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Analysis of anthropogenic activities on avian diversity along the coastal landscape of Sindh, Pakistan

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ABSTRACT

The avian species are the excellent bio-indicators which help to recognize concerned landscapes for conservation. This research was planned to know about the anthropogenic activities on diversity of birds along the coastal area of Sindh, Pakistan. The avian diversity was documented at the anthropogenically impacted landscapes of the study area. The data on diversity of different species of birds were documented through linear count survey. Two methods were applied; i) direct count method i.e. direct count and sound identification and ii) indirect count method i.e. to observe carcasses in study areas and individual and group meetings with native people. Every species has its own choice to select habitats, while disturbance of habitats may produce negative impacts on many avian species and on the other hand may produce positive impacts on some species. During the one year of avian surveys, a total of 74 species avian species has been listed along the coastal landscape of Sindh, Pakistan. Collected statistical data demonstrates that Shannon-Wiener diversity index gives a quantitative description of diversity which was the highest at Badin coastline (4.09) followed by Sunhara beach (3.68), Banbhore (3.63), Hawkes Bay (3.62), Keti Bundar (3.59) and Ibrahim Hydri (3.37). It was concluded from this research that human activities in an area are the main factors that produce positive and negative impacts on the abundance of avian species. Species of birds respond quickly to anthropogenic activities. Conservation and restoration of bird species may be focused at all important habitats.

Keywords: Wetland, Coastal, Birds, Anthropogenic activity

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INTRODUCTION

Wetlands are the most beneficial ecosystems of the world (Ghermandi *et al.*, 2008) and supply lot of ecological services to human of the world (Ten Brink *et al.*, 2012). They are fundamental habitats for the flora and fauna for their life activities (Bartram and Ballance, 1996). Water is essential for life (Gleick *et al.*, 2002) which has a very important role in evolution of societies of human.

Wetlands have vast variety of species according to their origin, geographical position, water chemistry, soil type and sediment features (SAC, 2011). More than 1275 Million hectares wetlands are present in the whole world (Finlayson and Spiers, 1999). Pakistan has round about 225 wetlands and roughly has 0.78 million hectares area. Out of total, 74% wetlands consist of freshwater and remaining 26% wetlands consists of marine water. Out of total wetlands, only 19 wetlands have been designated as Ramsar Sites under Ramsar Convention on Wetlands (Altaf *et al.*, 2014).

Among all the vertebrates birds represent maximum diversity. 668 species of birds are present in Pakistan (Grimmett, 1998; Mirza and Wasiq, 2007) which adds round about 7.4% of the world's bird species (9042 avifauna of the world) (Sibley and Monroe, 1990; Sibley and Monroe Jr, 1993). Indian subcontinent is famous for its prosperous and variety of avian species whose habitat, distribution and taxonomic features are well analyzed by scientist (Grimmett, 1998; Mirza and Wasiq, 2007; Ashraf *et al.*, 2019; Jadoon *et al.*, 2019). It is very essential to know the diversity and density of avian populations to explain the significance of local landscapes for birds' conservation (Altaf, 2010; Ali, 2017; Ali *et al.*, 2017). Also, evaluation of avian population has become a significant tool in conservation of diversity for knowing conservation methods in regions of high human pressure (Altaf *et al.*, 2018).

The avian species are the best bio-indicators and guide us to recognize main concern ecosystems for conservation. Major threats to birds of Pakistan include; illegal hunting, poaching, over grazing by livestock, deforestation, agriculture intensification, urbanization, industrialization, pollution and climate change. All these threats are main causing-agents to decline and extinction of avian species. The present study was designed to recognize diversity of avian species along the coastal habitats of Sindh, Pakistan.

MATERIALS AND METHODS

STUDY AREA

Sindh is located in a tropical to subtropical region (Figure 1 and Table 1), summer is hot (above 46 °C, during May and August) and winter is mild (2 °C, during December and January). The annual rainfall averages about 7 inches, falling mainly from July to August. (Rasul and Ahmad, 2012; Adnan *et al.*, 2015).

Table 1: Coordinates of study areas.

Study area	Code	Coordinate	Elevation (ft)
Badin coastline	BC	24′19°13 N, 68′51°43E	6
Keti Bundar	KB	24′08°40 N, 67′27°02E	10
Banbhore	BB	24′44°44N, 67′31°04E	8
Hawkes Bay	HB	24′50°56 N, 66′53°20E	13
Ibrahim Hydri	IH	24′47°31 N, 67′08°37E	26
Sunhara beach	SB	24′52°46 N, 66′41°36E	4

Dominant flora in coastal region of Sindh includes; gum acacia (*Acacia ruprstris*), rohida (*Techoma undulata*), khip (*Periploca aphylla*), phog (*Calligonum polygonides*), Babbur (*Acacia nilotica*), nim (*Azadirachta inidica*), ber (*Ziziphus vulagaris*), lai (*Tamarix orientalis*), kirrir (*Capparis aphyla*), Kandi (*Prosopis cineraria*), timmar (*Avicennia marina*) and chaunir (*Ceriops tagal*) (FDGOS, 2020). Common fauna in coastal region of Sindh includes; Sindh ibex, urial, black bear, fishing cat, striped hyena, jackal, fox, porcupine, common gray mongoose, hedgehog, hog deer, wild boar and Indus dolphin (FDGOS, 2020).

