Electronic Supplementary Material

The population density of an urban raptor is inextricably tied to human cultural practices

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Table S1. Landscape and human variables used to characterize each study plot in which we surveyed the population density of Black kite breeding pairs within the city of Delhi (India). Variables were chosen on the basis of our knowledge of kite ecology and of previous analyses of the factors that affect habitat preferences, breeding success and behavioural performance by Delhi kites (Kumar et al. 2018a,b, 2019). These variables characterized each plot in terms of its landscape structure, food availability (local availability of organic garbage, access to Muslim ritual-subsidies, local density of humans walking in the streets), and nest-site availability. See the Study Area section for background details on the rationale underlying the choice of indicators of human refuse and ritual subsidies. Further in-depth details can be found in Kumar et al. (2018a: Online Resource 2).

Variable	Description
Nest-site availability	Density (number/km^2) of structures potentially capable to support a kite nest, such as trees of sufficient height, or anthropogenic structures such as pylons and towers (Kumar et al. 2018a). For each plot, we: (1) digitized all large-enough trees clearly visible in Google Earth imagery; (2) visited each plot and mapped any additional trees that were not well visible in Google Earth (e.g. because of low quality, blurred imagery for some sectors of Delhi, or because of the shadow produced by tall buildings) and all potential anthropogenic nest-structures (e.g. poles, towers) that were typically too difficult to detect in Google Earth. For plots in which nesting-structures were too many to count individually, we: (1) plotted 20 random locations within each plot; (2) visited them in the field and counted all nesting-structures observed in a circular buffer of 200 m radius centered on each of these 20 random locations to calculate a cumulative density of nesting structures/km^2. Because more than 90 % of the available nest-structures were trees, we summed trees and artificial structures into a single cumulative estimate of breeding-site availability.
Refuse availability score	Level of sanitation of the plot: 1 = clean areas (efficient waste disposal with very scarce or no organic refuse in

	the streets); 2 = areas under poor waste management regime (abundant and widespread refuse in the streets throughout the area, either in small frequent piles, in illegal ephemeral dumps, or as individual items scattered a bit of everywhere through all streets).
Human density	Average number of people walking within 2m of a stationary observer during 5 min at 10 locations randomly plotted within 200 m of a nest, and averaged over all nests censused in a plot. When no of few nests were present in a plot, we conducted the human counts at five sites randomly distributed within the plot. Counts were only operated between 10:00-17:00 hrs and avoided during atypical, momentary peak periods of human traffic, such as exits from work or schools, in order to maintain consistency across sites (following Kumar et al. 2018a).
Access to Muslim subsidies	First component (PC1) of a principal component analysis on the density of Muslim inhabitants in the plot and on the proximity of the plot to the three closest Muslim colonies. A key variable in our previous analyses on the predictors of kite site selection, occupancy, breeding and behavioral performance was the ease of access to dense Muslim colonies, which provide abundant food supplies in the form of ritual subsidies (Kumar et al. 2018a, b). More specifically, we previously showed that Delhi kites preferred breeding sites closer than available to the 1st, 2nd and 3rd nearest Muslim colony (see Kumar et al. 2018a for details). Thus, to provide a comprehensive measure that integrated the proximity to the three nearest Muslim colonies with their human population density (under the assumption that higher rates of refuse and ritualized-feeding should occur in more densely-populated Muslim colonies), we extracted the first axis (PC1) of a Principal Component Analysis (PCA) run on these four aforementioned variables. Its PC1 (hereafter "access to Muslim subsidies") explained 83% of the variance and had a high positive loading on Muslim population density and high negative loadings on the distance to the 1st, 2nd and 3rd closest Muslim colonies. Thus, it provided an increasing index of access to abundant "Muslim subsidies". For clarity of presentation (e.g. in graphs), we added 1.63 to all values of this variable in order to avoid negative values. Finally, one plot with an unusually large negative value was rescaled to the closest value in order not to distort the graphs. Analyses with the original or rescaled value gave the same results.
Index of road density	Number of asphalted roads crossed by a 500 m north-south and a 500 m east-west transect crossing each other on a nest, and averaged over all nests censused in a plot.

