (10.95%) listed as near threatened, 2 species (2.73%) vulnerable, and 2 species (2.73%), while the remaining 61 (83.56%) species listed as least concern. Major threats for water birds were hunting, habitat loss, degradation, climate change, use of pesticides, pollution, human disturbance, trading, and agricultural development. Out of 73 species, 14 (56.16%) were pollution, 34 (46.57%) were human disturbance, 31 species (42.46%) were hunting, 30 species (41.09%) pollution, 22 species (30.13%) trading, 20 species of waterbirds are affected by pesticides (27.39%), 17 species (23.28%) climate change, 12 species (16.43%) agricultural development. The most hunted group is Anseriformes (43%), while the least is Suliformes (2%). The recommendation was suggested to conserve the water birds in the study area.

INTRODUCTION

Water birds are important biological indicators for measuring the quality and significance of wetlands as they are ecologically dependent upon wetlands. Among the many species that live in wetlands, there is a very diverse range of plants and animals. The number of wetlands that have disappeared globally has reached more than half over the past century, largely because of land conversion by humans over the course of the past century (Ma *et al.*, 2014; Davidson, 2018; Xu *et al.*, 2019). Waterbird populations have declined due to the loss of

wetlands (Studds *et al*., 2017). Around 23% of global water bird populations are declining due to habitat loss, pollution, overhunting, biological invasions, and climate change. Some water birds with small populations have not been recorded in the field in recent years, and 19% of water birds are threatened by the International Union for Conservation of Nature (IUCN). Globally, water bird conservation has received increasing attention due to the rapidly declining diversity of waterbirds (Wang *et al*., 2018). Wetlands are vital for all living beings (Ashraf *et al*., 2019), necessary for life and the evolution of life (Greb *et al*., 2006; Ali *et al*., 2018). The earth is covered by wetlands to the extent of approximately 2.5 million squares kilometers. The number of Ramsar sites in the world has almost reached 2400. Out of the total wetland area, 0.78 million hectares area is in Pakistan, 19 Ramsar sites are noted in Pakistan (Altaf *et al*., 2014).

Located at 30.3753°N and 69.3451°E in South Asia, Pakistan is a middle Asian migratory bird fling route that is connected to the West Asian fling routes and the East African migratory bird routes. It serves as a middle Asian fling route for birds passing through this part of the world (Umar *et al*., 2018). Across the Karakoram Range and down to the deltas of the Indus River in the south of the country, the migratory bird route number 4, more commonly known as the Indus Flyway, is a route of migratory birds. Water birds arriving from Siberia are found in abundance throughout the country's wetlands, which are found from the northern mountains to the southern coast. Approximately 4500 kilometers of perilous travel are taken by about 400 migratory birds each year in Pakistan (Galbraith, 2014). Indus basin wetlands and Ramsar sites facilitate these birds' 4-5-months trek in Pakistan that provides them habitat and food requirements. From September to November, these birds migrate into Pakistan via the Indus flyway, crossing the Karakorum and the Suleiman Mountain ranges, and then entering the delta of the Indus River, near the Arabian Sea, where they stay until February or March, before returning to their breeding grounds (Sheikh and Kashif, 2006).

Globally, there are 10960 species of birds, of which 1460 (13% of the species) are considered globally threatened (Cabrera-Cruz *et al*., 2018). Near threatened (NT) species include 1029 that are currently prone to being threatened due to the effects of climate change and human activity (Şekercioğlu *et al*., 2004). According to the available data on species conservation, there are 8405 species that are of least concern (LC), 449 species that are endangered (EN), and 786 species that are vulnerable (VU). In the Indo-Pak subcontinent, 2060 bird species have been reported, while in Pakistan, 656 bird species belonging to 272 genera have been reported, of which 63.4% are migrants that migrate in

winter, 43% are visiting species from Palearctic regions, 28% are regular winter visitors, and 33% use wetlands for food, shelter and breeding (Mirza, 2012; Akrim *et al*., 2019). In addition to anthropogenic landscapes, natural landscapes nearby may also play a role in wildlife conservation. It is unlikely that anthropogenic landscapes will play a significant role in population maintenance in areas where natural landscapes are well protected, whereas in areas where natural landscapes have been dramatically lost and degraded, anthropogenic landscapes can significantly contribute to wildlife conservation since there is no better habitat available (Tourenq *et al*., 2001; Jackson *et al*., 2020). It has been shown in previous studies that population trends vary by region for some species. The variation is due to differences in habitat conservation and management efforts at the local or regional level (Boere *et al*., 2006; Amano *et al*., 2010). Anthropogenic landscapes may contribute to the mitigation of population decline in different ways at different regions (e.g., along flyways).

The main aim of the current study is to find out the current population trends, threats facing, and conservation status of water birds in specific six wetlands from Punjab and Sindh province of Pakistan. Also, how to conserve them and suggested advance recommendation.

MATERIALS AND METHODS

Study area

This study was conducted at six different wetlands in Pakistan in order to identify current population status, threats, and conservation status of water birds. Total six sites were covered during field visits that were Uchali Wetland, Chashma Wetland, Dhapchapak Wetland, Taunsa Wetland, Raja Wetland, and Haleji Wetland. Raja and Haleji wetland are located in Sindh Province while the rest of four wetland are located in Punjab (Fig. 1, Table I).

Field visit and community-based survey

We conducted field surveys at the six wetlands from each September to March from 2017 to 2022. We surveyed birds using point count methods at one to fifteen vantage points in each sub lake using binoculars, monocular, and Nikon D7200 (150-600 lens) for five consecutive winter seasons. (Survey was conducted 11-12 times during suitable weather condition during each season) A random selection of observation sites was undertaken along the shorelines of each lake and adjacent wetlands, with high points being preferred. Topography, accessibility, structure, composition of vegetation, and observer safety were considered when establishing point count stations. The survey was carried out early in the morning from 07:30 Am to 11: 00 Am.

Table I. The study area.

