

## Avian Diversity at New Campus of Punjab University in Relation to Land Use Change

Safdar Sidra<sup>1</sup>, Zulfiqar Ali<sup>1</sup> \* and Muhammad Nawaz Chaudhry<sup>2</sup>

<sup>1</sup>Department of Zoology, University of the Punjab, Quaid-i-Azam Campus, Lahore

<sup>2</sup>College of Earth and Environmental Sciences, University of the Punjab, Quaid-i-Azam Campus, Lahore

**Abstract.-** University of the Punjab, New Campus (31° 30' 15" North, 74° 18' 23" East) covers a vast area of 1781 acres (721 ha/7.21 km<sup>2</sup>). The site has a variety of habitats. A previous study of the avian fauna of the New Campus carried out in 1997 reported the occurrence of 64 bird species. The present study was aimed to observe current bird species diversity and abundance at the New Campus as compared to the previous study and also to study the possible impact of land use change on them. Field surveys were carried out to record the avian species employing point count method from January 2011 to May 2011. Seventy six bird species were observed. As per seasonal abundance status of species, 49 were resident, 17 winter visitors, seven summer breeding, two passage migrants and one was accidental vagrant. Shannon-Wiener Diversity Index was calculated to be 2.548 indicating a moderate level of diversity in the study area. Census index was 2795 birds per km<sup>2</sup>. Garbage eating and scavenging birds (House Crow, Black Kite, and Common Myna) were considered to be relatively abundant (50.59%). The current landscape was compared with the master plan, prepared in year 2002, of the New Campus to observe the patterns of land use change. As per the master plan, it was revealed that due to the increasing demands; almost the entire agricultural area would be converted into buildings for departments and other purposes. This land use change will cause many species to migrate from the area as their habitat will be lost. Moreover, this urbanization will result in homogenization of species. Landscape management should be integrated into urban planning tools to ensure the maintenance of biodiversity within urbanized areas.

**Keywords:** Shannon-Wiener Diversity Index, Relative Abundance, Census Index.

### INTRODUCTION

**B**irds are considered excellent bio-indicators of the effects urbanization has on ecosystems since they are highly diverse and conspicuous elements of the ecosystem. Also they respond rapidly to changes in landscape configuration, composition and function. As a result they are used as indicators of long-term environmental disturbances, such as urbanization and land use change. Thus, they are useful models for studying a variety of environmental problems (Newton, 1995; Navarro and Benítez, 1995; Blair, 1999; Hobson and Rempel, 2001; Turner, 2002).

Habitat loss due to land use changes is the most important and often cited reason of loss of biodiversity (Palmer *et al.*, 2004). Due to increased urbanization, habitat modification is inevitable. Consequently, land use intensification can greatly reduce species richness and ecosystem functioning

(Flynn *et al.*, 2008). Land use change and habitat modification often causes habitat specialist species to decline or disappear altogether while the generalist species are favoured by the change (Cody, 1985; Andren *et al.*, 1997; Coppedge *et al.*, 2001; Marzluff, 2001).

A few decades ago, the New Campus of Punjab University was located outside the city of Lahore. The area where Punjab University is located was a natural jungle that had a variety of habitats and diversity of wildlife. However with the passage of time and increased urbanization, the city expanded and the campus area is now surrounded by urban development (Tanveer *et al.*, 2002). University of the Punjab, New Campus (31° 30' 15" North, 74° 18' 23" East) covers a vast area of 1781 acres (721 ha/7.21 km<sup>2</sup>). Of this area 1054 acre area (426.5 ha/ 4.27 km<sup>2</sup>) has been leased out and different crops (wheat, rice etc.) are cultivated here. Infrastructure including the roads, teaching departments, hostels and the residential colony has been developed on the rest of the area (727 acres/ 294.2 ha). The departments (361 acres/ 146.1 ha) and the residential colony (160 acres/ 64.7 ha) cover

\* Corresponding author: [dralizulfiqar@gmail.com](mailto:dralizulfiqar@gmail.com)

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an area of 521 acres (211 ha/2.11 km<sup>2</sup>) while the hostels are spread on the remaining 206 acres (83 ha/0.83 km<sup>2</sup>).

The New Campus has a diverse variety of habitats including agricultural fields, two waste water ponds (6.5 acres/ 2.6 ha), and constructed area. The departments have large sized beautiful lawns with a variety of vegetation. There are also a botanical garden, rose gardens and roadside plantations that provide habitats for many species of birds, small mammals and herps. The residential colony and hostels too have many plants and trees. The campus area viewed through Google Earth (satellite) stands distinctively as a green patch with rich vegetation amidst highly urbanized surroundings.

There are no previous studies about the landscape of the New Campus and surrounding areas. Moreover no studies have been carried out about avian diversity in the area other than that of Tanveer *et al.* (2002). The diverse habitat of New Campus provides home to a number of avian species. Tanveer *et al.* (2002) in 1997 reported 64 species of birds at the New Campus. Habitat fragmentation, land use change and air and water pollution are some of the various factors that can affect the diversity of species in an area. The New campus is located along the Lahore Canal. Throughout the day, heavy traffic along the canal road results in noise and air pollution. Moreover, within the campus, many new buildings are being constructed for the departments. As a result the agricultural area is shrinking gradually though at a slow pace; biodiversity can therefore be affected.

This study was intended to observe the avian diversity at the New Campus and determine whether there had been any significant change in the avian fauna of New Campus. The study also determined the pattern of land use change and its possible impacts on the bird diversity.

## MATERIALS AND METHODS

### Field surveys

Two major habitats were identified within the campus area *i.e.* the urban and cultivated area. The urban area covered 294.2 ha including the teaching departments, hostels and the residential colony

which were identified as sub-habitats in the urban area. The remaining 426.5 ha area was covered by agricultural fields, botanical garden, and flower cultivations. Two waste water ponds (2.6 ha) were included in the agricultural area. Appropriate (locations from where maximum observations were possible) observation points were selected to ensure maximum chances of observations; their global positioning was determined using Global Positioning System. Field surveys were carried out twice a month from January 2011 to May 2011 using binoculars (10 x 50) to observe the birds. Field guides of Grimmett *et al.* (2001) and Mirza (2007) were used to identify the birds. The highest number of each species observed during the month was tabulated and statistical analysis was carried out using Microsoft Excel sheets. Relative Abundance of each bird species was calculated. Species richness, evenness, Shannon-Wiener Diversity Index, and Census Index for birds for all selected sites were calculated using the following statistics (Stiling, 1999):

### Relative abundance ( $P_i$ )

$$P_i = N_i / N$$

Where,  $N_i$  is the number of Individuals of a species, and  $N$  is total population of birds.

