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Original Article

Assessment of anthropogenic-causing-agents act on waterbirds-diversity in the vicinity of Tarbela Dam, Indus River, Pakistan

Avaliação de agentes antropogênicos que agem na diversidade de aves aquáticas nas proximidades da Represa de Tarbela, rio Indus, Paquistão

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Abstract

Birds are among the best bio-indicators, which can guide us to recognize some of the main conservation concerns in ecosystems. Anthropogenic impacts such as deforestation, habitat degradation, modification of landscapes, and decreased quality of habitats are major threats to bird diversity. The present study was designed to detect anthropogenic causative agents that act on waterbird diversity in Tarbella Dam, Indus River, Pakistan. Waterbird censuses were carried out from March 2019 to February 2020 in multiple areas around the dam. A total of 2990 waterbirds representing 63 species were recorded. We detected the highest waterbird richness and diversity at Pehure whereas the highest density was recorded at Kabbal. Human activity impacts seemed to be the main factor determining the waterbird communities as waterbirds were negatively correlated with the greatest anthropogenic impacts. Waterbirds seem to respond rapidly to human disturbance.

Keywords: Indus, landscape, deforestation, waterbirds.

Resumo

As aves estão entre os melhores bioindicadores, o que pode nos orientar a reconhecer algumas das principais preocupações de conservação dos ecossistemas. Impactos antrópicos como desmatamento, degradação de habitat, modificação de paisagens e diminuição da qualidade dos habitats são as principais ameaças à diversidade de aves. O presente estudo foi desenhado para detectar agentes causadores antropogênicos que atuam na diversidade de aves aquáticas na Represa de Tarbella, rio Indus, Paquistão. Censos de aves aquáticas foram realizados de março de 2019 a fevereiro de 2020 em várias áreas ao redor da barragem. Um total de 2.990 aves aquáticas representando 63 espécies foi registrado. Detectamos a maior riqueza e diversidade de aves aquáticas em Pehure, enquanto a maior densidade foi registrada em Kabbal. Os impactos da atividade humana parecem ser o principal fator determinante das comunidades de aves aquáticas, uma vez que as aves aquáticas foram negativamente correlacionadas com os maiores impactos antrópicos. As aves aquáticas parecem responder rapidamente às perturbações humanas.

Palavras-chave: Indus, paisagem, desmatamento, aves aquáticas.

1. Introduction

Wetlands are vital for all living beings (Ashraf et al., 2019; Ghermandi et al., 2008; Ten Brink et al., 2012), necessary for life (Ali et al., 2018) and the evolution of life (Greb et al., 2006). Approximately, 2.5 million square kilometers of the earth is covered by wetlands. Almost, 2400 Ramsar sites are documented in whole world (Ramsar, 2014). 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).

Loss of habitat due to anthropogenic effects can be a reason for habitat fragments (Anjos, 2004; Leal et al., 2011) and degradation of habitat quality (Rais et al., 2010) and increased intensity of edge effects (Berry, 2001). The changes in habitat mainly influence range-restricted, rare birds, specialists, and migrants avian fauna (Bett et al.,

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2016). Main reason in decline of avian diversity is human activities impacts (Altaf, 2016). This shows that there is high risk to various tropical species of birds, because they are scarcely distributed and don't bear conditions outside of specific forest (Turner, 1996).

To knowing anthropogenic impacts on avian species is important for developing appropriate management guidelines and conservation plans (Ricketts and Imhoff, 2003). Particularly, the kind of relationship between anthropogenic influences and avian species inhabiting the site will govern the management and conservation approaches that can be utilized. If anthropogenic impact and avian species diversity show a positive relationship, conflicts are likely to rise due to the high need for humans for places and their sites at higher hazard (Chown et al., 2003). So, conservation and management efforts should focus on sites where anthropogenic influences are previously high and compensate for awaiting conflicts (Carroll et al., 2004). On the other hand, a negative relationship between anthropogenic influences and biodiversity proposes that the focus should be on sites with low human activities impacts because they harbor better diversity and may be higher effective in management and conservation (Luck et al., 2004).