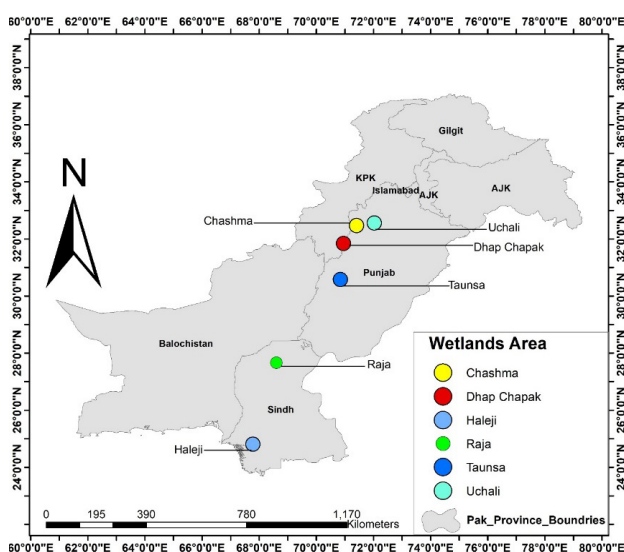| Wetland	Province	Latitude	Longitude	Relative humidity	Average depth (m)	Elevation (m)
Chashma	Punjab	32° 26' 54.79"	71° 26' 21.64"	22.0 – 85.0%	3.2	193
Dhapchapak	Punjab	31° 44' 15"	70.9° 41' 12"	20.0 – 82.0%	2.5	171
Taunsa	Punjab	30° 32' 20.78"	70° 49' 35.51"	25.0 – 85.0%	3.1	140
Uchali	Punjab	32° 33' 16.54"	72° 1' 9.28"	22.0 – 85.0%	3.9	762
Haleji	Sindh	24°48' 41.90"	67°47' 15.62"	21.0 – 86.0%	3.7	4.2
Raja	Sindh	27°39' 42.30"	68°36' 0.47"	23.0 – 85.0%	2.2	54

Fig. 1. Map of Pakistan showing study areas.

Threats and checklist

To collect data about population, threats, and conservation status of water birds, six sites were visited. Information was collected by filling questionnaire, interviewing from local hunters, shepherds, farmers, shopkeepers, and students at local schools, colleges, and universities. The community-based survey was used to understand the total number of water birds killed during 2017-2022 in six wetlands from Sindh and Punjab Province Pakistan

To understand the major threats to the water bird species, we observed personally threats facing like hunting, poaching etc., also conducted data from local wildlife office. We searched literature published about water birds from journals and websites. We also searched the database of the IUCN Red Lists (IUCN Red List of Threatened Species) and the Handbook of Birds of the World (Birds of the World- Cornell Lab of Ornithology).

RESULTS

Species composition

A total, 73 wintering waterbirds species grouped into 11 orders, and 73 species were observed in the study sites (Table II) during the 5 winter seasons from 2017 to 2022. Similarly, on species composition (Fig. 2), the number of species in the order Charadriiformes recorded was high (20 spp., 27.39%) followed by Anseriformes (16 spp.,

Table II. Population trends of waterbirds in each order.

Order	Increasing	Declining	Stable	Unknown	Number of species
Accipitriformes	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1
Anseriformes	4 (25%)	8 (50%)	1 (6%)	3 (18%)	16
Charadriiformes	3 (15%)	7 (35%)	3 (15%)	7 (35%)	20
Ciconiiformes	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2
Coraciiforms	1 (33%)	0 (0%)	0 (0%)	2 (66%)	3
Gruiformes	3 (100%)	0 (0%)	0 (0%)	0 (0%)	3
Passeriformes	0 (0%)	1 (25%)	2 (50%)	1 (25%)	4
Pelecaniformes	2 (18%)	4 (36%)	0 (0%)	5 (45%)	11
Phoenicopteriformes	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2
Podicipediformes	0 (0%)	1 (33%)	0 (0%)	2 (66%)	3
Suliformes	1 (12.5%)	3 (37.5%)	0 (0%)	4 (50%)	8
Total	16 (21.19%)	27 (36.98%)	6 (8.21%)	24 (32.87%)	73

21.19%), Pelecaniformes (11 spp., 15.06%), Suliformes (8 spp., 10.95%), Passeriformes (4 spp., 5.47%), Coracii-formes, Gruiformes, Podicipediformes (3 spp., 4.10%), Coraciiformes, Phoenicopteriformes (2 spp., 2.73%), and minimum species recorded in order Accipitriformes (1 spp., 1.36%).

