MONITORING THE IMPACTS OF JANGI WIND POWER FARM (91.8 MW) WITH SPECIAL REFERENCE TO BIRDS AND BATS

Final Report

Submitted to

M/s G P Wind (Jangi) Pvt. Ltd.

Arun P R, Rameshkumar S & Samsoor Ali, M

Sálim Ali Centre for Ornithology and Natural History
Coimbatore - 641108

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Principal Investigator: Dr Arun P R

Project Team: Ramesh Kumar S & Samsoor Ali M

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1 INTRODUCTION

The kinetic energy in the wind is a promising source of renewable energy with significant potential in many parts of the world. As concerns about climate change and increasing costs and long-term environmental impacts from the use of fossil fuels have heightened (McLeish 2002), wind has become an increasingly important sector of the energy industry and one of the fastest growing sources of renewable energy (Pasqualetti *et al*. 2004). Many of the commonly used methods of power generation cause negative environmental effects, though some are worse than others. Nuclear power creates thermal pollution in water-bodies and causes concern over waste disposal issues and the potential for harming the environment with radiation. Large hydroelectric facilities disrupt aquatic ecosystems and may submerge large areas of land, leading to various environmental concerns, including significant habitat loss for wild species. However, adverse effects of coal-burning co-generation plants have caused the most concern among environmentalists, regulators and the general public. Coal's contribution to greenhouse gas emissions and poor air quality has fuelled a need for alternative sources of energy.

Wind-generated electricity is renewable and generally considered environmentally clean, and recent technological advances and tax subsidies have allowed commercial wind generation to compete with energy produced from fossil fuels and nuclear power (Gipe 1995; Redlinger *et al*. 2002). Harnessing wind energy is an affordable form of power generation that is pollution-free with relatively less environmental impacts. These advantages have lead to a dramatic increase in its popularity in recent years and have resulted in the proliferation of wind farms around the world (Osborn *et al*. 2000).

In India, several wind farms are already working or under construction especially in those areas with wind resource is plentiful (WWEA 2014, MRNE 2013). In India, suitable areas tend to occur offshore or onshore in coastal areas, on ridges and mountains, in open agricultural areas and other open habitats. Many of these areas contain sensitive habitats and/or bird species, which heighten the importance of assessing the effects of wind energy projects. The development of wind power in India began in the 1990s, and has significantly increased in the recent years. The worldwide installed capacity of wind power reached 336 GW in the mid of 2014 and expect 360 GW by the end of the year(WWEA 2014).

India is relatively new to the wind energy sector as compared to Denmark or USA. But Indian policy support for wind energy has led it to ranked fifth with largest installed wind power capacity The total installed power capacity was 21'262 MW on June 2014 (WWEA 2014) and now India is just behind USA, China, Spain and Germany. As of 31 March 2011 the installed capacity of wind power in India was 14550 MW, mainly spread across Tamil Nadu (7196 MW), Maharashtra (3,294 MW), Gujarat (3,250 MW), Rajasthan (2,717MW), Karnataka (2,170 MW), Andhra Pradesh (514 MW), Madhya Pradesh (386 MW) and Kerala (35.7 MW).

Successful wind energy projects exist across the globe, including facilities in Africa, Asia, Europe, Australia, South America, the U.S. and Canada. However, concerns have been raised by the public and regulators regarding the potential environmental impact of these facilities and in particular their potential impacts on birds. This issue first became apparent in the late 1980s when birds of prey, especially Red-tailed Hawks, American Kestrels and Golden Eagles were first noticed to be killed by wind turbines and their associated power lines at Altamont Pass and Tehachapi Pass, in California. The high numbers of raptors killed at these sites have proven to be more of an anomaly than a typical situation. Nevertheless, these well-known examples continue to spark concerns among the public and other organizations and, more than anything else, have generated widespread fears that turbines are invariably fatal to birds. Wind farms affect birds mainly through collision with turbines and associated power lines (Drewitt & Langston 2006; Lekuona & Ursua 2007; Thelander & Smallwood, 2007) or disturbance displacement (Drewitt & Langston, 2006). Observed impacts vary geographically due to varying topography, habitat, weather conditions, flyways, species diversity and species abundance (GAO 2005). Considering that the number of wind turbines has more than doubled since 2005, and is expected to continue to increase in future years (WWEA 2009), wildlife conservation, specifically of birds and bats, is already, and will continue to be a serious problem. Bird fatalities associated with wind turbines are more significant when endangered or protected species of higher conservation priorities are involved, due to their small, fragmented and isolated populations. To understand and evaluate the real impact of these structures on the affected communities, both industry and government need to implement post-construction monitoring plans.

With a few important exceptions, studies that have been completed to date show very low numbers of bird fatalities at wind energy facilities. The observed mortality caused by wind energy facilities is other regarded very low compared to other existing sources of human-caused avian mortality. Erickson *et al.* (2001) provide an excellent review of studies conducted across the U.S.A., evaluating how wind turbines compare to other sources of bird mortality, such as communication towers and transmission wires. Based on 15,000 American wind turbines in operation, and a mortality of 2.19 birds per turbine per year, Erickson *et al.* (2001) suggest that 33,000 birds are killed each year by wind turbines in the U.S.A., 26,600 of which are killed in California. Another excellent review of the available literature is provided by Kerlinger (2001). This report summarizes what has been found at wind farms in North America and Europe, discussing both collision rates and disturbance studies.

Further detailed reviews are presented by Pedersen & Poulsen 1991; Phillips 1994; Leddy *et al*. 1999; Erickson *et al*. 2001; Howe *et al*. 2002; Langston & Pullan 2002; Percival 2003; Pettersson & Stalin 2003; Tingley 2003; de Lucas *et al*. 2004; Arnett *et al*. 2005; Jain 2005; Keil 2005; Kinglsley & Whittam 2005; Drewitt *et al*. 2006; Barclay *et al*. 2007; Everaert & Stienen 2007; Fiedler *et al*. 2007; Miller 2008; Cryan & Barclay 2009; Farfan *et al*. 2009; Fuller *et al*. 2009; Powlesland 2009; Sharp 2010; Graham & Hudak 2011,Hull *et al*. 2013, from various countries like USA, UK, Canada, New Zealand, Ireland, Denmark, Spain, Sweden, Belgium, etc. Nevertheless, the impact of wind farms on birds and bats from the Indian context is very less studied (Pande et al 2013). The present study "*Monitoring the impact of Jangi wind power farm (91.8 MW) with special reference to birds and bats*" will throw more light into the intrection of wildlife and wind turbines in India . This study was initiated in August 2011 with extensive field surveys in the wind farm location and our primary objectives were

- Documentation of bird and bat populations in and around the project sites
- Identification of roosting sites of bats and population estimations
- Study the response of avifauna to wind turbines
- Evaluate the impact of the project on Raptor roosting sites
- Assess the mortality risk caused by wind turbines to avifauna
- Preparing plans to mitigate the impacts

2 STUDY AREA

The Studied Genting Power wind farm is about 15 km to the south-east of Samakhiyali town, Bhachau Taluk, Kutch District, Gujarat, India (Fig 1). The study was conducted between August 2011 and July 2014 51 wind turbine locations covering four villages namely, Vandhiya, Modpar, Lakhapar and Jangi. The wind farms are situated between 23°15´5.18 and 23° 11´21.72 N and 70° 30´8.68 and 70°38´24.68 E with the mean sea level of 8 to 30m (Plate 1).Total land area covered in the study 250 Sq km. The wind turbines are located in different landscape types *viz*., agricultural land, un-irrigated land coastal line, human settlements, waste lands and several water-bodies of varying sizes. (Plate 1). The area is dry and arid with few crops cultivated. Bajra *Pennisetum americanum* is the major cultivated crop species in and around the study area followed by Ground nut *Arachis hypogea*, Cotton *Gossypium herbaceum*, Sorghum *Sorghum bicolour* and other minor crops.

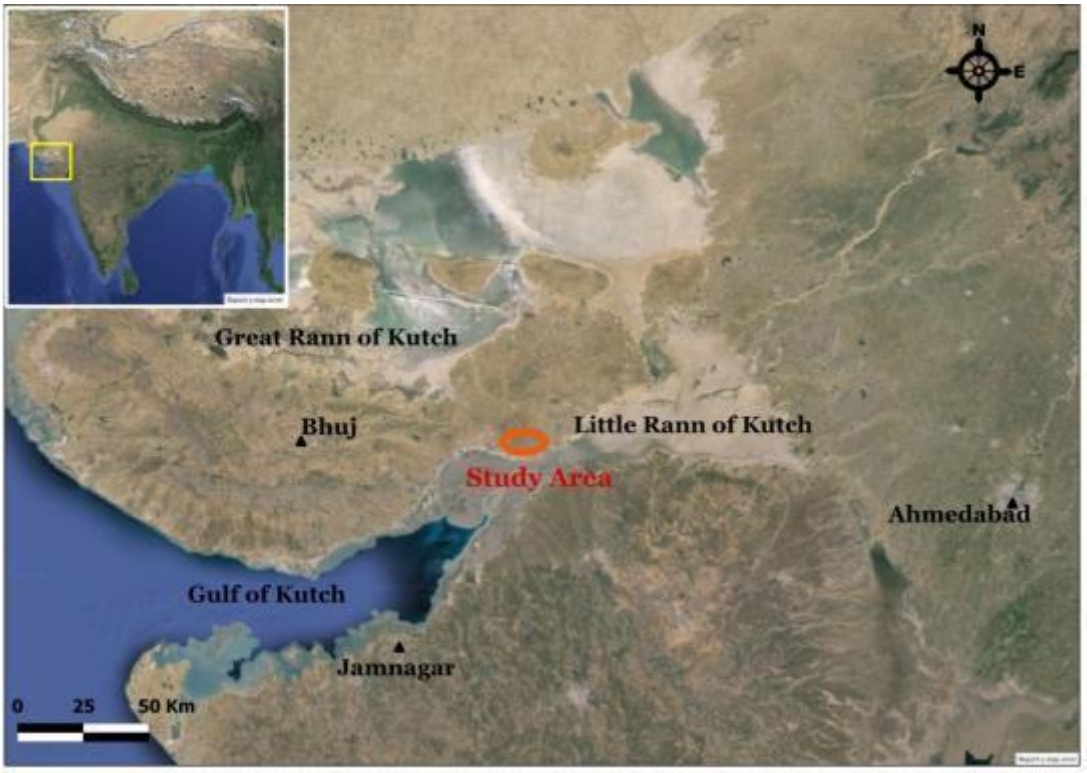


Figure 1 Map of India and Gujarat showing study site

The study area has a characteristic dry and hot climate. The Summer from late April till June are very hot and dry. Hot and humid climate occurs during July to September and cold and dry climate occurs between October and February. The average temperature during hottest months ranges from 17 to 49 °C and the average windspeed is varied from 4 m/s to 8m/s

(Fig 2). The annual rainfall varies from a few mm to 1000 mm the average being 700 mm(Fig 3). This area has a history of earthquakes and the seismicity of the area is coming under the very high damage risk zone categorized as Zone-V with seismic intensity of MSK-IX or more on the Medvedev-Sponheuer-Karnik scale.

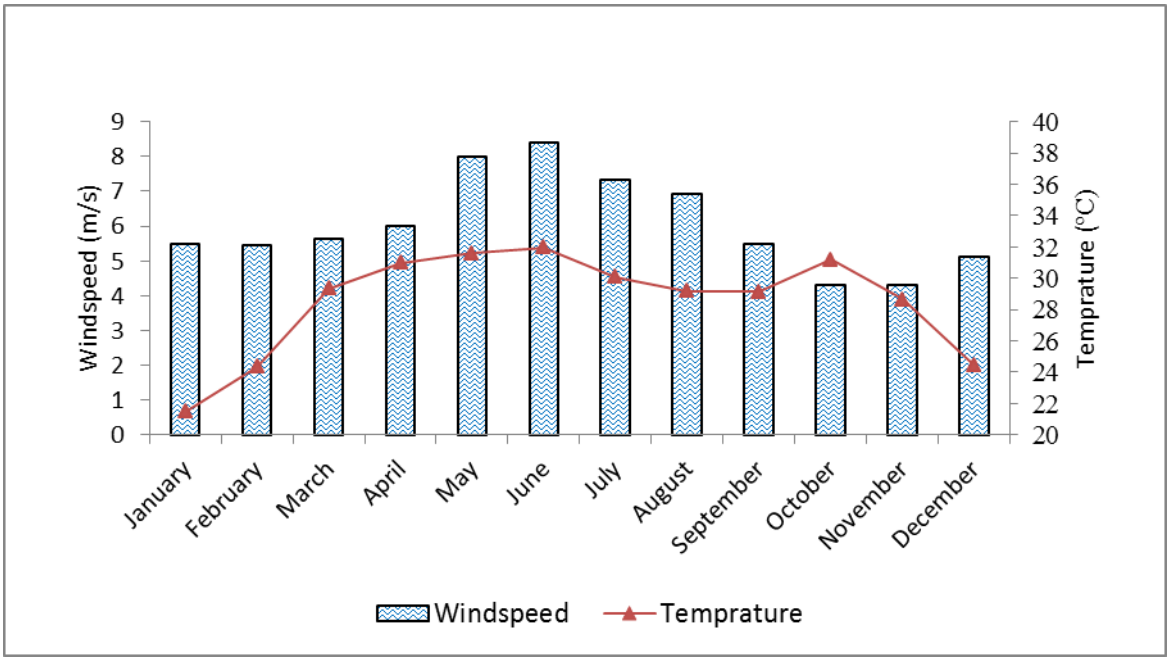


Figure 2. Temperature and Windspeed data of the study area (2011 to 2014)

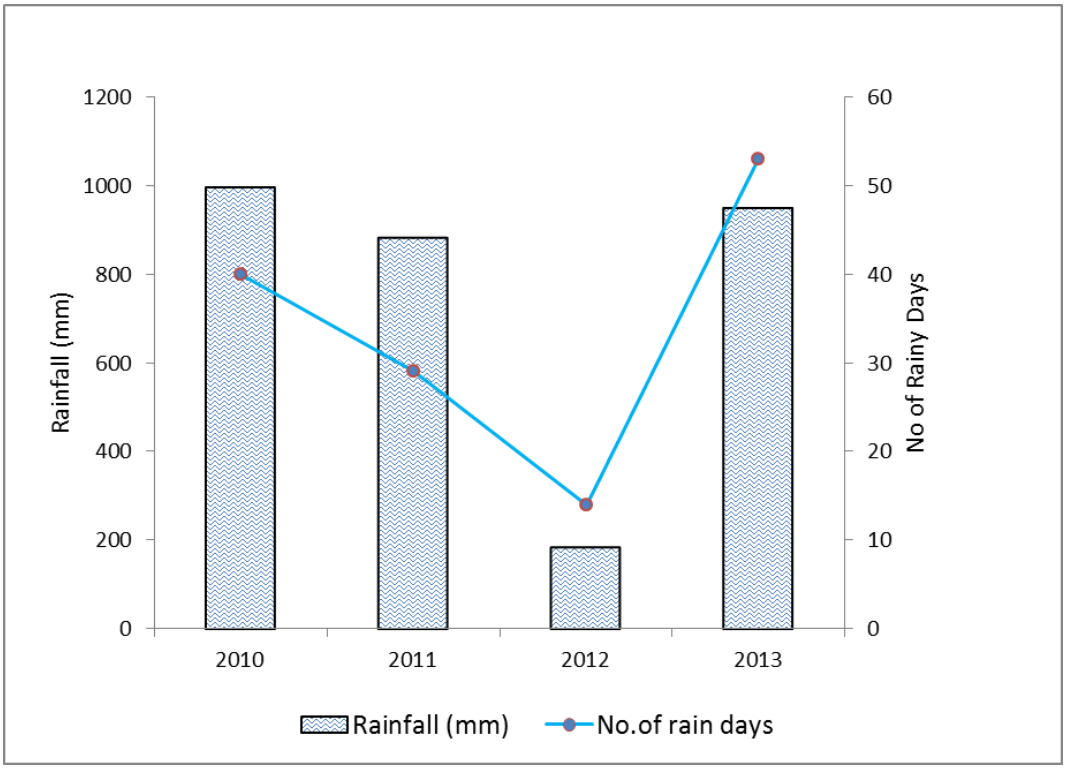
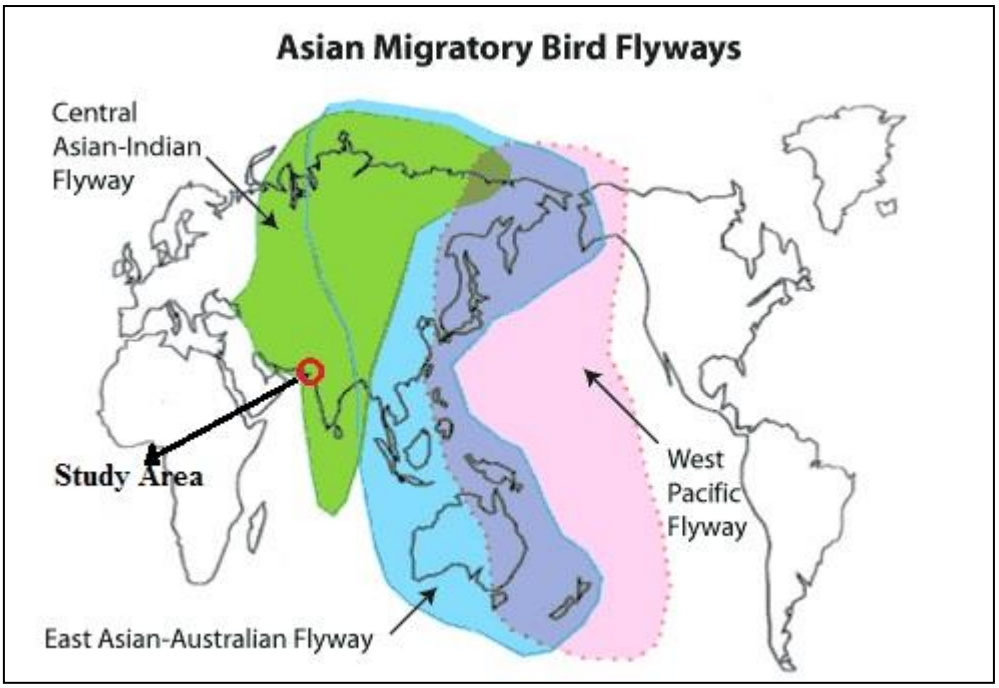


Figure 3. Annual rainfall of the studyarea

The study area is close to the vast expanse of Little Rann of Kutch and the Wild Ass Sanctuary area situated towards its southern border. Little Rann of Kutch is a unique true saline desert – cum-wetland habitat and it is a last abode of Indian Wild Ass *Equas hemionus khur*. More than 150 species of birds were recorded in the little rann of kutch including critically endangered Oriental white backed vulture *Gyps benghalensis* Long billed vulture, *Gyps indicus* (Shah et al 1995) The Study area also attracts more migratory birds as it is located on Central Asian migratory flyway (Fig 4). The Central Asian Flyway is among the shortest flyways in the world. Lying entirely within the Northern Hemisphere, it connects a large swathe of the Palaearctic with the Indian subcontinent. India is the core country of the Central Asian Flyway and supports 257 species of water birds. Of these, 81 species are migratory birds of Central Asian Flyway conservation concern, including three critically endangered species, six endangered species and 13 near threatened species. Over the full length of the flyway, important habitats for migratory birds are being rapidly degraded by a range of anthropogenic threats. Along India's coastlines, many important wader habitats have been severely degraded by a range of threats including the depletion of groundwater, saltwater intrusion, illegal hunting and the extension of salt-based industries.