The avian species are important for human (Jadoon et al., 2019; Mughal et al., 2020) and the best bio-indicators (Ashraf et al., 2018; Bibby, 1999; Khan et al., 2021), because they respond to environment change and human activity and guide us to recognize the main concern ecosystems for conservation. Major threats to the birds of Pakistan are illegal hunting, poaching, livestock grazing, deforestation, agriculture intensification, urbanization, industrialization, pollution, and climate change. All these threats are the main causing agents to decline and extinction of avian species. Same study is conducted in different elevation and ecosystems of Pakistan and other parts of world. Because threats are present in study area, therefore we decided to know the anthropogenic impacts on different sites of Tarbella Dam, Indus River, Pakistan.

2. Materials and Methods

2.1. Study area

The data were collected from March 2019 to February 2020and selected sub areas as; Kalabat town, Kiara, Labadam, Pehur, Sobera, Balongi, Kabbal and Gala (Table 1 and Figure 1). The Tarbela Dam is 2nd largest rock-filled dam built in world. The dam is present on the Indus river (34° 7′35″North, 72° 48′37″ East) in Haripur District, Khyber Pakhtunkhwa, about fifty kilometers northwest of Islamabad. The climate in Tarbella Dam is hot in summer (April to September) with maximum temperatures

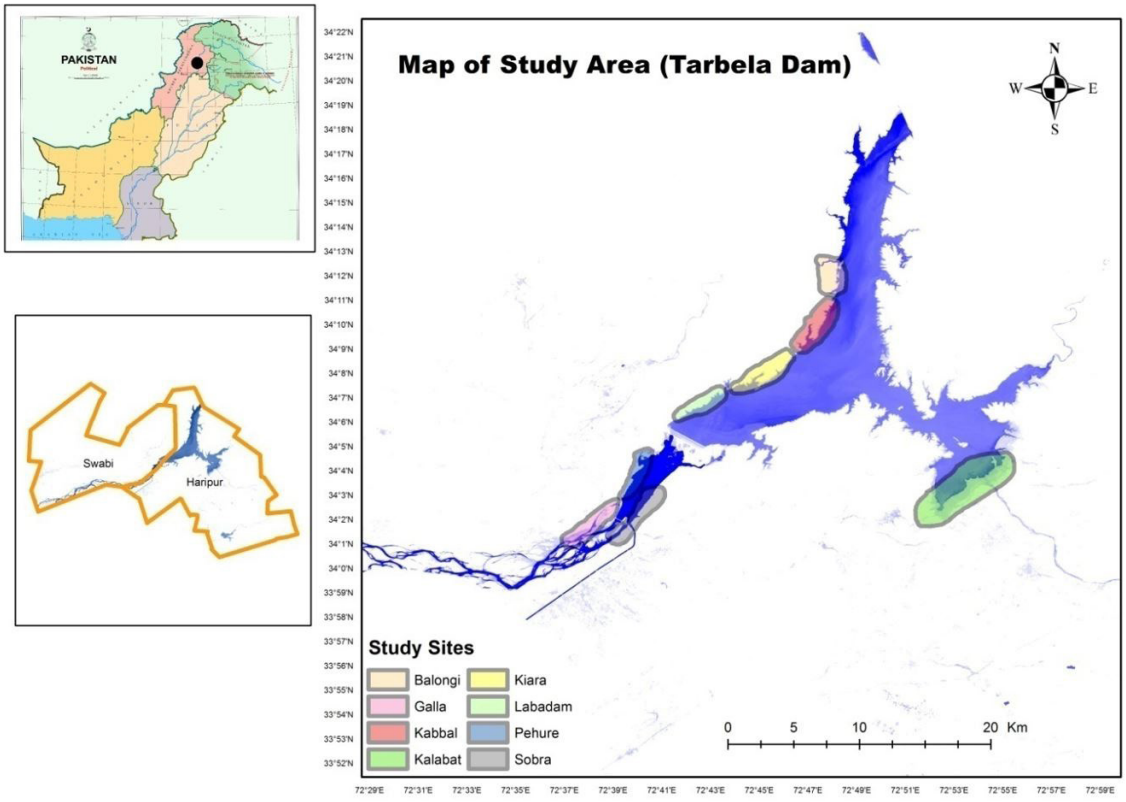

Figure 1. Map of the study area, that consist of study sites like Kalabat, Kiara, Sobra, Balongi, Kabbal, Labadam and Galla.