Water birds seem to respond rapidly to human disturbance. Human activity seems to be main factor determine the waterbirds communities as waterbirds were negative correlated with the greatest anthropogenic impacts. we recommended that government organizations or departments and NGOs should work to conserved the disturbed habitats.
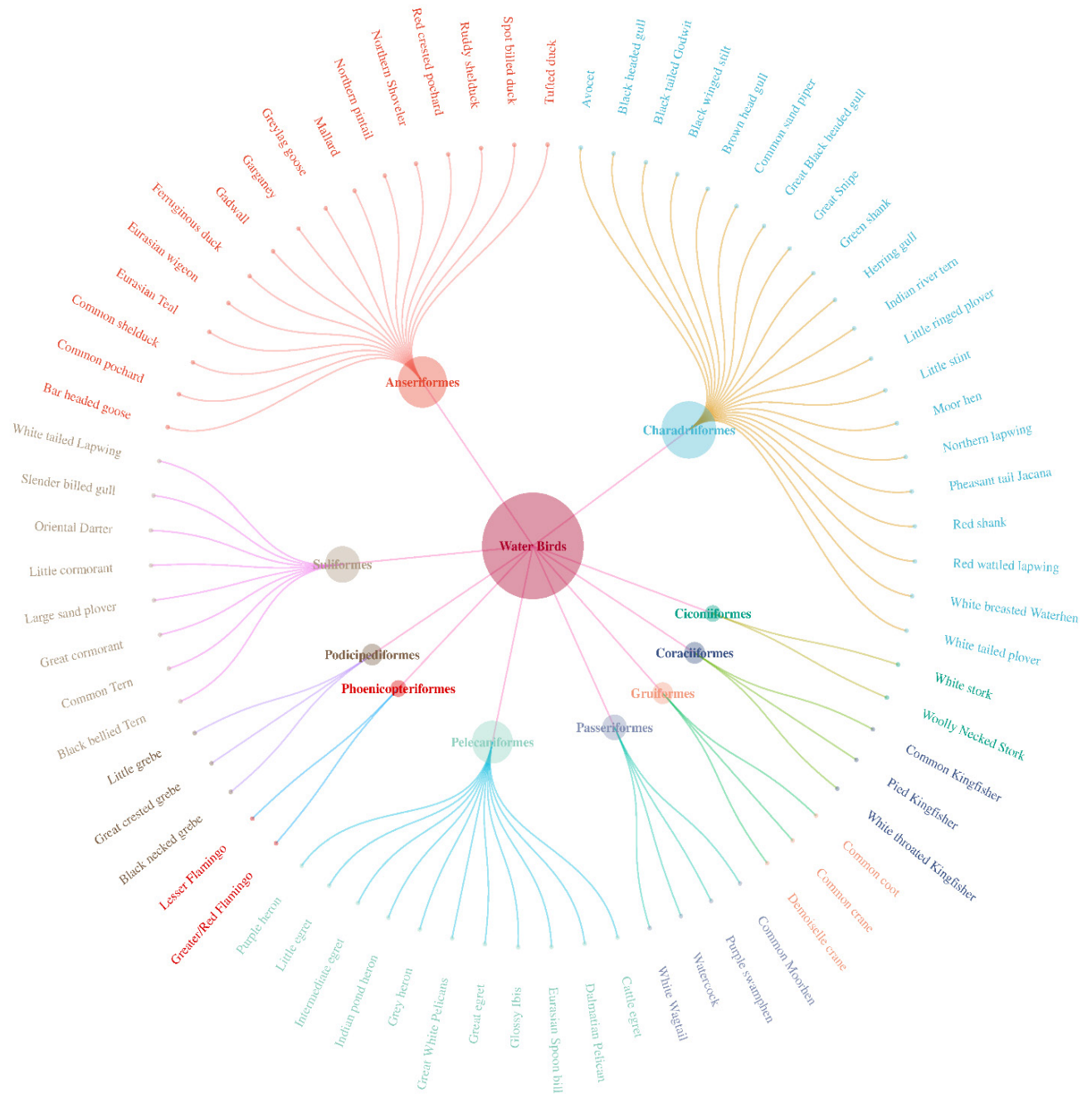

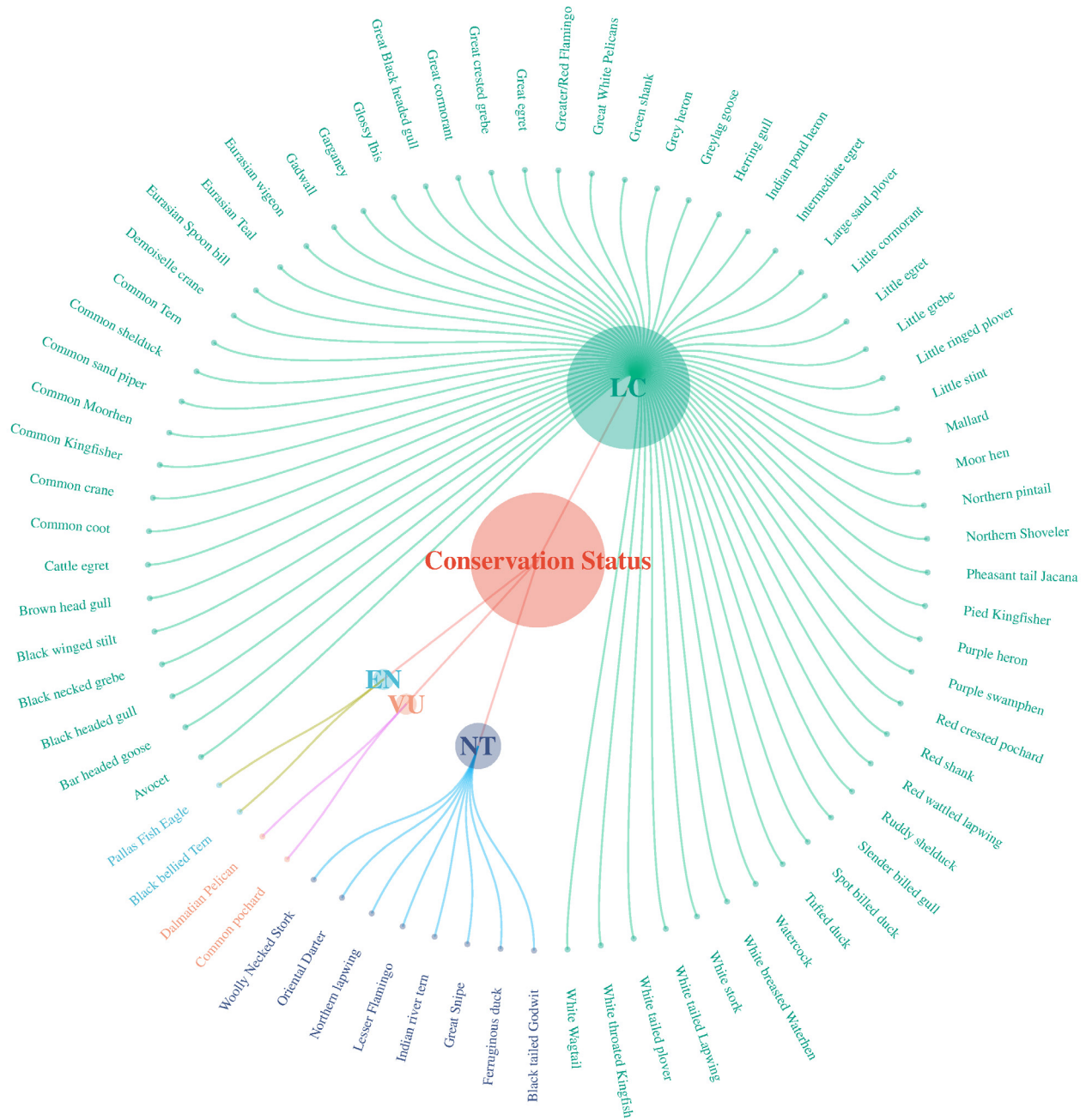Fig. 2. Order wise species of waterbirds.

