ESM (Electronic Supplementary Materials): Figures

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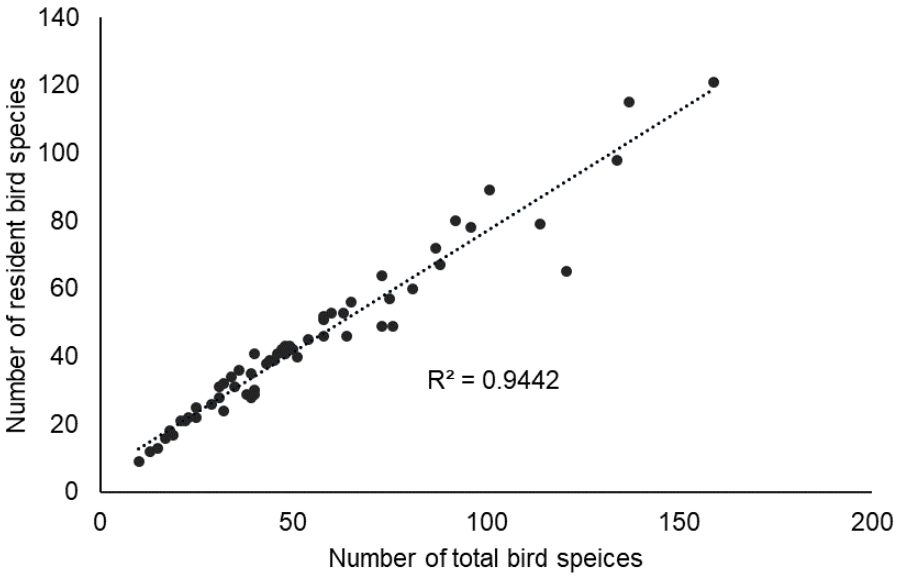
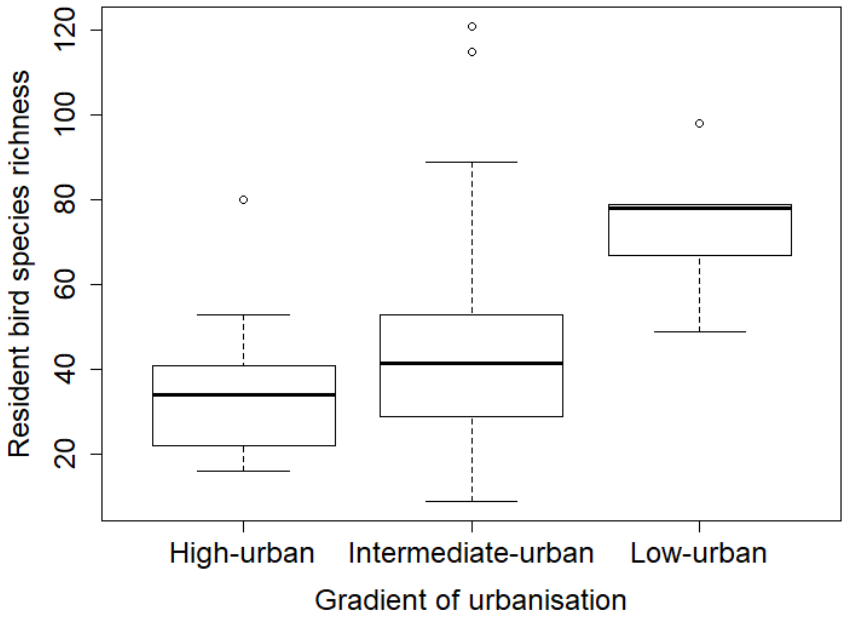
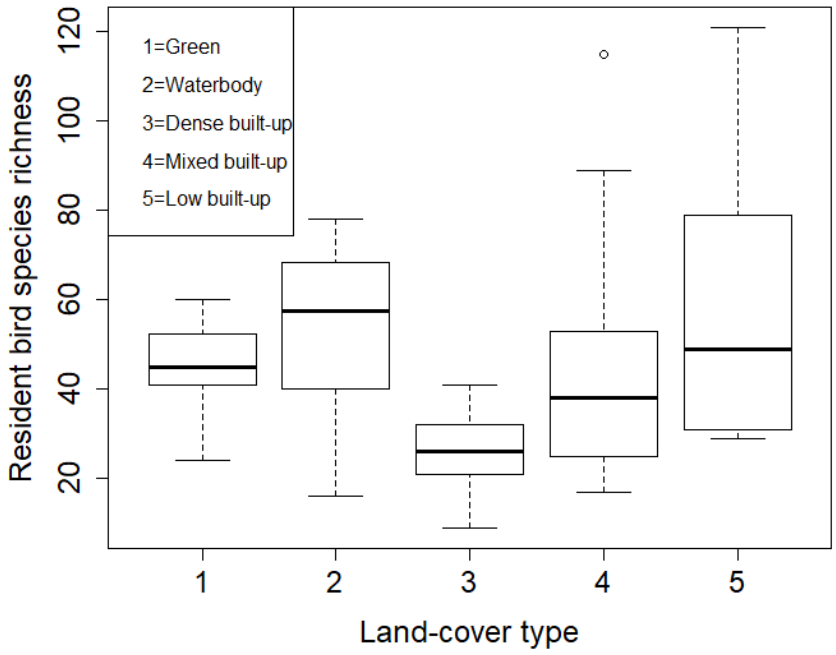
Journal name: Urban Ecosystem



