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Characteristics of habitat structure and its impact on nest success, breeding bird density and reduction of mortality in Pelicans by the participation of rural community connected to biosphere of PSKB area, India

H.G. Ravishankar[1]*, Govindharajalu Madhuramozhi[1], B.C. Leelaja[2] & G. Panduranga Murthy[3]
[1]PG & Research Department of Zoology, ADM College for Women, Bharathidasan University, Tamil Nadu, India
[2]DOS in Molecular Biology, University of Mysore, Mysore, Karnataka, India
[3]Hamsa Research Foundation, B. H. Road, Tumkur, Karnataka, India

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ABSTRACT

The main purpose of this study was to explore the consistency in the species diversity and evenness of Pelicans in the different locales of natural habitations by the participation of rural people at Pelican Sanctuary, Kokkare Bellur (PSKB), Mandya district, Karnataka, India. The subsequent objective was to assess the characteristic habitation and its compositions facilitating nest success, breeding bird density and reduction of mortality in Pelicans in the PSKB area. The survey was undertaken during 2018-2020 to analyse the relationship between natural habitation and Pelican's ecology. The natural habitation was categorized into forest land, farmland, grass land, river Shimsha basin connected with fresh water wetland, living area of village population respectively. The different ecological index was employed to study these objectives and the results reveals that, forest land connected with river basin area decreased the Pelican bird numbers, whereas, the farmland associated with natural habitation increased the Pelican's species richness. Further, the village area coupled with mixed tall trees and its vegetation were found to be important factors for nest success and breeding bird density of Pelican birds thereby the mortality was considerably reduced. Hence, the total inhabitation organization has been accomplished as two-tier habitats in the village for promoting higher bird species richness and evenness by the dynamic participation of rural community which is constantly connected to the Pelican biosphere.

Key Words - Pelicans, Nest success, Breeding bird density, Mortality reduction, Community participation, Conservation.

***Corresponding author :** ravishankar.hg@rediffmail.com

INTRODUCTION

The avian diversity can be found in many habitats of different geographical locations. Birds have been considered good predictors of habitat quality, as they relate to changes in their associated habitats in numerous ways. The biodiversity regions with closed canopy is relatively undisturbed habitat showed significant variation in habitat attributes, suggesting complexity of habitat structure. Bird species richness and diversity were significantly related to moderately concerned habitats

represented, where vegetation heterogeneity (vertical stratification and species composition) was relatively (Sandström *et al.*, 2006). The typical bird species are concomitant with high-density built-up or domiciliary areas. Many of these species are exotics that have capitalized on the presence of non-natural nest sites like, roof space, building niches and food sources like, garbage, bird-feeders (MacGregor-Fors, 2009).

Birds are the most iconic living creatures amongst all other ecological assets and very sensitive to changes of the surrounding habitat (Devictor and Jiguet, 2007; Wu *et al*., 2011). Therefore, the study on the relationship between various environs and diversity of bird has been a critical issue. In view of that, some numeral studies have explored the variety of bird diversity in the natural habitations such as, sanctuaries, bio-reserve areas, semi-urban, urban and rural areas, farmland, and forest land respectively (Barth *et al.*, 2015; Fontana *et al.*, 2011; Kath *et al.*, 2009; Ortega-Alvarez & Stagoll *et al.*, 2010; Strohbach *et al.*, 2013). Similarly, the remnants of natural communities of the diversity region can often be found in inaccessible coverings of habitat which is not fully formed. The most important types of habitats which are naturally mechanized for the occurrence wildlife is regarded as unique biodiversity with distinctive topographies; where the richness of bird species can be perceived although the year (Beukema *et al.*, 2007; Herzog *et al.*, 2005; Thiollay, 1995; Wuczyñski, 2015). However, the nest success is greatly influenced by these flourishing vegetations in their natural habitation opted by the avian community.

Subsequently, studies have also shown that, a higher ecological diversity not only benefits species survival but is also an important indicator of human well-being. The promotion of bird diversity is a useful method for generating human psychological benefits. As a consequence, the mechanism and effective prediction of bird diversity in various habitats should be understood (Mikusiñski *et al.*, 2001; Fuller *et al.*, 2007; Luck *et al.*, 2011; Hedblom *et al.*, 2014; Shoffner *et al.*, 2018).

The functional approach relating to different habitats and bird diversity with human actions is still not distinguished. The species richness and species evenness are two common concepts to measure species diversity (Harisha and Hosetti, 2009). The number of breeding bird species increases from urban to suburban, rural, and natural areas respectively. Besides, some previous studies indicated that sub-urbanization did not reduce bird species richness (*i.e*., the number of bird species) due to an abundant food supply, but rather increased the number of birds in a few dominant bird species. One of the main characteristics of built-up areas is the numerical dominance of a few abundant bird species, which means lower species evenness (Fontana *et al.*, 2011; Ortega-Alvarez & MacGregor-Fors, 2009). This observation relates to the crucial drive of the study: species evenness may demonstrate divergence in bird diversity between natural and meticulously developed environments. The previous studies have separately explored bird species richness and evenness to substantiate the variable habitations of bird diversity (Wuczyñski, 2016).