Table S2. Information on the population density of Black kites and its predictor variables collected at 28 study plots randomly scattered within Delhi (India). Variables names correspond to those of Table S1, which reports a description of each variable. The four columns on the right (density of Muslim inhabitants; distance to closest Muslim colony; distance to 2nd closest Muslim colony; distance to 3rd closest Muslim colony) report the variables used to build the PC1 index of "access to Muslim subsidies" (details in Table S1).

Plot ID	Year	density	nest-site availability	refuse availability score	human density	index of road density	access to Muslim subsidies	density of Muslim inhabitants	distance to closest Muslim colony	distance to 2nd closest Muslim colony	distance to 3rd closest Muslim colony
2	2013	67.09	2198.40	1	13.88	9.23	2.07	20307	885	1085	2071
2	2014	64.29	2198.40	1	13.88	9.23	2.07	20307	885	1085	2071
2	2015	72.28	2198.40	1	13.88	9.23	2.07	20307	885	1085	2071
2	2016	63.34	2198.40	1	13.88	9.23	2.07	20307	885	1085	2071
2	2017	46.00	2198.40	1	13.88	9.23	2.07	20307	885	1085	2071
2	2018	58.00	2198.40	1	13.88	9.23	2.07	20307	885	1085	2071
7	2013	87.04	3161.60	1	17.68	6.61	2.96	70009	245	1170	1196
7	2014	118.34	3161.60	1	17.68	6.61	2.96	70009	245	1170	1196
7	2015	109.30	3161.60	1	17.68	6.61	2.96	70009	245	1170	1196
7	2016	109.23	3161.60	1	17.68	6.61	2.96	70009	245	1170	1196
7	2017	104.62	3161.60	1	17.68	6.61	2.96	70009	245	1170	1196
7	2018	110.77	3161.60	1	17.68	6.61	2.96	70009	245	1170	1196
6	2013	5.00	953.54	1	2.34	3.29	1.80	2412	695	1843	1858
6	2014	2.25	953.54	1	2.34	3.29	1.80	2412	695	1843	1858
6	2015	4.71	953.54	1	2.34	3.29	1.80	2412	695	1843	1858
6	2016	4.35	953.54	1	2.34	3.29	1.80	2412	695	1843	1858
6	2017	5.34	953.54	1	2.34	3.29	1.80	2412	695	1843	1858
6	2018	5.00	953.54	1	2.34	3.29	1.80	2412	695	1843	1858
4	2013	4.81	336.06	1	4.05	2.46	0.99	8579	2226	2794	2816
4	2014	6.59	336.06	1	4.05	2.46	0.99	8579	2226	2794	2816
4	2015	5.60	336.06	1	4.05	2.46	0.99	8579	2226	2794	2816
4	2016	4.67	336.06	1	4.05	2.46	0.99	8579	2226	2794	2816

4	2017	5.34	336.06	1	4.05	2.46	0.99	8579	2226	2794	2816
4	2018	4.67	336.06	1	4.05	2.46	0.99	8579	2226	2794	2816
5	2013	4.33	164.32	2	16.09	4.25	0.66	4902	1877	3639	3708
5	2014	2.78	164.32	2	16.09	4.25	0.66	4902	1877	3639	3708
5	2015	3.51	164.32	2	16.09	4.25	0.66	4902	1877	3639	3708
5	2016	2.78	164.32	2	16.09	4.25	0.66	4902	1877	3639	3708
5	2017	2.78	164.32	2	16.09	4.25	0.66	4902	1877	3639	3708
5	2018	2.78	164.32	2	16.09	4.25	0.66	4902	1877	3639	3708
1	2013	7.34	527.64	2	5.07	8.29	1.56	11326	942	2367	2509
1	2014	3.85	527.64	2	5.07	8.29	1.56	11326	942	2367	2509
1	2015	3.77	366.64	2	5.07	8.29	1.56	11326	942	2367	2509
1	2016	3.91	366.64	2	5.07	8.29	1.56	11326	942	2367	2509
1	2017	3.84	366.64	2	5.07	8.29	1.56	11326	942	2367	2509
1	2018	3.64	366.64	2	5.07	8.29	1.56	11326	942	2367	2509
3	2013	5.73	1024.04	2	7.40	4.90	1.97	20267	924	1390	2140
3	2014	5.77	1024.04	2	7.40	4.90	1.97	20267	924	1390	2140
3	2015	5.11	1024.04	2	7.40	4.90	1.97	20267	924	1390	2140
3	2016	4.54	1024.04	2	7.40	4.90	1.97	20267	924	1390	2140
3	2017	5.00	1024.04	2	7.40	4.90	1.97	20267	924	1390	2140
3	2018	4.00	1024.04	2	7.40	4.90	1.97	20267	924	1390	2140
10	2013	0.00	900.45	1	0.00	0.00	0.67	0	2268	2525	4150
10	2014	0.00	900.45	1	0.00	0.00	0.67	0	2268	2525	4150
10	2015	0.00	900.45	1	0.00	0.00	0.67	0	2268	2525	4150
10	2016	0.00	900.45	1	0.00	0.00	0.67	0	2268	2525	4150
10	2017	0.00	900.45	1	0.00	0.00	0.67	0	2268	2525	4150
10	2018	0.00	900.45	1	0.00	0.00	0.67	0	2268	2525	4150
14	2013	0.00	851.03	1	0.00	0.00	0.01	0	2671	3999	5071
14	2014	0.00	851.03	1	0.00	0.00	0.01	0	2671	3999	5071
14	2015	0.00	851.03	1	0.00	0.00	0.01	0	2671	3999	5071
14	2016	0.00	851.03	1	0.00	0.00	0.01	0	2671	3999	5071