### Shannon-wiener diversity index ( $H'$ )

$$H' = - \sum P_i \ln P_i$$

Where,  $P_i$  is proportion of species  $i$  relative to the total number of species, and  $\ln P_i$  is natural logarithm of this proportion.

### Species evenness

$$\text{Species Evenness} = H' / \ln(S)$$

Where,  $H'$  is Shannon Diversity Index;  $S$  is Species Richness (number of species), and  $\ln(S)$  is natural logarithm of species Richness.

### Census index

$$\text{Census Index} = N / A$$

Where,  $N$  is total population of birds, and  $A$  is total study area.

### *Study of land use change*

The present landscape of the campus area was studied using Google Earth software. Information about the land use scenario during 1997 was available in the form of area covered by the agricultural fields and the built area of the new campus (Tanveer *et al.*, 2002). Moreover a satellite image dated 03/12/2000 was available (Source: Google Earth). The latest master plan (year 2002) of the New Campus, Punjab University was obtained from the office of Project Director, Resident Officer II of Punjab University. The previous land use scenario, current situation and the future projections were studied and compared to observe the probable changes that might take place over the years and how could they affect the avian diversity of the area.

## RESULTS

The campus area of Punjab University can be distinctively categorized into two types of habitats i.e. the urbanized area (293.7 ha) and the cultivated area (426.5 ha). However owing to the variety of habitats present within, and for the ease of study, these two habitats were further sub-divided. The urban habitat was sub-divided into the teaching departments and the residential area (residential colony and the hostels). Similarly the cultivated area included the agricultural fields, flower cultivations and botanical gardens. The waste water ponds were located within the fields and were classified as a sub-habitat of the same. Figure 1 is a satellite map of New Campus showing the observation points.

### *Urban area*

#### *Study site 1 (Teaching Departments)*

The teaching departments are spread over an area of 146.1 ha. Thirty five bird species were observed in the departments during the study and the total number of birds counted was 4495. The density of birds was 31 individuals/ ha. House crow (*Corvus splendens*) was the most dominant species with a relative abundance (Pi) of 0.267. Common Myna (*Acridotheres tristis*) and House Sparrow (*Passer domesticus*) were also found to be abundant species with a relative abundance value of 0.219 and 0.149 respectively. The Shannon-Wiener Diversity Index was calculated as 2.268 *i.e.* moderate diversity.

### *Study site 2 (Residential area)*

The residential area (148.1 ha) included the residential colony for the university staff and hostels for the students. The colony covers an area of 64.7 ha while the hostels cover an area of 83.37 ha at present. Forty eight species were observed in the residential area during the study with the total number of individuals counted as 7004. Density was 47 individuals per hectare. Shannon-Wiener Diversity Index was calculated as 2.142. The most abundant species were house crow (Pi = 0.264), house sparrow (Pi = 0.239) and Common myna (Pi = 0.212).

### *Cultivated area*

#### *Study site 3 (Cultivated area)*

The cultivated area included the agricultural fields (426.54 ha), flower cultivations (8.09 ha) and the botanical garden (20.23 ha). The total number of species observed during the study period was 53 with one species being an accidental vagrant (a species that has wandered miles away from its expected breeding or wintering grounds). The total number of birds counted during the surveys was 7048. Shannon-Wiener Diversity Index was calculated as 2.497. Common myna was the most abundant species at site 3 with Pi = 0.242 followed by house crow (Pi = 0.231) and house sparrow (Pi = 0.112). Density was 16 bird species per hectares.

#### *Study site 4 (Waste water ponds)*

There are two waste water ponds (2.6 ha) in the agricultural fields of the New Campus, their individual areas being 2.2 ha and 0.4 ha. Forty one species were observed in this area during the surveys. The total number of individuals counted during the surveys was 1604. Shannon-Wiener Diversity Index was calculated as 3.123. Common Myna (Pi = 0.128) was the most abundant species followed by Barn swallow (*Hirundo rustica*) (Pi = 0.102) and common starling (*Sturnus vulgaris*) (Pi = 0.086). Density was 62 individuals per hectare.

Overall 76 species of birds belonging to 14 orders and 33 families were observed in the campus area during the study (Tables I and II). Forty six species were passerine while the remaining thirty were non-passerines. Among these 49 species were resident, 17 were winter visitors, seven were

**Table I.- Summary of avian diversity data in the New Campus, Punjab University January 2011 to May 2011. R, Resident; S, Summer breeder; W, Wintering species; P, Passage migrant & Irregular Year-round Visitor; R.A., Relative Abundance; Site I, Teaching departments; Site II, Residential area; Site III, Cultivated area; Site IV, Waste water ponds.**

BIRDS	Mirza (2007)	Grimmett (2001)	Site I	Site II	Site III	Site IV	Total	Max	R.A	H'	Census index
Order: Piciformes											
Family: Picidae											
1. Eurasian Wryneck ( <i>Jynx torquilla</i> )	+, W	+, W	1	1	0	0	2	2	0.0099	-0.0009	0.2773
2. Golden Backed Woodpecker ( <i>Dinopium benghalense</i> )	+, R	+, R	0	4	4	0	8	4	0.0397	-0.0031	1.1095
3. Coppersmith Barbet ( <i>Megalaima haemacephala</i> )	+, R	+, R	0	9	1	0	10	9	0.0496	-0.0037	1.3869
Order: Coraciiformes											
Sub-Family: Capitonidae											
4. Indian Grey Hornbill ( <i>Ocyroceros birostris</i> )	+, R	+, R	6	5	6	0	17	6	0.0843	-0.0059	2.3578
Family: Bucerotidae											
Family: Upupidae											
5. Common Hoopoe ( <i>Upupa epops</i> )	+, R	+, R	12	12	13	0	37	13	0.1836	-0.0115	5.1317
Family: Alcedinidae											
6. White-Throated Kingfisher ( <i>Halcyon smyrnensis</i> )	+, R	+, R	0	0	4	6	10	6	0.0496	-0.0037	1.3869
Family: Meropidae											
7. Green Bee-Eater ( <i>Merops orientalis</i> )	+, R	+, R	17	41	112	14	184	112	0.9131	-0.0428	25.520
8. Blue Cheeked Bee-Eater ( <i>Merops persicus</i> )	+, S	+, S	6	0	20	0	26	20	0.1290	-0.0085	3.6061
Order: Cuculiformes											
Family: Cuculidae											
9. Asian Koel ( <i>Eudynamis scolopacea</i> )	+, S	+, S	2	2	6	0	10	6	0.0496	-0.0037	1.3869
Order: Psittaciformes											
Family: Psittacidae											
10. Rose-Ringed Parakeet ( <i>Psittacula krameri</i> )	+, R	+, R	34	52	50	10	146	52	0.7245	-0.0357	20.2490
Order: Apodiformes											
Family: Apodiidae											
11. House Swift ( <i>Apus affinis</i> )	+, R	+, R	143	0	2	0	145	143	0.7195	-0.0355	20.1109
Order: Strigiformes											
Family: Strigidae											
12. Collared Scops Owl ( <i>Otus bakkamoena</i> )	+, R	+, R	0	1	0	0	1	1	0.0049	-0.0004	0.1386
13. Spotted Owllet ( <i>Athene brama</i> )	+, R	+, R	0	1	32	0	33	32	0.1637	-0.0105	4.5769
Order: Columbiformes											
Family: Columbidae											
14. Blue Rock Pigeon ( <i>Columba livia</i> )	+, R	+, R	424	86	384	45	939	424	4.6598	-0.1428	130.2357