ESM_Fig_1: A correlation plot of the number of observed resident bird species in relation to the number of total bird species at the surveyed urban locations. The total bird species includes all observed species at the locations. In contrast, the resident bird species includes only the species which are site specific native and very likely to occur at the location throughout the year.



ESM_Fig_2: A box-and-whisker plot showing distribution of resident bird species richness across different gradient of urbanisation. Representation of gradient of urbanisation in the boxplot is as follows: Low-urban (Impervious surface <30%, human density<5,000/km2); Intermediate-urban (Impervious surface≥30 and ≤50%, human density>5,000/km2); High-urban (Impervious surface >50%, human density>5,000/km2). The plot shows a comparison of median value and inter-quartile range of the observed bird richness among high, intermediate and low built-up areas. The highest median value and lowest upper quartile at low urban area indicates that bird richness is consistently high at low urban sites which declined at high urban areas. The bird species richness at intermediate urban areas greatly vary which range from lowest to highest value.



ESM_Fig_3: A box-and-whisker plot showing distribution of resident bird species richness (BSR) among different land-cover types. It displays a comparison of median value and inter-quartile range of the observed richness among five land-cover types. The median values indicated that the average bird richness is high in waterbody, green and low built-up areas and is the lowest in dense built-up areas. Areas consisting of low built-up and mixed built-up areas contained higher variation in bird species richness compared to other land-cover types.

ESM (Electronic Supplementary Materials): Tables

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ESM_Tabe_1: The sources of study locations and bird data

Ref.Id.	References	City	Country
1	Sarker NJ, Sultana D, Jaman MF, Rahman MK (2009) Diversity and population of avifauna of two urban sites in Dhaka, Bangladesh. ECOPRINT 16:1-8	Dhaka	Bangladesh
2	Rajia S, Alam MM, Chowdhury GW, et al (2015) Status and diversity of birds of Ramna park, Dhaka, Bangladesh. Bangladesh J Zool 43(2):291-301, 2015	Dhaka	Bangladesh
3	Ahsan MS, Nayeem B (2016) Inventory of Urban Avifauna: A Comparison of Bird Species of Two Urban Sites in Dhaka, Bangladesh. Asian Journal of Applied Science and Engineering. 5:173-182	Dhaka	Bangladesh
4	Islam MS, Shahadat O, Kabir MM, et al (2014) Avifauna of National Botanical Garden of Bangladesh. J.Taxon.Biodiv.Res. 6:17-20	Dhaka	Bangladesh
5	Akash M, Hossain MA, Chowdhury GW, et al (2013) Status of Avifauna in Curzon hall premises university of Dhaka, Bangladesh. ECOPRINT 20:1-18	Dhaka	Bangladesh
6	Banu FA, Akash M, Chowdhury GW, Hossain MA (2016) Status and seasonal occurrence of birds in Dhaka University campus. Dhaka Univ. J. Biol. Sci. 25(1):27-37	Dhaka	Bangladesh
7	Chowdhuri S, Aich U, Shahadat O (2014) Checklist of avian fauna of Dhaka University Campus, Bangladesh. International Journal of Fauna and Biological Studies 1(5): 54-60	Dhaka	Bangladesh