Fig. 3. Threatened level of waterbirds.

Population trends

Of the total 73 waterbird species recorded, 16 (11.19%) species exhibited an increasing trend, 27 species (36.98%) declining trend, 6 species (8.21%) remained stable while, population trends were unknown for 24 species (32.87%). According to the classification of waterbirds, the proportion of declining species was the highest in Accipitriformes (100%), followed by

Anseriformes, Ciconiiformes and Phoenicopteriformes (50.0%) and Suliformes (37.5%). In addition, there was less than 50% of species with known population trends in Anseriformes, Charadriiformes, Passeriformes and Pelecaniformes (Table II).

Threatened species

In total 73 waterbirds, 12 species (16.43% of the

total) have been listed as threatened species, including 8 species (10.95%) Ferruginous duck, Northern lapwing, Indian river tern, black tailed Godwit, Great Snipe, Lesser Flamingo, Oriental Darter, Woolly Necked Stork being listed as Near Threatened, 2 species (2.73%) Common pochard and Dalmatian Pelican Vulnerable, and 2 species (2.73%) Pallas Fish Eagle and Black bellied Tern Endangered and 1 species (1.36%), while the remaining 61 species listed as least concern (Fig. 3, Table III).

The threatened species were mainly in the family Charadriiformes (4 species, 30.76%), followed by Anseriformes (2 species, 15.38%), while the Accipitriformes, Ciconiiformes, Pelecaniformes, Phoenicopteriformes and Suliformes (1 species, 7.69%) Table IV.

Table III. Threatened levels of waterbirds.

Conservation status	Number of species (%)
Endangered	2 (2.73%)
Least concern	61 (83.56%)
Near threatened	8 (10.95%)
Vulnerable	2 (2.73%)

Table IV. Threatened levels of waterbirds: Family wise.

Family	DD	EN	NT	VU	Total	%
Accipitriformes	0	1	0	0	1	7.69
Anseriformes	0	0	1	1	2	15.38
Charadriiformes	0	0	3	1	4	30.76
Ciconiiformes	0	0	1	0	1	7.69
Pelecaniformes	0	0	1	0	1	7.69
Phoenicopteriformes	0	0	1	0	1	7.69
Suliformes	0	1	1	0	2	15.38

DD, data deficient; WN, endangered; NT, near threatened; VU, vulnerable.

Threats to waterbirds

Waterbirds in Pakistan face various threats from both direct and indirect human activities, such as hunting, Habitat Loss and Degradation, Climate change, Use of Pesticides, Pollution, Human disturbance, Trading, and Agricultural Development (Table V). Most waterbird species suffer multiple types of threats (Table VI).

Habitat loss and degradation is the most common threat to waterbirds, affecting 37 of the 73 species (50.68%). Same like Human disturbance, affecting 34 of the 73 species (46.57%).

Waterbirds are also declined by hunting, which affects 31 species (42.46%) (Tables IV, V). 22 of the 73 waterbird species are affected by trading (30.13%), 20 species of

waterbirds are affected by pesticides (27.39%), 17 of the 73 species are affected by climate change (23.28%), and 12 species of waterbirds are affected by agricultural development (16.43%).
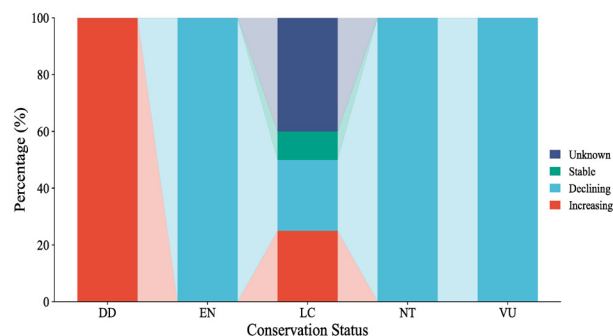

Fig. 4. Population trends and threatened levels of waterbirds.

Table V. Threats to the waterbirds.

S. No	Threats	Number of threatened species (%)
1	Hunting	31(42.46%)
2	Habitat loss and degradation	37(50.68%)
3	Climate change	17(23.28%)
4	Use of pesticides	20(27.39%)
5	Pollution	30(41.09%)
6	Human disturbance	34(46.57%)
7	Trading	22(30.13%)
8	Agricultural development	12(16.43%)

Hunting pressure on water birds in the study area

In order to collect information related to hunting, a questionnaire was used. A total of 450 questionnaires were distributed. In the field, interviews were conducted with local inhabitants, selected informants, hunters, local breeders, and sellers in local markets. During the fieldwork, observations and interviews were frequently used. The most hunted group are Anseriformes (43%) followed by Gruiform (27%), Accipitriformes (10%), Pelecaniformes (8%), Charadriiformes (4%), Ciconiiformes (3%) and Suliformes (2%). As the most hunted order, Anseriformes is preferred among locals due to the superior taste of its meat, which is often considered superior to that of other birds. The second most hunted family was Gruiformes, which includes the Common and Demoiselle cranes, Demoiselle cranes and common cranes have high market values, and the price ranges between ten thousand and ten lac per pair, so Gruiformes was the preferred family. Accipitriformes, which includes some eagle species, was the third most popular hunting family (Fig. 5).

Table VI. Showing the waterbirds recorded at conducted sites.