METHODOLOGY

The linear count survey was used to analyze variety of avian species in the study area from October 2017 to February 2018. Study area consists of 6 sites i.e. Badin coastline (given code as BC), Keti Bundar (KB), Banbhore (BB), Hawkes Bay (HB), Ibrahim Hydri (IH) and Sunhara beach (SB). Direct method i.e. Physical presence and sound of birds were documented and indirect method was documented through open and close chain interviews of the coastal communities. During the survey questions were asked from hunters, birdwatchers, farmers, fishermen and tourists about the presence, status of birds and threats to them. Each selected and observed area consisted of 1000 square hectares. An ornithologist compiled the data with naked eye, with help of binocular and camera. Field guide of "Birds of Pakistan" was used to identify the species of birds (Grimmett, 1998).

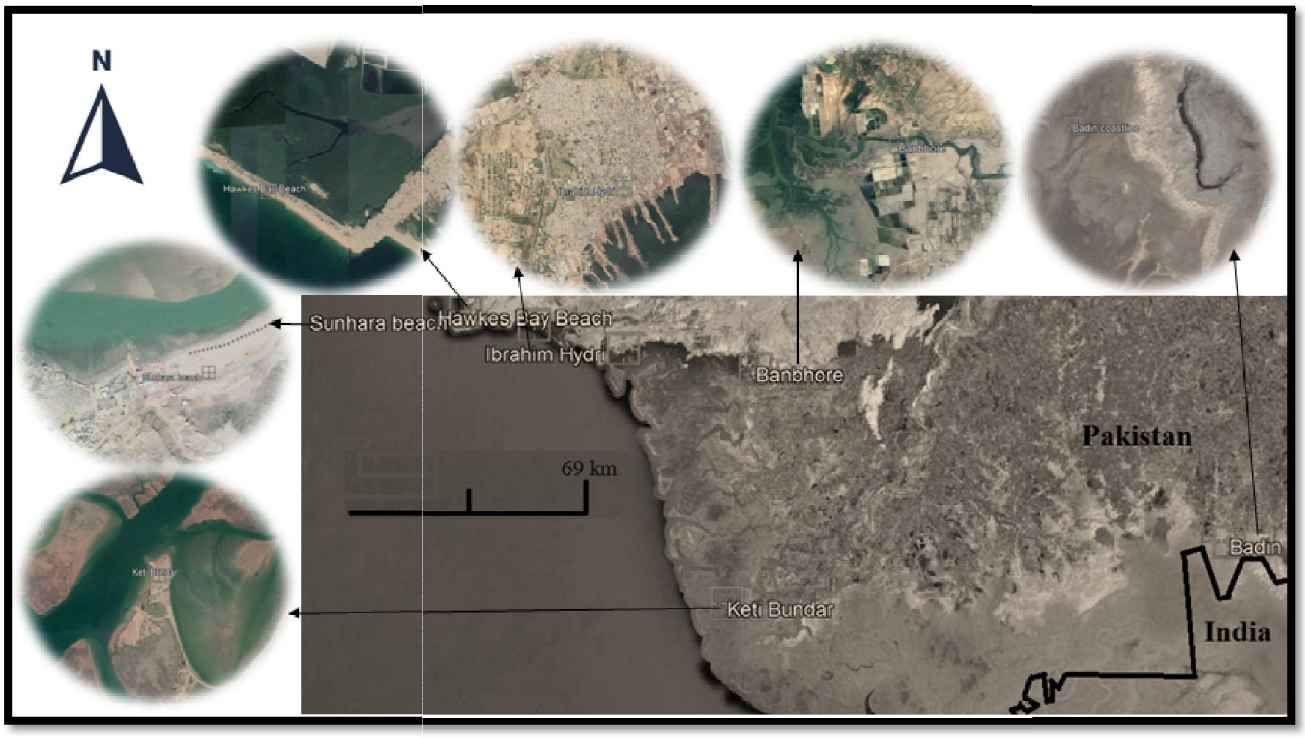

Figure 1: Map of the coastal area of Sindh, Pakistan.

STATISTICAL ANALYSIS

Past (version 3) statistical tool was applied to analyzes; the "Shannon-Wiener Diversity Index, "Simpson Diversity", "Evenness Index", "Richness Index", "Dominance Index", "Cluster Analysis" and "Principle Component Analysis" (Hammert *et al.*, 2001).

While "Density" was collected by the following formula

$$D' = n/\text{area (hectare)}$$

Where "n" is number of avian species.

RESULT AND DISCUSSION

During one year of bird surveys, a total of 74 species has been compiled which belongs to 44 genera, 13 families and 7 orders for all habitats along coastal area of Sindh, Pakistan (Table 2). Species richness was highest at the BC with 9.12; the richness in the other places was 7.5, 7.90, 7.09 and 7.26 at KB, BB, HB, IH and SB respectively. Collected statistical data demonstrates that Shannon-Wiener diversity index gives a quantitative description of diversity which was the highest at BC (4.09) followed by SB (3.68), BB (3.63), HB (3.62), KB (3.59) and IH (3.37). Similarly Simpson diversity index (D) which is used to measure avian species; was the highest at BC (0.98) followed by SB (0.97), BB (0.96), HB (0.96), KB (0.96) and IH (0.94). The highest density (8.39) recorded from the KB. The highest dominance (D) was noted from IH (0.06) and the lowest dominance recorded from BC (0.02) (Table 3).