Map Source : U.S. Fish and Wildlife Service

Figure 4. World map showing Central Asian Flyway and study area locatin

2.1 GENTING POWER WIND TURBINES

A total of 51 Genting Power wind turbines are working in the study area (Table 1). The first turbine commissioned in 31st August 2011 and last (51st) turbine commissioned in 23 December 2011. Each wind turbine consists of a gently tapering tubular tower, mounted with a rotor of 3 blades (connected with hub) and a nacelle containing the generator and gear box. The total height of each turbine from ground to tip of hub is 95m with a rotor diameter of 100m. The turbines are designed with the cut in wind speed of 3m/s and cut out wind speed of 20m/s, while the normal wind speed of the turbine is 12m/s. All turbines were manufactured by Vestas Wind Systems A/S, Denmark. Each turbine was covered an area of about 1.01 ha (2.5 acre).

Table 1. List of Genting turbines with locations

Sl. No	Turbine Name	Latitude	Longitude
1	JW03	23°12'16.65"N	70°34'27.18"E
2	JW06	23°12'44.30"N	70°33'49.52"E
3	JW07	23°12'35.12"N	70°34'5.76"E
4	JW17	23°12'14.76"N	70°31'22.60"E
5	JW18	23°12'31.47"N	70°31'21.84"E
6	JW19	23°12'26.44"N	70°30'12.84"E
7	JW20	23°12'41.69"N	70°31'32.88"E
8	JW21	23°12'25.44"N	70°30'49.38"E
9	JW22	23°12'14.10"N	70°30'52.84"E
10	JW24	23°14'29.29"N	70°35'25.51"E
11	JW26	23°12'56.37"N	70°34'39.82"E
12	JW28	23°12'19.94"N	70°34'48.56"E
13	JW31	23°13'21.21"N	70°34'29.70"E
14	JW32	23°13'13.51"N	70°31'51.56"E
15	JW33	23°13'38.04"N	70°34'46.57"E
16	JW34	23°13'47.70"N	70°34'31.51"E
17	JW35	23°13'33.63"N	70°35'49.48"E
18	JW36	23°14'20.51"N	70°34'34.33"E
19	JW37	23°13'15.62"N	70°34'49.28"E
20	JW39	23°15'11.30"N	70°33'37.38"E
21	JW40	23°14'13.52"N	70°33'38.98"E
22	JW41	23°14'27.39"N	70°33'58.97"E
23	JW42	23°14'21.80"N	70°32'31.94"E
24	JW43	23°14'30.80"N	70°34'18.3"E
25	JW44	23°13'46.31"N	70°33'45"E
26	JW45	23°13'56.38"N	70°33'22.80"E
27	JW46	23°14'21.73"N	70°33'15.99"E
28	JW47	23°14'37.16"N	70°33'52.9"E
29	JW48	23°14'22.76"N	70°32'47.96"E

Sl. No	Turbine Name	Latitude	Longitude
30	JW49	23°14'51.20"N	70°32'56.20"E
31	JW50	23°14'18.80"N	70°32'13.54"E
32	JW51	23°13'6.49"N	70°32'50.47"E
33	JW52	23°13'19.12"N	70°33'33.001"E
34	JW53	23°13'41.19"N	70°33'31.3"E
35	JW54	23°13'29.71"N	70°32'43.31"E
36	JW55	23°13'43.96"N	70°32'26.80"E
37	JW56	23°14'19.02"N	70°31'52.61"E
38	JW57	23°14'18.40"N	70°31'30.97"E
39	JW58	23°14'13.34"N	70°30'54.47"E
40	JW59	23°14'49.2"N	70°31'11.51"E
41	JW60	23°13'52.06"N	70°30'35.34"E
42	JW61	23°13'54.03"N	70°30'13.26"E
43	JW62	23°13'56.71"N	70°31'51.63"E
44	JW63	23°14'49.89"N	70°34'19.15"E
45	JW64	23°14'39.47"N	70°33'42.32"E
46	VW08	23°12'29.22"N	70°38'25.68"E
47	VW44	23°11'22.86"N	70°37'17.54"E
48	VW57	23°13'13.55"N	70°36'22.06"E
49	VW59	23°14'7.59"N	70°36'7.22"E
50	VW61	23°12'39.38"N	70°34'55.48"E
51	VW70	23°14'13.63"N	70°36'39.98"E

3 METHODOLOGY

3.1 FLORISTIC COMPOSITION SURVEY

In order to document the flora of the study area, a reconnaissance survey was made within 10 km radial distance zone at the wind farm site covering different habitats like human settlements, water bodies and agricultural field in and around the study site, duly recording the plant species available in the area.

3.2 BIRD SURVEYS

3.2.1 TERRESTRIAL BIRD SURVEY

Bird surveys using the line transect method (Gaston 1975) and point count method (Ralph *et al* 1995) was done to estimate the species composition and abundance of birds in the study site. Initially 4 transects with 3km length each were followed for sampling including one transect on shore line for the preliminary survey later a total of 70 survey plots (50m radius) were fixed and sampled repeatedly from September 2012 to July 2014 in and around the

wind farm in order to monitor the terrestrial bird population (Fig 4). In order to assess the response of birds to the wind turbines a control site was selected for comparing the avifauna (SNH 2009, Villegas-Patraca 2012). Control site was mostly similar to turbine site in physical and biological character except for the presence of wind turbines. Among the 70 bird count plots, 40 were on wind turbine area and 30 were in control area.

Raptors were surveyed from 15 vantage points (8 in turbine site & 7 in control site) repeatedly from September 2012 to July 2014 (Fig 5). Surveys were conducted from 0700 hrs to 1200 hrs, each count lasted for 30 minutes. Totally 9 surveys were conducted at each vantage point during the study. Long range binoculars and a high zoom (30x) digital camera were used to spot and photograph the raptors and were identified with the help of standard field guides (Ali and Ripley 1969, Grimmet et al 1998 and Naroji 2006).

3.2.2 WETLAND BIRDS SURVEY

Wetland birds' surveys were conducted once in a month in all the selected wetlands by total count method (Bibby et al., 2000). Counting of the waterbirds was made in the morning hours between 06:00 and 08:00 hrs following Namgail et al. (2009). The birds observed through a wide-range binoculars and recorded. Photography was done using a SONY Digital Camera with zoom lens. Wetland birds observed from study area were categorized into various categories like 'Resident', 'Winter Migrants' and 'Local Migrants' following Kumar et al. (2005). Birds were identified with the help of standard reference books (Grimmett et al. 2001; Kumar et al. 2005). Manakadan and Pittie (2001) was followed for the nomenclature.

In this study, totally 10 wetlands were selected for intensive bird surveys, of these five wetlands were selected near wind turbines (turbine sites) and five were in control site outside wind turbine area (with no wind turbine within 2 km radius). Data collected from both turbine and non-turbine sites to examine if bird assemblage and wetland use by different birdspecies differed between sites. Totally 140 surveys (14 surveys for each wetland) were conducted in the selected 10 wetlands between April 2012and July 2014.

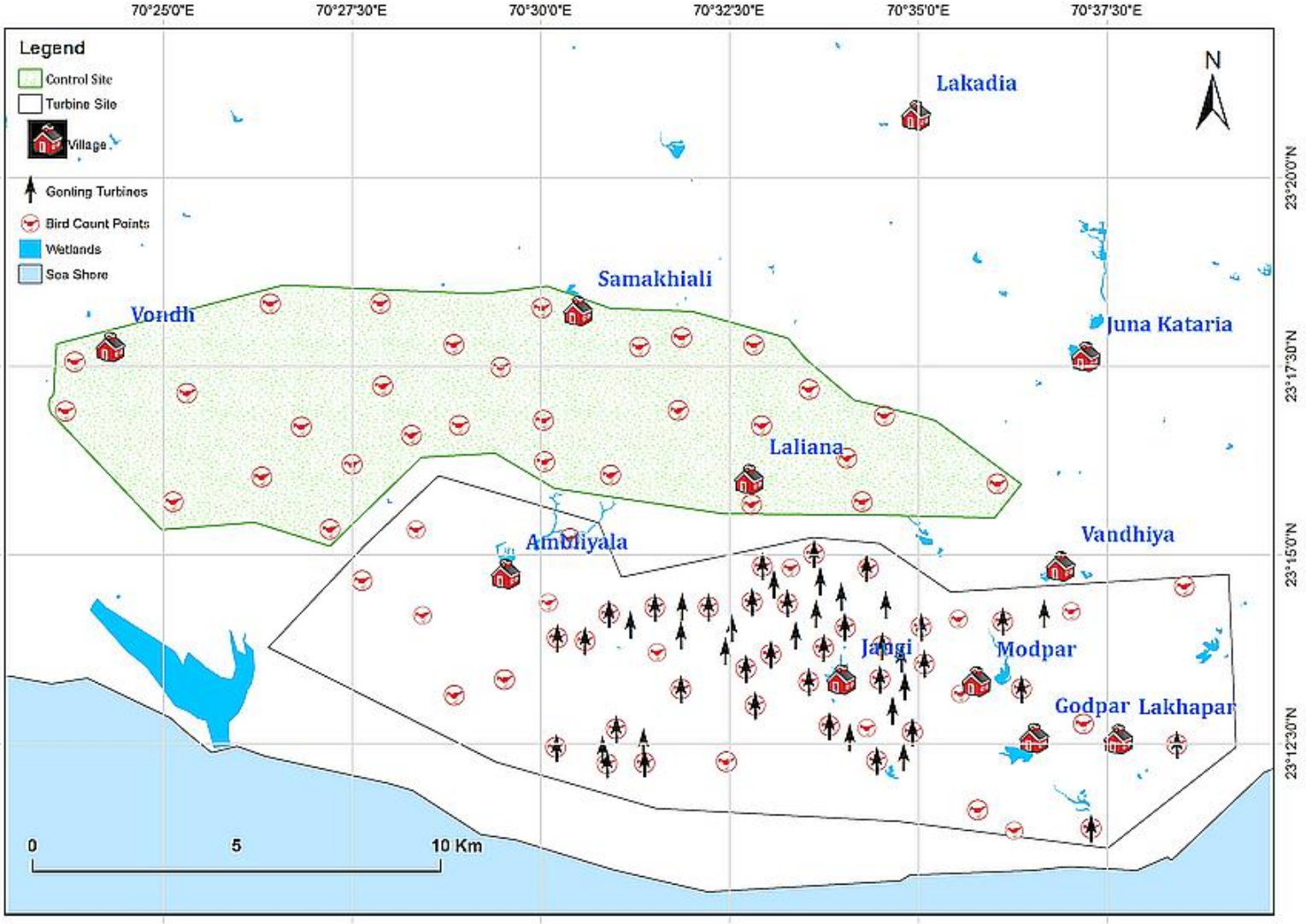


Figure 5 Sampling point locations; Control and turbine sites

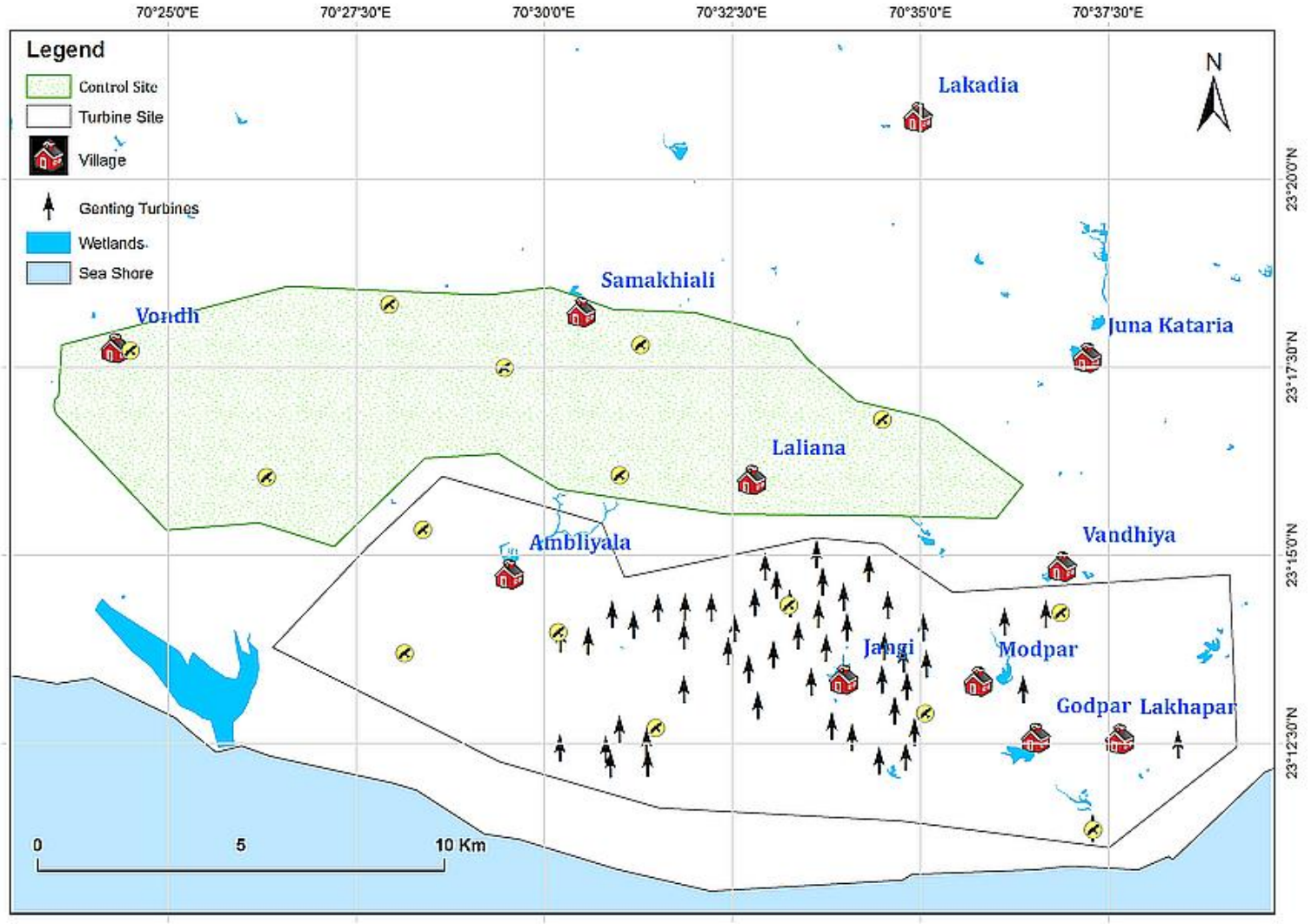


Figure 6. Raptor sampling points in the control and turbine site

3.3 Bird Nest and Roost Site Survey

The intensive searches were made to locate the nests and roost sites of birds in all potential nesting and roosting-sites like trees, bushes, buildings and towers (Ali and Ripley 1969). Ground nests were also searched for in few locations where the ground nesting birds were sighted. Once a nest is located, the structure of nest-site, height of nest location and surrounding habitats were documented. A Range finder (Ravi Multimeter^{TM}) was used to measure the height of nests from the ground. If a bird roosting sighted, number of birds, roost tree species and height of the tree were recorded.

3.4 Flight Height Patterns of Birds

Flight behavior of birds flying in windfarm was recorded in order to study the species level collision risk of birds. Totally six vantage points were used for monitoring the flight activity of the birds in the turbine sites. All points were situated in edges of the wind farm . Flight zone of the birds i.e. flying below (Zone A) or in the risk zone (Zone B) or above the turbine (Zone C) were recorded (Figure 7). The height of turbine from ground to tip of hub was 95m and each blade was 50m length, making the total height of the turbine from ground to top most points swept by rotor blade tips was 145m (Figure 7). The risk zone is the region between the lowest and top most points swept by the rotor blades or the aerial height band swept by the rotor blades that is from 45m to 145m. The surveys were conducted from dawn to dusk. Direct observation of flying zone, number of birds flying and duration of flight were observed using binoculars . A total of 92 hours of survey was conducted between September 2013 to July 2014.

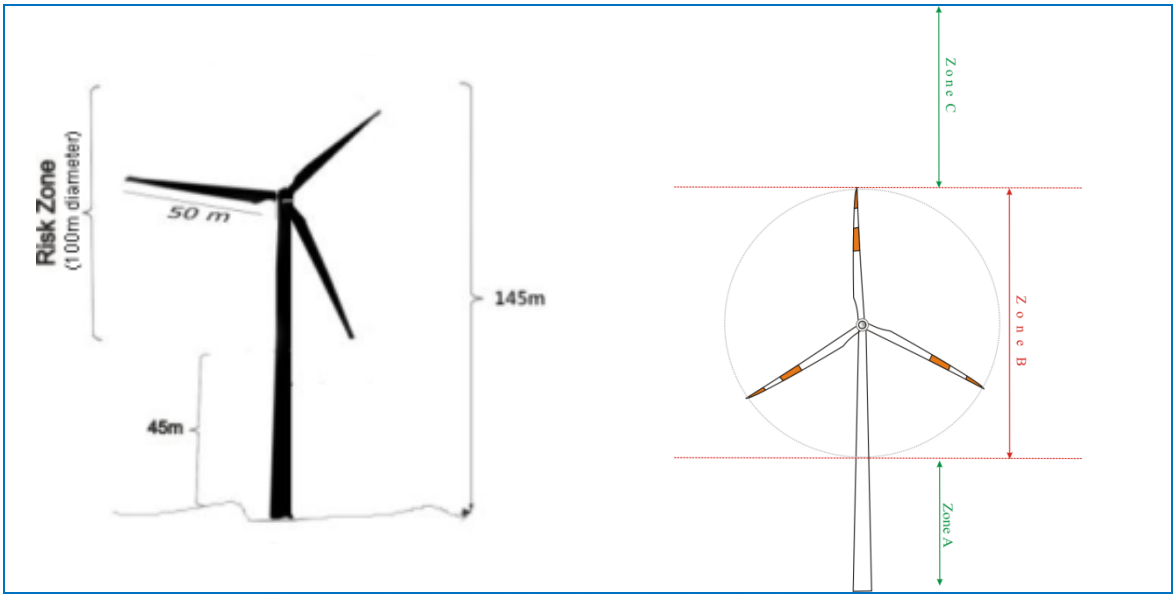


Figure 7. A typical wind turbine showing Risk zone area

3.5 BAT ACTIVITY MONITORING

To locate the day-time roosting-sites of bats, searches were conducted in possible trees and buildings in the study area (Reginald *et al*. 2008). "Direct roost count" method was followed to estimate the population size of the colony (Barlow 1999). Observations were mostly done visually, depending on the need, a pair of binoculars was also used to spot the bats. The local people were also shown photographs of bats and asked if they had seen them in their villages and also about their roosting sites if any. The opportunistic observations of nesting and roosting-sites were also documented in the study area. Surveys were conducted once in each season.