Order/Species name (Scientific name)	IUCN population trend	IUCN threatened level	Threats
Order: Accipitriformes			
Pallas fish eagle (*Haliaeetus leucoryphus*)	Decrease	EN	1,7
Order: Anseriformes			
Bar headed goose (*Anser indicus*)	Decrease	LC	1,2,5,6,7,
Common pochard (*Aythya ferina*)	Decrease	VU	1,2,5,6,7
Common shelduck (*Tadorna tadorna*)	Increasing	LC	1,2,5,6,7
Eurasian teal (*Anas crecca*)	Unk	LC	1,2,5 ,6,7
Eurasian wigeon (*Mareca penelope*)	Decrease	LC	1,2,5,6,7
Ferruginous duck (*Aythya nyroca*)	Decrease	NT	1,2,5,6,7
Gadwall (*Mareca strepera*)	Increasing	LC	1,2,5,6,7
Garganey (*Anas querquedula*)	Decrease	LC	1,2,5,6,7
Greylag goose (*Anser anser*)	Increasing	LC	1,2,5,6,7
Mallard (*Anas platyrhynchos*)	Increasing	LC	1,2,5,6,7
Northern pintail (*Anas acuta*)	Decrease	LC	1,2,5,6,7
Northern shoveler (*Spatula clypeata*)	Decrease	LC	1,2,5,6,7
Red crested pochard (*Netta rufina*)	Unk	LC	1,2,5,6,7
Ruddy shelduck (*Tadorn aferruginea*)	Unk	LC	1,2,6,7
Spot billed duck (*Anas poecilorhyncha*)	Decrease	LC	1,2,5,6,7
Tufted duck (*Aythya fuligula*)	Stable	LC	1,2,5,6,7
Order: Charadriiformes			
Little ringed plover (*Charadrius dubius*)	Stable	LC	5,4
Northern lapwing (*Vanellus vanellus*)	Decrease	NT	8
Red wattled lapwing (*Vanellus indicus*)	Unk	LC	2,8
White tailed plover (*Vanellus leucurus*)	Unk	LC	4
Pheasant tail jacana (*Hydrophasianus chirurgus*)	Decrease	LC	4,5,8
Black headed gull (*Chroicocephalus ridibundus*)	Unk	LC	4
Brown head gull (*Chroicocephalus brunnicephalus*)	Unk	LC	4
Great black headed gull (*Ichthyaetus ichthyaetus*)	Increasing	LC	4
Herring gull (*Larus argentatus*)	Decrease	LC	1,2,3
Indian river tern (*Sterna aurantia*)	Decrease	VU	2,3
Avocet (*Recurvi rostra*)	Unk	LC	4
Black winged stilt (*Himantopus himantopus*)	Increasing	LC	4,5
Moorhen (*Gallinula*)	Stable	LC	1,2,5
White breasted waterhen (*Amaurornis phoenicurus*)	Unk	LC	4
Black tailed godwit (*Limosa limosa*)	Decrease	NT	1,2,3
Common sand piper (*Actitis hypoleucos*)	Decrease	LC	1,3,6,8
Great snipe (*Gallinago media*)	Decrease	NT	1,2,3
Green shank (*Tringa nebularia*)	Stable	LC	2,5,6
Little stint (*Calidris minuta*)	Increasing	LC	1,2
Red shank (*Tringa totanus*)	Unk	LC	3

Table continued on next page.................

Order/Species name (Scientific name)	IUCN population trend	IUCN threatened level	Threats
Order: Ciconiiformes			
White stork (*Ciconia ciconia*)	Increasing	LC	1,2,4
Woolly necked stork (*Ciconia episcopus*)	Decrease	NT	1,8
Order: Coraciiformes			
Common kingfisher (*Alcedo atthis*)	Unk	LC	4
Pied kingfisher (*Ceryle rudis*)	Unk	LC	4
White throated Kingfisher (*Halcyon smyrnensis*)	Increasing	LC	4
Order: Gruiformes			
Common crane (*Grus grus*)	Increasing	LC	1,2,3,4,7,8
Demoiselle crane (*Grus virgo*)	Increasing	LC	1,2,3,4,7,8
Common coot (*Fulica atra*)	Increasing	LC	4
Order: Passeriformes			
Common moorhen (*Gallinula chloropus*)	Stable	LC	2,3
Purple swamphen	Unk	LC	6
Watercock (*Gallicrex cinerea*)	Decrease	LC	2,3,8
White wagtail (*Motacilla alba*)	Stable	LC	4
Order: Pelecaniformes			
Cattle egret (*Bubulcus ibis*)	Increasing	LC	2
Great egret (*Ardea alba*)	Unk	LC	5
Grey heron (*Ardea cinerea*)	Unk	LC	6
Indian pond heron (*Ardeola grayii*)	Unk	LC	5,6
Intermediate egret (*Ardea intermedia*)	Decrease	LC	1,2,3,5,8
Little egret (*Egretta garzetta*)	Increasing	LC	1,5
Purple heron (*Ardea purpurea*)	Decrease	LC	2,3
Dalmatian pelican (*Pelecanus crispus*)	Decrease	VU	1,2,3,8
Great white pelicans (*Pelecanus onocrotalus*)	Unk	LC	5
Eurasian spoon bill (*Platalea leucorodia*)	Unk	LC	5,6
Glossy ibis (*Plegadis falcinellus*)	Decrease	LC	2,3
Order: Phoenicopteriformes			
Greater/red flamingo (*Phoenicopterus roseus*)	Increasing	LC	7
Lesser flamingo (*Phoeniconaias minor*)	Decrease	NT	7
Order: Podicipediformes			
Black necked grebe (*Podiceps nigricollis*)	Unk	LC	4
Great crested grebe (*Podiceps cristatus*)	Unk	LC	6
Little grebe (*Tachybaptus ruficollis*)	Decrease	LC	3,4,5,8
Order: Suliformes			
Black bellied tern (*Sterna acuticauda*)	Decrease	EN	2,8
Common tern (*Sterna hirundo*)	Unk	LC	5
Large sand plover (*Charadrius leschenaultii*)	Decrease	LC	2,3,6,7
Oriental darter (*Anhinga melanogaster*)	Decrease	NT	1,3,5
Slender billed gull (*Chroicocephalus genei*)	Unk	LC	4
White tailed lapwing (*Vanellus leucurus*)	Unk	LC	4
Little cormorant (*Microcarbo niger*)	Unk	LC	6
Great cormorant (*Phalacrocorax carbo*)	Increasing	LC	2,6