The habitation types and characteristics have been studied and have shown constructive results for higher bird diversity. The existence of forestry is a progressive and idiosyncratic environmental conditions for bird diversity in various biodiversity settings. The proportion of tree cover is an essential variable for envisaging the density of birds and richness of the bird species (Kath *et al.*, 2009; Sandström *et al.*, 2006; Strohbach *et al.*, 2013; Wuczyñski, 2013). The diversified tree species are critical for attracting bird species and variegated evergreen & deciduous forests had a higher bird species richness (Palomino and Carrascal, 2006; Fontana *et al.*, 2011). In addition, some studies indicated analogous domino effect for bird diversity in mixed evergreen & deciduous forests.

The study of mixed vegetation and broadleaf forest had no influence on the bird Simpson's diversity index, but had an influence on bird community composition (Fontana *et al*., 2011). Consequently,

the agro-forests may be an important habitat for bird diversity because they attract fruit-eating species. The categorical study indicated that orchards had no or low effect on the bird species diversity (Herzog *et al*., 2011). In contrast, superfluous studies reported a similarity between the bird diversity of orchards and primary forests. There is no consistent relationship between various habitats and bird diversity. This observation relates to the concrete purpose of the proposed study: identifying of the habitat types and its composition predict higher diversity of Pelican bird corroborated through nest success and breeding behaviour (Beukema *et al.*, 2007). In addition, the bird habitations consist of various territory types: from the human-related environment linking with the living area, green park, total village area, farmland, and water bodies to the association of natural eco-system comprising of, forestland, grassland, river basins, streams, and wet land regions.

It is also demonstrated that certain aspects of psychological well-being of humans of urban greenspace increase as species richness of plants and birds in the greenspace increases. There are no precise reports on these objectives in the places where people live, where, debatably, the majority of human-nature relations occur. It has also been observed whether variation in bird and plant communities in residential neighbourhoods is related to the personal and neighbourhood well-being (*i.e.,* satisfaction with one's life overall or satisfaction with one's neighbourhood environment, respectively) of residents and residents' level of connection to natural environment (Fuller *et al*., 2007).

Chronological background

Since ancient times, the diversity and density of pelicans at this PSKB area was in all probability revealed in the research report (Jerdon, 1853), which was further comprehensively executed by the pioneering work. He has established viable solutions by introducing a compensatory scheme to benefit the villagers for furthering the cause of proliferation of this breed of pelicans (Neginhal, 1977). The birds and the villagers have coexisted now in total harmony for several decades. The Karnataka Forest Department compensates the villagers with a fixed sum of money for each tree that is used for nestling by birds, since benefits from the crops (for example, tamarind) from these trees and from the land below the tree are lost (Neginhal, 1997). Later, an ecological study of birds at Kokkare bellur has been accomplished (Sanjay, 1993). The unique association between Pelicans and People with respect to protection of the birds by people's participation has been apparently studied (Manu *et al.*, 2000). Since then, there are no distinguishable studies carried-out on eco-ornithological features relating to Pelican and Painted stork followed by other bird's species in the variable time of year. Both Pelican and Painted stork are recognized as near threatened bird species in the recent scenario. Hence, the current study has been undertaken to demonstrate the characteristics features of habitat structure in Kokkare bellur bird sanctuary and its impact on nest success, breeding bird density. In addition, the factors responsible for mortality and control measures for reducing the mortality in Pelicans through the strategic participation of rural community connected to biosphere has been projected in the present study.

STUDY AREA AND METHODOLOGY

Study Area

The field survey work was conducted at the Pelican sanctuary (Bio-reserve), Kokkare Bellur (PSKB) area Maddur taluk, Mandya district, Karnataka state, India (located between 12°13'N, 77°0'E), from July 2018 to April, 2020. The village Kokkare bellur, habitually abbreviated by the vernacular usage to Kokkare bellur is an explicit village located in Maddur taluk of Mandya district, Karnataka, India (Banks-Leite *et al*., 2011). The village is entitled after the painted stork (*Mycteria leucocephala*), which is named as 'Kokkare' in the native Kannada language (Kannada- ಕೊಕ್ಕರೆ ಬೆಳ್ಳೂರು) is derived from two words: 'kokkare' meaning "stork" or "pelican" and 'bellur' meaning" white village. This bird nests here in large numbers every year. The village is situated near Maddur between

the cities of Mysore and Bangalore. The uniqueness of this area is having the huge diversity of both spot-billed pelicans (*Pelecanus phillipensis*) and painted storks during the mid-course of the year.

The distinctiveness of Kokkare bellur lies in the long-established bond between the spot-billed pelicans and the village population who have adopted this pelican bird as their local heritage, since they consider the birds as indications of stroke of luck and fruitfulness to the village. The viable profits derived by the village farmers from these birds include manure enriched with nutrients (phosphorus and potassium) is obtained from the bird droppings (also known as guano). Since several years, the story of this unique relationship between the villagers and the migratory birds has attracted many visitors to the village connected to PSKB area (Fig.1).