The status of the avian species in coastal area of Sindh, Pakistan was calculated as; Near Threatened 5 (7%), Vulnerable 4 (5%) and Least Concern 65 (88%) (Figure 2). The feeding habits of the avian species noted as; 2 planktivorous (3%), 4 piscivorous (5%), 17 omnivorous (23%), 5 insectivorous (7%) and 46 carnivorous (62%) (Figure 3). And distribution was noted as; 42 native resident bird species and 32 winter visitor.

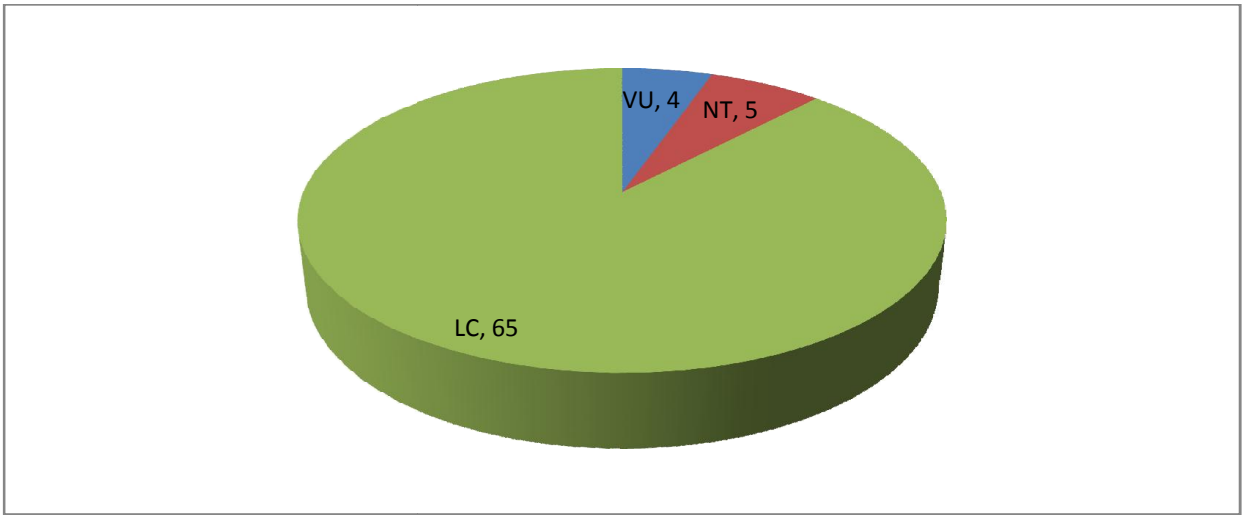

Figure 2: Status of avian species in the study area.

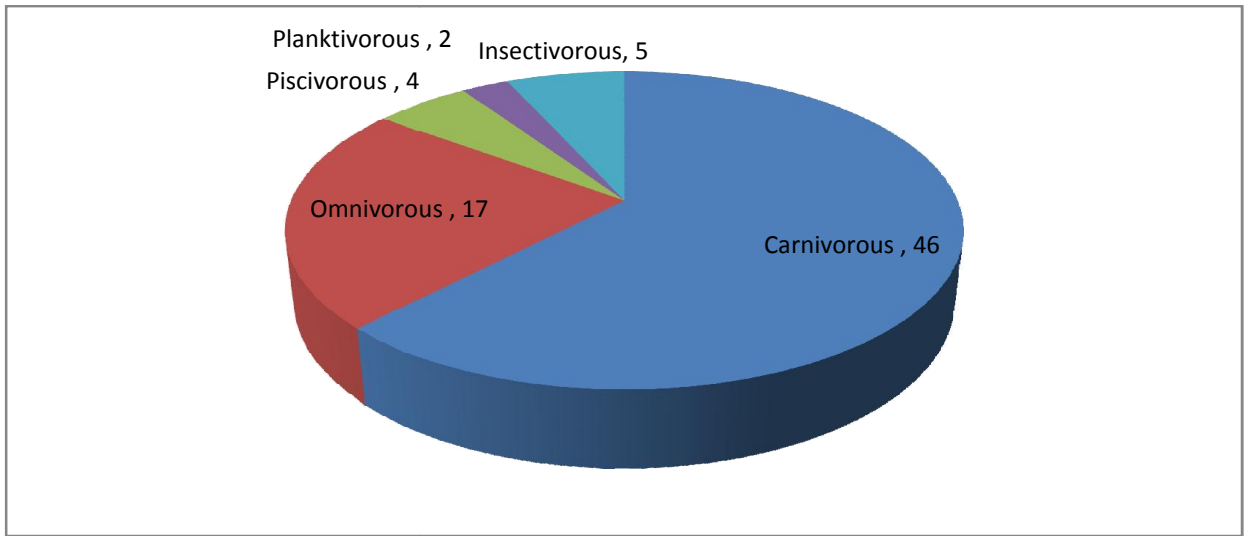

Figure 3: Feeding habits of avian species in study area.