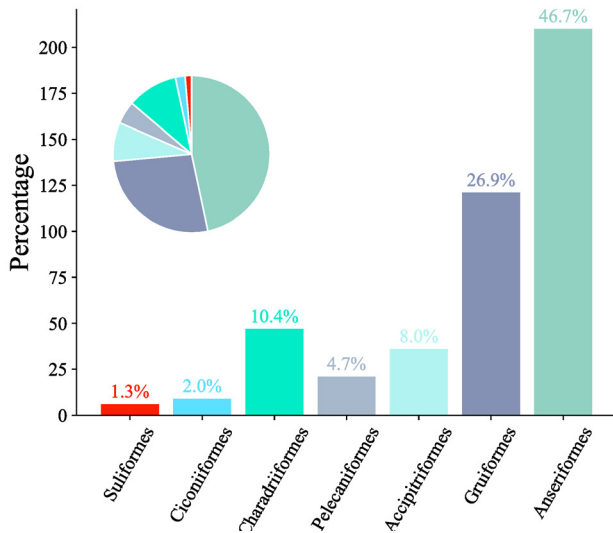EN, endangered. For other abbreviations, see Table IV.

Fig. 5. Hunted waterbirds: Order wise

DISCUSSION

During the wintering seasons of September 2017 through March 2022, 73 species of water birds belonging to 11 orders were recorded in the six wetlands. In these, 73 species of waterbirds, 16(11.19%) species are increasing, 27(36.98%) species are declining, 6(8.11%) species continue to remain stable, whereas 24 species (32.87%) are unknown. Among these, 73 waterbirds, 13 species (17.8% of the total) have been listed as threatened species, including 8 species (10.95%) Ferruginous duck, northern lapwing, Indian river tern, black-tailed godwit, great snipe, lesser flamingo, oriental darter, woolly necked stork being listed as near threatened, 2 species (2.73%) common pochard and dalmatian pelican vulnerable, and 2 species (2.73%) pallas fish eagle and black-bellied tern endangered and 1 species (1.36%) , while the remaining 61 species listed as least concern. This study found that waterbirds facing different threats like hunting, habitat loss and degradation, climate change, pesticide use, pollution, human disturbance, trading, and agricultural development.

In Pakistan, bird hunting has traditionally been a method of obtaining food and economic income. The hunting and capture of birds in Pakistan for consumption and sports has led to a decline in local populations, but the species' overall status is stable (Fuller *et al*., 2000; Bennett and Whitten, 2003). The dalmatian pelican (*Pelecanus crispus*) is a winter visitor to Pakistan whose population has declined due to hunting and disturbance. Similar to black-headed Ibis, black-headed Ibis visit Pakistan irregularly throughout the year and are at risk of being hunted and habitat destruction mainly because of

drainage and cultivation (Reference please). Overhunting has resulted in a marked decline in the number of painted storks in Pakistan during the winter season. Other threats to migratory birds, such as geese, coots, and ducks, include illegal hunting (Umar *et al*., 2018).

Waterbirds affected by climate change, around the world. As the sea level rises as a result of global warming, coastal wetlands along the East Asian-Australasian flyway have decreased, which impacts the refueling habitats of many waterbirds. An estimated 72% decline in the population of ten long-distance migratory shorebirds is predicted due to sea-level rise reducing 23–40% of intertidal habitat (Iwamura *et al*., 2013). In contrast, climate change would affect waterbirds' temporal and spatial linkages with their biological and abiotic environments, as different biological groups respond differently to climate change. As a result of mismatches between breeding and food peak, fitness declines. Waterbird populations can also be adversely affected by climate change due to increased frequency of extreme weather events, like droughts and floods (Both and Visser, 2001).

Avifauna are also adversely affected by harmful pesticide use. In gulls, eagles, terns, and cormorants, the DDT metabolite is linked to thinning of eggshells and diminished reproductive success (Mitra *et al*., 2011). The geographical areas from which migratory birds acquire contamination are numerous. European and North American bird species have been studied for contaminants accumulation (Fyfe, 1991). It is alleged that ducks, primarily bar-headed geese and ruddy shelducks, damage crops so that wheat grains mixed with pesticide granules are used and then sold in local markets for consumption (Ali *et al*., 2011). In Mangla reservoir, pesticides are also reported to have had an enormous effect on entomophagous birds (Khan and Ali, 2014).

According to our study, environmental pollution affects more than 41% of waterbirds. The main environmental problem in Pakistan is the discharge of pollutants. A high level of heavy metals (Cd, Pb, and Cr) in the environment poses adverse effects on birds, such as cattle egrets. The feathers of this bird are used for biomonitoring heavy metal contamination (Malik and Zeb, 2009). Due to the breakdown of Pir Pranjal rocks and catchments of River Jhelum, heavy metals pollution was alarming, resulting in a decline in bird diversity and distribution in favorable locations (Ali *et al*., 2011). Cranes with crowns stand for grace, riches, life, and fortune. In spite of their legendary beauty, they have ironically fallen out of favor in Pakistan and around the world (Ullah *et al*., 2023). In recent years, both crane populations have decreased rapidly due to unlawful captures. There are many ways in which people capture these animals in order

to make money (Kumar *et al.*, 2002). Due to agricultural activities' expansion and intensity in the past, most landscapes have seen significant changes. Cranes and their habitats have advantages and disadvantages as agriculture changes. Cranes can be assisted by working with farmers and agricultural organizations to develop and implement environmentally sound and financially viable techniques (Harris and Mirande, 2013).