*Continued*

BIRDS	Mirza (2007)	Grimmett (2001)	Site I	Site II	Site III	Site IV	Total	Max	R.A	H'	Census index
15. Little Brown Dove ( <i>Streptopelia senegalensis</i> )	+, R	+, R	126	160	230	40	556	230	2.7591	-0.0990	77.1151
16. Spotted Dove ( <i>Streptopelia chinensis</i> )	+, W	+, W	1	2	0	0	3	2	0.0148	-0.0013	0.4160
17. Red Collared Dove ( <i>Streptopelia tranquebarica</i> )	+, S	+, S	6	4	0	0	10	6	0.0496	-0.0037	1.3869
18. Indian Ring Dove ( <i>Streptopelia decaocto</i> )	+, R	+, R	106	139	79	29	353	139	1.7517	-0.0708	48.9597
19. Yellow-Footed Green Pigeon ( <i>Treron phoenicoptera</i> )	+, R	+, W	0	17	37	0	54	37	0.2679	-0.0158	7.4895
Order: Gruiformes											
Family: Rallidae											
20. White-Breasted Waterhen ( <i>Amaurornis phoenicurus</i> )	+, R	+, R	0	0	0	58	58	58	0.2878	-0.0168	8.0443
21. Common Moorhen ( <i>Gallinula chloropus</i> )	+, R	+, R	0	0	0	78	78	78	0.3870	-0.0214	10.8183
Order: Scolopaciidae											
Sub-Family: Tringinae											
22. Green Sandpiper ( <i>Tringa ochropus</i> )	+, W	+, W	0	0	0	30	30	30	0.1488	-0.0096	4.1608
23. Wood Sandpiper ( <i>Tringa glareola</i> )	+, W	+, W	0	0	0	19	19	19	0.0942	-0.0065	2.6352
24. Common Sandpiper ( <i>Actitis hypoleucos</i> )	+, W	+, W	0	0	0	7	7	7	0.0347	-0.0027	0.9708
Order: Charadriiformes											
Family: Charadriidae											
25. Red-Wattled Lapwing ( <i>Vanellus indicus</i> )	+, R	+, R	32	7	187	90	316	187	1.5681	-0.0651	43.8280
Order: Accipitriformes											
Family: Accipitridae											
26. Black Kite ( <i>Mitvus migrans</i> )	+, R	+, R	140	275	599	32	1046	599	5.1908	-0.1535	145.0762
Order: Ciconiiformes											
Family: Ardeidae											
27. Cattle Egret ( <i>Bubulcus ibis</i> )	+, R	+, R	0	0	51	23	74	51	0.3672	-0.0205	10.2635
28. Indian Pond Heron ( <i>Ardeola grayii</i> )	+, R	+, R	5	2	12	71	90	71	0.4466	-0.0241	12.4826
29. Black-Crowned Night Heron ( <i>Nycticorax nycticorax</i> )	+, S	+, S	0	0	2	1	3	2	0.0148	-0.0013	0.4160
Order: Passeriformes											
Family: Laniidae											
30. Bay-Backed Shrike ( <i>Lanius vittatus</i> )	+, R	+, R	9	7	12	0	28	12	0.1389	-0.0091	3.8834
31. Long-Tailed or Rufous-Backed Shrike ( <i>Lanius schach</i> )	+, R	+, R	0	10	11	0	21	11	0.1042	-0.0071	2.9126
32. Southern Grey Shrike ( <i>Lanius meridionalis</i> )	-	+, R	4	3	8	4	19	8	0.0942	-0.0065	2.6352
Family: Corvidae											
33. Rufous Treepie ( <i>Dendrocitta vagabunda</i> )	+, R	+, R	0	1	0	0	1	1	0.0049	-0.0004	0.1386

Continued

<b>BIRDS</b>	Mirza (2007)	Grimmett (2001)	Site I	Site II	Site III	Site IV	Total	Max	R-A	H'	Census index
34. House Crow ( <i>Corvus splendens</i> ) Family: Oriolidae	+ , R	+ , R	1200	1852	1629	104	4785	1852	23.745	-0.3414	663.6615
35. Eurasian Golden Oriole ( <i>Oriolus oriolus</i> ) Family: Rhipiduridae	+ , S	+ , S	5	5	2	0	12	5	0.0595	-0.0044	1.664355
36. White-Browed Fantail Flycatcher ( <i>Rhipidura aureola</i> ) Family: Dicruridae	+ , R	+ , W	4	7	2	0	13	7	0.0645	-0.0047	1.8030
37. Black Drongo ( <i>Dicrurus macrocoercus</i> ) Family: Turdidae	+ , R	+ , R	13	55	66	37	171	66	0.8485	-0.0404	23.7170
38. Blue-Throat ( <i>Luscinia svecica</i> )	+ , W	+ , W	0	0	1	2	3	2	0.0148	-0.0013	0.4160
39. Oriental Magpie Robin ( <i>Copsychus saularis</i> )	+ , R	+ , R	11	14	5	0	30	14	0.1488	-0.0096	4.1608
40. Indian Robin ( <i>Saxicoloides fulicata</i> )	+ , R	+ , R	6	13	11	0	30	13	0.1488	-0.0096	4.1608
41. Black Redstart ( <i>Phoenicurus ochruros</i> )	+ , W	+ , W	4	5	0	0	9	5	0.0446	-0.0034	1.2482
42. Pied Bush-Chat ( <i>Staxicola caprata</i> )	+ , R	-	0	2	1	0	3	2	0.0148	-0.0013	0.4160
43. Brown Rock-Chat ( <i>Cercomela fusca</i> )	+ , W	+ , R	7	7	7	0	21	7	0.1042	-0.0071	2.9126
44. Dark-Throated Thrush ( <i>Turdus rufigollis</i> ) Family: Sturnidae	-	+ , W	0	0	1	2	3	2	0.0148	-0.0013	0.4160
45. Common Starling ( <i>Sturnus vulgaris</i> )	+ , W	+ , W	16	51	87	138	292	138	1.4490	-0.0613	40.4993
46. Asian Pied Starling / Myna ( <i>Sturnus contra</i> )	+ , Rare	+ , Rare	12	25	8	15	60	25	0.2977	-0.0173	8.3217
47. Brahminy Starling / Myna ( <i>Sturnus pagodarum</i> )	+ , R	+ , Rare	0	9	0	2	11	9	0.0545	-0.0041	1.5256
48. Common Myna ( <i>Acridotheres tristis</i> )	+ , R	+ , R	987	1482	1707	206	4382	1,707	21.745	-0.3317	607.7669
49. Bank Myna ( <i>Acridotheres ginginianus</i> ) Family: Hirundinidae	+ , R	+ , R	150	241	206	66	663	241	3.2901	-0.1123	91.9556
50. Barn Swallow ( <i>Hirundo rustica</i> ) FAMILY: PYCNONOTIDAE	+ , W	+ , W	0	16	41	164	221	164	1.0967	-0.0494	30.6518
51. Red-Vented Bulbul ( <i>Pycnonotus cafer</i> )	+ , R	+ , R	183	501	245	50	979	245	4.8583	-0.1469	135.7836