It is noted that two groups (i.e. G1 and G2) are noted in the cluster analysis (CA) i.e. Group one i.e. G1 as well as Group two i.e. G2. Group one i.e. G1 has two sub-groups i.e. SG1-I and SG1-II, similarly Group two i.e. G2 has also two sub group i.e. SG2-I and SG2-II. Both groups (i.e. Group one as well as Group two) show extremely low similarity (-0.32). SG1-I has HB habitat, which is 30% anthropogenically impacted, while has two habitats i.e. KB and IB, both are 80% and 70% respectively anthropogenically impacted. Similarly SG2-I has Single habitat i.e. BB, and it was less (10%) anthropogenically impacted, while SG2-II has two habitats i.e. SB and BC, SB was only (5%) anthropogenically impacted and BC consist of 100% natural habitats (Figure 4). Anthropogenic impacts are noted as; urbanization, agriculture, industrialization and tourism.

The 2 axes of the Principal Component Analysis i.e. PCA explained 94.2% of difference in avian diversity (PC 1: 86.28 %; PC 2: 7.89%). Variables loading onto PC 1 included BC (r = 0.06), KB (r = 0.678), BB (r = 0.165), HB (r = 0.3), IH (r = 0.628) and SB (r = 0.155). 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 (BC: r = 0.015, KB: r = 0.366, BB: r = 0.479, HB: r = 0.161, IH: r = -0.69 and SB: r = 0.365). Both principal component (PC) is not correlated with each other; likewise, birds' diversity patterns extracted by PC 2 are not related to those explained by PC 1. Almost all variables landscapes does not resemble considerably with other PCA component showing that human activity impacts was the principal factor determining the avian community (Figure 5). These variables show that avian species has more negative correlation with more anthropogenically impacted habitats . During the survey noted that specialized birds are declined due to agricultural intensification, urbanization, industrialization and tourism, avian diversity also positively correlated with plant species and insect species by Fraterrigo and Wiens (2005).