Ref.Id.	References	City	Country
8	Akter S, Mandal BK, Khatun R, Alim MA (2017) Seasonal prevalence of giant mealy bug Drosicha mangiferae (Homoptera: Pseudococcidae) in the college of home economics, Dhaka, Bangladesh. Journal of Entomology and Zoology Studies 5(5):192-199	Dhaka	Bangladesh
9	Shovon SC, Islam MS, Mahmud JA, Chowdhury MSN, et al (2014) Diversity of avifauna in Sher-E-Bangla Agricultural University campus. International Journal of Business, social and scientific research 2(1):58-63	Dhaka	Bangladesh
10	Reza AMS, Hasan MA, Hossain M, Parween S (2012) Anotated checklist of birds of Rajshahi University campus: An update. University Journal of Zoology Rajshahi University 31:39-47	Rajshahi	Bangladesh
11	Wadatkar JS (2001) Checklist of birds from Amravati University Campus, Maharashtra. Zoos' Print Journal 16(5):497-499	Amravati	India
12	Rajashekara S, Venkatesha MG (2017a) Seasonal Incidence and Diversity Pattern of Avian Communities in the Bangalore University Campus India. Proc Zool Soc 70(2):178–193	Bengalore	India
13	Rajashekara S, Venkatesha MG (2017b) Additions to the Birds of Bangalore University Campus (BUC), India. Proc Zool Soc (July-Dec 2017) 70(2):178–193	Bengalore	India
14	Singh M, Kumar K, Roy TK, Ulman Y (2017) Avifaunal Composition of Jawaharlal Nehru University Campus, New Delhi. Current World Environment 12(2):317-325	Delhi	India
15	Chattopadhyay R, Ghoshal S (2015) Avifaunal diversity in two residential localities of Kolkata, India. International letters of natural sciences 48:61-66	Kolkata	India
16	Ghose PS, Santra SC (2008). Pattern of avian diversity in urban environment: a case study in Kolkata. Zoological research in human welfare 11: 127-148	Kolkata	India
17	Shengupta S, Mondal M, Basu P (2014) Bird species assemblages across a rural urban gradient around Kolkata, India. Urban Ecosystem 17(2):585-596	Kolkata	India

Ref.Id.	References	City	Country
18	Kedar GT, Patil GP (2012) Study of Avifauna diversity of Gandhi Sagar Lake, Nagpur, Maharashtra. Vidyabharati International Interdisciplinary Research Journal 1(2): 40-46	Nagpur	India
19	Nerlekar AN, Warudkar AM, Gowande GG, et al (2016) A review of the faunal diversity of the Fergusson College campus, Pune, India. Zoos' Print 31(10):4-25	Pune	India
20	Dahal BR, Bhuju DR (2008) Bird Mobility and Their Habitat at Tribhuvan International Airport, Kathmandu. Nepal Journal of Science and Technology 9:119-130	Kathmandu	Nepal
21	Shaukat SS, Raza A (2016) Birds of Karachi University and Dow University of health sciences campuses, Karachi: With notes on their feeding habit. International Journal of Fauna and Biological Studies 3(5): 07-15	Karachi	Pakistan
22	Abbas S, Hussain S, Gabol K, Tabassum R, et al (2013) Study of Avifauna in Safari park and University of Karachi, Pakistan. International Journal of Pure and Applied Zoology 1(3): 241-248	Karachi	Pakistan
23	Joshua G, Ali Z (2011) Avian diversity with the varying urban congestions of Lahore. Journal of Animal and Plant Sciences 21(421-428)	Lahore	Pakistan
24	Sidra S, Ali Z, Chaudhury MN (2013) Avian Diversity at New Campus of Punjab University in Relation to Land Use Change. Pakistan Journal of Zoology 45(4): 1069-1082	Lahore	Pakistan

ESM_Table_2: The 57 urban locations used in the analysis, with duration of study, the number of total bird species, the number of resident bird species and the data source. The distribution of the locations with their unique ID are also presented in Fig.1.