Continued

BIRDS	Mirza (2007)	Grimmett (2001)	Site I	Site II	Site III	Site IV	Total	Max	R-A	H'	Census index
Family: Sylviidae											
52. Ashy Prinia ( <i>Prinia socialis</i> )	+, R	+, R	0	0	11	0	11	11	0.0545	-0.0041	1.5256
53. Plain Prinia ( <i>Prinia inornata</i> )	+, R	+, R	0	0	71	0	71	71	0.3523	-0.0199	9.8474
54. Graceful Prinia ( <i>Prinia gracilllis</i> )	+, R	+, R	0	0	41	4	45	41	0.2233	-0.0136	6.2413
55. Common Tailorbird ( <i>Orthotomus sutorius</i> )	+, R	+, R	0	40	27	0	67	27	0.3324	-0.0189	9.2926
56. Lesser White-Throat ( <i>Sylvia curruca</i> )	+, W	+, W	0	2	0	0	2	2	0.0099	-0.0009	0.2773
57. Common Chiffchaff ( <i>Phylloscopus collybita</i> )	+, W	+, W	0	0	0	3	3	3	0.0148	-0.0013	0.4160
Family: Timaliidae											
58. Common Babbler ( <i>Turdoides caudatus</i> )	+, R	+, R	46	8	31	0	85	46	0.4218	-0.0230	11.7891
59. Striated Babbler ( <i>Turdoides earlet</i> )	+, R	+, R	0	0	0	5	5	5	0.0248	-0.0020	0.6934
60. Jungle Babbler ( <i>Turdoides striatus</i> )	+, R	+, R	74	73	56	0	203	74	1.0073	-0.0463	28.1553
Family: Nectariniidae											
61. Purple Sunbird ( <i>Nectarinia asiatica</i> )	+, S	+, S	33	59	24	0	116	59	0.5756	-0.0296	16.0887
Family: Passeridae											
62. House Sparrow ( <i>Passer domesticus</i> )	+, R	+, R	670	1672	789	45	3176	1672	15.761	-0.2912	440.4993
63. Spanish Sparrow ( <i>Passer hispaniolensis</i> )	+, P	+, P	0	0	0	37	37	37	0.1836	-0.01156	5.1317
64. Chestnut-Shouldered Petronia ( <i>Petronia xanthocolis</i> )	+, S	+, S	0	0	1	0	1	1	0.0049	-0.0004	0.1386
Family: Motacillidae											
65. White Wagtail ( <i>Motacilla alba</i> )	+, W	+, W	0	13	11	2	26	13	0.1290	-0.0085	3.6061
66. White-Browed Wagtail ( <i>Motacilla maderaspatensis</i> )	+, R	+, R	0	0	0	4	4	4	0.0198	-0.0016	0.5547
67. Citrine Wagtail ( <i>Motacilla citreola</i> )	+, W	+, W	0	0	0	43	43	43	0.2133	-0.0131	5.9639
68. Yellow Wagtail ( <i>Motacilla flava</i> )	+, W	+, P	0	0	33	79	112	79	0.5558	-0.0288	15.5339
69. Grey Wagtail ( <i>Motacilla cinerea</i> )	+, W	+, W	0	2	0	30	32	30	0.1588	-0.0102	4.4382
70. Paddy field Pipit ( <i>Anthus rufulus</i> )	-	+, R	0	0	68	0	68	68	0.3374	-0.0192	9.4313
Family: Ploceidae											
71. Streaked Weaver ( <i>Ploceus manyar</i> )	+, R	+, R	0	0	0	1	1	1	0.0049	-0.0004	0.1386
72. Baya Weaver ( <i>Ploceus philippinus</i> )	+, R	+, R	0	0	0	7	7	7	0.0347	-0.0027	0.9708

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BIRDS	Mirza (2007)	Grimmett (2001)	Site I	Site II	Site III	Site IV	Total	Max	R.A	H'	Census index
Family: Estrildidae											
73. Indian Silverbill ( <i>Lonchura malabarica</i> )	+ R	+ R	0	0	3	0	3	3	0.0148	-0.0013	0.4160
74. Scaly-Breasted or Spotted Munia ( <i>Lonchura punctulata</i> )	+ R	+ R	0	9	0	0	9	9	0.0446	-0.0034	1.2482
Family: Muscicapidae											
75. Verditer Flycatcher ( <i>Muscicapa thalassina</i> )	Found in Kaghan Valley, Neelum Valley, Jhelum Valley, and Murree Hills		0	0	1	0	1	1	0.0049	-0.0004	0.1386
Order: Caprimulgiformes											
Family: Caprimulgidae											
76. European Nightjar ( <i>Caprimulgus europaeus</i> )	+ W	-	0	0	0	1	1	1	0.0049	-0.0004	0.1386
Total			4495	7004	704	1604	20151	9190		-2.5480	
Species Richness (S)			35	48	53	41					
Shannon-wiener Diversity Index (H')			0.718	0.658	0.64	0.686					
Species Evenness H'/ln(S)			2.5480427								

summer breeding species while two species were passage migrants and year round visitors. Thirteen species were sighted only once during the study although the status of these species is known to be resident, winter migrant or summer breeding in the area. One species was accidental vagrant, being recorded only once in March.