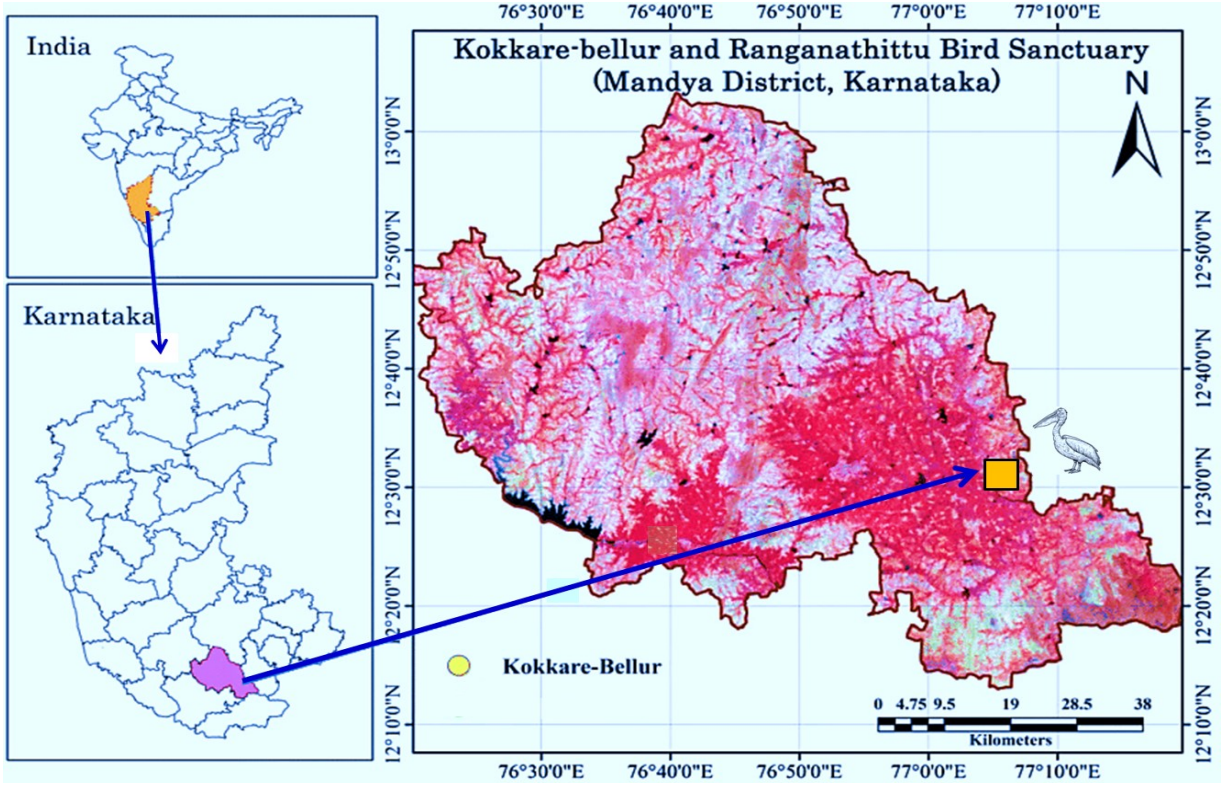


Fig.1- Geographical locations of Kokkare Bellur area

Topography of the PRKB Area

The village coupled with PSKB area is located 800 metres (2,600 ft) to the west of the Shimsa River. The area in the surrounding area of the village offers large water bodies in the form of number of large tanks for instance, the Tailur Kere ('Kere' means "tank"), the Maddur Kere and the Sule Kere that sustain food needs (particularly, fishes and shell-fishes) of the pelicans and other birds. The village associated PRKB area has nesting trees in the form of *Ficus* (*F religiosa*, *F bengalensis*) and tamarind (*Tamarindus indica*) trees. The Mandya district, where the village is located, has extensive agricultural fields with sugarcane as a major crop. During the course of migration, the birds comprising of large colonies of spot-billed pelicans and painted storks are seen nesting, typically in tall trees like, tamarind trees, banyan trees, terminalia tree and *Ficus* tree respectively.

METHODOLOGY

Environmental Variables

The variables on environmental and demographic factors and resident's well-being and connection to nature in 4 neighbourhoods were measured in each location (08 zones) and defined environs

boundaries followed by the smallest sampling unit (40 houses) at PSKB area. Furthermore, the regions selected with stratified random sampling to capture the full range of variation in housing density, earnings levels, vegetation cover and community participation for birds' conservation etc., (Luck *et al*., 2009).

It is observed that, the annual average temperature of the PSKB region ranges from 18.4 to 21.5°C. Since the region is set with special geographical position, unique climate conditions and topography, PSKB area connected with river and nearby water bodies provides pertinent eco-environment for a wide variety of avifaunal diversity along with floral composition. Exclusively, the water obtainability will be reduced in winter and summer; the grass lands expose and provide sufficient food for birds. The river Shimsha and the adjacent water bodies increasingly have become an important seasonal habitats and corridor for migratory birds at PSKB area (**Plate-1a-h**).