For nocturnal bat survey to monitor and collect ultrasonic bat call signatures, BATBOX III D bat detector with a band width of 16 kHz and frequency range from 19 to 125 kHz was used. Bat detector was operated at the wind turbine sites as well as in adjacent fields devoid of wind towers. Three transects of 1km length were walked slowly at different intervals of time between 1800 and 0100 hours. The time taken to complete one transect survey was 50 to 60 minutes. One transect was in a control area where no wind turbines are installed. Other two transects were from turbine rich area. The whole stretch of transects were recorded for exploring the bat activity and the diversity. A total of 7 rounds of surveys were conducted in all transects from July 2012 to July 2014 (Table 2).

Table 2.Annual schedule followed for bat and bird surveys

Year	2011			2012			2013			2014		
	Bird	Bat1	Bat2	Bird	Bat1	Bat2	Bird	Bat1	Bat2	Bird	Bat1	Bat2
January										*		*
February							*	*	*			
March												
April				*	*					*	*	*
May				*			*		*	*		
June												
July				*	*	*				*		
August							*	*	*			
September	*											
October	*			*	*	*						
November	*			*								
December	*	*		*	*	*	*	*	*			

Bird- bird survey**, Bat1**- Bat Roost surveys, **Bat2**- nocturnal Bat survey

3.6 MORTALITY SEARCHES

In order to record the mortality of birds and bats at turbine sites, searches for bird and bat carcasses as evidence of fatalities were conducted at all the 51 turbines. Each turbine was searched within 100m radial zone from the base while slowly walking in a spiral path outwards from the base of the turbine (Orloff & Flannery 1992; Anderson *et al*. 1999), however regular scanning was also done beyond the distance for anything obvious farther away and often extended search for 20 to 30m downwind because strong wind might have carried feathers and other remnants of carcasses farther away. Base of the turbines were mostly bare land with small grasses like *Dactyloctenium sp., Brachiaria sp*. and crops like *Ricinus communis,* so there was no difficulty in searching the carcasses. Mostly, the searches were made at fortnightly intervals in each turbine site during the study period. The time spend to search a turbine site was approximately 30 minutes. When a carcass was found, data on species, sex, distance to the closest turbine, kind of visible injuries and estimated time of death were recorded (Orloff & Flannery 1992; Christensen *et al*. 2003). Totally 23 rounds of searches were conducted at each turbine site consisting of 586 hours of search

(Table 3). The seasonal changes in the land cover under the turbines were also monitored for examining any possible relation with the mortality rates.

3.6.1 CARCASS REMOVAL AND SEARCHER EFFICIENCY BIAS CORRECTION

The objective of the carcasses removal study is to determine the average length of time that an avian carcass remains under the turbine before being removed from the study area by scavengers. The methods used in practice to estimate mortalities include the Erickson et al. (2000, 2004), Shoenfeld (2004), Kerns et al. (2005), Jain et al. (2007),Huso (2010) and Korner-Nievergelt et al. (2011) estimators. A detailed review of the mortality estimators is also available (Bernardino et al. 2013). In this study, the estimator followed by Erickson et al (2000, 2003) and Jhonson et al (2003) was used. During the mortality survey 10 bird carcasses were left in the field and the length of time each individual carcass remained on the field before being naturally removed/disappear was recorded. ie. the number of days between the time the carcass was planted and the last search date on which it could be detected. The mean length of time a carcass remained on a plot (T) was calculated based on the following equation Erickson et al, 2003

$$T = \sum ti / S$$

Where ti is the length of time a carcass remained on site, S is the total number of carcasses planted for the study.

The estimated number of annual fatalities (m) per turbine was calculated using the following formula from Jhonson et al. (2003)

$$M = N \times I \times C / k \times t \times e$$

where **N** is the total number of turbines , **I** is the interval between searches in days, **C** is the total number of carcasses found **k** is the number of turbines sampled, t is the mean length of time carcasses remained on site before being scavenged, and **e** searcher efficiency. Since the area under the turbines were relatively plain with high (100%) chance of detectability of the carcasses during the initial trials, the searcher efficiency was considered as 100% for the calculations.

Table 3. Summary of field sampling activities

	Activity	Period		No. of Cycles	No. of Man Hours
		From	To		
1	Bird-Point count	September 2012	July 2014	8	132 hrs
2	Raptor survey	September 2012	July 2014	9	37 hrs
3	Water bird survey	April 2012	July 2014	14	280 hrs
4	Flight activity Survey	September 2013	July 2014	3	92 hrs
5	Bird Roost Survey	September 2011	July 2014	13	130 hrs
6	Bat Roost Survey	September 2011	July 2014	13	140 hrs
7	Nocturnal Bat activity Survey	September 2012	July 2014	7	21 hrs
8	Carcass survey	September 2011	July 2014	23	586 hrs

4 RESULTS

4.1 FLORISTIC COMPOSTION

A total of 273 plant species were recorded from 190 genera and 69 families. Of these, 126 species were herbs, 69 species were trees, 34 species shrubs, 22 species stragglers/climbers and 22 species were grasses. The predominant tree species found in the study area are *Acacia nilotica*, *Acacia leucophloa*, *Aegle marmelos, Annona squamosa, Azadirachta indica, Cassia fistula, C. siamea, Cordia myxa, C. sebastiana, Dalbergia sisoo, Phoenix sylvestris, Sterculia foetida, Phyllanthus emblica, Pongamia pinnata, Prosopis juliflora, Thespesia populnea* and *Ziziphus mauritiana*. Important herbaceous and shrub species are *Alysicarpus spp. Biophytum reinwardii, Cassia auriculata, C. tora, C. occidentalis, Calotropis procera, Cleome viscosa, Dichrostachys cinerea, Echinops echinatus, Clerodendrum phlomides, Crotalaria spp. Indigofera spp. Bulbostylis barbata, Cyperus spp. Fimbristylis spp. Phyllanthus amarus, P. maderaspatansis, Polygala sp.* The grasses like, *Aristida spp. Bothriochloa pertusa, Andropogon pumilus, Brachiaria spp. Eremopogon foveolatus, Sehima nervosum, Cenchrus ciliaris, C. barbatus, C. setigera, Chloris barbata, C. tenella, Dactyloctenium aegyptium, Digitaria bicornis, Eragrostis spp. Paspalum sp., Paspalidium flavidum, Phragmites karka, Setaria verticillata, Typha angustifolia, Themeda triandra, T. quadrivalvis,* etc. are commonly seen in and around the study site.

4.2 AVIFAUNA OF THE STUDY AREA

During the study span, 173 bird species belonging to 45 families and 17 orders were observed. Among the 16 orders, Passeriformes dominated the list with 54 species followed by Charadriiformes with 35 species and Falconiformes with 18 species (Fig 9). Maximum percentage of occurrence was found in the families: Scolopacidae (9.30 %), Accipitridae (8.14 %) Anatidae (6.40 %) Ardeidae (5.81%) (Table 4). A family-wise list depicting birds common name, scientific name, IUCN status, residential status and Indian Wildlife Protection Act status are given in Appendix 5.

Among the 173 species recorded, only 158 species were recorded during the systematic bird surveys. The remaining 15 species were recorded only through opportunistic observations.

Of all bird species, 61 % were resident, 38 % were both winter visitor and 1 % were passage migrant (Fig 8, Table 5). Accipitridae accounted for maximum winter visitors (10 species) followed by turnidae (8 species) among the resident birds Sylviinae had maximum number of species (6 species) followed by Columbidae with 5 species. Out of 173 species recorded, two species namely Dalmatian Pelican *Pelecanus crispus,* Greater Spotted Eagle *Aquilanipalensi* are Vulnerable and 9 species Darter *Anhinga melanogaster,* Painted Stork *Mycteria leucocephala*, Black-necked Stork *Ephippiorhynchus asiaticus,* Oriental White Ibis *Threskiornis melanocephalus*, Pallid Harrier *Circus macrourus,* Black-tailed Godwit *Limosa limosa,* Eurasian Curlew *Numenius arquata*, River Tern *Sterna aurantia*, and European Roller *Coracias garrulous* are listed as Near Threatened according to IUCN Red data list. In all, 16 species were listed as schedule-I, 156 species were listed as schedule- IV, and one species House crow is listed as Schedule-V under Indian wildlife protection act (amendment) 2002. This law gives at most protection for the animals comes under schedule-I.

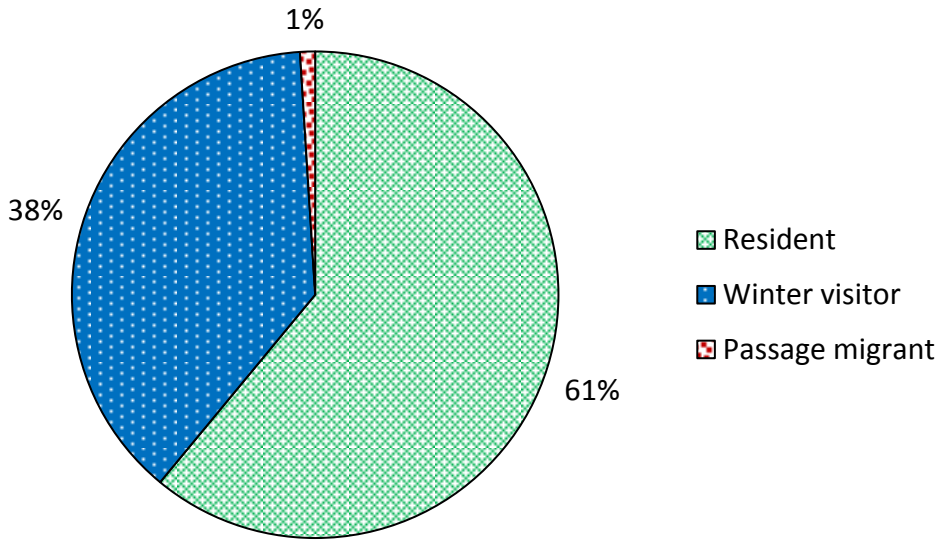


Figure 8.Migratory Status of bird species recorded in the study area.

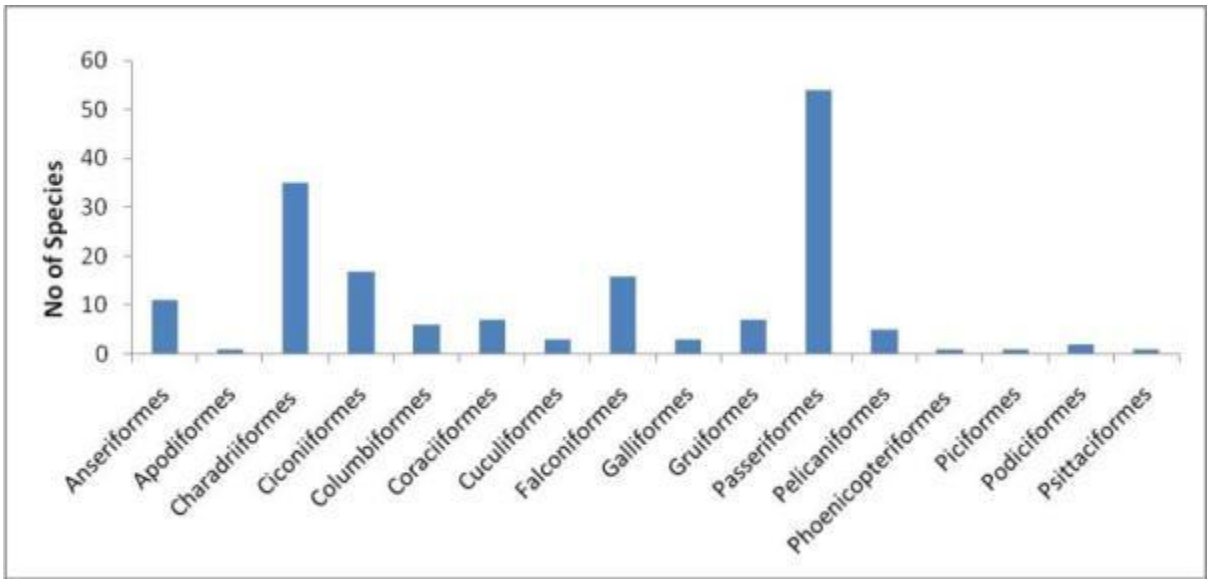


Figure 9.Order-wise distribution of avifauna in the study site

Table 4.Family wise species richness of birds in the study area

No.	Family	Species	Percentage	No.	Family	Species	Percentage
1	Accipitridae	14	8.14	23	Nectariniidae	1	0.58
2	Alaudidae	4	2.33	24	Passeridae	2	1.16
3	Alcedinidae	3	1.74	25	Pelecanidae	1	0.58
4	Anatidae	11	6.40	26	Phalacrocoracidae	4	2.33
5	Apodidae	1	0.58	27	Phasianidae	3	1.74
6	Ardeidae	10	5.81	28	Phoenicopteridae	1	0.58
7	Burhinidae	1	0.58	29	Picidae	1	0.58
8	Charadriidae	7	4.07	30	Ploceidae	2	1.16

No.	Family	Species	Percentage	No.	Family	Species	Percentage
9	Ciconiidae	3	1.74	31	Podicipedidae	2	1.16
10	Columbidae	5	2.91	32	Psittacidae	1	0.58
11	Coraciidae	2	1.16	33	Pteroclididae	1	0.58
12	Corvidae	3	1.74	34	Pycnonotidae	2	1.16
13	Cuculidae	3	1.74	35	Rallidae	4	2.33
14	Dicruridae	2	1.16	36	Recurvirostridae	2	1.16
15	Estrildidae	2	1.16	37	Scolopacidae	16	9.30
16	Falconidae	2	1.16	38	Strigidae	2	1.16
17	Gruidae	3	1.74	39	Sturnidae	4	2.33
18	Hirundindae	4	2.33	40	Sylviinae	8	4.65
19	Jacanidae	1	0.58	41	Threskiornithidae	4	2.33
20	Laniidae	4	2.33	42	Timaliinae	1	0.58
21	Laridae	8	4.65	43	Turdinae	9	5.23
22	Meropidae	1	0.58	44	Upupidae	1	0.58
23	Motacillidae	6	3.49				

Table 5.Migratory status of bird species in each family

No	Family	Resident	Winter Visitor	Passage Migrant
1	Accipitridae	4	10	0
2	Alaudidae	4	0	0
3	Alcedinidae	3	0	0
4	Apodidae	1	0	0
5	Columbidae	5	0	0
6	Coraciidae	1	0	1
7	Corvidae	3	0	0
8	Cuculidae	3	0	0
9	Dicruridae	2	0	0
10	Estrildidae	2	0	0
11	Falconidae	0	2	0
12	Gruidae	0	3	0
13	Hirundindae	2	2	0
14	Laniidae	3	1	0
15	Meropidae	1	0	0
16	Motacillidae	1	5	0
17	Nectariniidae	1	0	0
18	Passeridae	2	0	0
19	Phasianidae	2	1	0
20	Picidae	0	1	0
21	Ploceidae	2	0	0
22	Psittacidae	1	0	0
23	Pteroclididae	1	0	0
24	Pycnonotidae	2	0	0

No	Family	Resident	Winter Visitor	Passage Migrant
25	Strigidae	1	1	0
26	Sturnidae	3	1	0
27	Sylviinae	6	1	0
28	Timaliinae	1	0	0
29	Turdinae	1	8	0
30	Upupidae	1	0	0

4.2.1 TERRESTRIAL BIRDS

A total of 58 species of terrestrial birds were recorded in the sampling of which 44 species recorded in Monsoon, 50 species were recorded in winter and 33 species were recorded in summer (Plate 2). Among Passerines Rosy starling was the most abundant bird (17.21 %) followed by Common Babbler (11.98%) and House sparrow (9.06%). But the abundance varied between seasons. In Monsoon, Rosy starling accounted 29.49% of total bird records followed by Common babbler (11.00%).In winter, House sparrow was most abundant (14.74%) followed by Common babbler (14.24%). During Summer, Blue Rock Pigeon was most abundant species (17.80%) folowed by Common babbler. Bird species like Ashy prinia, Black redstart ,Blue throat, Booted warbler, Brahminy starling, Common stone chat, Crested lark, Desert wheatear, Dusky craig martin, Greater coucal, Hume's white throat, Indian roller, Plain prinia, Rufous fronted prinia, Wire tailed swallow and Yellow throated sparrow were recorded very rarely (Relative abundance < 0.1%)

4.2.2 RAPTORS

A total of 19 species of raptors from three families were recorded in the study area including 16 diurnal and 2 nocturnal raptor species (Owls)(Table 6). Of which Accipitridae had maximum number of species (14) , followed by Falconidae (2) and Strigidae (2). Among 19 species recorded, Greater spotted eagle is categorised as Vulnerable and Pallid Harrier is categorised as Near Threatened according to IUCN Redlist. All the 19 speceis are protected by Indian Wildlife Protection Act- 1972, of which 15 species are in shedule I, killing of this species is severly punishable with imprisonment and fine. 12 species of raptors were recorded in Monsoon 18 species were recorded in Winter and only 3 species were recorded in Summer (Fig 10). In Monsoon Black Shouldered kite had maximum density (1.38 bird/Sqkm/hr), in winter, Western Marsh Harrier (3.5 bird/Sqkm/hr) and Steppe eagle (2

bird/Sqkm/hr) were abundant and in summer Black Shouldered kite was the most abundant (1 bird/Sqkm/hr).

Table 6.Raptors recorded in the study area.