Table 1. Habitats and their coordinates at Tarbella Dam, levels of anthropogenic impacts were noted directly as well as with Google earth.

Sr. No.	Habitats	Code	Coordinates	Level of anthropogenic impact on land (%)	Elevation (ft)
1	Kalabat town	KT	34°02'14.00"N 72°54'21.00"E	30	1556
2	Galla	GA	34°02'36.00"N 72°39'02.00"E	60	1085
3	Pehure	PE	34°04'13.00"N 72°40'01.00"E	10	1131
4	Sobra	SO	34°02'07.00" N 72° 40'05.00"E	40	1117
5	Labadam	LA	34°06'25.00"N 72°42'14.00"E	50	1496
6	Kiara	KI	34°07'08.00"N 72°43'43.100"E	30	1411
7	Pehure	PE	34°04'13.00"N 72°40'01.00"E	10	1131
8	Balongi	BA	34°10'08.50"N 72°48'439.50"E	50	1456
9	Kabbal	KA	34°09'06.50"N 72°48'42.470"E	70	1480

between 38 to 46 °C. Winters are relatively cold with minimum temperatures between 3 to 14 °C. Average rainfall recorded was as 1026mm/annum. The humidity is relatively high throughout the year. Total 130 genera of plants were documented from the study area. *Asteraceae, Lamiaceae, Leguminosae and Euphoriaceae* are the most dominant families are present in Tarbella Dam. A total of 29 mammalian species, 9 species of amphibians and 26 species of reptiles and 89 species of water bird including 68 migratory avian species are documented from Tarbela dam (Khan, 2006; Rafique et al., 2020; Roberts, 1991, 1992).

2.2. Sampling layout

The diversity of waterfowl of study area was estimated through linear count survey method and the direct (i.e. physical count mean direct observation with camera and naked eye and voices) and indirect (i.e. nests and group questionnaire surveys or meetings) methods were utilized. Each study site consists of 500 hectare square area. To identify the avian species of the study area, key books i.e. "Birds of Pakistan"(Mirza and Wasiq, 2007) and "Birds of the Indian subcontinent" (Grimmett et al., 1998) were utilized.

2.3. Statistical analysis

The data were analyzed through PAST software (version 3) and Shannon-Wiener diversity index (H'), Dominance (D), Simpson Index (S), Richness (R) and Evenness (E) were recorded following (Hammert et al., 2001).

Census Index/Density was computed using following Formula 1.

$$Census\ Index = numbers\ of\ birds\ /\ area\ (500\ hectare) \quad (1)$$

3. Results and Discussion

During the study period total populations of 2990 waterbirds representing 63 species were recorded from Tarbella Dam (Table 2 and Figure 2). Species richness was the highest at the Pehure (i.e. PE) with 9.613, the richness in the other places was 8.496, 7.849, 7.666, 6.848, 6.588, 6.513 and 6.251at Kalabat town (abbreviated as KT), Kiara (abbreviated as KI), Sobra (abbreviated as SO), Balongi (abbreviated as BA), Kabbal (abbreviated as KA), Labadam (abbreviated as LA) and Galla (abbreviated as GA) respectively. Collected statistical data demonstrates that Shannon-Wiener diversity index gives a quantitative description of diversity which was the highest at PE (H'=3.85) followed by KT (3.567), SO (3.51), KI (3.516), BA (3.436), KA (3.431), GA (3.242) and LA (3.321). Similarly, Simpson diversity index (S) which is used to measure avian species; was the highest at PE (0.975) followed by KT (0.9618), SO (0.9631), BA (0.9618), KI (0.96), KA (0.9597), LA (0.9533) and GA (0.9329). The highest density (D'=1.024)

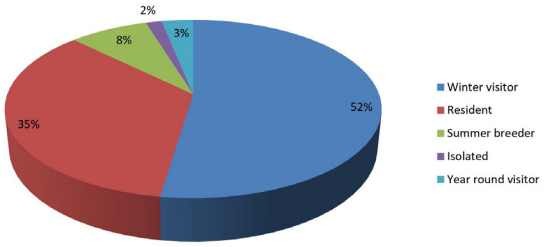

Figure 2. Status of waterbirds species in the study area, more than fifty percent are residents while others are migrants.

recorded from the KB. The highest dominance (D) was noted from GA (0.06713) and the lowest dominance recorded from BC (0.02). While the highest Evenness (E=9.613) was recorded from PE. During the survey noted that the highest Evenness (CI=1.202) was recorded from GA (Table 3).