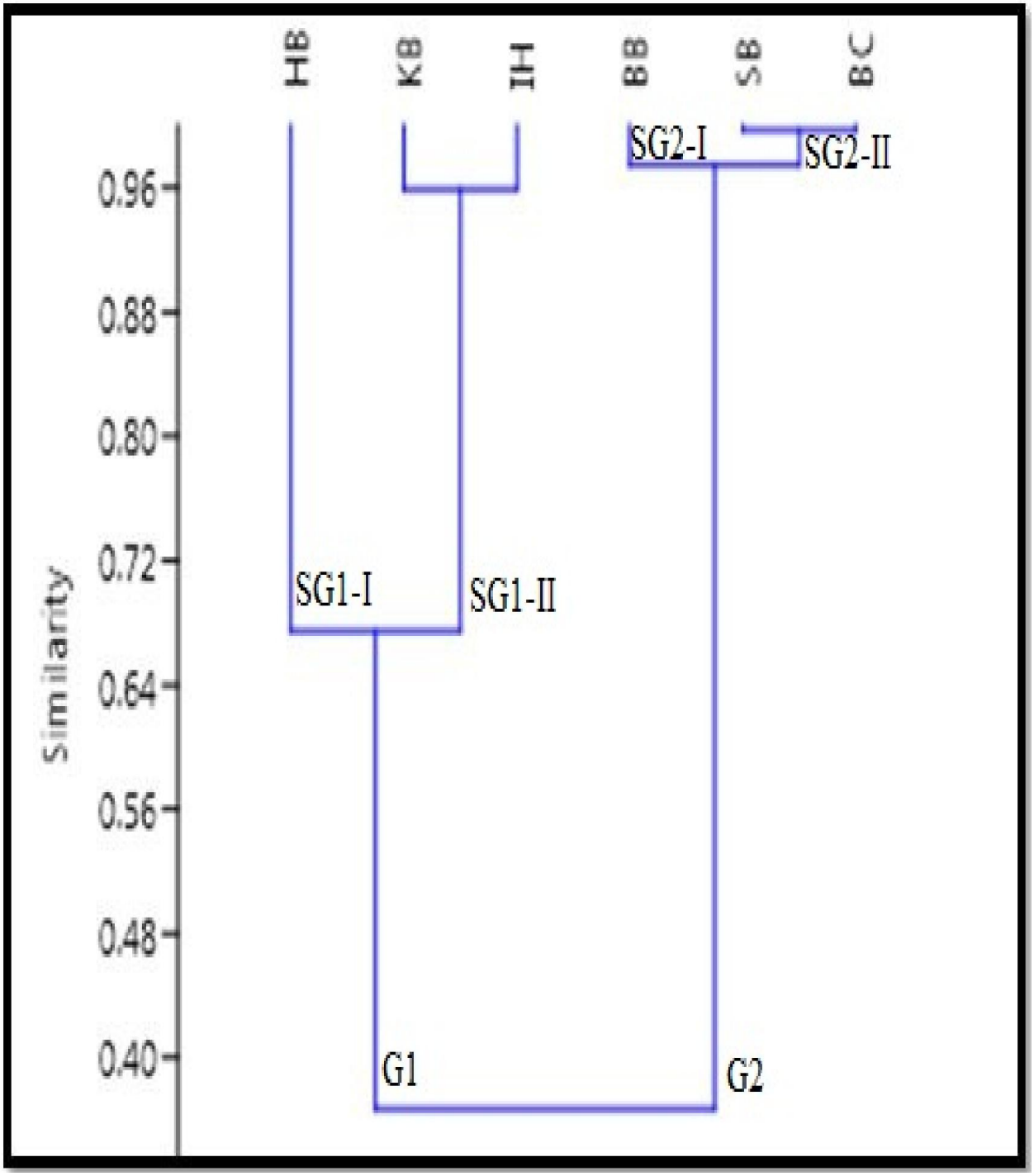

Figure 4: Analysis of anthropogenic impacts on the study areas with the help of cluster analysis, while HB represents to Hawkes Bay, KB represents to Keti Bundar), IH represents to Ibrahim Hydri, BB represents to Banbhore), SB represents to Sunhara beach and BC represents to Badin coastline.

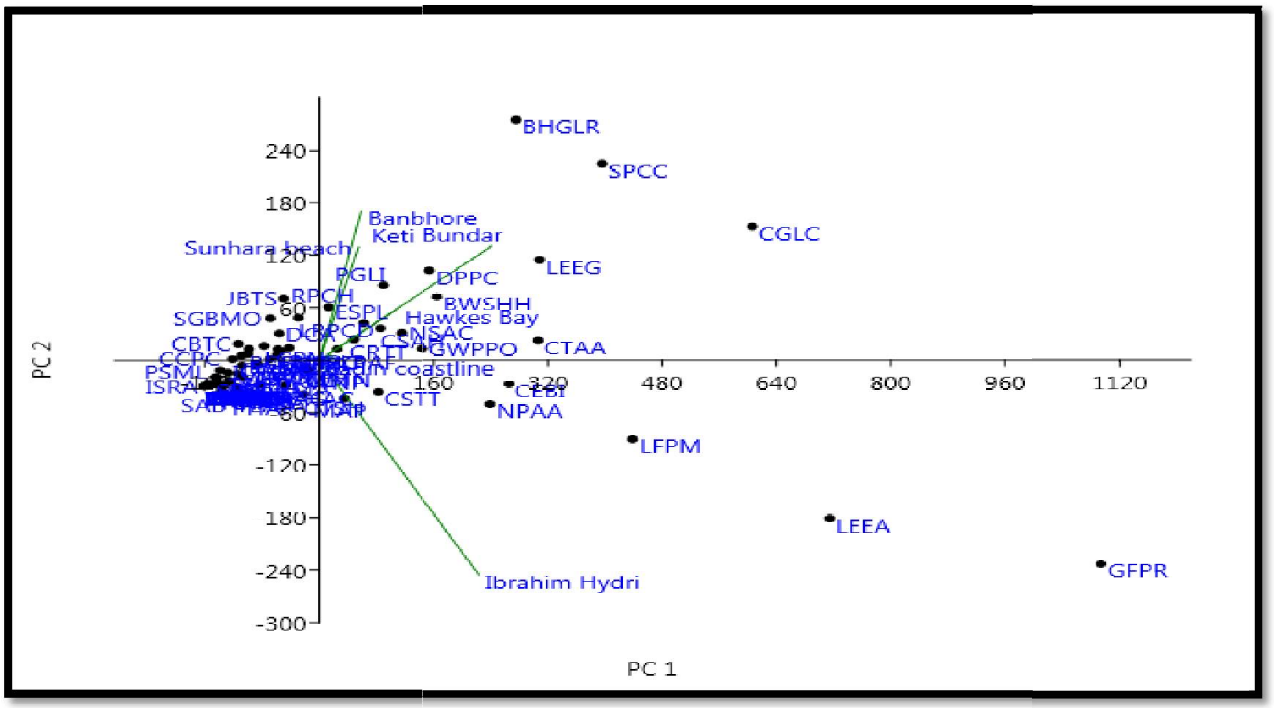

Figure 5: Principal components analysis represents the diversity of birds (code present in Table 2) across the different habitats.

Collected data explain that environment and occurrence of foodstuff of birds species is a major factor in the distribution of avian species, similarly specialist birds were not present in intensive urban habitats; on the other hand, generalist birds are present in huge numbers, this observation is also supported by scientists (Fernández-Juricic, 2004; Devictor *et al.*, 2007; Clavel *et al.*, 2010; Altaf, 2016). Garbage and insects in urban landscapes are positively correlated with each other. Due to these reasons, insectivore and granivore especially omnivore species of birds have high population in anthropogenically impacted landscape. Urban and peri-urban landscapes offer food and shelters i.e. roofs and houses spaces. Some avian species are shy in nature and do not like human presence in their territories because of this many species are only restricted in natural environment.

Collected data explain that agriculture intensification has also produced negative impacts on the avian diversity which include; reduce nesting sites, disturbance due to farming operations and pesticides. It is has been observed that agriculture area with large numbers of trees has positive correlation with the avian diversity, as birds obtain shelter and food form the trees. It has also been documented that abundance and species of birds also enhanced at the ecotone regions. Farmsteads and hedgerows also produce magnetism for the avian species and also supported by many ornithologist (Fernández-Juricic, 2004; Golawski and Kasprzykowski, 2011; Hiron *et al.*, 2013).