No	Bird Name	*Scientific Name*	IUCN	Migratory Status	IWPA
	Family: Accipitridae				
1	Black-shouldered Kite	*Elanus caeruleus*	LC	R	I
2	Eurasian Griffon	*Gyps fulvus*	LC	WM	I
3	Short-toed Snake Eagle	*Circaetus gallicus*	LC	R	I
4	Western Marsh-Harrier	*Circus aeruginosus*	LC	WM	I
5	Pallid Harrier	*Circus macrourus*	NT	WM	I
6	Montagu's Harrier	*Circus melanoleucos*	LC	WM	I
7	Shikra	*Accipiter badius*	LC	R	I
8	Eurasian Sparrow Hawk	*Accipiter nisus*	LC	WM	I
9	White-eyed Buzzard	*Butastur teesa*	LC	R	I
10	Common Buzzard	*Buteo buteo*	LC	WM	I
11	Long-legged Buzzard	*Buteo rufinus*	LC	WM	I
12	Oriental Honey Buzzard	*Pernis ptilorhyncus*	LC	WM	I
13	Greater Spotted Eagle	*Aquila nipalensi*	VU	WM	I
14	Steppe Eagle	*Aquila clanga*	LC	WM	I
15	Booted Eagle	*Hieraaetus pennatus*	LC	WM	I
	Family: Falconidae				
16	Laggar Falcon	*Falco jugger*	LC	R	IV
17	Common Kestrel	*Falco tinnunculus*	LC	WM	IV
	Family: Strigidae				
18	Pallid Scoops-Owl	*Otus brucei*	LC	WM	IV
19	Spotted Owlet	*Athene brama*	LC	R	IV

4.2.3 WATER BIRDS

Totally 89 species of waterbirds and wetland dependant birds belonging to 10 orders and 21 families were recorded from the wetlands surveyed during the study. The maximum number of species (n =19) was from the family Scolopacidae comprising of Sandpipers, Stints, Snipes, Godwits and Curlews; followed by the families Anatidae (ducks and geese) represented by 11 species, and Ardeidae (herons and egrets) represented by 10 species (Figure 11). Of the total species, 42 (47.2%) species of birds were winter migrants, 36 (40.4%) were residents and 11 (12.4%) were local migrants (Figure 12). Among 89 species, 23 species each were wading birds and shorebirds, 17 were open water birds, 16 were waterfowl, seven were passerines and three were raptors (Figure 13).

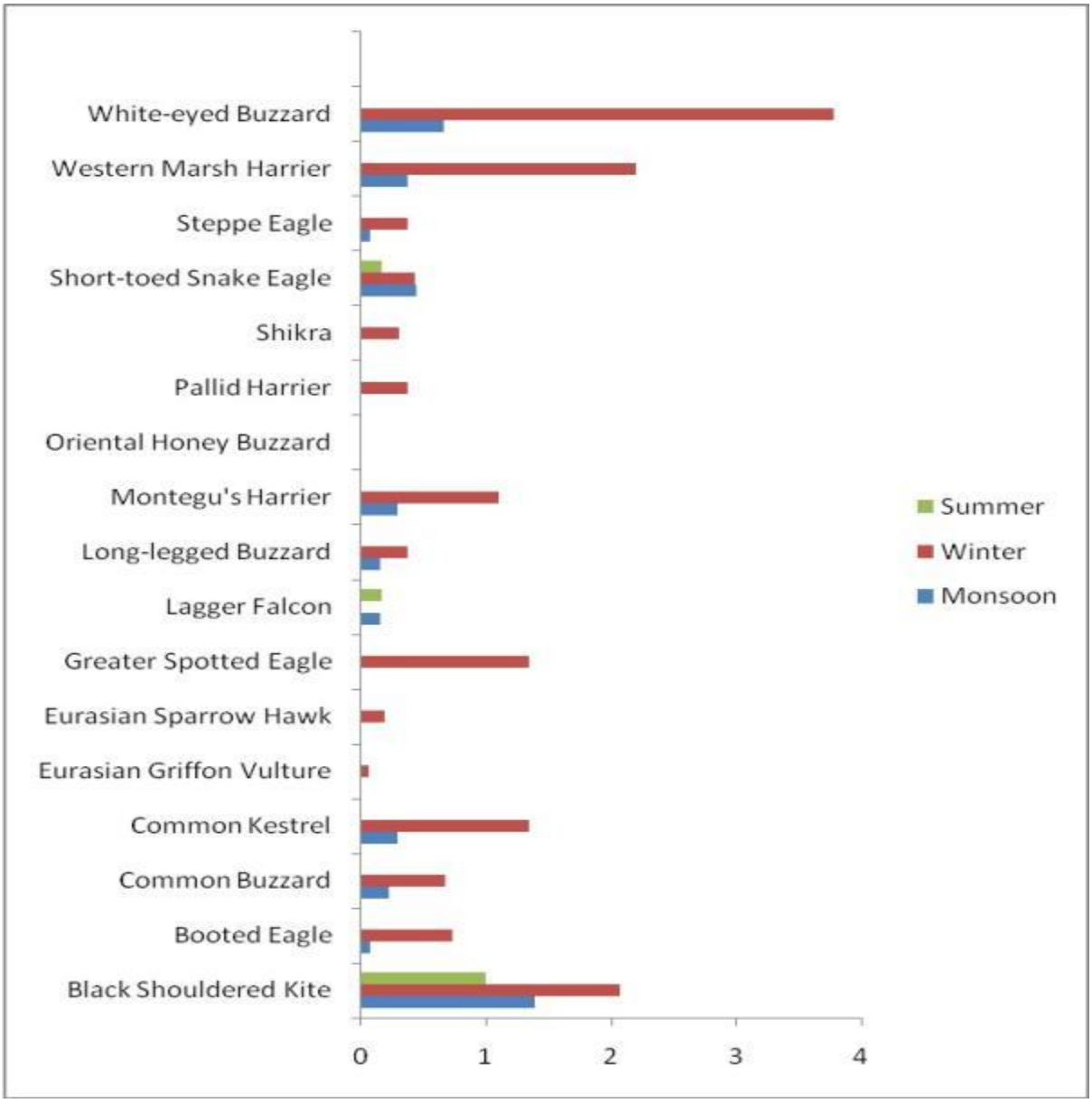


Figure 10.Density of Raptors in each season in the study area.

Of the total species documented, three species namely, Dalmatian Pelican *Pelecanus crispus*, Sarus Crane *Grus antigone* and Greater Spotted Eagle *Aquila clanga* are categorized as "Vulnerable" and seven species namely, Darter *Anhinga melanogaster*, Painted Stork *Mycteria leucocephala*, Black-necked Stork *Ephippiorhynchus asiaticus*, Oriental White Ibis *Threskiornis melanocephalus*, Black-tailed Godwit *Limosa limosa*, Eurasian Curlew *Numenius arquata* and River Tern *Sterna aurantia* are categorized as "Near Threatened" in the IUCN Red list of threatened species. The Eurasian Spoonbill *Platalea leucorodia*, Western Marsh-Harrier *Circus aeruginosus*, Greater Spotted Eagle *Aquila clanga* and Steppe Eagle *Aquila nipalensis* are listed under Schedule I of the Wildlife (Protection) Act, 1972. The Dalmatian Pelican *Pelecanus crispus* and Eurasian Spoonbill *Platalea leucorodia*, Greater Flamingo

Phoenicopterus ruber, Comb Duck *Sarkidiornis melanotos*, Sarus Crane *Grus antigone*, Demoiselle Crane *Grus virgo*, Common Crane *Grus grus*, Western Marsh-Harrier *Circus aeruginosus*, Greater Spotted Eagle *Aquila clanga* and Steppe Eagle *Aquila nipalensis* are listed Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2014).

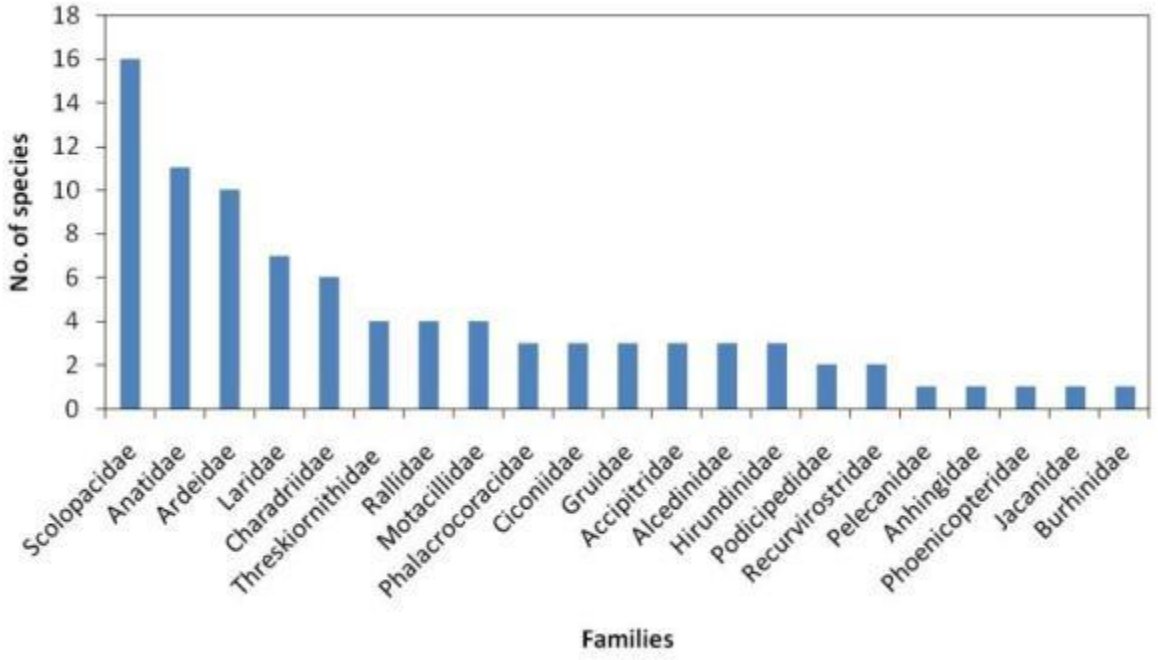


Figure 11. Family wise species richness of wetland birds in the study

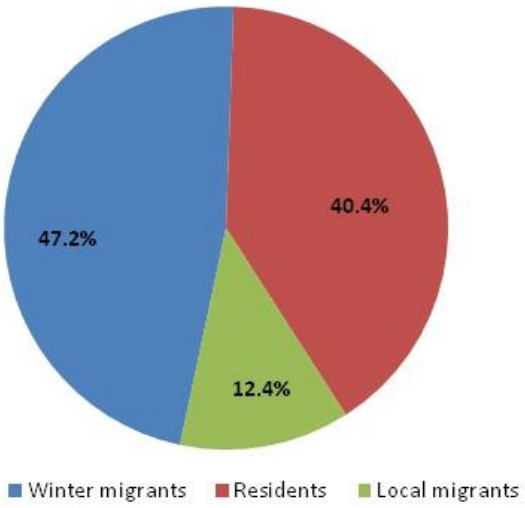


Figure 12. Residential status of wetland birds recorded in the study area

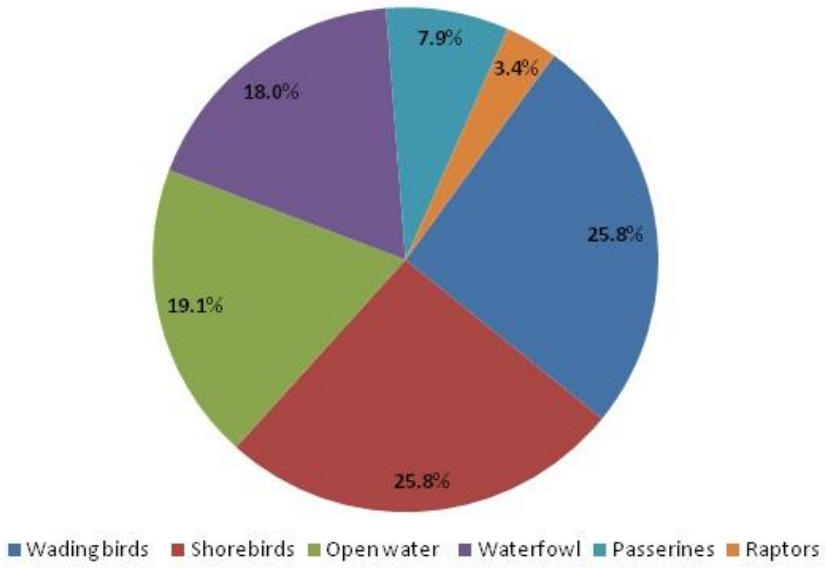


Figure 13. Guild structure of wetland birds recorded in the study area

4.3 RESPONSE OF BIRDS TO THE WIND TURBINES

4.3.1 RESPONSE OF TERRESTRIAL BIRDS

In all 58 bird species recorded from the sampling (transects and point counts) during the study, 57 and 51 speceies respectively were recorded in control and turbine sites (Table 8). Bird species namely Black redstart, Blue throat, Booted warbler, Brahminy starling, Dusky crag martin, Greater coucal and Yellow-throated sparrow were only recorded in control site during sampling while Sothern grey shrike is sampled only in Turbine site. The density of birds also varied in two sites. In control site the House sparrow had maximum density (120 birds/Sqkm) followed by Common babbler (102 birds/Sqkm) and Blue rock pegion (83 birds/ Sqkm), whereas in Turbine site Rosy starling (155 birds/Sqkm) had maximum density followed by Ashy crowned sparrow lark (75 birds/Sqkm). The diversity indices such as Shannon index and Simpson index were higher in control site (Shannon = 3.187, Simpson=0.9333) than the Turbine site (Shannon= 2.737, Simpson= 0.8607). Evenness of the species was also higher in control site (0.425) than turbine site (0.3028). The avifauna of the two sites were significantly different from each other (Mann Whitney U test : p=0.0067). The bird composition in both site varied in varying season. In all season the bird diversity

was lower in turbine site than the control site. In both site,winter season had more diversity followed by monsoon and summer (Figure 14 & 15)

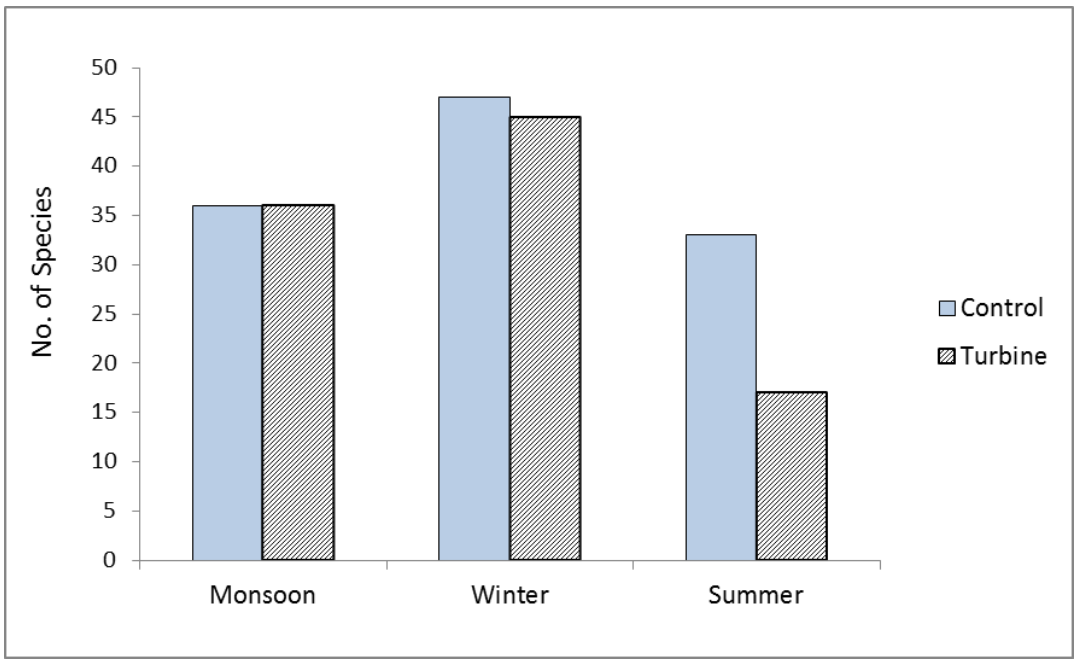


Figure 14.Species richness of control and turbine site in various seasons

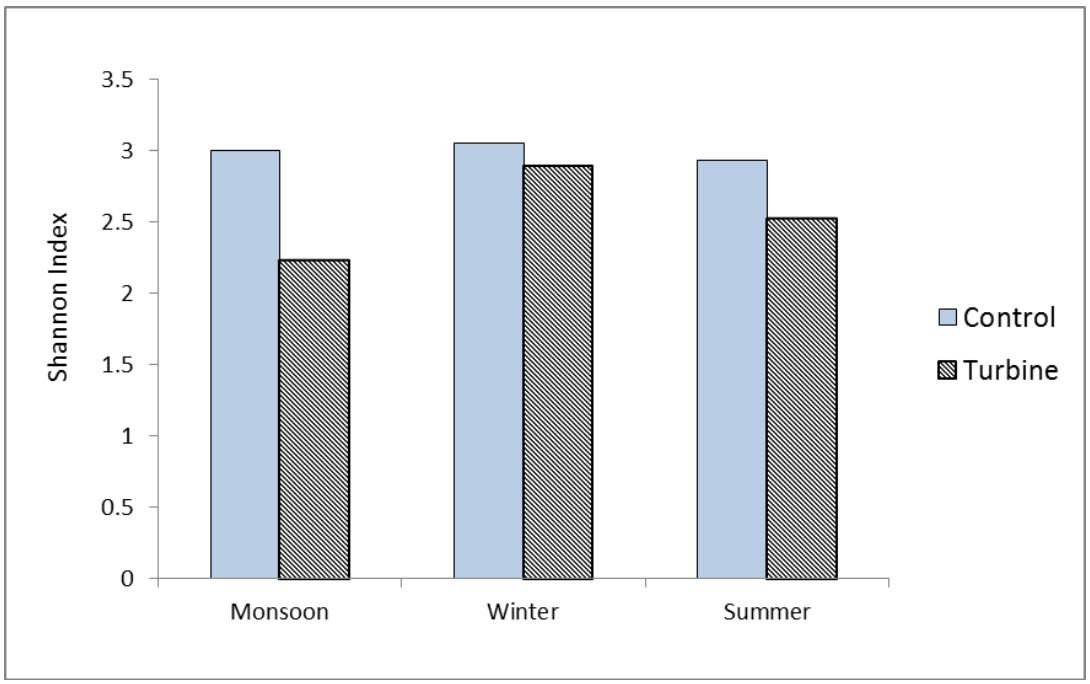


Figure 15. Shannon diversity index of control and turbine site in various seasons