The status of waterbirds of Tarbella Dam, Indus river, Pakistan was calculated as; Near Threatened 3, Endangered 1, Vulnerable 1 and Least Count 58 (Table 2 and Figure 2). Distribution was noted as; 22 resident and 33 winter visitor, 2 summer breeder, 1 isolated and 2 year-round visitors (Figure 3). The feeding habits of the avian species

Table 2. Waterbirds diversity of the study area.

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
1	Gadwall *Anas strepera* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	10	8	10	10	12	8	6	10	74
2	Common Teal *Anas crecca* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	10	20	10	16	14	4	6	0	80
3	Mallard *Anas platyrhynchos* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	28	18	7	14	24	12	12	12	127
4	Northern Pintail *Anas acuta* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	8	12	10	6	10	4	0	10	60
5	Shoveler *Anas clypeata* Linnaeus, 1758 Anatidae Anseriformes	Carnivorous	LC	WV	4	0	6	2	4	2	0	0	18

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
6	Red crested Pochard *Netta rufina* Pallas, 1773 Anatidae Anseriformes	Herbivore	LC	WV	2	0	12	6	0	3	0	0	23
7	Common Pochard *Aythya ferina* Linnaeus, 1758 Anatidae Anseriformes	Carnivorous	VU	WV	10	16	10	8	10	7	2	8	71
8	Tufted Duck *Aythya fuligula* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	1	0	1	1	0	0	0	0	3
9	Garganey *Anas querquedula* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	16	0	6	6	12	5	0	8	53
10	Eurasian wigeon *Mareca penelope* Linnaeus, 1758 Anatidae Anseriformes	Herbivore	LC	WV	8	0	4	4	6	8	0	6	36
11	Common Golden eye *Bucephala clangula* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	0	0	4	0	0	0	0	0	4
12	Purple swamp hen *Porphyrio porphyrio* Linnaeus, 1758 Rallidae Gruiformes	Omnivore	LC	R	4	5	3	3	2	3	2	0	22

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
13	Common shelduck *Tadorna tadorna* Linnaeus, 1758 Anatidae Anseriformes	Omnivore	LC	WV	2	4	4	0	0	2	0	0	12
14	Ruddy Shelduck *Tadorna ferruginea* Pallas, 1764 Anatidae Anseriformes	Omnivore	LC	WV	4	0	2	0	0	0	0	0	6
15	Ferruginous Duck *Aythya nyroca* Güldenstädt, 1770 Anatidae Anseriformes	Omnivore	NT	WV	2	0	1	0	0	0	0	0	3
16	Smew Duck *Mergellus albellus* Linnaeus, 1758 Anatidae Anseriformes	Carnivore	LC	WV	0	0	0	0	1	0	0	0	1
17	Intermediate Egret *Mesophoyx intermedia* Wagler, 1827 Ardeidae Pelecaniformes	Carnivore	LC	Y	14	8	10	14	8	10	10	8	82
18	Little White Egret *Egretta garzetta* Linnaeus, 1766 Ardeidae Pelecaniformes	Carnivore	LC	I	10	40	8	10	10	16	14	8	116
19	Grey Heron *Ardea cinerea* Linnaeus, 1758 Ardeidae Pelecaniformes	Carnivore	LC	WV	2	3	2	0	1	1	0	0	9