14	2017	0.00	851.03	1	0.00	0.00	0.01	0	2671	3999	5071
14	2018	0.00	851.03	1	0.00	0.00	0.01	0	2671	3999	5071
11	2014	33.34	674.87	2	17.50	8.14	3.22	42530	21	67	87
11	2015	33.34	674.87	2	17.50	8.14	3.22	42530	21	67	87
11	2016	41.50	674.87	2	17.50	8.14	3.22	42530	21	67	87
11	2017	37.74	674.87	2	17.50	8.14	3.22	42530	21	67	87
11	2018	41.50	674.87	2	17.50	8.14	3.22	42530	21	67	87
13	2016	188.89	3840.54	2	15.93	11.00	2.55	18126	348	683	850
13	2017	180.00	3840.54	2	15.93	11.00	2.55	18126	348	683	850
13	2018	177.50	3840.54	2	15.93	11.00	2.55	18126	348	683	850
15	2014	12.00	1001.06	1	11.44	5.00	1.55	29	1549	1738	1826
16	2014	31.58	863.61	1	23.56	11.00	2.24	7767	356	1103	1312
17	2014	3.79	928.57	1	23.56	9.67	1.53	4521	1249	1747	2590
18	2014	2.67	180.52	2	16.92	4.00	2.35	28461	702	1110	1376
19	2014	3.50	1162.90	1	18.16	6.00	2.12	17923	884	1153	1631
20	2014	3.17	1115.70	1	10.55	9.00	1.15	4902	1996	2426	2601
21	2014	1.00	941.84	1	3.75	5.00	1.65	0	525	1605	2960
22	2015	14.55	1006.75	1	21.00	6.80	2.14	10731	725	1236	1313
23	2015	1.00	143.88	1	3.44	3.00	0.01	0	5933	6738	7230
9	2015	16.90	1001.11	1	17.57	7.00	2.64	46620	631	631	1567
24	2015	2.82	608.64	1	6.50	5.00	2.38	1342	233	508	1149
25	2015	0.00	1159.11	1	3.25	7.00	1.05	0	2037	2037	3209
26	2015	0.00	911.90	1	7.00	0.00	1.88	0	665	1408	1860
8	2015	12.50	1165.39	2	19.23	7.40	3.46	72904	0	144	476
27	2016	3.70	774.27	1	5.86	4.00	1.75	0	1002	1522	1895
12	2016	10.81	1074.66	1	20.34	6.80	1.54	4360	991	2150	2438
28	2016	2.50	794.84	1	1.50	4.00	1.57	3243	1294	1842	2121

Appendix S1. Spatial analysis of Black kite density

Methods

Because of potential spatial dependency, kite density was initially modelled through a spatial linear mixed model (LMM) by means of Bayesian methods, as detailed in Zuur et al. (2017). The model incorporated a Guassian Markov random field that controls for spatial dependency and autocorrelation. The estimation of the spatial random field was based on the creation of a dense triangular grid (mesh) overlaid on the study area (Fig. 1 below) to solve a "continuous domain stochastic partial differential equation" (SPDE), in turn used to calculate the parameters of the Matérn correlation function which estimates the spatial random term. The explanatory variables (see Methods and Table S1) were fitted to the model through diffuse priors, and considered as "important" when their 25 % and 95 % credible intervals did not overlap zero. Study plot identity was always fitted as a random effect. Support for inclusion of a spatial random field was examined by comparing the LMM with and without the spatial field by means of the DIC statistic. Zuur et al. (2017) suggest a ΔDIC > 10 units to provide support for a model over another. All model building and checking procedures follow Zuur et al. (2017).