Table 7.Density of terrestrial birds/sqkm in control and turbine area in different seasons

Bird Name	Control				Turbine			
	Monsoon	Winter	Summer	Overall	Monsoon	Winter	Summer	Overall
Asian koel	19	6	31	17	1	1	5	2
Ashy crowned sparrow lark	56	40	17	38	89	89	17	76
Ashy prinia	0	1	0	1	0	1	0	0
Baya weaver	2	0	21	6	0	2	0	1
Black drongo	0	4	0	2	3	5	0	3
Black redstart	0	1	0	0	0	0	0	0
Blue rock pigeon	34	25	229	84	5	8	4	6
Blue throat	1	4	0	2	0	0	0	0
Booted warbler	1	1	0	1	0	0	0	0
Brown shrike	0	7	0	3	1	1	0	1
Brahminy starling	0	1	5	2	0	0	0	0
Cattle egret	2	0	8	3	9	0	0	3
Common babbler	112	114	86	106	79	87	28	74
Common hoopoe	1	3	0	2	0	1	0	0
Common stone chat	0	1	0	1	0	1	0	1
Common swallow	0	21	5	10	0	3	0	1
Common tailor bird	4	1	2	3	1	1	0	1
Crested lark	0	1	0	1	0	1	0	0
Desert wheatear	0	1	0	1	0	1	0	1
Dusky craig martin	3	0	0	1	0	0	0	0
Eurasian collared dove	67	48	51	54	39	28	18	30
European roller	4	0	0	1	3	0	0	1
Green bee-eater	18	18	24	19	14	15	1	12
Grey breasted prinia	75	31	44	47	19	5	5	10
Greater coucal	2	0	1	1	0	0	0	0
Grey francolin	2	0	8	3	5	5	27	9
Greenish leaf warbler	2	20	0	9	1	1	0	1
House crow	43	21	66	39	13	8	11	10
House sparrow	69	187	69	120	13	47	8	28
Hume's white throat	0	0	2	1	0	0	0	0
Indian peafowl	0	0	30	8	1	0	0	0
Indian robin	33	28	47	35	20	16	32	20
Indian roller	2	1	0	1	0	0	0	0
Indian silver bill	8	10	3	8	20	0	0	7
Isabelline wheatear	0	7	0	3	0	5	0	2
Jungle pirina	2	10	2	5	1	3	0	2
Lesser white throat	0	6	0	3	0	1	0	0
Little brown dove	47	45	59	49	15	9	13	11
Long tailed shrike	0	2	0	1	1	2	0	1
Paddy field Pipit	7	5	0	4	1	3	0	2
Pied bush chat	8	10	0	6	0	1	0	0
Plain prinia	0	1	0	1	1	0	0	0
Purple sun bird	43	36	51	42	11	5	14	9

Bird Name	Control				Turbine			
Red collared dove	2	1	5	3	11	9	2	8
Red rumped swallow	15	19	23	19	3	2	0	2
Red vented bulbul	88	43	76	65	25	16	28	21
Red wattled lapwing	26	12	28	21	4	3	1	3
Rose ringed parakeet	0	1	22	7	0	1	0	0
Rosy starling	47	115	52	78	358	70	0	156
Rufous fronted prinia	0	0	3	1	0	0	0	0
Rufous tailed lark	13	10	5	10	20	29	1	21
southern grey shrike	0	0	0	0	2	4	0	3
Tickelle's flower pecker	0	11	0	5	0	4	0	2
variable wheatear	0	2	0	1	6	14	0	9
White breasted kingfisher	11	19	14	15	3	4	0	3
Wire tailed swallow	0	4	0	2	1	0	0	0
Yellow throated sparrow	0	0	1	0	0	0	0	0
Yellow wattled lapwing	7	4	0	4	1	2	0	1

4.3.2 RESPONSE OF RAPTORS

17 species of diurnal raptors recorded in sampling were taken for the analysis. All 17 species were recorded in the control site where as 13 species were recorded in Turbine Site (Fig 16). 4 species of raptors namely Booted Eagle, Short-toed snake eagle and Oriental honey buzzard and Eurasian griffon vulture were not recorded in the turbine site in the sampling period. Western marsh harrier (1.77 bird/Sqkm/hr) was the most abuntant raptor in the Control site followed by Black shouldered kite (1.30 bird/Sqkm/hr) while Black shouldered kite (1.72 bird/Sqkm/hr) accounted maximum abundance followed by Western marsh harrier in turbine site (1.41 bird/Sqkm/hr). During winter both control site had maximum raptor density than other seasons (Fig 17, 18). In Winter Western marsh harrier , Steppe eagle, Common ketrel had higher density in both site. During Monsoon and summer Black shouldered kite had maximum density in both the sites. There was no significant difference between the raptor population between two sites (Mann whitney U test: P=0.748).

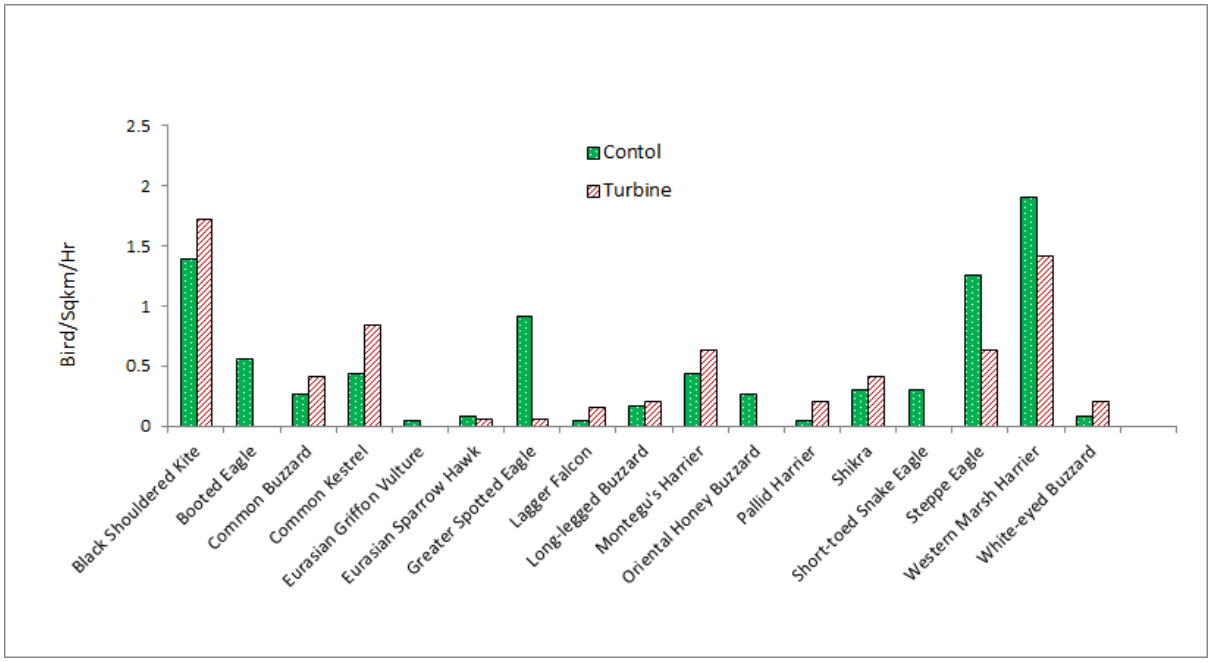


Figure 16. Raptor density at Control and Turbine sites

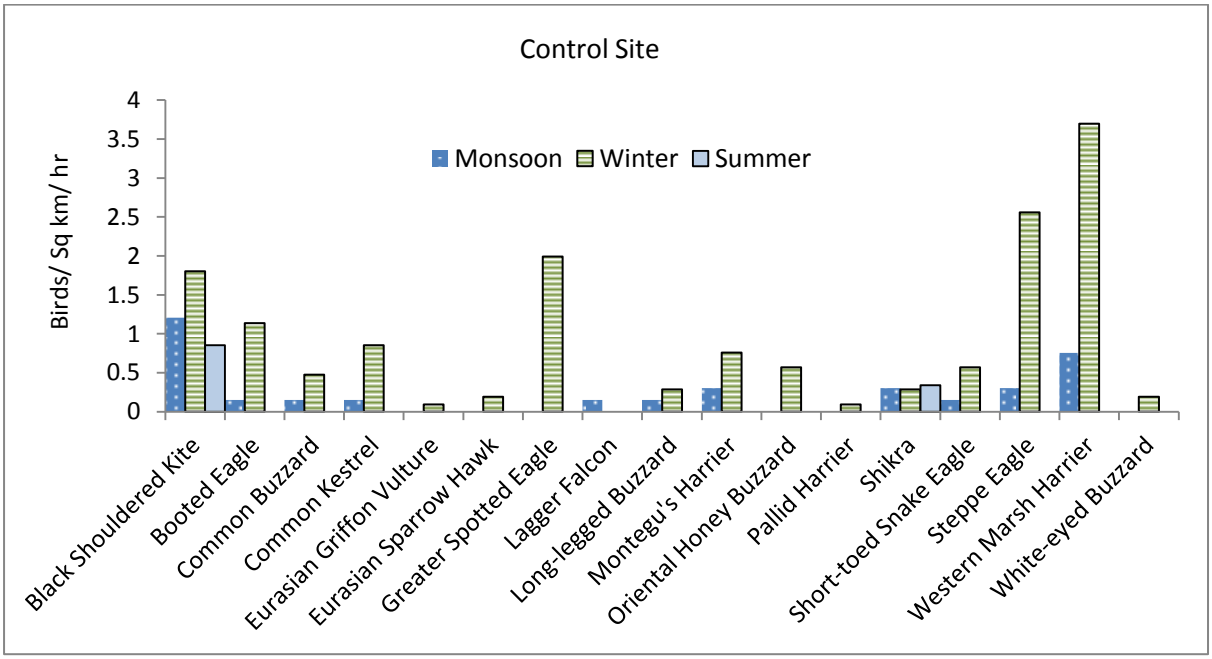


Figure 17. Raptors density in control site in each season

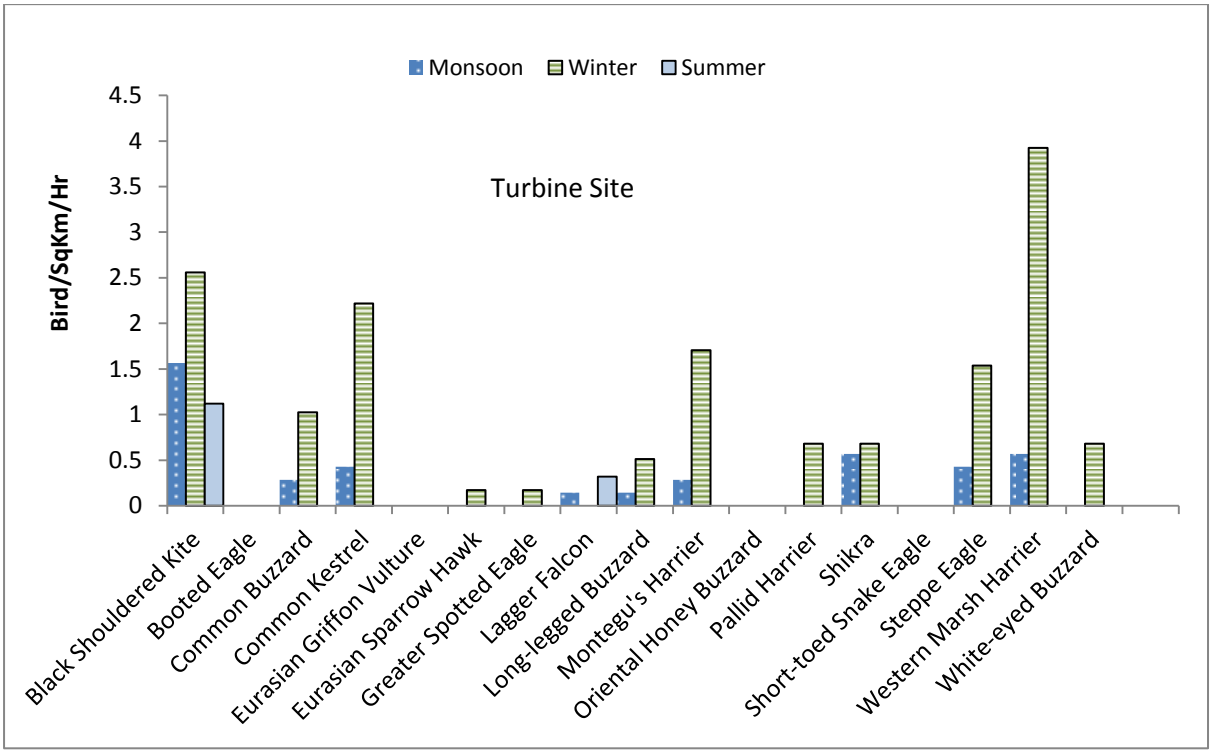


Figure 18. Raptors density in Turbine site in each season

4.3.3 RESPONSE OF WETLAND BIRDS

4.3.3.1 Distribution patterns of wetland birds

Totally 48,588 individual from 82 wetland bird species belonging to 19 families were recorded in turbine site during the study period (Table 8). Of the 82 species, 37 (45.1%) were winter migrants, 36 (43.9%) residents and nine (11.0%) were local migrants. The top 10 abundant wetland bird species in the wind turbine sites were Demoiselle Crane (10.40%), Ruff (8.37%), Little Cormorant (5.13%), Common Coot (4.87%), Northern Shoveller (4.74%), Little Grebe (4.63%), Spot-billed Duck (4.55%), Black-winged Stilt (4.32%), Lesser Whistling-Duck (4.04%) and Northern Pintail (3.87%) (Table 8).

A total of 41, 808 individual from 82 species of wetland birds belonging to 19 families were recorded in control site during the entire study period (Table 10). Among the 82 species, 37 (45.1%) were winter migrants, 35 (42.7%) residents and 10 (12.2%) were local migrants. The most 10 dominant species were Demoiselle Crane (36.39%), Ruff (7.05%), Little Cormorant (4.24%), Common Coot (3.73%), Spot-billed Duck (3.22%), Little Grebe (3.09%), Lesser Whistling-Duck (2.76%), Little Egret (2.61%), Black-winged Stilt (2.40%) and Red-wattled Lapwing (2.09%) .

Table 8. General pattern of wetland birds in control and turbine locations

S. No.	Species	Guild	Turbine Site		Control Site	
			Sum	RA %	Sum	RA %
1	Little Grebe	Open water	2,248	4.63	1,293	3.09
2	Great Crested Grebe	Open water	18	0.04	14	0.03
3	Dalmatian Pelican	Open water	746	1.54	201	0.48
4	Little Cormorant	Open water	2,494	5.13	1,771	4.24
5	Indian Shag	Open water	417	0.86	404	0.97
6	Great Cormorant	Open water	546	1.12	372	0.89
7	Darter	Open water	117	0.24	116	0.28
8	Little Egret	Wader	1472	3.03	1,092	2.61
9	Western Reef-Egret	Wader	48	0.1	11	0.03
10	Grey Heron	Wader	115	0.24	58	0.14
11	Purple Heron	Wader	2	0	17	0.04
12	Large Egret	Wader	694	1.43	378	0.9
13	Median Egret	Wader	351	0.72	251	0.6
14	Cattle Egret	Wader	1,303	2.68	858	2.05
15	Indian Pond-Heron	Wader	432	0.89	255	0.61
16	Little Green Heron	Wader	7	0.01	4	0.01
17	Black-crowned Night-Heron	Wader	260	0.54	124	0.3
18	Painted Stork	Wader	408	0.84	283	0.68
19	Asian Openbill-Stork	Wader	25	0.05	35	0.08
20	Black-necked Stork	Wader	9	0.02	0	0
21	Glossy Ibis	Wader	58	0.12	165	0.39
22	Oriental White Ibis	Wader	369	0.76	232	0.55
23	Black Ibis	Wader	165	0.34	183	0.44
24	Eurasian Spoonbill	Wader	829	1.71	451	1.08
25	Greater Flamingo	Wader	115	0.24	57	0.14
26	Lesser Whistling-Duck	Waterfowl	1,963	4.04	1,155	2.76
27	Comb Duck	Waterfowl	71	0.15	80	0.19
28	Eurasian Wigeon	Waterfowl	558	1.15	352	0.84
29	Spot-billed Duck	Waterfowl	2,209	4.55	1,347	3.22
30	Northern Shoveller	Waterfowl	2,304	4.74	800	1.91
31	Northern Pintail	Waterfowl	1,881	3.87	270	0.65
32	Garganey	Waterfowl	981	2.02	192	0.46
33	Common Teal	Waterfowl	1,516	3.12	536	1.28
34	Common Pochard	Waterfowl	920	1.89	560	1.34
35	Tufted Pochard	Waterfowl	125	0.26	39	0.09
36	Demoiselle Crane	Wader	5,054	10.4	2	0
37	Common Crane	Wader	137	0.28	2	0
38	White-breasted Waterhen	Waterfowl	117	0.24	15,212	36.39
39	Purple Moorhen	Waterfowl	118	0.24	504	1.21
40	Common Moorhen	Waterfowl	132	0.27	192	0.46
41	Common Coot	Waterfowl	2366	4.87	98	0.23
42	Pheasant-tailed Jacana	Waterfowl	21	0.04	148	0.35