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
20	Black crowned night Heron *Nycticorax nycticorax* Linnaeus, 1758 Ardeidae Pelecaniformes	Carnivore	LC	WV	1	0	4	0	2	0	0	0	7
21	Little Cormorant *Microcarbo niger* Vieillot, 1817 Phalacrocoracidae Suliformes	Carnivore	LC	R	40	120	15	14	30	24	14	28	285
22	Great Cormorant *Phalacrocorax carbo* Linnaeus, 1758 Phalacrocoracidae Suliformes	Carnivore	LC	R	6	10	10	2	4	4	0	8	44
23	Great Crested Grebe *Podiceps cristatus* Linnaeus, 1758 Podicipedidae Podicipediformes	Carnivore	LC	WV	4	0	4	0	12	4	0	6	30
24	Little Greb *Tachybaptus ruficollis* Linnaeus, 1758 Podicipedidae Podicipediformes	Carnivore	LC	R	4	0	6	2	0	4	6	15	37
25	Water Rail *Rallus aquaticus* Linnaeus, 1758 Rallidae Gruiformes	Omnivore	LC	R	6	8	12	4	4	4	4	4	46
26	Eurasian bittern *Botaurus stellaris* Linnaeus, 1758 Ardeidae Pelecaniformes	Carnivore	LC	Y	2	0	4	1	4	0	0	0	11

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
27	Black or Eurasian Coot *Fulica atra* Linnaeus, 1758 Rallidae Gruiformes	Omnivore	LC	R	36	50	17	20	36	12	13	18	202
28	Greylag Goose *Anser anser* Linnaeus, 1758 Anatidae Anseriformes	Herbivore	LC	WV	0	8	2	0	0	0	0	6	16
29	Great White Fronted Goose *Anser albifrons* Scopoli, 1769 Anatidae Anseriformes	Herbivore	LC	WV	0	0	1	0	0	0	0	0	1
30	White or Pied Wagtail *Motacilla alba* Linnaeus, 1758 Motacillidae Passeriformes	Carnivore	LC	S	14	10	6	6	10	8	6	12	72
31	Black winged stilt *Himantopus himantopus* Linnaeus, 1758 Recurvirostridae Charadriiformes	Omnivore	LC	R	6	5	4	4	2	4	2	2	29
32	Common Crane *Grus grus* Linnaeus, 1758 Gruidae Gruiformes	Omnivore	LC	WV	2	6	0	0	2	0	4	0	14
33	Great White Pelican *Pelecanus onocrotalus* Linnaeus, 1758 Pelecanidae Pelecaniformes	Carnivore	LC	WV	0	0	1	0	0	0	0	0	1

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
34	Small Pied Kingfisher *Ceryle rudis* Linnaeus, 1758 Alcedinidae Coraciiformes	Carnivore	LC	R	6	6	4	4	5	2	4	6	37
35	Common kingfisher *Alcedo atthis* Linnaeus, 1758 Alcedinidae Coraciiformes	Carnivore	LC	R	4	5	3	2	3	4	2	2	25
36	Eurasian Oyster Catcher *Haematopus ostralegus* Linnaeus, 1758 Haematopodidae Charadriiformes	Carnivore	NT	WV	0	0	6	2	4	4	2	3	21
37	Grey Plover *Pluvialis squatarola* Linnaeus, 1758 Charadriidae Charadriiformes	Carnivore	LC	WV	6	0	4	0	0	3	4	4	21
38	Kentish or Snowy Plover *Charadrius alexandrinus* Linnaeus, 1758 Charadriidae Charadriiformes	Carnivore	LC	WV	12	0	2	2	0	2	2	4	24
39	Temminck's stint *Calidris temminckii* Leisler, 1812 Scolopacidae Charadriiformes	Herbivore	LC	WV	0	4	6	4	4	4	6	4	32
40	Common Snipe *Gallinago gallinago* Linnaeus, 1758 Scolopacidae Charadriiformes	Herbivore	LC	WV	0	16	4	0	4	4	8	0	36