**Table II.- Number of orders and families observed during the study**

Order	Family	No. of species
1 Piciformes	1 Picidae	2
	2 Capitonidae	1
2 Coraciiformes	3 Bucirotidae	1
	4 Upupidae	1
	5 Alcedinidae	1
	6 Meropidae	2
3 Cuculiformes	7 Cuculidae	1
4 Psittaciformes	8 Psittacidae	1
5 Apodiformes	9 Apodidae	1
6 Strigiformes	10 Strigidae	2
7 Columbiformes	11 Columbidae	6
8 Gruiformes	12 Rallidae	2
9 Scolopacidae	13 Scolopacinae	3
10 Charadriiformes	14 Charadriidae	1
11 Accipitriiformes	15 Accipitridae	1
12 Ciconiiformes	16 Ardeidae	3
13 Caprimulgiformes	17 Caprimulgidae	1
	18 Lanidae	3
14 Passeriformes	19 Corvidae	2
	20 Oriolidae	1
	21 Monarchidae	1
	22 Dicuridae	1
	23 Turdidae	7
	24 Sturnidae	5
	25 Hirundinidae	1
	26 Pycnonotidae	1
	27 Sylviidae	7
	28 Timaliidae	3
	29 Nectariniidae	1
	30 Passeridae	3
	31 Motacillidae	6
	32 Plocidae	2
33 Estrildidae	2	

Previously 64 species of birds had been identified by Tanveer *et al.* (1997). Among these 42 species were resident; six species were winter visitors, 12 were summer breeding while two species were irregular year round visitors. Thirty one species were non-passerines while the remaining 33 were passerines. No individual counts



of the species were mentioned by Tanveer *et al.* (2002) nor any statistical analysis carried out. The study undertaken by Tanveer *et al.* (2002) was carried out for one year, while in the current study; the surveys were carried out from January 2011 to May 2011. For reasons unknown, the waste water sites were not included in the previous study and therefore their distinctive avian fauna had not been mentioned by Tanveer *et al.* (2002).

If the results of Tanveer *et al.* (2002) are compared with the current results, many of the species found in 1997 were not observed in this recent study. Although the number of species observed in this study has increased *i.e.*, 76 species observed during five months of this study; only 43 species are common in both studies (Table IV). This can be attributed to different factors such as unavailability of food, space and other resources that can affect the specialist species more pronouncedly than the generalist species. Difference in number of species can also be attributed to the migration trends of the species (Maan and Chaudhry, 2001). Also the waste water sites were obviously not included in the study by Tanveer *et al.* (2002).

Another important observation during the surveys was the increased number of garbage eating birds. House crows ( $P_i = 0.237$ ), common mynas ( $P_i = 0.217$ ) and black kites (*Milvus migrans*) ( $P_i = 0.0519$ ) were the most abundant species (Fig. 2). The presence of a skip outside the boundary wall of university and a meat seller at observation point 3.1 (Fig. 1) may have resulted in the large number of crows and kites.

*Census Index*

Census index (birds/ ha) is the density of the species in the area. Density of birds in the major habitats is given in the following Table III:

**Table III.- Census Index /Density of birds in habitats.**

Habitat	Number of Birds	Area (ha)	Census Index / Density (birds per ha)
Urban area	11,499	293.7	39
Cultivated area	8,652	426.5	20
Total study area	20,151	721	28

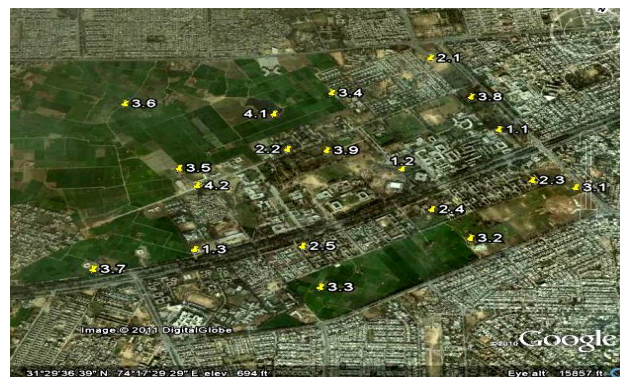


Fig. 1. Observation points marked for the surveys (Source: Google earth). (1.1 denotes Site number 1, observation point 1).

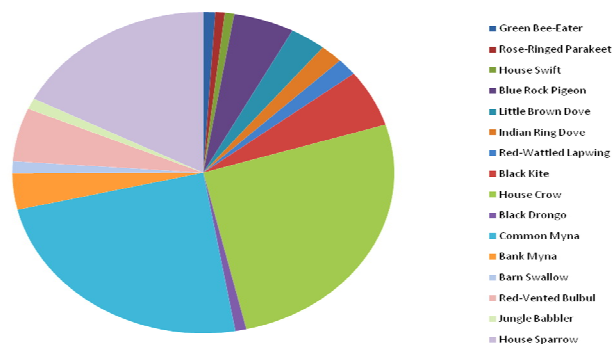


Fig. 2. Bird species abundance in Punjab University New Campus, Lahore.

*Patterns of land use change in the campus area  
Land use in 1997 and 2000*

According to Tanveer *et al.* (2002), the campus area covered an area of 1781 acres (721 ha) in 1997 *i.e.*, the same as today. The teaching departments were spread over an area of 93 acres (37.6 ha) while the residential area covered 358 acres (144.9 ha). The agricultural fields were extended over 977 acres (395.4) of land while open area covered 253 acres (102.4 ha). The botanical garden was spread over 50 acres (20.2 ha). The area of botanical garden is the same in the year 2012 also. Overall the urban area extended over 451 acres (182.5 ha) while the cultivated area and open area covered 1280 acres (518 ha). The satellite imagery of year 2000 (Fig. 3A) also complies with the above given data.