CONCLUSION

The human activities are the main factors that produce positive and negative impacts on the abundance of avian species. Statistical analysis can calculate the avian diversity in different anthropogenically impacted landscapes. Species of birds respond quickly to anthropogenic activities. Conservation and restoration may be focused at all important habitats.

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Table 2: Diversity, status and distribution of birds in study areas.

Sr.	Common Name Scientific Name Species authority	Order Family	Food Habit	Code	BC	KB	BB	HB	IH	SB	Status	Distribution
1	Shikra *Accipiter badius* Gmelin, 1788	Accipitriformes Accipitridae	Carnivorous	SAB	11	2	5	21	29	15	LC	NR
2	Tawny Eagle *Aquila rapax* Temminck, 1828	Accipitriformes Accipitridae	Carnivorous	TEAR	2	8	5	34	38	24	VU	NR
3	Marsh harrier *Circus aeruginosus* Linnaeus, 1758	Accipitriformes Accipitridae	Carnivorous	MHCA	4	9	1	12	18	21	LC	WV
4	Brahminy kite *Haliastur Indus* Boddaert, 1783	Accipitriformes Accipitridae	Carnivorous	BKHI	18	5	4	15	18	20	LC	NR
5	Mallard *Anas platyrhynchos* Linnaeus, 1760	Anseriformes Anatidae	Omnivorous	MAP	32	75	45	150	140	25	LC	WV
6	Northern Paintail *Anas acuta* Linnaeus, 1758	Anseriformes Anatidae	Omnivorous	NPAA	67	270	15	150	250	57	LC	WV
7	Northern shovler *Anas clypeata* Linnaeus, 1758	Anseriformes Anatidae	Omnivorous	NSAC	45	270	14	79	98	26	LC	WV
8	Common teal *Anas crecca* Linnaeus, 1758	Anseriformes Anatidae	Omnivorous	CTAA	98	300	150	175	270	75	LC	WV
9	Garganey *Anas querquedula* Linnaeus, 1758	Anseriformes Anatidae	Omnivorous	GAQ	17	45	25	29	35	43	LC	WV
10	Common pochard *Aythya ferina* Linnaeus, 1758	Anseriformes Anatidae	Omnivorous	CPAF	77	145	12	85	75	56	VU	NR
11	Common shelduck *Tadorna tadorna* Linnaeus, 1758	Anseriformes Anatidae	Omnivorous	CSTT	43	150	24	46	170	100	LC	WV
12	Kentish plover *Charadrius alexandrinus*	Charadriiformes Charadriidae	Omnivorous	KPCA	43	4	19	25	35	64	LC	WV

	Linnaeus, 1758											
13	Sand plover *Charadrius mongolus* Pallas, 1776	Charadriiformes Charadriidae	Carnivorous	SPCC	1	450	300	180	200	150	LC	WV
14	Little ring plover *Charadrius dubius* Scopoli, 1786	Charadriiformes Charadriidae	Carnivorous	LRPCD	32	100	68	95	28	35	LC	WV
15	Ringed plover *Charadrius hiaticula* Linnaeus, 1758	Charadriiformes Charadriidae	Carnivorous	RPCH	57	140	54	85	46	84	LC	WV
16	Red wetled lapwing *Vanellus indicus* Boddaert, 1783	Charadriiformes Charadriidae	Omnivorous	RWLVI	75	0	0	0	0	0	LC	NR
17	Indian Courser *Cursorius coromandelicus* Gmelin, 1789	Charadriiformes Glareolidae	Carnivorous	ICCC	41	2	0	0	0	0	LC	WV
18	Small Pratincole *Glareola lactea* Temminck, 1820	Charadriiformes Glareolidae	Carnivorous	SPGL	21	21	5	0	0	0	LC	NR
19	Brown Headed-gull *Larus brunnicephalus* Jerdon, 1840	Charadriiformes Laridae	Omnivorous	BHGLB	61	89	65	35	49	21	LC	WV
20	Caspian gull *Larus cachinnans* Pallas, 1811	Charadriiformes Laridae	Carnivorous	CGLC	44	600	150	250	350	250	LC	WV
21	Pallas,s gull *Larus ichthyaetus* Pallas, 1773	Charadriiformes Laridae	Carnivorous	PGLI	42	140	135	129	111	150	LC	WV
22	Black Headed gull *Larus ridibundus* Linnaeus, 1766	Charadriiformes Laridae	Carnivorous	BHGLR	62	400	200	250	49	150	LC	WV
23	Indian Skimmer *Rynchops albicollis* Swainson, 1838	Charadriiformes Laridae	Carnivorous	ISRA	17	1	0	0	0	0	VU	NR
24	Little turn *Sternula albifrons* Pallas, 1764	Charadriiformes Laridae	Carnivorous	LTSA	23	12	19	29	35	14	LC	WV
25	Common turn	Charadriiformes	Carnivorous	CTSH	15	95	12	25	95	32	LC	WV