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
41	Marsh Sandpiper / *Tringa stagnatilis* / Bechstein, 1803 / Scolopacidae / Charadriiformes	Carnivore	LC	WV	0	4	12	2	0	2	6	4	30
42	Black stroke / *Ciconia nigra* / Linnaeus, 1758 / Ciconiidae / Ciconiiformes	Carnivore	LC	WV	2	0	0	0	0	1	0	0	3
43	White stroke / *Ciconia ciconia* / Linnaeus, 1758 / Ciconiidae / Ciconiiformes	Carnivore	LC	WV	2	0	0	0	0	2	0	0	4
44	Common Black-headed Gull / *Larus ridibundus* / Linnaeus, 1766 / Laridae / Charadriiformes	Carnivore	LC	R	40	16	6	6	16	20	16	14	134
45	Great Black-backed Gull / *Larus marinus* / Linnaeus, 1758 / Laridae / Charadriiformes	Carnivore	LC	R	12	10	4	2	18	8	14	8	76
46	Red-wattled Lapwing / *Vanellus indicus* / Boddaert, 1783 / Charadriidae / Charadriiformes	Omnivore	LC	WV	2	6	4	2	0	0	8	0	22
47	Yellow-wattled Lapwing / *Vanellus malabaricus* / Boddaert, 1783 / Charadriidae / Charadriiformes	Carnivore	LC	WV	2	4	10	8	0	0	0	2	26

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
48	Collard Sand Martin *Riparia riparia* Linnaeus, 1758 Hirundinidae Passeriformes	Carnivore	LC	R	12	16	4	4	6	6	6	12	66
49	Red-rumped Swallow *Cecropis daurica* Laxmann, 1769 Hirundinidae Passeriformes	Herbivore	LC	R	4	10	6	8	4	4	6	4	46
50	*Sterna acuticauda* Black-bellied tern Laridae Charadriiformes	Carnivore	EN	R	30	40	22	20	20	33	20	30	215
51	Common Merganser *Mergus merganser* Linnaeus, 1758 Anatidae Anseriformes	Carnivore	LC	WV	4	12	2	0	0	0	2	2	22
52	Indian Pond Heron *Ardeola grayii* Sykes, 1832 Ardeidae Passeriformes	Carnivore	LC	R	4	18	4	4	0	4	2	4	40
53	Common Moorhen *Gallinula chloropus* Linnaeus, 1758 Rallidae Gruiformes	Omnivore	LC	R	2	9	6	4	4	0	2	6	33
54	Greater Thicknee/ Stone Plover *Esacus recurvirostris* Cuvier, 1829 Burhinidae Charadriiformes	Carnivore	NT	R	2	6	10	4	4	4	4	4	38

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
55	Water Cock *Gallicrex cinerea* Gmelin, 1789 Charadriidae Charadriiformes	Omnivore	LC	R	12	0	14	12	2	12	2	6	60
56	Great egret *Ardea alba* Linnaeus, 1758 Anatidae Pelecaniformes	Carnivore	LC	R	4	8	4	6	0	6	0	6	34
57	Pale crag Martin *Ptyonoprogne obsoleta* Cabanis, 1850 Hirundinidae Passeriformes	Carnivore	LC	R	4	8	2	4	0	6	4	0	28
58	Lesser Sand Plover *Charadrius mongolus* Pallas, 1776 Charadriidae Charadriiformes	Carnivore	LC	R	6	4	4	6	6	3	8	4	41
59	Caspian Gull *Larus cachinnans* Pallas, 1811 Charadriidae Laridae	Carnivore	LC	S	30	8	8	0	0	12	12	0	70
60	Lesser Black-headed Gull *Larus fuscus* Linnaeus, 1758 Motacillidae Laridae	Omnivores	LC	S	12	14	8	2	16	8	6	14	80
61	Grey Wagtail *Motacilla cinerea* Tunstall, 1771 Motacillidae Passeriformes	Carnivore	LC	S	14	0	7	2	0	0	2	0	25

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 2. Continued...

Sr. No.	Common name / Scientific name / Species Authority / Family / Order	Food habit	Conservation Status	Distribution	KT	GA	PE	SO	LA	KI	BA	KA	Total
62	Common Tern *Sterna hirundo* Linnaeus, 1758 Laridae Passeriformes	Carnivore	LC	S	16	16	14	10	6	6	8	8	84
63	Cattle Egret *Bubulcus ibis* Linnaeus, 1759 Ardeidae Pelecaniformes	Carnivore	LC	R	12	10	0	0	0	0	0	0	22

Note: Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered), Resident (R), Summer Visitor (S), Winter Visitors (WV), Isolated (I) and Year round visitors (Y).