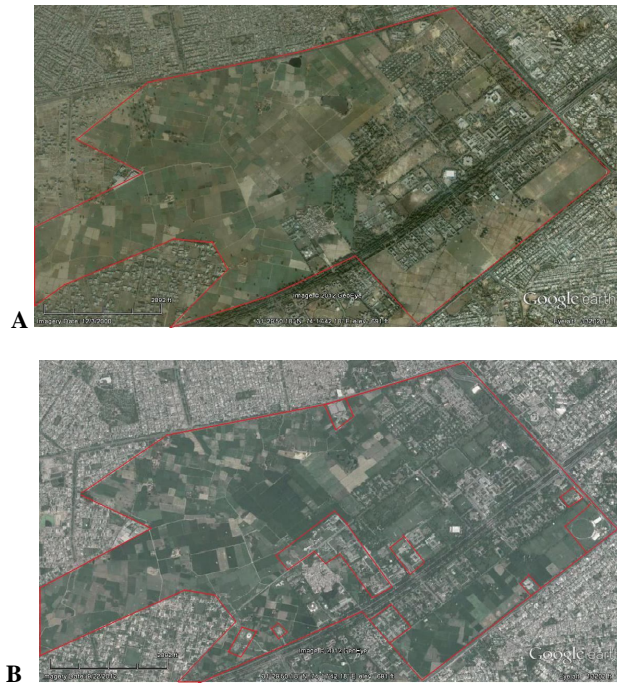


Fig 3. New Campus, Punjab University, during the year 2000 (A) and 2012 (B), Major changes that occurred after year 2000 have been marked (Source: Google Earth)

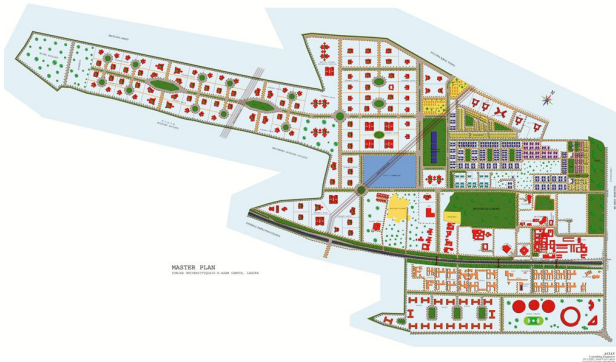


Fig. 4. Master plan of New Campus, Punjab University (2002)

#### *Land use pattern in the current year, 2012*

The recent scenario of land use was also obtained through satellite imagery which provided a valuable insight on the changes that have occurred in the campus since the year 2000. The area covered by the buildings and the agricultural fields was obtained from the Resident Officer II, New Campus, Punjab University. Area extent of some places was

not available so it was measured using the ARC GIS software ([www.arcgis.com](http://www.arcgis.com)). As mentioned earlier, 727 acres (294.2 ha) out of the total 1781 acres (720.7 ha) is urbanized in the form of departments, and residential area. The remaining 1054 acres (426.5 ha) is still under cultivation.

A comparison of the area coverage during the year 1997 and 2012 reveals that the urban area has increased by 15.5 % over the last 15 years or at the rate of 1.03 % per year. The major developments undertaken in the campus area after the year 2000 have been marked in Figure. 3B. The area covered by the departments increased by 8.31% while the residential area increased only by 0.45%. The cultivated area and open area covered 1280 acres (518 ha), 71.87% of the total area) in 1997 while now this area is 1054 acres (426.5 ha), 59.18 % of the total area). The cultivated area therefore has decreased by 12.69 % over the last 15 years or at the rate of 0.84 % per year.

#### *Land use pattern according to the master plan*

The latest master plan of the university was prepared in year 2002. As per this master plan, the entire agricultural area has been dedicated for the construction of various departments, research centers and residential blocks. Although most of the area is still intact and it is not known that until when this development will take place, it is quite clear that the campus area will sooner or later lose its natural habitats.

## DISCUSSION

Increased urbanization can increase the stress on the natural environment. Rapid urbanization leads to modification, fragmentation and even loss of habitat for many species. As a result biodiversity is confined to specific places in urban areas such as parks, road-side plantations and other such locations (Oka, 2009). New Campus, Punjab University is also a confined habitat for a variety of avian species. In this study, 76 species of birds were identified in the New Campus during the field surveys while Tanveer *et al.* (2002) reported 64 species in 1997. However this increase in species number does not mean that the avian diversity in the area has increased. As mentioned previously, higher

**Table IV. - Comparison of the bird species found in 1997 and 2011 in New Campus, Punjab University**

Birds	1997	2011
1 Rain Quail ( <i>Coturnix coromandelica</i> )	+	-
2 Grey Partridge or Francolin ( <i>Francolinus pondicerianus</i> )	+	-
3 Eurasian Wryneck ( <i>Jynx torquilla</i> )	-	+
4 Yellow-Crowned Woodpecker ( <i>Dendrocopos mahrattensis</i> )	+	-
5 Golden Backed Woodpecker ( <i>Dinopium benghalense</i> )	+	+
6 Coppersmith Barbet ( <i>Megalaima haemacephala</i> )	-	+
7 Indian Grey Hornbill ( <i>Ocyroceros birostris</i> )	-	+
8 Common Hoopoe ( <i>Upupa epops</i> )	+	+
9 Indian Roller ( <i>Coracias benghalensis</i> )	+	-
10 White-Throated Kingfisher ( <i>Halcyon smyrnensis</i> )	+	+
11 Pied Kingfisher ( <i>Ceryle rudis</i> )	+	-
12 Green Bee-Eater ( <i>Merops orientalis</i> )	+	+
13 Blue Cheeked Bee-Eater ( <i>Merops persicus</i> )	+	+
14 Blue-Tailed Bee-Eater ( <i>Merops philippinus</i> )	+	-
15 Pied Cuckoo ( <i>Clamator jacobinus</i> )	+	-
16 Common Hawk Cuckoo ( <i>Hierococcyx varius</i> )	+	-
17 Asian Koel ( <i>Eudynamus scolopacea</i> )	+	+
18 Greater Coucal ( <i>Centropus sinensis</i> )	+	-
19 Alexandrine Parakeet ( <i>Psittacula eupatria</i> )	+	-
20 Rose-Ringed Parakeet ( <i>Psittacula krameri</i> )	+	+
21 House Swift ( <i>Apus affinis</i> )	+	+
22 Collared Scops Owl ( <i>Otus bakkamoena</i> )	-	+
23 Spotted Owlet ( <i>Athene brama</i> )	+	+
24 Blue Rock Pigeon ( <i>Columba livia</i> )	+	+
25 Laughing or Little Brown Dove ( <i>Streptopelia senegalensis</i> )	+	+
26 Spotted Dove ( <i>Streptopelia chinensis</i> )	-	+
27 Red Collared Dove ( <i>Streptopelia tranquebarica</i> )	+	+
28 Eurasian Collared Dove ( <i>Streptopelia decaocto</i> )	+	+
29 Yellow Footed Green Pigeon ( <i>Treron phoenicoptera</i> )	-	+
30 White Breasted Waterhen ( <i>Amauornis phoenicurus</i> )	-	+
31 Common Moorhen ( <i>Gallinula chloropus</i> )	-	+
32 Green Sandpiper ( <i>Tringa ochropus</i> )	-	+
33 Wood Sandpiper ( <i>Tringa glareola</i> )	-	+
34 Common Sandpiper ( <i>Actitis hypoleucos</i> )	-	+
35 Red Wattled Lapwing ( <i>Vanellus indicus</i> )	-	+
36 Black Kite ( <i>Milvus migrans</i> )	+	+
37 White Rumped Vulture ( <i>Gyps bengalensis</i> )	+	-
38 Tawny Eagle ( <i>Aquila rapax</i> )	+	-
39 Little Egret ( <i>Egretta garzetta</i> )	+	-
40 Cattle Egret ( <i>Bubulcus ibis</i> )	+	+
41 Indian Pond Heron ( <i>Ardeola grayii</i> )	+	+
42 Black-Crowned Night Heron ( <i>Nycticorax nycticorax</i> )	-	+
43 Bay Backed Shrike ( <i>Lanius vittatus</i> )	+	+
44 Long Tailed or Rufous Backed Shrike ( <i>Lanius schach</i> )	+	+
45 Southern Grey Shrike ( <i>Lanius meridionalis</i> )	-	+
46 Great Grey Shrike* ( <i>Lanius excubitor</i> )	+	-
47 Rufous Treepie ( <i>Dendrocitta vagabunda</i> )	-	+
48 House Crow ( <i>Corvus splendens</i> )	+	+
49 Eurasian Golden Oriole ( <i>Oriolus oriolus</i> )	+	+