Study operation with Ecological Index

The Bird Survey was used to analyse the relationship/association between habitat/ habitation and bird ecology. The habitat type was divided into seven categories and its sub-types: forest-land, farm-land, grass-land, freshwater wetland, Lakes/Tanks, pond/ditches and Human living/house area. However, four ecological indexes were used: the number of bird individuals, the number of species, the Margalef Richness Index, and the Pielou Evenness Index respectively.

Bird survey

The samplings were conducted from October to April in each year to record diversified species and each site was sampled once or twice a year. Based on the extensive experience, nearly 10-12 representative sampling sites were investigated (**Plate-1a-f**). To exclude year-to-year variation in bird patterns; it was recorded the same sampling sites by same method every year. It is well known that the distribution of birds may differ between years (Johnson, 2008). However, the difference seemed negligible in the study. The bird surveys were carried out within a radius of 1 km of the sampling site each year on fine weather without rain or significant wind (Chapman and Reich, 2007).

Birds were observed by monocular (Nikula 10 × 42) and binocular (Swarovski). During surveys, the geographical position of each site was also recorded by using a handheld global positioning sys-tem (GPS; Vista). To estimate the densities of individual species, a list of all species with visual footages was documented.

RESULTS & DISCUSSION

A total of 2,655 records of single bird detection (Pelican), 4,872 records of single bird detection (Painted stork), 141 other bird species, and 8,666 birds (in number) has been documented during 2017 to 2020, including breeding birds and non-breeding migratory birds. The entire list of 141 bird species has been assessed of these, 106 were excluded due to missing information at variable habitation type, wind, and weather followed by unusual incidents. A total of 8561 legitimate archives were obtained for data analysis. The mean (S.D.) number of individual birds and species at each sampling point was 19.64 (17.89) and 13.65 (4.76), respectively (Table 1). Similarly, the mean (SD) of richness index and Evenness index measured was 6.55 (0.78) and 1.68 (0.63) respectively.

Subsequently, the regions of Forestland (52.6%), farmland (38.6%), grass land regions (18.6%), Village associated regions (20.5%), and freshwater wetlands (17.4%) were assessed as main landscape habitat categories (Table 2). Further, the data on Broadleaf Forest (24.6%), mixed vegetation with Broad leaf forest area (8.8%), Bamboo engrossed area (3.6%), Forest with monoculture tree sps. (10.6%) were generated. The data on Tall Grass area (9.2%), Dry agri-land area (9.8%), Aquatic agri-land area (13.3%) and Orchards inclusive of coconut/ areca farms (14.8%) were accomplished under main landscape sub-habitation areas (Table 2).

The Prediction of Bird Diversity by Habitat Type

The unstandardized and standardized coefficients of habitat types (dummy variable) on bird diversity through regression analysis are shown in Table 3.

Grass-land, freshwater wet-land, farm-land and village associated area significantly increased the number of birds by 2.44 (B = 0.05, p < 0.001), 2.56 (B = 0.04, p < 0.001), 6.86 (B = 0.25, p < 0.001) and 4.45 (B = 0.26, p < 0.001) birds, respectively (Plate-1a-h).

However, forestland significantly decreased the number of birds by 3.92 (B = "0.08, p < 0.001). Forest-land, grass-land, freshwater wet-land, farm-land, and village associated regions significantly increased the number of bird species by 0.43 (B = 0.03, p < 0.001), 1.02 (B = 0.08, p < 0.001), 0.91 (B = 0.05, p < 0.001), 2.08 (B = 0.16, p < 0.001) and 2.11 (B = 0.03, p < 0.01), respectively (Table 3). Consequently, forest-land, grass-land, freshwater wet-land, and farm-land significantly increased the Richness Index by 0.35 (B = 0.14, p < 0.001), 0.22 (B = 0.06, p < 0.001), 0.20 (B = 0.02, p < 0.001), and 0.28 (B = 0.12, p < 0.001), respectively. The village associated regions significantly decreased the Richness Index by 0.09 (B = "0.02, p < 0.001). Forest-land and grass-land significantly increased the Evenness Index by 0.02 (B = 0.05, p < 0.001), and 0.01 (B = 0.04, p < 0.001), respectively (Table 3). Similarly, village associated regions considerably increased the Evenness index by 0.01 (B = "0.02, p < 0.001) which is significantly superior (Plate-2a-f).

Furthermore, the analytical approach on the obtained results indicates that forestland and grassland significantly increased the number of bird species, richness, and evenness, although the presence of forestland significantly decreased bird numbers. Farm-land and freshwater wetlands significantly increased bird numbers, the number of bird species, and richness, but did not affect evenness. The village associated regions significantly increased bird numbers and the number of bird species, but significantly decreased species evenness, which means that the number of birds per bird species was not equal (Table 4 and Graph 1 & Plate-1a-h).