Location ID	Study area	City	Country	Study duration	Total bird species	Resident bird species	Source: Appendix. 2
1.	Sector 7 in Uttara	Dhaka	Bangladesh	Aug 2004-Jul 2005	25	22	1
2.	Setor 9 in Uttara	Dhaka	Bangladesh	Aug2004-Jul05	18	18	1
3.	Ramna park in Shahbagh	Dhaka	Bangladesh	[2]Jul 2013-March 2014; [3]March 2012	54	45	2,3
4.	National Botanical Garden in Mirpur	Dhaka	Bangladesh	Sep 2011-Feb 2012	65	56	4
5.	Campus of University of Dhaka	Dhaka	Bangladesh	[5]Jan 2012-Jan 2014; [6]Jul 2013-Feb 2014; [7]Jan 2012-Jun 2014	92	80	5,6,7
6.	Home Economics College in Azimpur	Dhaka	Bangladesh	Jan 2015- Jan 2016	23	22	8
7.	Sher-e-Bangla Agricultural University Campus in Tejgaon	Dhaka	Bangladesh	May 2013-April 2014	60	53	9
8.	Curzon Hall of Dhaka University	Dhaka	Bangladesh	Jan2012-Jan2014	50	42	5

Location ID	Study area	City	Country	Study duration	Total bird species	Resident bird species	Source: Appendix. 2
9.	Dhanmondi lake in Dhanmondi	Dhaka	Bangladesh	March 2012	17	16	3
10.	Rajshahi university campus	Rajshahi	Bangladesh	March 2008-July 2012	159	121	10
11.	Amravati University Campus	Amravati	India	1996-Jan2000	88	67	11
12.	Bangalore Unviersity campus	Bangalore	India	[12]Feb 2008-Jan 2010; [13]Feb 2010-Jan 2014	134	98	12,13
13.	Jawaharlal Nehru University campus	Delhi	India	Jan 2013-Dec 2016	114	79	14
14.	Dhakuria	Kolkata	India	Dec 2013-Nov 2014	48	41	15
15.	Crossipore	Kolkata	India	Dec 2013-Nov 2014	44	39	15
16.	ISI Baranagar	Kolkata	India	2004-2006	45	39	16
17.	Charaktala	Kolkata	India	Feb - Apr 2009	21	21	17
18.	Kharadah	Kolkata	India	Feb - Apr 2009	32	32	17
19.	Urban parks and gardens-Rabindra Sarovar	Kolkata	India	2004-2006	58	46	16
20.	Urban parks and gardens-Victoria	Kolkata	India	2004-2006	49	43	16

Location ID	Study area	City	Country	Study duration	Total bird species	Resident bird species	Source: Appendix. 2
21.	Open Areas- Maiden	Kolkata	India	2004-2006	39	35	16
22.	Urban parks and gardens-Eden Gardens	Kolkata	India	2004-2006	51	40	16
23.	Urban parks and gardens-Rajbhawan	Kolkata	India	2004-2006	40	41	16
24.	Protected area-Narendrapur	Kolkata	India	2004-2006	81	60	16
25.	Barbaria	Kolkata	India	February to April 2009	36	36	17
26.	Gandhighat	Kolkata	India	February to April 2009	31	31	17
27.	Open Area-Kalyani Unviersity	Kolkata	India	2004-2006	73	49	16
28.	Protected area-Tollygunj Golf Club	Kolkata	India	2004-2006	48	43	16
29.	Urban parks and gardens-AHSI	Kolkata	India	2004-2006	58	52	16
30.	Urban parks and gardens-Subhash Sarovar	Kolkata	India	2004-2006	46	41	16
31.	Protected area-Banabitan	Kolkata	India	2004-2006	75	57	16