50 White-Browed Fantail Flycatcher ( <i>Rhipidura aureola</i> )	+	+
51 Black Drongo ( <i>Dicrurus macrocercus</i> )	+	+
52 Common Wood Shrike ( <i>Tephrodornis pondicerianus</i> )	+	-
53 Blue Throat ( <i>Luscinia svecica</i> )	-	+
54 Oriental Magpie Robin ( <i>Copsychus saularis</i> )	+	+
55 Indian Robin ( <i>Saxicoloides fulicata</i> )	+	+
56 Black Redstart ( <i>Phoenicurus ochruros</i> )	-	+
57 Common Stonechat ( <i>Saxicola torquata</i> )	+	-
58 Pied Bush Chat ( <i>Saxicola caprata</i> )	+	+
59 Brown Rock-Chat ( <i>Cercomela fusca</i> )	-	+
60 Dark Throated Thrush ( <i>Turdus ruficollis</i> )	-	+
61 Common Starling ( <i>Sturnus vulgaris</i> )	+	+
62 Asian Pied Starling/Myna ( <i>Sturnus contra</i> )	+	+
63 Brahminy Starling / Myna ( <i>Sturnus pagodarum</i> )	+	+
64 Common Myna ( <i>Acridotheres tristis</i> )	+	+
65 Bank Myna ( <i>Acridotheres ginginianus</i> )	+	+
66 Barn Swallow ( <i>Hirundo rustica</i> )	+	+
67 Red-Vented Bulbul ( <i>Pycnonotus cafer</i> )	+	+
68 Ashy Prinia ( <i>Prinia socialis</i> )	-	+
69 Plain Prinia ( <i>Prinia inornata</i> )	-	+
70 Graceful Prinia ( <i>Prinia gracilllis</i> )	-	+
71 Zitting Cisticola or Fan-Tailed Warbler ( <i>Cisticola juncidis</i> )	+	-
72 Common Tailorbird ( <i>Orthotomus sutorius</i> )	-	+
73 Lesser White-Throat ( <i>Sylvia curruca</i> )	-	+
74 Common Chiffchaff ( <i>Phylloscopus collybita</i> )	+	+
75 Common Babbler ( <i>Turdoides caudatus</i> )	+	+
76 Striated Babbler ( <i>Turdoides earlei</i> )	-	+
77 Jungle Babbler ( <i>Turdoides striatus</i> )	+	+
78 Crested Lark ( <i>Galerida cristata</i> )	+	-
79 Oriental Sky Lark ( <i>Alauda gulgula</i> )	+	-
80 Purple Sunbird ( <i>Nectarinia asiatica</i> )	+	+
81 House Sparrow ( <i>Passer domesticus</i> )	+	+
82 Spanish Sparrow ( <i>Passer hispaniolensis</i> )	-	+
83 Yellow-Throated Sparrow ( <i>Petronia xanthocollis</i> )	-	+
84 White Wagtail ( <i>Motacilla alba</i> )	+	+
85 White-Browed Wagtail ( <i>Motacilla maderaspatensis</i> )	+	+
86 Citrine Wagtail ( <i>Motacilla citreola</i> )	-	+
87 Yellow Wagtail ( <i>Motacilla flava</i> )	-	+
88 Grey Wagtail ( <i>Motacilla cinerea</i> )	-	+
89 Paddy field Pipit ( <i>Anthus rufulus</i> )	-	+
90 Richard's Pipit** ( <i>Anthus novaeseelandiae</i> )	+	-
91 Streaked Weaver ( <i>Ploceus manyar</i> )	+	+
92 Baya Weaver ( <i>Ploceus philippinus</i> )	+	+
93 Indian Silverbill ( <i>Lonchura malabarica</i> )	-	+
94 Scaly-Breasted or Spotted Munia ( <i>Lonchura punctulata</i> )	+	+
95 European Nightjar ( <i>Caprimulgus europaeus</i> )	-	+
96 Black Throated Weaver ( <i>Ploceus benghalensis</i> )	+	-
97 Green Barbet ( <i>Megalaima zeylanica</i> )	+	-
98 Verditer Flycatcher*** ( <i>Muscicapa thalassina</i> )	-	+

\*Great Grey Shrike: Vagrants recorded from Baluchistan, very much similar to Southern Grey Shrike (Grimmett *et al.*, 2001)  
 \*\*Richard's Pipit: Status in Pakistan unclear due to resemblance with Paddy field Pipit (Grimmett *et al.*, 2007)  
 \*\*\*Accidental Vagrant in Lahore sighted in agricultural fields on 13-03-2011. Originally found in Kaghan Valley, Neelam Valley, Jhelum Valley, and Murree Hills (Mirza, 2007)

diversity could be attributed to the fact that waste water sites were not included by Tanveer *et al.* (2002) in their study and thus the characteristic bird fauna of these sites was not mentioned. Moreover, the unavailability of food, space and other resources is known to affect the specialist species more pronouncedly than the generalist species (Maan and Chaudhry, 2001).