S. No.	Species	Guild	Turbine Site		Control Site	
43	Pacific Golden-Plover	Shorebird	7	0.01	1,560	3.73
44	Little Ringed Plover	Shorebird	777	1.6	45	0.11
45	Kentish Plover	Shorebird	182	0.37	484	1.16
46	Lesser Sand Plover	Shorebird	237	0.49	115	0.28
47	Yellow-wattled Lapwing	Wader	780	1.61	138	0.33
48	Red-wattled Lapwing	Wader	1,476	3.04	537	1.28
49	Black-tailed Godwit	Shorebird	38	0.08	873	2.09
50	Whimbrel	Shorebird	2	0	56	0.13
51	Eurasian Curlew	Shorebird	27	0.06	9	0.02
52	Spotted Redshank	Shorebird	6	0.01	11	0.03
53	Common Redshank	Shorebird	492	1.01	435	1.04
54	Marsh Sandpiper	Shorebird	701	1.44	241	0.58
55	Common Greenshank	Shorebird	140	0.29	157	0.38
56	Green Sandpiper	Shorebird	225	0.46	163	0.39
57	Wood Sandpiper	Shorebird	505	1.04	256	0.61
58	Terek Sandpiper	Shorebird	75	0.15	80	0.19
59	Common Sandpiper	Shorebird	249	0.51	134	0.32
60	Little Stint	Shorebird	667	1.37	228	0.55
61	Ruff	Shorebird	4,067	8.37	361	0.86
62	Black-winged Stilt	Shorebird	2,101	4.32	63	0.15
63	Pied Avocet	Shorebird	169	0.35	2,946	7.05
64	Heuglin's Gull	Open water	5	0.01	1,002	2.4
65	Pallas's Gull	Open water	12	0.02	22	0.05
66	Brown-headed Gull	Open water	174	0.36	54	0.13
67	Gull-billed Tern	Open water	1	0	25	0.06
68	River Tern	Open water	222	0.46	129	0.31
69	Common Tern	Open water	14	0.03	24	0.06
70	Whiskered Tern	Open water	227	0.47	115	0.28
71	Western Marsh-Harrier	Raptor	44	0.09	28	0.07
72	Greater Spotted Eagle	Raptor	31	0.06	16	0.04
73	Steppe Eagle	Raptor	26	0.05	21	0.05
74	Small Blue Kingfisher	Open water	52	0.11	80	0.19
75	White-breasted Kingfisher	Open water	121	0.25	137	0.33
76	Lesser Pied Kingfisher	Open water	51	0.1	73	0.17
77	Common Swallow	Passerine	158	0.33	203	0.49
78	Wire-tailed Swallow	Passerine	45	0.09	137	0.33
79	Red-rumped Swallow	Passerine	642	1.32	623	1.49
80	White Wagtail	Passerine	46	0.09	39	0.09
81	Large Pied Wagtail	Passerine	27	0.06	31	0.07
82	Citrine Wagtail	Passerine	0	0	3	0.01
83	Yellow Wagtail	Passerine	46	0.09	40	0.1
	Total		48,588	100	41,808	100

RA-Relative Abundance

4.3.3.2 Monthly fluctuations of wetland birds

4.3.3.2.1 Turbine site

The monthly fluctuations of bird population, species richness and Shannon Wiener diversity index in wind turbine site is given in Figure 19. In all wetlands, a peak of bird population and number of species was observed during winter months i.e. December, January and February. In Jangi, a maximum bird population (1,111 birds), species richness (69 species) and diversity (H´ = 3.68) was recorded during February 2013. A maximum bird population at Modapr was observed during January 2014 with 2,457 birds and species richness was highest in December 2013 (61 species). The diversity was highest during February 2013 (H´ = 3.75). In Ambliala, the bird population was higher during January 2014 (2,640 birds) and maximum number of species was reported during December 2012 with 65 species. The diversity was highest during April 2014 (H´= 3.17). A maximum bird population (2,431 birds) and species richness (65 species) in Lakhdhirgadh was noted during January 2014. The highest diversity value was recorded during December 2012 (H´ = 3.87). In Surajbari, February 2013 had a maximum bird population (1,268 birds) and number of species (63 species) but diversity was higher in November 2012 (H´ = 3.88) (Fig. 19).

4.3.3.2.2 Control site

The monthly fluctuations of bird population, species richness and Shannon Wiener diversity index in non-wind turbine site is given in Figure 19. In Laliana, Chhadavada and Vondh a maximumbird population was recorded during January 2014 with 2,507, 2,054 and 2,808 birds respectively. However, highest number of species at respective wetlands was recorded during December 2012 (73 species), February 2013 (72 species) and December 2012 (75 species) respectively. December 2012 showed a highest number of bird population and species richness at Samakhiali (662 and 53 respectively) and Nava Katariya (625 and 58 respectively). In Laliana, Chhadavada, Vondh, Samakhiali and Nava Katariya the diversity value was higher during May 2014 (H´ = 3.98), May 2012 (H´ = 3.52), November 2012 (H´ = 3.38), December 2013 (H´ = 3.44) and February 2013 (H´ = 3.47) respectively (Fig 19)

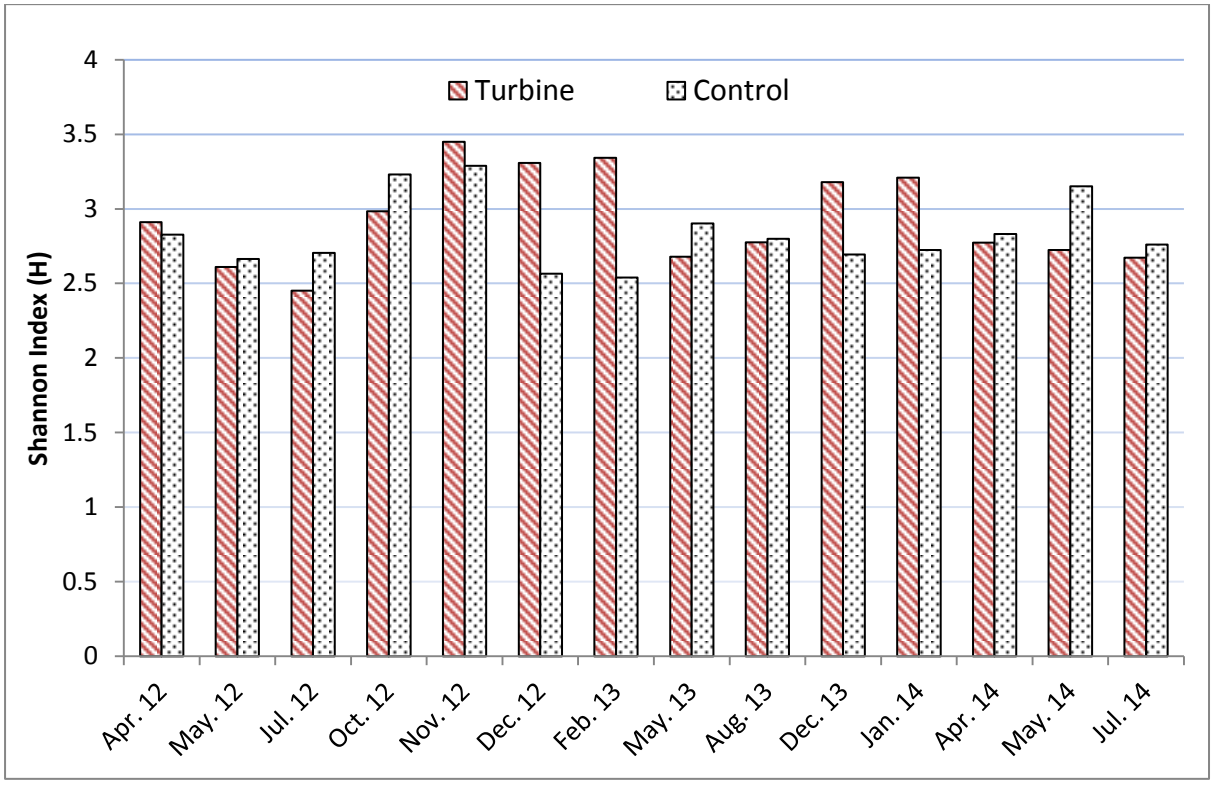


Figure 19.Shannon Weiner diversity index (H') of wetland birds

4.3.3.3 Guild structure of wetland birds

The waterfowl were most dominant group among the turbine site wetland birds community, which comprised 31.5% of the individuals, but fourth in number of species (18.3%). The wading birds were second dominant in number of individuals (29.0%) and first in number of species (26.8%). The shorebirds were third dominant group in both individual (22.0%) and species (23.2%). The open water guild ranked fourth in both individual (15.4%) and number of species (20.7%). The passerine and raptor guilds contained the fewest species and individuals which ranked fifth and sixth respectively (Table 9). Among the waterfowl guild the Common coot was dominant species (15.5%) followed by the Northern shoveller (15.1%) and Spot-billed duck (14.5%). Within the wading birds guild the Demoiselle crane was abundant species (35.8%) followed by the Red-wattled lapwing (10.5%) and Little Egret (10.4%). Among the shorebirds guild the Ruff was predominant species (38.1%) followed by Black-winged stilt (19.7%) and Marsh sandpiper (6.6%). The Little cormorant was most abundant species (33.4%) with the open water guild followed by Little Grebe (30.1%) and Dalmatian pelican (10.0%). The Red-rumped Swallow (66.6%) and Western Marsh Harrier (43.6%) was dominant species among passerines and raptors guild.

In control wetlands wading birds were predominant guild in number of individuals (51.6%) and species (26.8%). The waterfowl were second in number of individuals (17.6%), but fourth in number of species (19.5%). The shorebirds were third dominant guild, which comprised 16.5% of the total individuals and 23.2% of the species. The open water birds were fourth in number of individuals (11.5%) and species (18.3%). The passerines and raptors were least guild groups among wetland birds community The Demoiselle crane was the most abundant of the wading birds, accounting for 70.5% followed by the Little Egret (5.1%) and Cattle egret (4.1%). In the shorebirds guild, the Ruff was the most frequently recorded species (42.7%), followed by Black-winged Stilt (14.5%) and Little Ringed Plover (7.0%). Among the open water guild, the Little Cormorant was dominant species (36.8%), followed by the Little Grebe (26.9%) and Indian Shag (8.4%). The Common coot wasthe most abundant species (21.1%) among the waterfowl guild, followed by Spot-billed Duck (18.3%) and Lesser whistling duck (15.7%). The Red-rumped swallow (57.9%) and Western marsh harrier (43.1%) was dominant species among passerines and raptors guilds respectively.

Table 9.Wetland birds recorded for each guild in turbine and control site

Guild	Turbine site		Control site	
	No. of species	No of sightings	No. of species	No of sightings
Wading birds	22	14,109	22	21,582
Shorebirds	19	10,667	19	6,901
Open water	17	7,465	15	4,808
Waterfowl	15	15,282	16	7,376
Passerines	6	964	7	1,076
Raptors	3	101	3	65
Total	82	48,588	82	41,808

4.4 Flight Activities

Totally 72 species of birds were recorded flying in the turbine area of which 49 species were recorded in risk zone (Table 12). Among 72 species 65 were recorded in the zone below risk zone, 10 species were recorded above risk zone, 49 species were recorded in risk zone and six species were recorded in all three zones. Bird species namely Steppe eagle, Glossy ibis, Little cormorant, Northern pintail, Oriental white ibis, Huglen's Gull, Booted eagle, Blue rock pigeon, Greater spotted eagle, Common buzzard, Common tern, Greater flamingo, Short toed snake eagle had more than 80% percentage of collision risk. Painted stork, Western

reef egret, Eurasian spoon bill, Cattle egret, Black drongo, Spot billed duck, White eyed buzzard, Common kestrel, had 50 to 75% of Collision risk. Birds such as Ashy crowned sparrow lark, Asian koel, Baya weaver, Black crowned night heron, Common babbler, Common swallow, Eurasian griffon vulture, Greater coucal, Green sand piper, Grey breasted prinia, Grey francolin, House sparrow, Indian robin, Indian silver bill, Intermediate egret, Large egret, Lesser whistling duck, Little pied kingfisher, Red collared dove, Red vented bulbul, Rufous tailed lark, White eared bulbul had minimal collision risk.

Table 10.Flight activity of birds in different zones

No	Bird Name	Below Risk Zone (Minutes)	Collision Risk Zone (Minutes)	Above Risk Zone (Minutes)	% Time spend in Collision Risk zone
1	Ashy crowned sparrow lark (17)	18.82(17)	0	0	0
2	Asian koel (6)	1.2(6)	0	0	0
3	Baya weaver (7)	2.8(7)	0	0	0
4	Black crowned night heron (1)	1.25(1)	0	0	0
5	Black drongo(3)	0.33(1)	0.67 (2)	0	66.67
6	Black ibis (20)	135.3(18)	4.8 (2)	0	3.43
7	Black necked stork (8)	5.4(6)	3.17 (2)	0	36.96
8	Black shouldered kite (4)	3.25(3)	0.38 (1)	0	10.55
9	Black winged stilt (23)	24.9(18)	3.83 (5)	0	13.34
10	Blue rock pigeon (74)	15.33(20)	225.9 (54)	0	93.64
11	Booted eagle (2)	0.58(1)	5.33 (1)	0	90.14
12	Cattle egret (156)	1318.6(76)	2441.33 (80)	0	64.93
13	Common babbler (30)	54.5(30)	0	0	0
14	Common buzzard (4)	0.48(1)	33 (3)	0	98.56
15	Common kestrel (21)	48(10)	128.7 (11)	0	72.84
16	Common sandpiper (4)	1.35(3)	0.5 (1)	0	27.03
17	Common swallow (6)	28(6)	0	0	0
18	Common tern (22)	0	172.7 (22)	0	100
19	Dalmatian pelican (438)	61.42(67)	733.93 (101)	4806 (270)	13.1
20	Demoiselle crane (552)	0	286.67 (200)	3930.13 (352)	6.8
21	Eurasian collared dove (103)	1700.9(93)	17.47 (10)	0	1.02
22	Eurasian griffon vulture (1)	0	0	7.02 (1)	0
23	Eurasian spoon bill (47)	45.47(30)	82.73 (17)	0	64.53
24	Glossy ibis (54)	0	62.52 (31)	13.42 (23)	82.33
25	Greater coucal (1)	0.08(1)	0	0	0
26	Greater flamingo (2)	0	1 (2)	0	100
27	Greater spotted eagle (7)	0	91.58 (5)	4.5 (2)	95.32
28	Green bee-eater (15)	11.6(13)	0.17 (2)	0	1.42

No	Bird Name	Below Risk Zone (Minutes)	Collision Risk Zone (Minutes)	Above Risk Zone (Minutes)	% Time spend in Collision Risk zone
29	Green sand piper (2)	0.33(2)	0	0	0
30	Grey breasted Prinia (5)	1.75(5)	0	0	0
31	Grey francolin (3)	0.25(3)	0	0	0
32	Grey heron (7)	16(6)	1.75 (1)	0	9.86
33	House crow (155)	4549.5(136)	134.33 (20)	0	2.87
34	House sparrow (38)	75.37(38)	0	0	0
35	Huglen's Gull (3)	0.5 (1)	4.53 (2)	0	90.07
36	Indian robin (2)	0.67 (2)	0	0	0
37	Indian silver bill (3)	1.65 (3)	0	0	0
38	Intermediate egret (1)	0.53 (1)	0	0	0
39	Large egret (2)	0.33 (2)	0	0	0
40	Lesser whistling duck (22)	57.2 (22)	0	0	0
41	Little egret (155)	4.72 (9)	4.67 (7)	0	49.73
42	Little brown dove (239)	2592.17 (151)	1 (4)	0	0.04
43	Little cormorant (16)	116.75 (78)	590.13 (155)	3(6)	83.13
44	Little pied kingfisher (4)	1.73 (4)	0	0	0
45	Montagu's Harrier (6)	16.25 (5)	2 (1)	0	10.96
46	Northern pintail (133)	16 (32)	90.67 (101)	0	85
47	Northern Shoveller (138)	378.55 (113)	10.42 (25)	0	2.68
48	Oriental honey buzzard (3)	2.37 (2)	2.17 (1)	0	47.79
49	Oriental white ibis (6)	1.75 (3)	11.25 (3)	0	86.54
50	Painted stork (353)	150.5 (44)	11212.68 (178)	9080.37 (131)	54.85
51	Pallid harrier (2)	0.5 (1)	0.17 (1)	0	25
52	Pond heron (5)	3.9 (3)	2.33 (2)	0	37.43
53	Purple sunbird (42)	174.75 (38)	0.4 (4)	0	0.23
54	Red collared dove (2)	0.67 (2)	0	0	0
55	Red rumped swallow (50)	696.9 (46)	3.33 (4)	0	0.48
56	Red vented bulbul (23)	52.13 (23)	0	0	0
57	Red wattled lapwing (21)	47.62 (20)	0.3 (1)	0	0.63
58	Rosy starling (3675)	36971.03 (1802)	6178.03 (1378)	371.25(495)	14.2
59	Ruff (64)	66 (44)	11.67 (20)	0	15.02
60	Rufous tailed lark (1)	0.15 (1)	0	0	0
61	Sandpiper (13)	5.9 (13)	0	0	0
62	Shikra (4)	1.75 (3)	0.57 (1)	0	24.46
63	Short toed snake eagle(1)	0	2.88(1)	0	100
64	Spot billed duck(84)	155.47 (44)	385.33 (40)	0	71.25
65	Steppe eagle(20)	8.33 (2)	235.33 (13)	47.6(5)	80.8
66	River tern(4)	4.55 (3)	0.67 (1)	0	12.78

No	Bird Name	Below Risk Zone (Minutes)	Collision Risk Zone (Minutes)	Above Risk Zone (Minutes)	% Time spend in Collision Risk zone
67	Western marsh harrier(37)	409.6 (24)	164.5 (10)	25.75 (3)	27.42
68	Western reef egret(2)	0.42 (1)	0.58 (1)	0	58.33
69	Whiskered tern (11)	9.83 (8)	1.72 (3)	0	14.86
70	White eared bulbul (3)	1.65 (2)	0 (1)	0	0
71	White eyed buzzard (4)	0.13 (3)	0.33 (1)	0	71.43
72	White throated kingfisher (5)	5 (5)	1.5 (4)	1 (1)	23.08
	Total time spend for the observation = 92 hrs; Number of sightings is given in parenthesis				

4.5 ROOSTING-SITES OF BIRDS

From the turbine sites three different bird roosting-sites were recorded during the study period. All the roosting-sites were found on Neem Trees (*Azadirachta indica*). A total of 106 Small Bee-eater (*Merops orientalis*) roosted in a single tree and close to wind turbine number. JW-53. In another location a large number of Cattle Egret, Little Cormorant, Rosy Starling, Common Myna and Indian Peafowl were found roosting in a single Neem tree. The Rose-ringed Parakeet, House Crow, Asian Koel and Spotted Owlet roosting were recorded in Jangi Village (Table 13). The last two roosting-sites were 250m apart. No mass roosting site of raptors was recorded in the study area.

Table 11.Some Roosting-sites of birds located in the study area

Location	Roost Tree	Bird Species (No. of Birds)
23°13'37.10"N	*Azadirachta indica*	Green Bee-eater (106)
70°33'6.25"E		
23° 13' 22.16"N		Cattle Egret (98)
70° 33' 47.03"E	*Azadirachta indica*	Little Cormorant (56)
		Rosy Starling (60)
		Common Myna (32) &
		Indian Peafowl (10)
23°13'24.22"N	Azadirachta indica	Rose ringed parakeet (30)
70°33'54.45"E		House crow(40)
		Asian Koel (6) &
		Spotted Owlet (4)

4.6 NEST-SITES OF BIRDS

In total, 15 bird species belonging to 11 families were found nesting in the study area. Highest number of nests were that of Blue Rock Pigeon (430), followed by House sparrow (280), House Crow (162), Red-vented Bulbul (60) and Red-rumped Swallow (32). Of the total species, nests sites of 10 species were recorded only in the control sites and remaining 5 species were constructed their both control and wind turbine sites (Table 14).