Location ID	Study area	City	Country	Study duration	Total bird species	Resident bird species	Source: Appendix. 2
32.	Protected area-Botanical Garden	Kolkata	India	2004-2006	63	53	16
33.	Esplanade	Kolkata	India	2004-2006	39	28	16
34.	Tala Park	Kolkata	India	2004-2006	40	30	16
35.	Panashree	Kolkata	India	Feb to Apr2009	25	25	17
36.	Shyamkhola	Kolkata	India	2004-2006	96	78	16
37.	IIM, Joka	Kolkata	India	2004-2006	87	72	16
38.	Wetland-Bheri Areas,Nalban	Kolkata	India	2004-2006	121	65	16
39.	Wetland-Kalyani Jheel	Kolkata	India	2004-2006	58	51	16
40.	Wetland-Nature Park	Kolkata	India	2004-2006	73	64	16
41.	Wetland-Santragachi	Kolkata	India	2004-2006	64	46	16
42.	Gandhi Sagar Lake	Nagpur	India	Jan-Sep 2010	34	34	18
43.	Fergusson College campus	Pune	India	2011-2014	137	115	19
44.	Tribhuvan International Airport	Kathmandu	Nepal	Jan-Dec 2001	35	31	20

Location ID	Study area	City	Country	Study duration	Total bird species	Resident bird species	Source: Appendix. 2
45.	Dow University of Health Sciences (D.U.H.S.)	Karachi	Pakistan	2008-2015	40	29	21
46.	Safari park	Karachi	Pakistan	Mar-Dec 2009	32	24	22
47.	Karachi University campus	Karachi	Pakistan	Mar-Dec 2009	38	29	22
48.	Samanabad Town (N Block)	Lahore	Pakistan	Mar-Dec 2009	15	13	23
49.	Data Ganj Baksh Town	Lahore	Pakistan	Mar-Dec 2009	22	21	23
50.	Shalimar Town (SinghPura)	Lahore	Pakistan	Mar-Dec 2009	10	9	23
51.	Ravi Town (Shairan Wala/Sheranwala gate)	Lahore	Pakistan	Mar-Dec 2009	13	12	23
52.	Gulberg Town (Gulberg III)	Lahore	Pakistan	Mar-Dec 2009	29	26	23
53.	Asif Block of Allama Iqbal Town	Lahore	Pakistan	Mar-Dec 2009	31	28	23
54.	Campus of Punjab Uni	Lahore	Pakistan	Jan-May2011	76	49	24
55.	Nishtar Town (Askari III Baidian Road)	Lahore	Pakistan	Mar-Dec 2009	43	38	23

Location ID	Study area	City	Country	Study duration	Total bird species	Resident bird species	Source: Appendix. 2
56.	Aziz Bhatti Town (Infantry road)	Lahore	Pakistan	Mar-Dec 2009	19	17	23
57.	Wagah Town (Batapur)	Lahore	Pakistan	Mar-Dec 2009	47	42	23

ESM_Table_3: A list of local environmental factors used in the preliminary investigation. The predictor variables which are used in the model analysis are shown in bold and are also presented in Table 1.