The habitat sub-type influence on bird diversity has been assessed. The results indicated that forestland sub-types significantly increased the number of bird species, richness, and evenness, except for broadleaf forest. The broadleaf forest only increased species richness and the bird number was significantly decreased in the broadleaf forest and mixed vegetation broadleaf forest and significantly increased in the windbreak forest. The forest region significantly increased the values of all four indexes, especially increasing the bird numbers and numbers of species respectively. The forest-land sub-type did not have high bird numbers, but had high species evenness compared to other sub-types. Although the values of richness and evenness in the forest-land sub-type were similar to the mixed forest sub-type, the mixed forest had slightly higher values (Table 4 and Graph 1 & Plate-2a-f).

In grass-land sub-types, tall grassland significantly increased the value of all indexes. The high marsh significantly increased bird species evenness. Obviously, low grass-land and low marsh did not influence the bird species richness and evenness. Also, grass-land sub-types led to a significant increase in bird numbers and number of species, except for bamboo grass-land. Although bamboo grass-land significantly decreased bird numbers and the number of species; there was a significant increase in bird species evenness. The results indicated that the height of grass-land had a positive effect on species evenness, as greater heights are the common feature of tall grass-land, high marsh, and bamboo grass-land (Table 4 and Graph 1 & Plate-2a-f).

Wildlife Archives

Apart from the pelicans, the other birds found nestling and breeding in the village trees are the painted stork (*Ibis leucocephalus*), little cormorant (*Phalacrocorax niger*), black ibis (*Pseudibis papillosa*), grey heron (*Ardea cinerea*), black-crowned night heron (*Nycticorax nycticorax*) and Indian pond heron (*Ardeola grayii*). The birds are seen nesting in clusters of 15 to 20 pairs per tree and are thought to use the same tree each year. They arrive after monsoon rains ends in September when the birds create their nests, lay eggs from October to November, thereafter fledge around for three months after laying of eggs, till March and tirelessly feed their hatchlings through

the summer season (Plate-1a-d, Plate-2a-f). As summer peaks in May, they re-migrate, year after year, except when they sense drought conditions in their colonial habitat. Village women turning sentimental about the birds returning to their homeland say: *these birds are like a daughter coming home for delivery*-for villagers (Plate-3a-d).

The birds have distinctly different large anatomical dimensions and colours but both are very active in feeding and protecting their hatchlings. While the painted stork is large in size, the pelican is half this size. Storks have snow-white plumage, lay 2-5 white dotted eggs and have a yellow tapering bill. The pelicans have grey and greyish white plumage, short stout legs, large webbed feet, flat and enormous bill with an elastic bag of purple skin hanging below the throat (that facilitates to collect fish from water surfaces), with length or height in the range of 127–140 centimetres (50–55 in) with tufted crown at the back of the head and lay a maximum of three chalk white eggs at a time (Plate-1a & b).

Conservation policies

The spot-billed pelicans are protected by law in India and also in several other countries of the region (Sri Lanka, China, Myanmar, Thailand, Cambodia and Laos) to avert threats in the form of tree felling for agricultural purposes. A community-based project has been established to perpetuate historical links of the pelicans with the villagers.

Kokkre bellur is not a reserved forest sanctuary but is a small village where the storks and pelicans coexist freely, mostly in tamarind trees in the middle of the village, in total harmony with the villagers. Consequently, reports indicate increased nestling activity in recent years. Thus, efforts to conserve these birds have been fruitful and hailed as a 'role model' for replication at other places. The villagers are exerting their time and energy incessantly for the welfare and betterment of both Pelican and painted stork through their vigorous participation (Plate-2g &h).

The authorities of Forest Department, the district Panchayath, the Department of Minor Irrigation and Department of Fisheries and the Karnataka State Tourism Development Corporation (KSTDC) have collectively supported the Local Village Level Committee and NGO organizations to conserve and develop all facilities for the birds. The list of planned activities involved covers the following:

- Establish and provide grants to the Village Forest Committee (VFC) to protect the birds by nurturing and enhancing the trees (*Ficus religiosa* & *Ficus bengalensis*) and tamarind (*Tamarindus indica*) trees where the birds nest, collect manure generated by the 'guano' or bird droppings of the nestling birds for use by villagers (Plate-3a-d).
- Encourage tourism to the village for bird watching and thus assist villagers by way of employment as guides, charging of parking fee for vehicles, camera fee, paid toilet, opportunity for running a restaurant or other tourist facilities
- Provide incentives to the villagers to compensate for the loss of crops (particularly, from the tamarind trees)
- Maintain hygienic environment in the village through establishing adequate water supply and drainage system
- Create food sources for the birds in the tanks (reservoirs) in the vicinity of the village by introducing indigenous fish species (banning commercial carp culture), discourage fishing activities and also de-silt the tanks to maintain water in adequate quantity and quality.
- Established an association called, 'Hejjarle Balaga' (meaning "relatives of pelican") an NGO projected to, work in unison with the villagers in providing protection to these birds.
- The villagers with support from volunteers of the interested NGOs tend to the injured hatchlings/fledglings that fall from the trees by housing them in exclusively built pens, nurse and feed them with fish caught from nearby water bodies.