Table 12. Nests of birds recorded in the study area

No	Species	Number of nests		
		Turbine site	Control site	Total
1	House Crow	51	111	162
2	Blue Rock Pigeon	185	245	430
3	Black Ibis	0	26	26
4	House Sparrow	0	280	280
5	Brahminy Starling	0	2	2
6	Craig Martin	0	2	2
7	Eurasian Spoonbill	0	18	18
8	Glossy Ibis	0	6	6
9	Baya Weaver	2	2	4
10	Purple Sunbird	5	5	10
11	Red vented bulbul	20	40	60
12	Red rumped Swallow	0	32	32
13	Shikra	0	2	2
14	Common Myna	0	4	4
15	Indian Robin	9	21	30

4.6.1 HOUSE SPARROW NESTS

The nests were build in and around the human habitation. In wall holes of houses and bridges, roof spaces, gap in shutters, gaps in unused electric meter box, gaps in fan cup or any such kind of places were found to be used for nesting by sparrows. In some places artificial nest boxes were also found occupied. The height of the nest locations ranged between 4.5m to 18m. All the 280 nests recorded during the study period were outside the turbine sites.

Figure 20 House sparrow nests

4.6.2 BLUE ROCK PIGEON NESTS

The Blue Rock Pigeon constructed their nests on different human-made structures such as gaps in shutters of hotels and stores, holes or cavities in bridges, temple towers and petrol bunks and other such human made structures. The height of the nest location varied from 6 to 17m. Totally 430 nests were recorded of that 245 in control site, 185 in Turbine area during the study period.

Figure 21 Nest sites of Blue Rock Pegion

4.6.3 HOUSE CROW NESTING ON PYLONS

Crow nests were observed extensively in power transmission pylons. A total of 231 pylons of six types were checked, and 122 active nesting pylons with 162 house crow nests were observed. Of the six types of pylons available (Figure 22), House Crows mostly preferred pylon types 'A' (37.7%) followed by type 'B' (18.0%) and type 'E' (13.9%). The height of occupied pylons ranged between 20m and 50m and location of nests on pylons varied from 15m to 49m. The number of nests found on a single pylon ranged from one to three: single nests was recorded on 73.8% of nest pylons, two nests on 20.5% of nest pylons and three nests on 5.7% of nest pylons. Of the 161 nests examined, higher number of nests were placed in the top console (48.4%), followed by the bottom console (27.3%) and the middle console (24.2%) of the pylons. The House Crows preferred to built their nests on pylons with six electric lines (53.3%) more often than on pylons with three lines (40.2%) or twelve lines (6.5%). More nests were located on 66 kV pylons (50%) followed by 132 kV (29.5%), 220 kV (13.9%) and 400 kV pylons (6.6%). Among the 162 nests, 111 nests were in the control site and 51 in turbine site.

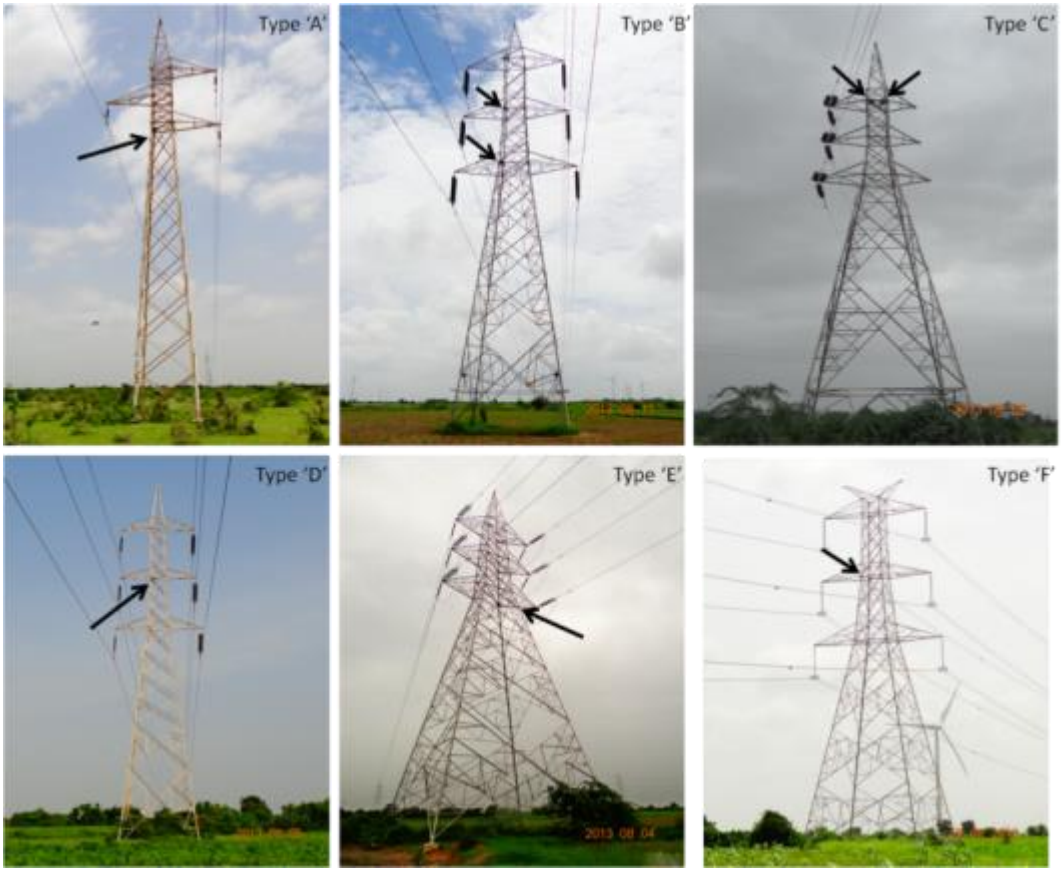


Figure 22 Crow nest sites on different types of pylons

4.6.4 BLACK IBIS NESTING ON PYLONS

All observed Black Ibis nests were on transmission pylons. A total of 26 active Black Ibis nest sites were recorded from four different types of pylons. Majority of the nests were found on type 'A' (42.3%), followed by type 'B' (30.8%), type 'D' (19.2%) and type 'C' (7.7%). The pylons used for nesting were between 20 and 30 m in height and height of the nest location on pylons varied from 15 to 29m. Most of the nests were found on a middle console (48.5%) followed by top console (30.1%) and bottom console (21.4%) of the pylons . All the pylons have carried single nest only. The Black Ibis preferred to built their nests on pylons with three electric lines (60.5%) more often than on pylons with six lines (39.5%). More nests were occurred on 66 kV pylons (68.4%) followed by 132 kV (21.5%) and 220 kV (10.1%). Interestingly 13 times we recorded House Crow and Black Ibis nests on the same pylons. All the 26 nests were recorded in the control sites.

Figure 23 Black Ibis Nesting on pylons

4.6.5 OTHER BIRD NESTS

Eighteen nests of Eurasian Spoonbill and 6 nests of Glossy Ibis were recorded in a heronry (on *Prosopis juliflora*) in the non turbine area near Modpar. Four nest-sites with 35 nests of Baya Weaver were recorded in both control (2 sites) and turbine sites (2 sites). Two nests of Brahminy Starling were recorded in holes of bridge and all were in control sites. Two nests of the Dusky Craig Martin were recorded near Bachau, they constructed oval bowl like mud nests attached to the wall of a temple. The Purple Sunbird constructed their nests in different plant species in the study area. The height of the nest location from the ground varied from 3 to 5.5m. During the study 5 nests were recorded in control sites and 5 were in turbine site.

The Red-vented Bulbuls preferred small bushes and trees for nest construction in the study area. Totally 60 nests were recorded: 40 in control sites and 20 in turbine sites. The height of plant species used for nesting by Red-vented Bulbuls ranged from 2.5 to 8.5m. A total of 32 nest sites (all in control sites) of Red-rumped Swallow were recorded under the stone culverts. Two nests (in control sites) of the Shikra was recorded in different tree species and nest location height ranged between 6.5 and 8m. Four nests of the Common Myna were recorded in holes of bridge walls and all the nests were recorded in the control site.

	
Eurasian Spoonbill	Brahminy Starling
	
Dusky Graig Martin	Baya Weaver
	
Purple Sunbird	Red Vented Bulbul
	
Red-rumped Swallow	Shikra
	
Common Mynah	Indian Robin

Figure 24 Nests of other birds recorded from the area

4.7 BAT ACTIVITIES

4.7.1 BAT ROOSTING SITES AND FRUIT BATS

Intensive searches were conducted to locate the roosting-sites of different bat species in the study area. Only one roosting site of Indian Flying Fox and one roosting site of Greater mouse tailed bat were identified. No other bat roosting-sites was recorded during the study period. The colony of Indian Flying Fox *Pteropus giganteus* was observed in a *Ficus benghalensis* tree at Laliana village (23° 16‘07.9” N and 70° 32’ 34.4” E) near Jangi . The tree with 15-17 m in height was surrounded by wetlands (village pond) and human habitations and vegetaion was dominated by *Azadirachta indica and Prosopis juliflora.* The Population size of the roosting colony varied from 15 to 37 (Fig 20). Maximum individuals were found in April 2014 (37 Individuals) followed by December 2013 (35) and December 2012 (32). Minimum number of individual (15 individuals) were found in the December 2011. Based on information given by locals another old roosting site location of *Pteropus giganteus* was located in *Ficus benghalensis* (23° 15‘48. 11”N 70° 32’ 12.84”E) 1 km away from the first roooosting site but no bats found roosting on that tree.

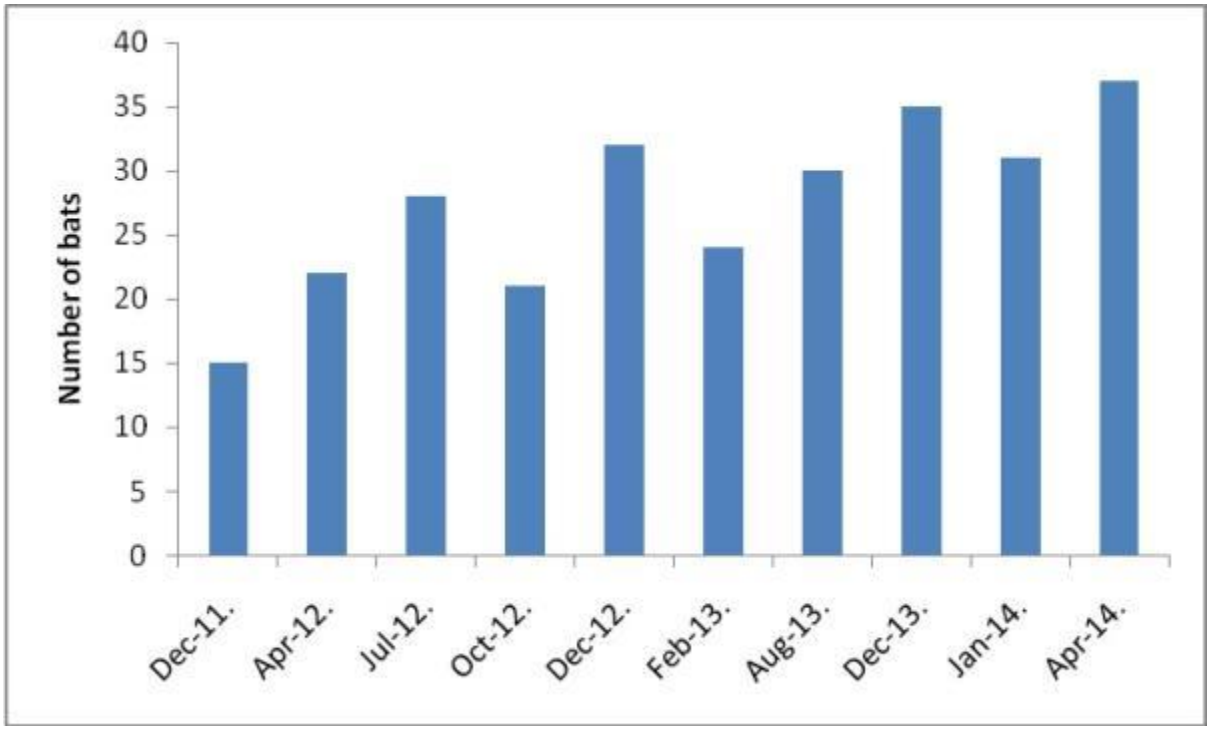


Figure 25. Population trend of Indian Flying Fox (*Pteropus giganteus*) in the roosting-site

A roosting site of Greater mouse tailed bat was in one abandon building (23°13'25.56"N, 70°34'6.19"E) in the Jangi village. During the visit in January 2013 eight individuals were observed but on next visits no bats were found in that building. Residents of modpar villagers reported insectivorous bats were found roosting in an abandoned granary (23°13'21.28"N, 70°35'50.29"E) in past years but after it was reconstructed no bats are roosting there. Apart from these, no other bat roosting sites could be found in the area during the study period.

4.7.2 NOCTURNAL BAT ACTIVITIES

A total of 190 bat echolocation calls (bat passes) were recorded in all three transects in seven surveys contucted during study period. Of these, 90 bat passes were recorded from first transect where there were no wind turbines. A total 57 and 43 bat passes were recorded from 'transect 2' and 'transect 3' respectively (Table 13). Bat passes were highest in December-2013 (17 passes/Km/hr) and low in February 2013 (3 passes/Km/hr). The monthly variations of nocturnal acoustic calls of bats recorded in three different transects in the study area are given in Table 15. Recorded bat call frequency varied from 31 kHz to 56 kHz**.** Maximum 40 calls were recorded in the frequency 40 kHz. Among the frequency band 36-40 KHz had maximum number of bat passes (4.2 passes/Km/Hr) followed by 41-45 with 3.6 passes/Km/Hr) (Fig 21). In general bat activities were comparatively low in turbine area than non-turbine area. The Average bat passes were high in control site (12.85 passes/Km/Hr) when compared with turbine site (7.14 Passes/Km/Hr). In both sites bat passes were high during December 2013 (Control: 21 Passes/Km/Hr Turbine: 12 Passes/Km/Hr) and low in February 2013 (Control: 4 Passes/Km/Hr Turbine: 2 Passes/Km/Hr) (Fig 22). Among the frequency band 36-40 kHz had maximum number of observations (Control: 5.14 Passes/Km/Hr Turbine: 3.28 Passes/Km/Hr) in both Control and Turbine site.

Table 13.Monthly observations of bat echolocation calls in the study area

Months	Control Transect	Turbine Transect 1	Turbine Transect 2
July'12	13	9	5
October'12	8	10	7
December'12	16	4	4

Months	Control Transect	Turbine Transect 1	Turbine Transect 2
February'13	4	3	2
May'13	9	7	6
August'13	19	10	9
December'13	21	14	10
Total	**90**	**57**	**43**

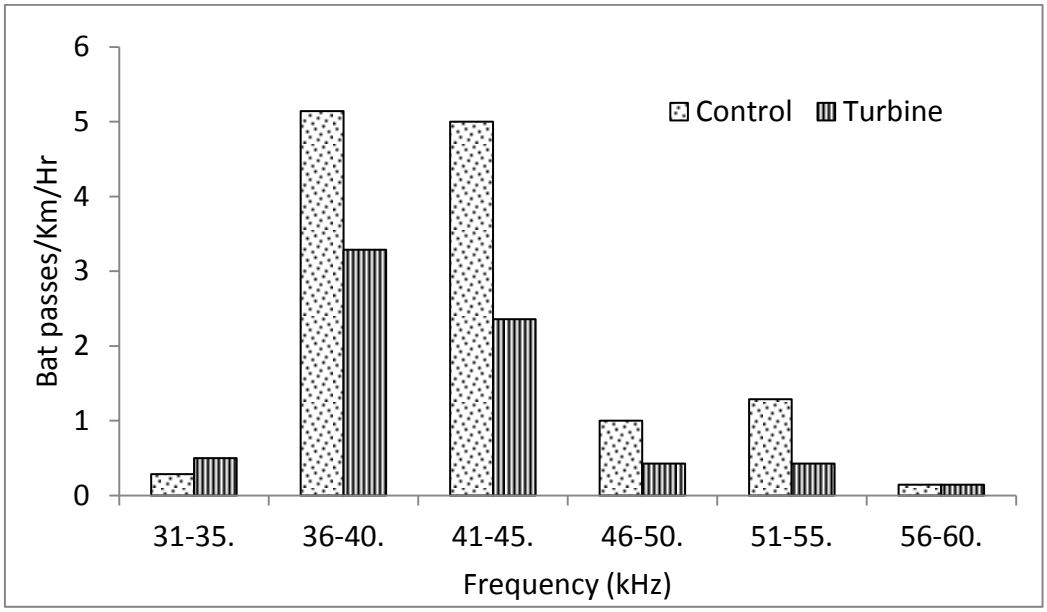


Figure 26.Frequency band-wise bat pass records in turbine and Control sites

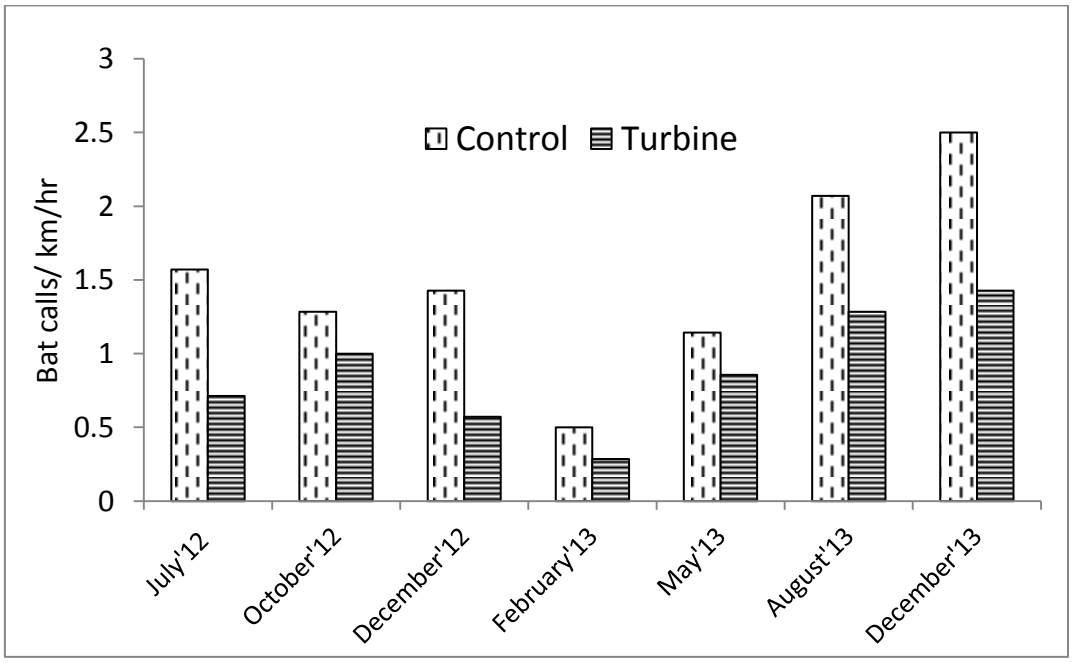


Figure 27. Temporal pattern in bat passes recorded based on echo-location calls

4.8 BIRD AND BAT MORTALITIES

4.8.1 BIRD MORTILITIES

During the study period totally 39 carcass were found under the wind turbines comprising at least 9 species of birds (Table 16). Of these 35 were caused by collision with turbines and the rest 4 from electrocution. Among this Eurasian Collared dove Accounted for maximum number of carcasses (10) followed by Blue Rock Pigeon (5), Cattle Egret (4), House Crow (3), Common Kestrel (2), Black Crowned Night Heron (1) , Black Drongo (1), Pallid Scops Owl (1). Four carcasses could be identified only up to family level (all 4 belonging to Accipitridade) and 4 more carcasses could not be identified even to family level as the carcasses were scavenged almost completely (Table 17). In 39 carcasses recorded, 4 were Indian peafowl and it was learned from locals and eye witnesses that the peafowl deaths were caused by electrocution at the power evacuation transmission line passing through the area.