Another important observation during the surveys was the increased number of garbage eating birds. Although the solid waste in the residential area is thrown in the specific purpose built spots from where it is regularly collected, these small cemented skips are open thereby inviting the birds to feast on their contents. Moreover the presence of a skip outside the boundary wall of the University for collecting of solid waste is a favourite spot for these birds. Consequently House Crows ( $P_i = 0.237$ ), Common Mynas ( $P_i = 0.217$ ), House Sparrow ( $P_i = 0.158$ ) and Black Kites ( $P_i = 0.0519$ ) were the most abundant species. Moreover, large number of trees in the university provide roosting sites for crows, kites and mynas. As a result, large flocks of these birds were seen every evening roosting on the trees. Other species that were found in abundance include: Red Vented Bulbul (*Pycnonotus cafer*) ( $P_i = 0.0486$ ), Blue Rock Pigeon (*Columba livia*) ( $P_i = 0.0467$ ), Little Brown Dove (*Streptopelia senegalensis*) ( $P_i = 0.0278$ ), and Ring Dove (*Streptopelia decaocto*) ( $P_i = 0.0175$ ). The presence of agricultural fields provides a very fine source for their food since these species are mainly grainivorous.

#### *Study of land use change*

The New Campus of Punjab University was once located outside the city of Lahore. However with the passage of time, it is now a part of the city amidst highly urbanized settings (Tanveer *et al.*, 2002). The satellite imagery of year 2000 and 2012 present a comparison of the urban development being carried out in the area (Fig. 3A, B). The areas surrounding the campus and within the campus in 2000 were not as developed as in 2012. The area under construction has increased at the annual rate of 1.03 % over the last fifteen years.

The latest master plan (2002) of the campus was also compared with the current landscape.

Although many buildings proposed in the recent master plan have not been built yet, some of them are under construction and over the years, this development will cover the entire area. As a result of this land use change, many characteristic species of birds which are found only in the agricultural fields and the waste water ponds may lose their habitats. It should be noted that the highest number of individuals and also the highest number of species was observed in the cultivated area i.e. 7048 birds of 53 species. Converting this area into buildings will result in the loss of habitat for these species forcing them to find some other habitat for themselves which may be a difficult task due to the rapid urbanization all around. It has been estimated that 17 of the total species including those specifically found at the waste water sites also will have to move away from the area as a result of this conversion. The land use change in the form of urbanization shall also result in the homogenization of the species.

Although there are a large number of trees in the built area, botanical gardens, and lawns of departments and along the roads, they may not be a good alternative for many species. Throughout the day these places are occupied by people, be it students, visitors or residents of the colony. The noise of the traffic and people can also disturb many avian species.

At present the urban area *i.e.* the departments, residential colony, and the hostels covers only 293.7 ha as compared to the 426.54 ha of the cultivated land. However, as proposed in the master plan of the New Campus, the entire cultivated area is intended to be converted into different departments and buildings gradually. Although this change is inevitable in order to accommodate the increasing needs of the university, it can result in the migration of many species from the area.

Species richness at the waste water ponds was 41 species. The elimination of the waste water ponds will result in the loss of many species from the area such as White Breasted Waterhen (*Amaurornis phoenicurus*), Common Moorhen (*Gallinula chloropus*) and many more as their habitat will be changed. Moreover many winter migrants such as the Wagtails (*Motacilla spp.*), Blue throat (*Luscinia svecica*), Sandpipers (*Tringa spp.*

and *Actitis spp.*) and many others may also lose their wintering grounds. Although there are fish ponds in the agricultural area not far away from the waste water ponds, only the pond herons (*Ardeola grayii*) and cattle egrets (*Bubulcus ibis*) were occasionally sighted at the fish ponds during the study period. Moreover the ponds are an artificial habitat with no dense vegetation at the banks that is usually helpful in providing the nesting and hiding sites to many species. Therefore they may not be a suitable alternative of the waste water ponds.

Similarly, the conversion of agricultural land into buildings will cause many species such as Paddy Field Pipit (*Anthus rufulus*), Ashy Prinia (*Prinia socialis*), and Bee-eaters (*Merops spp.*) etc. to migrate from the area. Moreover, this expansion may also cause damage to Spotted Owlets (*Athene brama*), a single population of about ten birds observed on a tree in the agricultural area (observation point 3.5; Fig. 1). It should be noted that although this species was sighted twice in other areas of the campus, only one site is known as their nesting site. However it is possible that the large number of trees in the campus area may serve as an alternative habitat for them and also for many other species.

This urbanization will result in homogenization of species with a few species being far more abundant than others. As discussed earlier, urbanization favours generalist species rather than the specialist species. Therefore it is possible that this land use change will favour species such as House Sparrow, Babblers (*Turdoides spp.*), Red Vented Bulbul, Common Myna, Black Kite etc. which are already in abundance resulting in a sharp decrease in the diversity of birds in the campus area.

### CONCLUSIONS

Although New Campus, Punjab University has a variety of habitats that provide food and shelter to many species of birds, increasing demands for more buildings and developments can significantly decrease the moderate level of biodiversity to the least level. The habitat alteration can result in an increase in generalist species. Garbage eating birds were found to be already in abundance and in case of the proposed land use change, their

numbers may increase further. Urban centers usually have a homogenized fauna with very little variety. Although there are lawns of the departments, road-side plantations in hostels and the residential colony of the campus, it is possible that when the agricultural area is converted into the buildings, not much of the present 76 species will remain

This study was limited owing to the unavailability of any previous study regarding detailed changes in land use in the campus area. Satellite imagery before the year 2000 was also not available. Moreover there was no other previous study on the avian diversity of the campus other than the one conducted by Tanveer *et al.* (2002) in 1997.

### RECOMMENDATIONS

The campus area exhibits a variety of avian fauna which can be greatly affected by the land use change in the form of urbanization. In order to maintain the diversity of habitats and avian species in the campus area, following measures are recommended:

(i) Covered area under parks, lawns and other open areas should be enhanced in order to provide habitat for the avian species and to improve the landscape.

(ii) Indigenous flora should be planted to attract native species of birds.

(iii) Feeding points should be established so that the birds, especially grainivorous species, do not face scarcity of food.

(iv) Cutting of trees should be discouraged. If necessary, replanting them elsewhere should be ensured.

(v) Local biodiversity in these urban settings should be protected and precious populations of plants or animals or rare species should also be protected. This can be done by creating awareness among public, by enforcing laws that protect these species and also by protecting the habitat of these species so that they could survive.

(vi) Steps should be taken to reduce pollution so that biodiversity is not affected such as proper disposal of solid waste, treatment of waste water before it enters the water reservoirs, planting more

trees to reduce both noise and air pollution etc.

(vii) Solid waste should be managed and disposed properly so as not to attract the garbage eating species which are already in abundance and create a nuisance.

(viii) Development should be integrated with landscape management so that habitat fragmentation and degradation can be reduced in the agricultural areas within the campus.

(ix) Awareness must be raised among people to understand the importance of biodiversity.

(x) More studies regarding the bio-diversity in urban areas and the effect of habitat and land use alteration should be carried out.

(xi) Biodiversity studies may be made a regular activity of the Botany and Zoology Departments.

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