It is reported that, there are nearly 5000-6000 birds' population concentrated in southern India, at about 20-22 locations in the states of Karnataka, Andhra Pradesh and Tamil Nadu. It is also recorded that its entire inhabitants in an area of 181,000 square kilometres (72,000 sq. mi) in various countries of Asia is explicitly described in the range of 14,000 - 18,000). Kokkare bellur, in particular, has the distinction of increasing its spot-billed pelican population by more than double in recent years. In addition, the local community enabled planting more trees under 'go green' programme to facilitate more trees for birds for their nesting and breeding during the course of migration to this PSKB area.

Finally, the focal objective was determined relating to the response variables, Environment Variables Species richness of birds (45-149); Abundance of Native birds (10-20/ha); Surroundings Vegetation cover (20-85%); Impervious surface cover (5-90%); Demographic Variables like, Age, Gender (Categorical), Activity level in adjacent Environs (Categorical) General Activity level (Categorical) Residential Activity (Categorical) Social & Economic status with respect to species richness, species abundance, vegetation cover, vegetation density, and level of urban development respectively. It was also measured a range of variables in each environs that represented these aspects, but applying these variables that had the strongest and most consistent relations with the response variables has been recorded (Table-4).

Table 1- Showing statistics of Bird diversity at PSKB area

Sl. No.	Index	Minimum	Maximum	Mean	S.D.
1.	Individual Birds (N)	2.00	686.00	19.64	17.89
2.	Species (S)	2.00	141	13.65	4.76
3.	Richness Index (d)	0.00	24.66	6.55	0.78
4.	Evenness Index (J)	0.00	2.00	1.68	0.63

Table 2- Descriptive statistics for landscape habitat types and sub-types

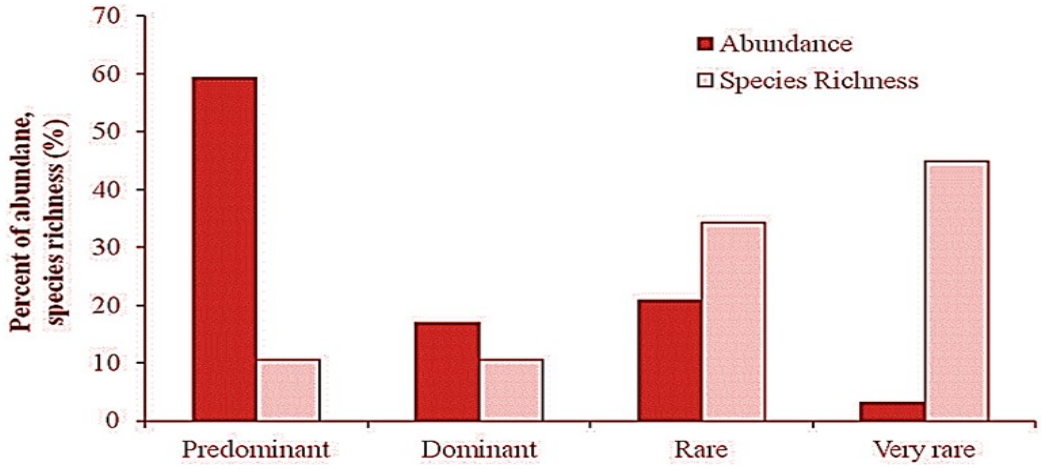
Sl. No.	Landscape habitat	n	%
Forest region		14,684	52.6
	Broad leaf forest area	9,166	24.6
	Mixed vegetation with Broad leaf forest area	2,768	8.8
	Bamboo engrossed area	1,101	3.6
	Forest with monoculture tree sps.	2,889	10.6
Grassland region		4,866	18.6
	Tall Grass area	2.361	9.2
	Low Grass area	1,366	4.7
	High Swamp	669	2.1
	Low swamp	444	1.6
	Bamboo slanted grass area	206	0.8
Fresh Water regions		5,266	17.4
	Water storage area	409	1.4
	Lake (Natural)	669	2.2
	Ponds, Ditches (Natural)	348	0.8
	Streams (Seasonal)	452	1.3
	River (Water surface width-500ft)	3,542	13.6
Farm Land regions		15,651	38.6
	Dry agri-land area	2,987	9.8
	Aquatic agri-land area	4,277	13.3
	Orchards (Coconut/Areca Farms)	4,751	14.8
	Flooded area	839	2.8
	Abandoned/wild field	86	0.3
Village associated regions		6,864	20.5
	Village houses area	4,592	11.5
	Park & green space area	1,321	4.2
	Bird Nurturing area	981	2.9

Note: Each survey sampling point recorded one or two main landscape habitat types and sub-types

Table 3. Effect of habitat types on the diversity index at PSKB area Control variables and Independent Variables included in the Prototype model