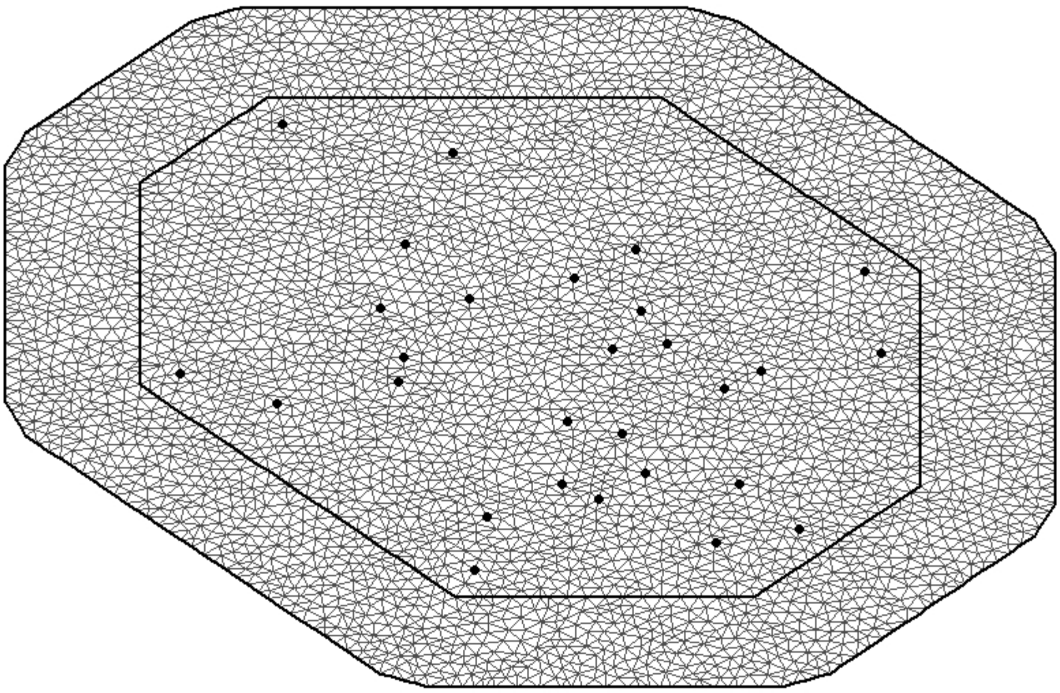

Fig. 1. Mesh overlaid on the Delhi study area to estimate the spatial field fitted to the linear mixed model used to relate kite density to explanatory variables. The mesh was based on a grid of > 4000 triangle-vertices (4299), following recommendations by Zuur et al. (2017). The black circles represent the kite study plots.

Results

Two variables appeared as important, as their 25 % and 95 % credible intervals did not overlap zero (see Table 1 below). These were: human density and the interaction between Access to Muslim subsidies and Nest availability. There was poor support for the need of a spatial random field: the spatial model was only 2.78 DIC units less than the model without a spatial random field.

Table 1. Slope and credible intervals of a spatial linear mixed model testing the effect of landscape structure, food availability and breeding-site availability on the population density of an urban raptor. Important variables, whose credible intervals do not overlap zero, are highlighted in bold .

Variable	Mean	25 % credible interval	95 % credible interval
Intercept	-15.33	-44.63	14.55
Access to Muslim subsidies	-3.40	-27.08	20.35
Quadratic effect of Access to Muslim subsidies	-6.84	-18.52	4.87
Nest availability	-0.01	-0.04	0.02
Hygiene score	-1.27	-4.53	1.96
Human density	**18.18**	**3.76**	**32.23**
Index of road density	1.04	-1.64	3.76
Access to Muslim subsidies * Hygiene score	0.87	-0.99	2.74
Access to Muslim subsidies * Nest availability	**0.01**	**0.01**	**0.03**