	Sterna hirundo Linnaeus, 1758	Laridae										
26	Black winged stilt *Himantopus himantopus* Linnaeus, 1758	Charadriiformes Recurvirostridae	Carnivorous	BWSHH	76	200	150	140	160	120	LC	NR
27	Pied avocet *Recurvirostra avosetta* Linnaeus, 1758	Charadriiformes Recurvirostridae	Omnivorous	PARA	49	12	5	19	21	29	LC	NR
28	Common sandpiper *Actitis hypoleucos* Linnaeus, 1758	Charadriiformes Scolopacidae	Carnivorous	CSAH	78	200	10	140	85	64	LC	WV
29	Sanderling *Calidris alba* Pallas, 1764	Charadriiformes Scolopacidae	Carnivorous	SCA	21	14	1	5	8	9	LC	NR
30	Dunlin *Calidris alpine* Linnaeus, 1758	Charadriiformes Scolopacidae	Carnivorous	DCA	23	85	54	59	25	29	LC	WV
31	Little stint *Calidris minuta* Leisler, 1812	Charadriiformes Scolopacidae	Carnivorous	LSCM	29	0	0	0	0	0	LC	WV
32	Temnick,s Stint *Calidris temminckii* Leisler, 1813	Charadriiformes Scolopacidae	Carnivorous	TSCT	8	25	16	19	11	9	LC	WV
33	Common snipe *Gallinago gallinago* Linnaeus, 1758	Charadriiformes Scolopacidae	Omnivorous	IRHGG	41	0	0	0	0	0	LC	WV
34	Wood snipe *Gallinago nemoricola* Hodgson, 1836	Charadriiformes Scolopacidae	Omnivorous	WSGN	23	0	0	0	0	0	VU	WV
35	Jack Snipe *Lymnocryptes minimus* Brünnich, 1764	Charadriiformes Scolopacidae	Omnivorous	JSLM	12	1	0	8	4	6	LC	WV
36	Eurasian curlew *Numenius arquata* Linnaeus, 1758	Charadriiformes Scolopacidae	Carnivorous	ECNA	38	49	32	38	12	15	NT	WV
37	Whimbrel *Numenius phaeopus* Linnaeus, 1758	Charadriiformes Scolopacidae	Carnivorous	WNP	36	95	45	43	84	36	LC	WV
38	Common greenshank *Tringa nebularia*	Charadriiformes Scolopacidae	Carnivorous	CGTN	49	85	65	46	83	27	LC	WV

	Gunnerus, 1767											
39	Marsh sandpiper *Tringa stagnatilis* Bechstein, 1803	Charadriiformes Scolopacidae	Carnivorous	MSTS	85	85	20	25	36	38	LC	WV
40	Common Redshank *Tringa totanus* Linnaeus, 1759	Charadriiformes Scolopacidae	Carnivorous	CRTT	47	190	24	39	84	65	LC	WV
41	Sindh green bee-eater *Merops orientalis* Latham, 1802	Coraciiformes Meropidae	Insectivorous	SGBMO	29	89	95	12	14	19	LC	NR
42	Blue-cheeked bee-eater *Merops persicus* Pallas, 1773	Coraciiformes Meropidae	Insectivorous	BCBMP	53	58	42	15	11	16	LC	NR
43	Grey-backed shrike *Lanius tephronotus* Vigors, 1831	Passeriformes Laniidae	Carnivorous	LBHIM	16	1	1	0	0	0	LC	WV
44	Bay backed shrike *Lanius vittatus* Valenciennes, 1826	Passeriformes Laniidae	Carnivorous	BBSLV	17	8	1	0	2	0	LC	NR
45	Jungle babbler *Turdoides striata* Dumont, 1823	Passeriformes Leiothrichidae	Omnivorous	JBTS	49	135	105	0	0	0	LC	NR
46	Common babbler Argya caudata Blyth, 1847	Passeriformes Leiothrichidae	Omnivorous	CBTC	34	54	59	0	0	0	LC	NR
47	Forest wagtail *Dendronanthus indicus* Gmelin, 1790	Passeriformes Motacillidae	Insectivorous	FWDI	11	0	0	0	0	0	LC	WV
48	White wagtail *Motacilla alba* Linnaeus, 1758	Passeriformes Motacillidae	Carnivorous	WWMA	53	25	21	35	29	15	LC	WV
49	Grey wagtail *Motacilla cinerea* Tunstall, 1771	Passeriformes Motacillidae	Carnivorous	GWMC	49	85	49	24	38	26	LC	WV
50	Citrine wagtail *Motacilla citreola* Pallas, 1776	Passeriformes Motacillidae	Carnivorous	CWMC	53	58	28	35	42	53	LC	WV
51	Yellow wagtail *Motacilla flava*	Passeriformes Motacillidae	Carnivorous	YWMF	45	49	43	29	35	14	LC	WV