Parameters	Diversity Index							
	N		S		d		J	
	Prototype Model-1		Prototype Model-2		Prototype Model-3		Prototype Model-4	
	B(SE)	Beta	B(SE)	Beta	B(SE)	Beta	B(SE)	Beta
Constant	16.86 (0.42)		6.64 (0.05)		2.44 (0.03)		1.02 (0.00)	
Control Variable								
Wind	0.07 (0.24)	0.00	-0.65 (0.05)	-0.12***	-0.24 (0.01)	-0.10***	-0.05 (0.00)	-0.05***
Cloudy	0.96 (0.21)	0.001***	0.42 (0.03)	0.02**	0.03 (0.01)	0.02**	0.00 (0.00)	0.01
Overcast	1.96 (0.26)	0.04***	0.20 (0.02)	0.00**	0.02 (0.01)	0.01	0.00 (0.01)	-0.02
Fog intensity	-0.02 (0.45)	0.01	-0.08 (0.14)	0.01	0.01 (0.02)	0.00	-0.01 (0.00)	-0.01
Independent Variable								
Forest region	-3.92 (0.25)	-0.08***	0.43 (0.04)	0.03**	0.35 (0.02)	0.14***	0.02 (0.00)	0.05**
Grassland region	2.44 (0.22)	0.05**	1.02 (0.03)	0.08***	0.22 (0.02)	0.06***	0.01 (0.00)	0.04***
Fresh Water regions	2.56 (0.40)	0.04**	0.91 (0.03)	0.05***	0.20 (0.02)	0.05***	0.00 (0.00)	0.01**
Farm Land regions	6.86 (0.25)	0.21***	2.08 (0.04)	0.16**	0.28 (0.02)	0.12***	0.01 (0.00)	0.00
Village associated regions	4.45 (0.26)	1.04***	2.11 (0.04)	0.03**	-0.09 (0.02)	0.02***	-0.01 (0.00)	-0.02***
R^2		0.096		0.056		0.052		0.016
ΔR^2		0.091		0.047		0.041		0.011
AdjR^2		0.095		0.056		0.052		0.015

N-number of birds; S-number of species; d-Margalef Richness Index; J-Pielou Evenness Index. * $p < 0.05$; **$p < 0.01$; ***$p < 0.001$.



Graph 1. Showing the abundance and Species richness of the Birds at PSKB area

Table 4- Different variables used at PSKB area to examine the relations between surrounding environment and personal well-being, adjacent well-being, and connection to nature and the relations between adjacent demography and personal well-being, adjacent well-being, and connection to nature

Sl. No.	Variable (range)[a]	Parameters	Objectives description	Source of Data [b]
1.	Environment Variables Species richness of birds (45-149)	Species richness	No. of Bird species in each locale	Model survey
2.	Abundance of Native birds (10-20/ha)	Abundance	Abundance of all species of native birds corrected for detection probability (square root)	Model survey
3.	Surroundings Vegetation cover (20-85%)	Vegetation cover	Proportion of the Surrounding vegetation covered in woody and non-woody (herbs and grasses) ground & crown vegetation (arc sine square root)	Satellite imagery (Advanced Land Observation Satellite)
4.	Impervious surface cover (5-90%)	Built-up (*Urban approach*) Expansion	proportion of the adjacent vegetation covered in impervious surfaces (arc sine square root)	Satellite imagery (Advanced Land Observation Satellite)
5.	Demographic Variables Age, Gender (Categorical) Activity level in adjacent Environs (Categorical)	Adjacent Environs Activity	55 or ≥ 55 years old male or female high (engaging in activities ≥ twice per week) or low (engaging in activities ≤ once or thrice per month)	Model survey
6.	General Activity level (Categorical)	General activity	High (engaging in activities ≥ once per week) or low (engaging in activities ≤ once or twice/ month)	Field Survey
7.	Residential Activity (Categorical)	Inhabited Activity	Number of years lived in the Adjacent Environs (≤ 10 years or > 10 years)	Baseline Survey
8.	Social & Economic status	Community & Cost-effective stand-up	Composite variable combining the positively correlated measures of earnings, family/home title, and education level (Supplementary Information)	Reliable Sources

[a]*The name and type of variable (categorical variables noted; all other variables are continuous). The range of values across adjacent environs is included in parentheses for each continuous variable except social and economic status.*

[b]*Supplementary Information for further details of data collection methods.*

[c]*Survey delivered to residents to measure personal and Surroundings well-being and connection to nature.*