Table 3. Diversity indices of waterbirds of study area.

Diversity Indices	KT	GA	PE	SO	LA	KI	BA	KA
Species	54	41	58	44	39	46	39	39
Individuals (I)	512	601	376	273	342	309	257	320
Dominance (D)	0.0382	0.06713	0.02503	0.03686	0.04668	0.04002	0.03817	0.04029
Simpson (S)	0.9618	0.9329	0.975	0.9631	0.9533	0.96	0.9618	0.9597
Shannon (H')	3.567	3.242	3.85	3.51	3.321	3.516	3.436	3.431
Evenness (E)	0.6561	0.624	0.8103	0.7604	0.7097	0.7314	0.7968	0.7928
Richness (R)	8.496	6.251	9.613	7.666	6.513	7.849	6.848	6.588
Density/Census Index (D')	1.024	1.202	0.752	0.546	0.684	0.618	0.514	0.64

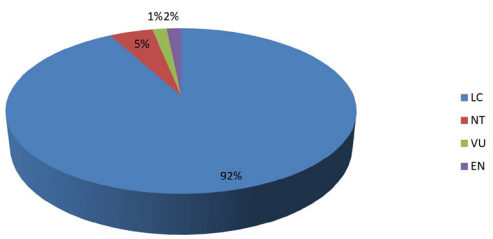

Figure 3. Distribution of waterbirds species in the study area, more than 90% species has no threats while other species are facing threats according to IUCN (Least Count (LC), Vulnerable (VU), Near Threatened (NT), EN (Endangered).

noted as; Carnivore (n=37), Omnivore (19) and Herbivore (7) (Figure 4). This data are collected from Book "Birds of Pakistan" Roberts (Roberts, 1992; 1991).

The statistical analysis of cluster analysis shows that two groups are present in the cluster analysis i.e. Group one (G1) and Group two (G2). SG1 consists of PE, selected landscape was 10% anthropogenically impacted. G2 has two subgroups i.e. SG2a and SG2b. Both groups show extremely low similarity (-0.32). SG2b consists of GA and KA, both were 60% and 70% anthropogenically impacted respectively. G2a consists of two further subgroups i.e. G2a-I and G2a-II. G2a-I consists of SO, LA and BA, all were 40%,

50% and 50% respectively anthropogenically impacted. G2a-II consists of KT and KI, both were 30% anthropogenically impacted (Figure 5). Cluster analysis show that different study sites have different level of anthropogenic impact and so more effected study sites have more affected on the diversity of waterbirds. Anthropogenic impacts are noted as; urbanization, agriculture, industrialization, fishing, hunting and tourism, which are negatively impact on avian species (Ali et al., 2020; Altaf, 2016; Bashir et al., 2018; Haider et al., 2017; Hakeem et al., 2017; Rauf et al., 2017).

The two axes of the PCA explained 88.782% of difference in avian diversity (PC 1: 77.799%; PC 2: 10.983). Variables loading onto PC 1 included KT (r = 0.37222), GA (r = 00.76394), PE (r = 0.13562), SO (r = 0.16852), LA (r = 0.29682), KI (r = 0.23431), BA (r = 0.16765) and KA (r = 0.24484). The direction of these associations shows that PC 1 synthesized the response of the avian community from natural to anthropogenically impacted landscapes as well as can be documented as a gradient of development extent. Natural and disturbed habitats also loaded into PC 2 (KT: r = 0.53806, GA: r = -0.63746, PE: r = 0.17178, SO: r = 0.20238, LA: r = -.26481, KI: r = 0.27525, BA: r = 0.21203 and KA: r = 0.20694). Both principal component (PC) is not correlated with each other; likewise, waterbirds' diversity patterns extracted by component 2 are not related to those explained by component 1. Approximately, all variables (i.e. study sites) do not resemble noticeably with each other in PCA. It is noted that human activity impacts were the main factor determining the waterbirds community (Figure 6 and 7). These variables show that waterbirds species has the highest negative correlation with the greatest anthropogenically impacted study sites as studied by other researchers (Bashir et al., 2018; Haider et al., 2017; Rauf et al., 2017). During the research documented that specialized birds are declined due to deforestation, degradation and modification of study sites, waterbirds diversity also has positively relation with plant species and insect species by Fraterrigo and Wiens (2005).