RECOMMENDATIONS FOR CONSERVATION OF WATER BIRDS IN PAKISTAN

There were multiple threats facing water birds in Pakistan. In order to conserve waterbirds, we recommended the following comprehensive measures:

1. Crackdown on illegal bird hunting and better enforcement of wildlife protection laws

A stronger enforcement of the Wildlife Protection Law is needed to ensure that illegal acts are punished accordingly. In order to ensure that these threatened birds are protected by law, we recommend that the checklist of the national key of water bird species be updated on a regular basis (e.g., every five years).

2. In order to provide shelter and food, more trees need to be planted

Plant species native to the region provide a conductive environment for endangered species to breed and increase in population. Promote and plant agroforestry species that reduce deforestation and enhance bird conservation indirectly by reducing pressure on other native plant species.

3. Change farming techniques, practice proper agriculture, and control pesticides

Pesticides are hazardous to waterbirds, which thins their eggshells when they nest. It is necessary for lawmakers to pass laws that can be enforced in order to stop farmers from using these chemicals. Modern farming techniques use chemicals that destroy both the food and habitat of endangered birds, which has had a detrimental effect on their survival. To practice proper agriculture practices, less chemical pesticides should be used and organic farming should be adopted. A conductive environment for birds is one that uses organic farming techniques instead of industrial chemicals to fertilize the crop, which increases insect population and ensures fruits and grain are not harmful to birds.

4. Wetland pollution control, especially industrial waste

Water birds are especially at risk when they come into contact with waste like oil pollution, sewage, and industrial waste. Food sources for birds are destroyed by such waste. As a result of such waste, there are increased nutrients in water that are toxic to microbes and lead to algal blooms, which in turn kill thousands of fish, which are then consumed by water birds, ultimately resulting negative impact. Therefore, it is imperative to control pollution in order to conserve and protect waterbird populations.

5. Improve public awareness of waterbird conservation

Consequently, it is necessary to strengthen public education and extension by local politicians and religious leaders in order to target the youth, decision-makers, and communities of underdeveloped regions with education and extension. Through increased awareness, direct action, effective campaigns, increased pressure on the government, and effective collaborations between public and private sectors, increased public awareness will greatly improve conservation through increased advocacy and direct action.

6. Survey long-term waterbird populations

It is necessary for local wildlife departments, the State Administration of Forestry, the Ministry of Environmental Protection and a number of government agencies to organize regional water bird surveys in order to save the birds from extinction. As a result of these surveys, information has been gathered about the distribution, the population status, and key habitats of water birds in the region, thereby promoting water bird conservation in the area. To fill knowledge gaps, we recommend that systematic and long-term surveys of water birds should be conducted in close cooperation between government agencies and the public in order to fill in these knowledge gaps. In addition, in order to provide basic data for analyzing water bird population trends and to support the formulation of conservation measures, an integrated water bird database containing both information about water birds and habitats should be shared by all in a transparent manner. This database should be shared by everyone in a transparent manner.

7. Conservation of threatened species through captive breeding program

In order to protect some critically endangered species from extinction, that have small populations, it is crucial to increase their populations (through captive breeding program).

Water birds that are threatened, such as cranes and waterfowl, have been bred in captivity successfully, and this has provided the basis for reintroducing these threatened species into the wild, as long as suitable habitat remains. Considering the dramatic loss of habitats in Pakistan over the last several decades, it is imperative that habitat conservation is given the highest priority in order to ensure the survival of species in this country. In the case of nature reserves, it is always the first priority to ensure

that the habitat is protected.

CONCLUSION

Author concluded that most of the birds from order Charadriiforms are residential and local community does not hunt. Most of the species were least concern that is 60% while the percentage of endangered water birds were 1%. Most common threats to water birds were habitat loss and degradation, and uses of pesticide which was considering as major threa ts. Author also concludes that water birds are very important part of biodiversity and play key role in environmental services. Water birds needs to be conserved in the entire study area.

ACKNOWLEDGEMENT

Statement of conflict of interest
The authors have declared no conflict of interest.

REFERENCES

Akrim, F., Mahmood, T., Andleeb, S., Hussain, R. and Collinson, W.J., 2019. Spatiotemporal patterns of wildlife road mortality in the pothwar plateau, pakistan. *Mammalia*, **83**: 487-495. https://doi.org/10.1515/mammalia-2017-0101

Ali, A., Khan, M.S.H. and Altaf, M., 2018. Winter survey of birds at district of the Badin, Pakistan. *J. Wildl. Ecol.*, **2**: 11-22.

Ali, Z., Shelly, S., Bibi, F., Joshua, G., Khan, A., Khan, B. and Akhtar, M., 2011. Peculiarities of mangla reservoir: Biodiversity with sustainable use options. *J. Anim. Pl. Sci.*, **21**: 372-380.

Altaf, M., Javid, A. and Umair, M., 2014. *Biodiversity of ramsar sites in pakistan: Wildlife and ecology*. LAP LAMBERT Academic Publishing.

Amano, T., Székely, T., Koyama, K., Amano, H. and Sutherland, W.J., 2010. A framework for monitoring the status of populations: An example from wader populations in the east asian–australasian flyway. *Biol. Conserv.*, **143**: 2238-2247. https://doi.

org/10.1016/j.biocon.2010.06.010

Ashraf, S., Riaz, A. and Muhammad, N., 2019. Assessments of avian diversity of uchhali lake. *Pak. J. Wild Ecol.*, **3**: 8-15.