Variables	Description	Data type	Data source
Proportion of impervious surface	Value 0-100, Percentage of 'Impervious surface' from 'Global Man-made Impervious Surface (GMIS) and Global Human Built-up and Settlement Extent (HBASE) data products', resolution ~30m	Continuous	Brown et al 2017
Human population density	Average density of populations of the years 2005, 2010, 2015, from Gridded Population of the World Version 4 (GPWv4), resolution ~1Km	Continuous	CIESIN 2016
Gradient of urbanisation*	High-urban, Intermediate-urban, Low-urban	Categorical	Brown et al 2017; CIESIN 2016
Habitat Shannon metrics	Value of 'Diversity of EVI (Enhanced Vegetation Index)', from Global Habitat Heterogeneity dataset, resolution ~ 30 arc-second	Continuous	Tuanmu and Jetz 2015
Habitat dissimilarity	Value of habitat dissimilarity index, from Global Habitat Heterogeneity dataset, resolution ~ 30 arc-second	Continuous	Tuanmu and Jetz 2015
Habitat homogeneity	Value of habitat homogeneity index from Global Habitat Heterogeneity dataset, resolution ~ 30 arc-second	Continuous	Tuanmu and Jetz 2015
Built-up area	Value 13 from MODIS based Global Land Cover Climatology dataset, based on 10 years (2001-2010), resolution ~500m	Categorical	Broxton 2014
Wetland area	Value 0 and11 from MODIS based Global Land Cover Climatology dataset,	Categorical	Broxton 2014

Variables	Description	Data type	Data source
	based on 10 years (2001-2010), resolution ~500m		
Barren area	Value 16 from MODIS based Global Land Cover Climatology dataset are based on 10 years (2001-2010), resolution ~500m	Categorical	Broxton 2014
Presence of cropland	Value 20, Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%), GLOBCOVER dataset, resolution ~300m	Categorical	ESA 2009, Arino et al. 2008
Forest area	Value 110, Mosaic forest or shrubland (50-70%) / grassland (20-50%), 'GLOBCOVER' dataset, resolution ~300m	Continuous	ESA 2009, Arino et al. 2008
Tree canopy cover	Value 0-100, Percentage of tree canopy cover, Global Landsat TreeCover 2010 dataset, resolution ~30 m	Continuous	Sexton 2013
Annual Temperature	Bio-1: Average annual temperature, WorldClim dataset, resolution ~1Km	Continuous	Fick et al 2017
Seasonal temperature	Bio-4: Average temperature seasonality, WorldClim dataset, resolution ~1Km	Continuous	Fick et al 2017
Annual Precipitation	Bio-12: Average annual precipitation, WorldClim dataset, resolution ~1Km	Continuous	Fick et al 2017
Seasonal precipitation	Bio-15: Average precipitation seasonality, resolution ~1Km	Continuous	Fick et al 2017
Elevation	SRTM elevation 2000 dataset, resolution ~ 3 arc-second	Continuous	de Ferranti 2017
Land cover types[†]	As green, waterbody, built-up[‡] (high built-up, mixed built-up, low built-up)	Categorical	Source paper, Google Earth

Note: *Gradient of urbanisation: we explored three categories of degree of urbanisation as follows: 'Low-urban' (Impervious surface <30%, human density <5000/km^2), 'Intermediate-urban' (Impervious surface =>30 and =<50%, human density >5000/km^2) and 'High-urban' (Impervious surface >50%, human density

>5000/km^2). Here, we followed the threshold of impervious surface for urbanisation categories, used by Marzluff (2001). However, for human population density, we considered 5000/km2 (instead of 1000/km2 as proposed by Marzluff et al. 2001) as a threshold. None of our locations was in a pure rural site, and the majority contained population densities >1000/km2. This categorisation allowed us to visualise dissimilarity in bird species richness among the urban locations at 1000m scale extent but not at 5000m scale extent.

†Land cover types: We recorded five land cover types among the study locations. We noted each study site to one of three land-cover type in reference to the original publication, 'Green' (if the study sites were declared as parks, protected areas, garden or a green area), 'Waterbody' (if the study sites were declared as lakes, rivers or a wetland site) and 'Built-up'(if study sites were declared as local administrative units, campus areas, or any urban sites). 'Built-up' areas were further sub-divided into 'Dense built-up', 'Mixed built-up' and 'Low built-up'. These built-up categories were documented, using satellite images of nearest corresponding year from Google Earth, with an approximate eye alt view of 1 km. See the template images below for more clarity.

Dense built-up area

Mixed built-up

Low built-up

References

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Tuanmu MN, Jetz W (2015) A global, remote sensing-based characterization of terrestrial habitat heterogeneity for biodiversity and ecosystem modelling. Global Ecology and Biogeography. doi: 10.1111/geb.12365