During the survey noted that foodstuff is also a main factor in the distribution of species, specialist waterbirds are recorded in restricted areas; on the other hand, generalist birds are documented in variety of landscapes, this concept is also documented by researcher (Ali et al., 2020; Altaf, 2016; Clavel et al., 2010; Devictor et al., 2007; Fernández-Juricic, 2004). Insect and Garbage in anthropogenically impacted landscapes are highly positively related with one another. Due to anthropogenic impacts, insectivore particularly omnivore species of waterfowl have high population in modified landscape. Urban and rural area provides food and shelters, which attracted to insectivore and omnivore waterfowls. On the other hand, some waterfowl species do not like human presence in their environment, in the response; many waterfowl species are restricted in niche.

It is documented that agriculture intensification also creates negative impacts on the waterfowl diversity, due to direct as well as indirect impacts i.e. noise, air and water pollution. It is also documented that diversity and distribution is increase at the ecotone regions. Bushes and herbs also create positive impact for the waterfowl diversity and this concept is also supported by the ornithologist (Fernández-Juricic, 2004; Golawski and Kasprzykowski, 2011; Hiron et al., 2013).

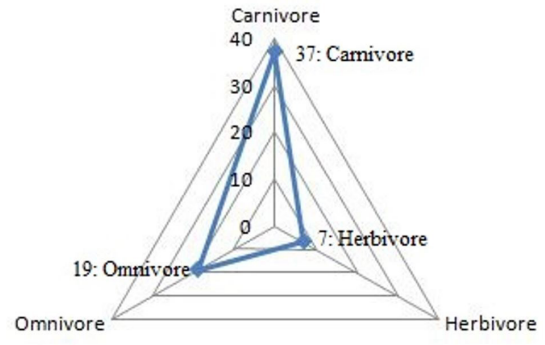

Figure 4. Feeding habits of waterbird species in the study area.

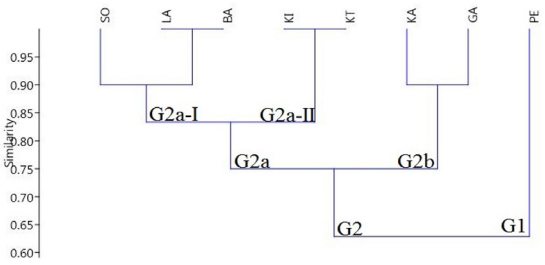

Figure 5. Analysis of anthropogenic impacts on the study areas with the help of cluster (Jaccard) analysis.

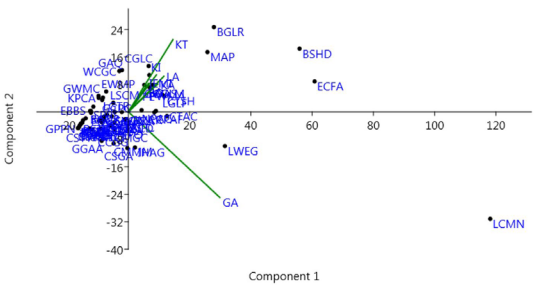

Figure 6. Principal components analysis represents the diversity of birds (code present in Table 2) across the different habitats.

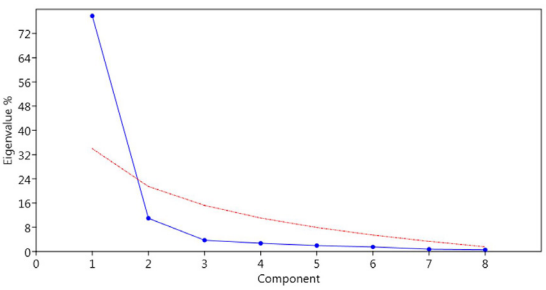

Figure 7. Evaluation of each component in Principal components analysis.

4. Conclusion

During the study, noted that human activities are the major issue that creates negative as well as positive impacts on the diversity and distribution of avian species. Waterbirds species respond rapidly to human activities disturbance. We recommended that Government Organizations or departments and NGOs should work to conserve the disturbed habitats.

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