Bennett, J. and Whitten, S., 2003. Duck hunting and wetland conservation: Compromise or synergy? *Can. J. Agric. Econ. Rev. Can. Agroecon.*, **51**: 161-173. https://doi.org/10.1111/j.1744-7976.2003.tb00171.x

Boere, G.C., Galbraith, C.A. and Stroud, D.A., 2006. *Waterbirds around the world: A global overview of the conservation, management and research of the world's waterbird flyways*. **Publisher?**

Both, C. and Visser, M.E., 2001. Adjustment to climate change is constrained by arrival date in a long-distance migrant bird. *Nature*, **411**: 296-298. https://doi.org/10.1038/35077063

Cabrera-Cruz, S.A., Smolinsky, J.A. and Buler, J.J., 2018. Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world. *Sci. Rep.*, **8**: 3261. https://doi.org/10.1038/s41598-018-21577-6

Davidson, N., 2018. Wetland losses and the status of wetland-dependent species. In: *The wetland book ii: Distribution, description, and conservation*. Springer, pp. 369-381. https://doi.org/10.1007/978-94-007-4001-3_197

Fuller, R., Caroll, J. and McGowan, P., 2000. *Partridges, quails, francolins, snowcocks, guinefowl and turkeys*. *Status survey and conservation action plan 2000–2004*. Wpa/birdlife/ssc partridges, quails and francolin specialist group. Iucn. The World Conservation Union, Gland, Switzerland: pp. 63.

Fyfe, L., 1991. *The molecular approaches to the therapy of hiv infection: The scid-hu mouse as a model to study strategies for the treatment of hiv*. MRC Aids Directed Research Programme Newsletter.

Galbraith, C.A., 2014. *A review of migratory bird flyways and priorities for management*. UNEP/CMS Secretariat.

Greb, S.F., DiMichele, W.A. and Gastaldo, R.A., 2006. *Evolution and importance of wetlands in earth history*. https://doi.org/10.1130/2006.2399(01)

Harris, J. and Mirande, C., 2013. A global overview of cranes: Status, threats and conservation priorities. *Avian Res.*, **4**: 189-209. https://doi.org/10.5122/cbirds.2013.0025

Iwamura, T., Possingham, H.P., Chadès, I., Minton, C., Murray, N.J., Rogers, D.I., Treml, E.A. and Fuller, R.A., 2013. Migratory connectivity magnifies the consequences of habitat loss from sea-level rise for shorebird populations. *Proc. R. Soc. B Biol.*

Sci., **280**: 20130325. https://doi.org/10.1098/rspb.2013.0325

Jackson, M.V., Choi, C.Y., Amano, T., Estrella, S.M., Lei, W., Moores, N., Mundkur, T., Rogers, D.I. and Fuller, R.A., 2020. Navigating coasts of concrete: Pervasive use of artificial habitats by shorebirds in the asia-pacific. *Biol. Conserv.*, **247**: 108591. https://doi.org/10.1016/j.biocon.2020.108591

Khan, B. and Ali, Z., 2014. Assessment of birds fauna, occurrence status, diversity indices and ecological threats at mangladam, ajk from 2011 to 2014. *J. Anim. Pl. Sci.*, **25**: 397-403.

Kumar, K., Lipscomb, J. and Menon, J., 2002. *Personalizing rich media presentations based on user response to the presentation*. Google Patents.

Ma, Z., Melville, D.S., Liu, J., Chen, Y., Yang, H., Ren, W., Zhang, Z., Piersma, T. and Li, B., 2014. Rethinking china's new great wall. *Science*, **346**: 912-914. https://doi.org/10.1126/science.1257258

Malik, R.N. and Zeb, N., 2009. Assessment of environmental contamination using feathers of bubulcus ibis l., as a biomonitor of heavy metal pollution, pakistan. *Ecotoxicology*, **18**: 522-536. https://doi.org/10.1007/s10646-009-0310-9

Mirza, Z., 2012. *A field guide to birds of Pakistan*. WWF.

Mitra, A., Chatterjee, C. and Mandal, F.B., 2011. Synthetic chemical pesticides and their effects on birds. *Res. J. Environ. Toxicol.*, **5**: 81-96. https://doi.org/10.3923/rjet.2011.81.96

Şekercioğlu, Ç.H., Daily, G.C. and Ehrlich, P.R., 2004. Ecosystem consequences of bird declines. *Proc. Natl. Acad. Sci.*, **101**: 18042-18047. https://doi.org/10.1073/pnas.0408049101

Sheikh, K. and Kashif, N., 2006. Strategic role of pakistan wetland resources: Prospects for an effective migratory waterbird conservation network. *Waterbirds Around World,* pp. 292-293.

Studds, C.E., Kendall, B.E., Murray, N.J., Wilson, H.B., Rogers, D.I., Clemens, R.S., Gosbell, K., Hassell, C.J., Jessop, R. and Melville, D.S., 2017. Rapid population decline in migratory shorebirds relying on yellow sea tidal mudflats as stopover sites. *Nat. Commun.*, **8**: 14895. https://doi.org/10.1038/ncomms14895

Tourenq, C., Bennetts, R.E., Kowalski, H., Vialet, E., Lucchesi, J.L., Kayser, Y. and Isenmann, P., 2001. Are ricefields a good alternative to natural marshes for waterbird communities in the camargue, southern france? *Biol. Conserv.*, **100**: 335-343. https://doi.org/10.1016/S0006-3207(01)00037-4

Ullah, I., Sun, X., Wu, Q-M., Deng, W., Rajpar, M., Majeed, A. and Ditta, A., 2023. Determining the relative abundance of, habitat preferences of and occurences of gastrointestinal parasites in common crane and demoiselle crane inhabiting three distinct habitats. *Appl. Ecol. environ. Res.*, **21**: 451-465. https://doi.org/10.15666/aeer/2101_451465

Umar, M., Hussain, M., Murtaza, G., Shaheen, F.A. and Zafar, F., 2018. Ecological concerns of migratory birds in pakistan: A review. *Punjab Univ. J. Zool.*, **33**: 69-76. https://doi.org/10.17582/pujz/2018.33.1.69.76

Wang, X., Kuang, F., Tan, K. and Ma, Z., 2018. Population trends, threats, and conservation recommendations for waterbirds in china. *Avian Res.*, **9:** 1-13. https://doi.org/10.1186/s40657-018-0106-9

Xu, W., Fan, X., Ma, J., Pimm, S.L., Kong, L., Zeng, Y., Li, X., Xiao, Y., Zheng, H. and Liu, J., 2019. Hidden loss of wetlands in china. *Curr. Biol.*, **29**: 3065-3071. e3062. https://doi.org/10.1016/j.cub.2019.07.053