PLATE-1

Fig. a- Pelican Birds

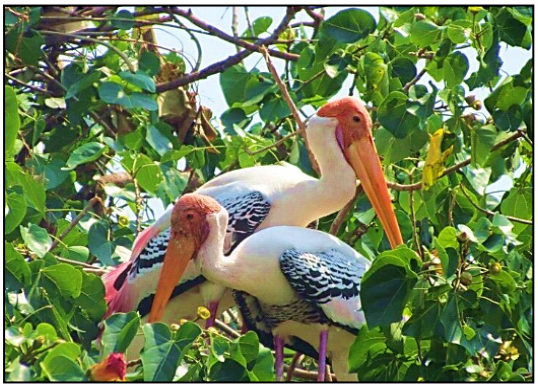


Fig. b- Painted stork Birds

Fig. c- Pelican Birds at formation of Nest

Fig. d- Painted stork in cluster approach

Fig. e. Birds at Nesting on a Tree

Fig.f. Pelican- on a vegetative habitat

Fig. g- River Shimsha coupled with PSKB area

Fig. h-Water bodies at PSKB area

PLATE-2

Fig. a- Ground vegetation at PRKB area

Fig. b- Birds cluster at Water bodies, PRKB area

Fig. c- Birds at river basin- a view

Fig. d- Birds cluster at water bodies

Fig. e- Birds rests at Nests on a Tree

Fig. f- Pelicans nurturing the young ones

Fig. g- Birds died at PSKB area

Fig. h- Nurturing of diseased Pelicans by a great human

PLATE-3

Fig. a- Tall tree habitation for nesting

Fig. b- A Tamarind tree for nesting & breeding

Fig. c.- Showing People tree with nesting & breeding of Pelicans at Village associated locale of PSKB area

Fig. d- Displaying 2-Tier Village: Upper-Pelican family & Lower Human family in Banyan Tree @ PSKB area

DISCUSSION

The generated data of results showed that bird species richness and evenness were different between natural and human-associated habitats. The first and foremost characteristics are identified in different segments namely; a lesser bird number was noticed as a main forest region characteristic because in most other natural, farmland-linked and human-connected habitation types, there was an increase in the number of birds. Built-up areas often showed a higher bird density in the previous studies (Jokimaki *et al.*, 1996). This study found that high bird numbers were not only present in village associated regions and nearby farm-lands but also in grass-lands, freshwater wetlands like Lakes, tanks and ponds/ditches.

Further, forest-land and grass-land demonstrated an increase in species richness and evenness. The dissimilarity in the number of birds between forest-land and grass-land could be explained by food availability. Obviously, the grass-lands may have higher food availability, which is the ultimate determinant of variation in local bird density. Therefore, natural habitations found to have greater positive effect on bird species evenness compared to farmland-related and urban habitats (Nilsson, 1979).

The forest-land, grass-land, fresh-water wetland, and farmland had a positive effect on species richness. The unique approach of the association of villagers and birds' community facilitated the increased trend of the species richness in the PSKB area was noticed. Therefore, in the subsequent segment, the characteristic trend showed the increased bird species richness in natural and farmland-related habitats. The forestland sub-types had a similar positive effect on bird species richness.

Parts of natural and farmland-related habitats, including tall grass-land, river, stream, dry farmland, orchard, and abandoned fields had a positive effect on bird species richness. These environments reflected a higher food availability to promote bird species richness; the higher food availability in the orchard habitat had the highest effect on bird species richness and the seasonal change in primary productivity altered bird species richness (Nilsson, 1979; Leveau *et al.*, 2018).

Finally, the one more focal characteristic was in line with the increased approach of bird species evenness in natural habitations which are substantiated by the previous studies indicating that built-up or semi-urban areas with green vegetation have higher evenness values compared to other urban areas. The results showed that only forest-land and grass-land had an increased effect on bird species evenness in natural habitats (Sandstrom *et al.*, 2006). In the analysis of sub-types habitations, only the orchard had an increased effect on bird species evenness in association with the farm-land- habitats. This is in accordance with the previous study where, the bird species evenness was lowest in cultivated land and highest in a natural conservation area are reported. Therefore, most of the areas with increased bird species evenness were exclusively of natural habitats (Mzendah *et al.*, 2015).

In all, the results virtually displayed that five forest-land sub-types effectively predict bird species richness and evenness: deciduous forest, mixed vegetation run with broadleaf forest, bamboo forest, mixed bamboo–broadleaf forest, and windbreak forest. Mixed trees, conifer forests, and bamboo engrossed area were affirmed as important characteristics to promote both species richness and evenness. Excitingly, the broadleaf forests did not affect bird species evenness to the greater extent, but mixed vegetation with broadleaf forests had a positive effect. In addition, the mixed vegetation with broadleaf forest was very close to various human accomplishments (human association), possibly facilitating the good relationship between habitat and bird ecology. This is the most exceptional and a magnanimous bondage between Pelican and other birds and human population which can be seen at PSKB area, Karnataka, India.

Besides, the forest vegetation coupled with river basin & adjacent water bodies will have progressive nest success and further increase nest density for

bird species at PSKB area (Flaspohler *et al.*, 2001). In human-associated locale of PSKB area, the values on bird species richness are superficial to site-specific habitat characteristics. The effect of maturity in forest vegetation and fragmentation was also a potential element affecting species richness and evenness. However, in the current study, the village associated areas facilitated the bird species richness and evenness to the superior range through their valuable and integrated approach between birds and human population (Cushman & Mc Garigal, 2003; Yuan *et al.*, 2014).

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