	Linnaeus, 1758											
52	White browned wagtail *Motacilla maderaspatensis* Gmelin, 1789	Passeriformes Motacillidae	Insectivorous	WBMM	59	35	42	19	21	4	LC	NR
53	Pied bushchat *Saxicola caprata* Linnaeus, 1766	Passeriformes Muscicapidae	Insectivorous	PBSC	29	21	2	6	0	0	LC	NR
54	Darter *Anhinga melanogaster* Pennant, 1769	Pelecaniformes Anhingidae	Carnivorous	DAM	20	49	28	34	5	4	NT	NR
55	Pond heron *Ardeola grayii* Sykes, 1832	Pelecaniformes Ardeidae	Carnivorous	PHAG	35	48	15	26	49	16	LC	NR
56	Grey heron *Ardea cinerea* Linnaeus, 1758	Pelecaniformes Ardeidae	Carnivorous	GHAC	11	64	25	39	78	37	LC	NR
57	Purple heron *Ardea purpurea* Linnaeus, 1766	Pelecaniformes Ardeidae	Carnivorous	PHAP	10	25	5	11	45	21	LC	NR
58	Cattle egret *Bubulcus ibis* Linnaeus, 1758	Pelecaniformes Ardeidae	Carnivorous	CEBI	112	250	140	79	300	100	LC	NR
59	Large egret *Egretta alba* Linnaeus, 1758	Pelecaniformes Ardeidae	Carnivorous	LEEA	123	500	200	150	700	75	LC	NR
60	Little egret *Egretta garzetta* Linnaeus, 1766	Pelecaniformes Ardeidae	Carnivorous	LEEG	65	400	150	75	200	140	LC	NR
61	Indian reef heron *Egretta gularis* Bosc, 1792	Pelecaniformes Ardeidae	Carnivorous	NRHEG	23	10	5	8	20	5	LC	NR
62	Little bittrn heron *Ixobrychus minutus* Linnaeus, 1766	Pelecaniformes Ardeidae	Carnivorous	LBHIN	38	21	14	8	20	8	LC	WV
63	Night heron *Nycticorax nycticorax* Linnaeus, 1758	Pelecaniformes Ardeidae	Piscivorous	NHNN	23	5	2	1	4	2	LC	NR
64	Painted stork	Pelecaniformes	Carnivorous	PSML	11	8	0	0	0	0	NT	NR

	Mycteria leucocephala Pennant, 1769	Ciconiidae										
65	Dalmatian Pelican *Pelecanus crispus* Bruch, 1832	Pelecaniformes Pelecanidae	Carnivorous	DPPC	76	300	58	96	85	100	NT	WV
66	Great white Pelican *Pelecanus onocrotalus* Linnaeus, 1758	Pelecaniformes Pelecanidae	Carnivorous	GWPPO	98	150	100	140	190	130	LC	WV
67	Great cormorant *Phalacrocorax carbo* Linnaeus, 1758	Pelecaniformes Phalacrocoracidae	Carnivorous	GCPC	11	5	8	9	15	14	LC	NR
68	Indian cormorant *Phalacrocorax fuscicollis* Stephens, 1826	Pelecaniformes Phalacrocoracidae	Piscivorous	ICPF	19	27	29	16	10	32	LC	NR
69	Little cormorant *Phalacrocorax niger* Vieillot, 1817	Pelecaniformes Phalacrocoracidae	Piscivorous	LCPN	25	58	59	53	25	14	LC	NR
70	Eurasian Spoonbill *Platalea leucorodia* Linnaeus, 1758	Pelecaniformes Threskiornithidae	Piscivorous	ESPL	83	150	89	92	100	76	LC	NR
71	Lesser flamingo *Phoenicopterus minor* Saint-Hilaire, 1798	Phoenicopteriformes Phoenicopteridae	Planktivorous	LFPM	67	400	45	200	400	40	NT	WV
72	Greater flamingo *Phoenicopterus ruber* Linnaeus, 1758	Phoenicopteriformes Phoenicopteridae	Planktivorous	GFPR	55	800	50	400	900	100	LC	WV
73	Common chiffchaff *Phylloscopus collybita* Vieillot, 1817	Phoenicopteriformes Phoenicopteridae	Omnivorous	CCPC	11	29	16	0	0	0	LC	WV
74	Little grebe *Podiceps ruficollis* Pallas, 1764	Phoenicopteriformes Podicipedidae	Carnivorous	LGPR	28	100	15	24	35	45	LC	NR

Note: NR (native resident), WV (winter visitor), LC (Least Count), VU (Vulnerable), NT (Near Threatened), HB (Hawkes Bay), KB (Keti Bundar), IH (Ibrahim Hydri), BB (Banbhore), SB (Sunhara beach) and BC (Badin coastline).

Table 3: Diversity indices in study areas.

Indices	BC	KB	BB	HB	IH	SB
Species	74	69	65	60	60	59
Individuals	3004	8391	3290	4116	6125	2965
Dominance (D)	0.01943	0.03844	0.03612	0.03673	0.05642	0.03285
Simpson (S)	0.9806	0.9616	0.9639	0.9633	0.9436	0.9672
Shannon (H')	4.086	3.589	3.628	3.616	3.37	3.682
Evenness (E)	0.8041	0.5244	0.5788	0.6195	0.4844	0.6733
Richness (R)	9.116	7.526	7.903	7.089	6.766	7.255
Density (D')	3	8.391	3.29	4.116	2.965	2.965

Note: HB (Hawkes Bay), KB (Keti Bundar), IH (Ibrahim Hydri), BB (Banbhore), SB (Sunhara beach) and BC (Badin coastline).

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Authors' contributions: Ali has designed project and collected data, Altaf has written this article and Khan critically analysis this article and approved as final.