All carcasses located were found within 150 m from the base of the turbine. In all 39 carcasses recorded, 30 carcasses were recorded within 50 m distance, 7 carcasses between 50 -100 m distance and 1 carcass between 100-150m distances from the base of the turbine (Fig 23). Among the Turbine locations, JW39 and JW52 had three bird carcasses in each while JW31 JW41 and JW49 had two bird and one bat carcasses in each locations. JW33, JWW40, JW44, JW45, JW57, and JW 61 had two bird carcasses in each (Fig 23 & Fig 24). Among the mortalities recorded Indian Peafowl *(Pavo cristatus)* is protected under Schedule 1 of the Indian wildlife protection act 1972 (Amended on 2002) which enables at most protection. Other species Eurasian Collared Dove, Cattle Egret, Common Kestrel, Black Crowned Night Heron, Black Drongo and Pallid Scops Owl are protected under schedule IV of the same act.

Table 14.Bird carcass recorded under Genting turbines during the study.

No	Date	Turbine No	Bird Name	Distance from Turbine (m)	IWPA Schedule
1	30.10.2011	JW 39	Blue Rock Pigeon	21	
2	31.10.2011	JW 33	House Crow	56	V
3	16.12.2011	JW 40	Cattle Egret	25	IV
4	18.12.2011	JW 33	Eurasian Collared Dove	54	IV
5	19.12.2011	JW 06	Unidentified	51	
6	20.12.2011	VW 08	Cattle Egret	19	IV
7	08.10.2012	JW 43	House Crow	14	V
8	09.10.2012	JW 57	Eurasian Collared Dove	2	IV

No	Date	Turbine No	Bird Name	Distance from Turbine (m)	IWPA Schedule
9	26.11.2012	JW 26	Common Kestrel	28	IV
10	29.11.2012	VW 57	Indian Peafowl*	29	I
11	01.12.2012	JW 57	Indian Peafowl*	145	I
12	03.12.2012	JW 31	Indian Peafowl*	98	I
13	03.12.2012	JW 31	Blue Rock Pigeon	19	
14	02.02.2013	JW 39	Blue Rock Pigeon	11	I
15	02.02.2013	JW 46	Unknown raptor	86	
16	04.02.2013	JW 52	Black Crowned Night Heron	30	IV
17	05.02.2013	JW 37	Pallid Scops Owl	10	IV
18	08.02.2013	JW 61	Blue Rock Pigeon	76	
19	16.02.2013	JW 49	Eurasian Collared Dove	23	
20	16.02.2013	JW 44	Raptor	24	I
21	01.12.2013	JW 41	Eurasian Collared Dove	3	IV
22	01.12.2013	JW 39	Eurasian Collared Dove	5	IV
23	01.12.2013	JW 41	Eurasian collared dove	15	IV
24	03.12.2013	JW 03	Black Drongo	35	IV
25	04.12.2013	JW 32	Cattle Egret	15	IV
26	04.12.2013	JW 48	Unidentified	10	
27	04.12.2013	JW 59	Eurasian Collared Dove	3	IV
28	05.12.2013	JW 58	Eurasian Collared Dove	3	IV
29	05.12.2013	JW 60	Unidentified	8	
30	11.12.2013	JW 45	Common kestrel	12	IV
31	11.12.2013	JW 45	Eurasian Collared Dove	16	IV
32	11.12.2013	JW 44	Indian peafowl*	72	I
33	18.01.2013	JW 49	Raptor	19	I
34	19.01.2014	JW 52	Eurasian Collared Dove	15	IV
35	20.01.2014	JW 55	Cattle Egret	21	IV
36	27.04.2014	JW 40	Raptor	89	I
37	28.04.2014	JW 61	Blue Rock Pigeon	44	
38	30.04.2014	JW 52	Unidentified	14	
39	01.05.2014	JW 56	House Crow	23	V

** Peafowl mortalities (04 nos) were caused by electrocution and hence was excluded from the mortality rate estimation caused be collition with turbines*

Table 15. Species-wise bird mortalities recorded

No	Bird Name	Number of individuals	IWPA Schedule	Estimated Collision Risk %
1	Eurasian Collared Dove	10	IV	1.02
2	Blue Rock Pigeon	5	-	93.64
3	Cattle Egret	4	IV	64.93
4	House Crow	3	V	2.87
5	Common Kestrel	2	IV	72.84
6	Black Crowned Night Heron	1	IV	0.00

No	Bird Name	Number of individuals	IWPA Schedule	Estimated Collision Risk %
7	Black Drongo	1	IV	66.67
8	Pallid Scops Owl	1	IV	-
9	Indian Peafowl *	4	I	-
10	Unidentified (Accipitridade)	4	I	-
11	Unidentified	4	-	-

** Mortality due to electrocution at transmission line*.

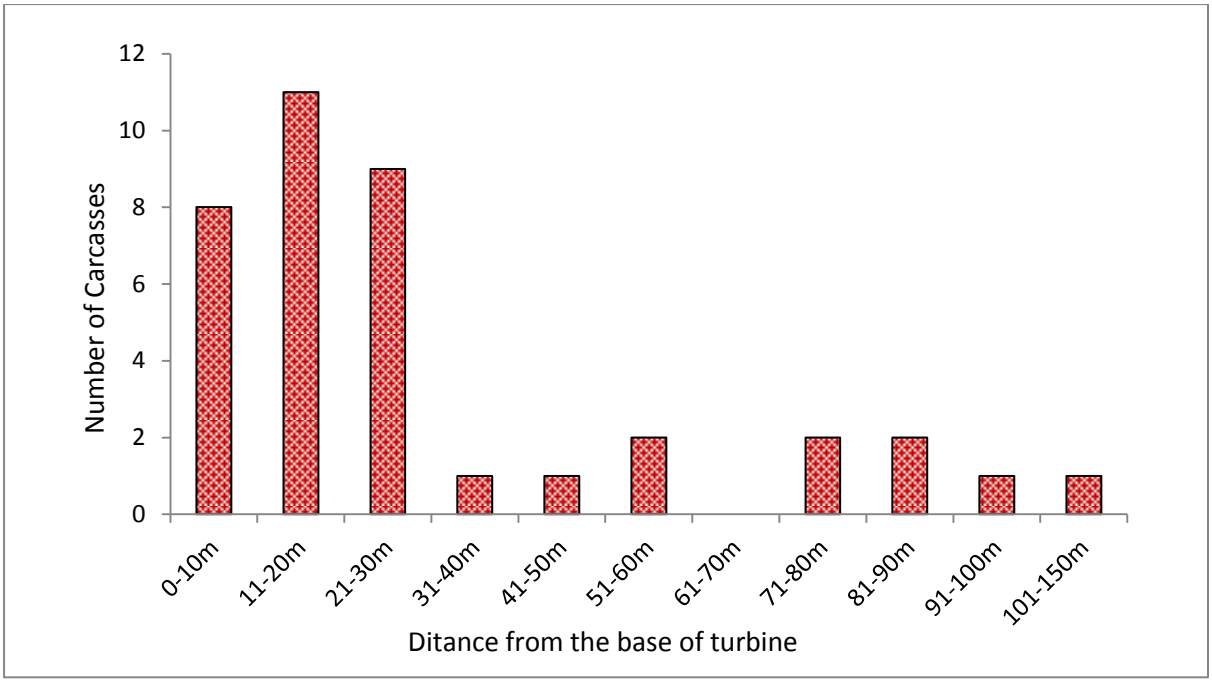


Figure 28 Distance of bird carcasses recorded from the turbine base.

4.8.2 BAT MORTALITIES

During the study period totally 4 bat carcasses was recorded under the turbines. Among that 2 individual were Greater mouse tailed bat and other two carcass could not be identified. All 4 carcasses were found within twenty meter from the base of four different turbines (Table 18, Fig 25).

Table 16. Bat mortalities recorded under Genting turbines during the study period

No.	Date	Turbine	Common name	Distance from the turbine base (m)
1	08.10.2012	JW43	Greater Mouse tailed Bat	3
2	08.10.2012	JW41	Greater Mouse tailed Bat	5
3	02.12.2013	JW31	Unidentified bat	10
4	18.01.2014	JW49	Unidentified bat	20

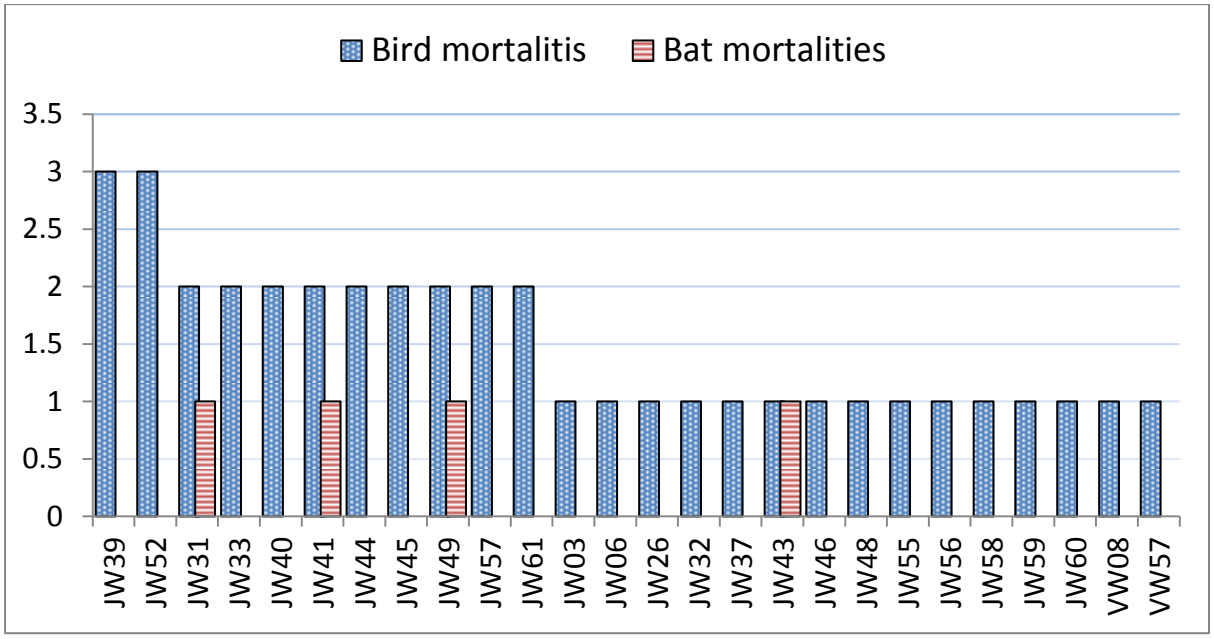


Figure 29 Bird and bat carcasses recorded at various turbine sites

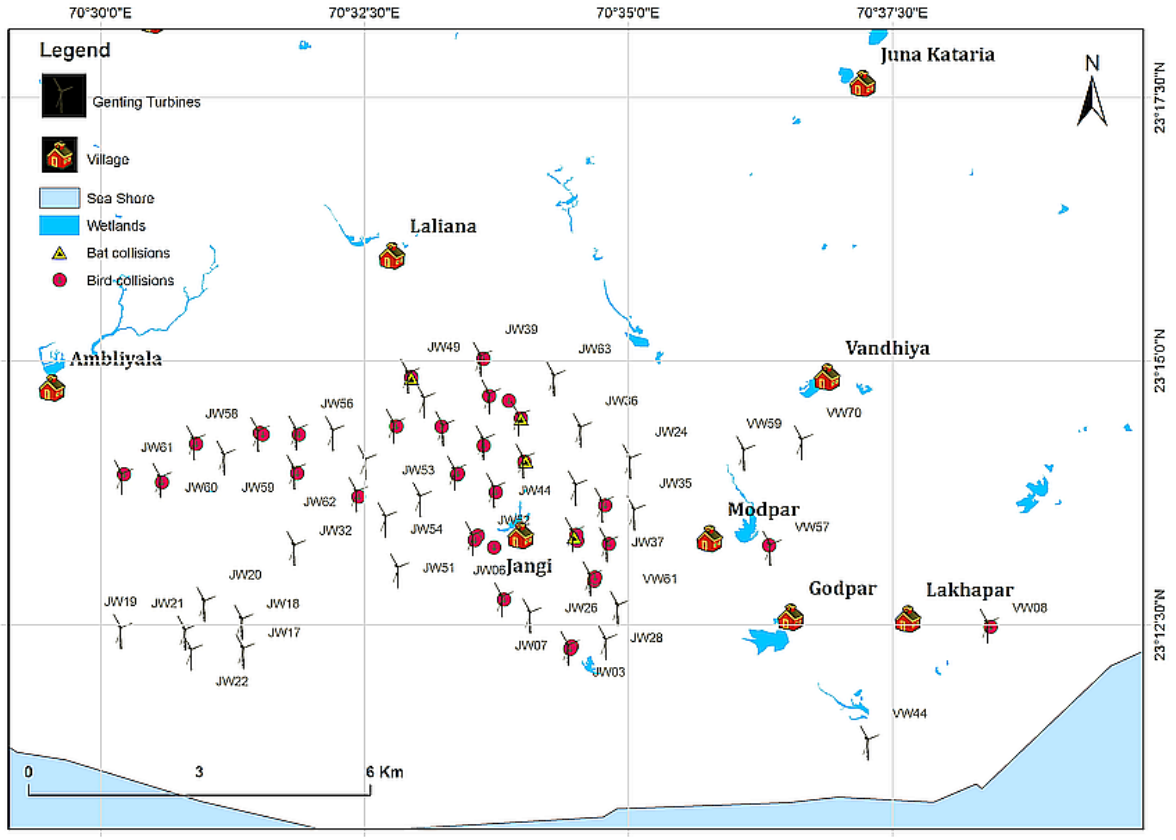


Figure 30. Spatial distribution of bird and bat mortality records

4.8.3 CLIMATIC FACTORS AND BIRD AND BAT COLLISIONS

Analysis revealed that mortalities recorded hasd no correlation with average wind speed and power generation (Figure 31). Wind speed was low (3.9 to 6.0 m/s) in the winter

(October to February) when most of mortalities recorded compared to other moths from March to September (5.0 to 9.8m/s). The power generation also was high in the months when mortalities found (23288 MWh) comparing to other moths (Average: 12414 MWh). There were no mortalities found when the direction was on South East direction. The Average ambient temperature in mortality recorded months was 26ºC while the other months had an average ambient temperature of 29.7ºC. 27 of the mortalities were recorded when the wind direction was on North east or North West and 4 mortalities each in the months with wind direction N-W, N-E , S-W and S-W, N-W (Fig 28).

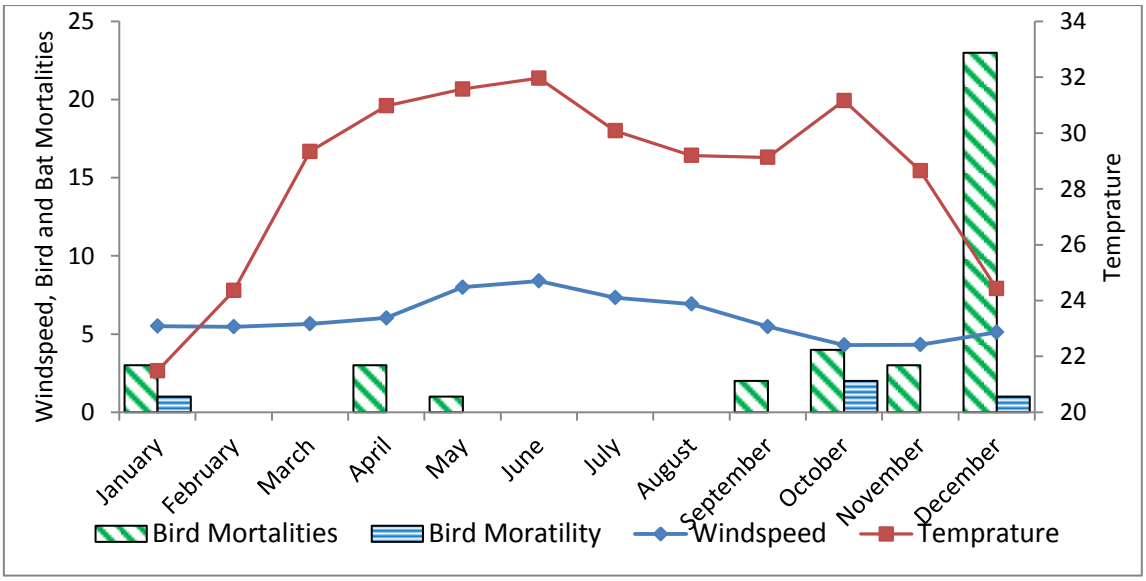


Figure 31. Relation between bird and bat mortality, wind speed and power generation.

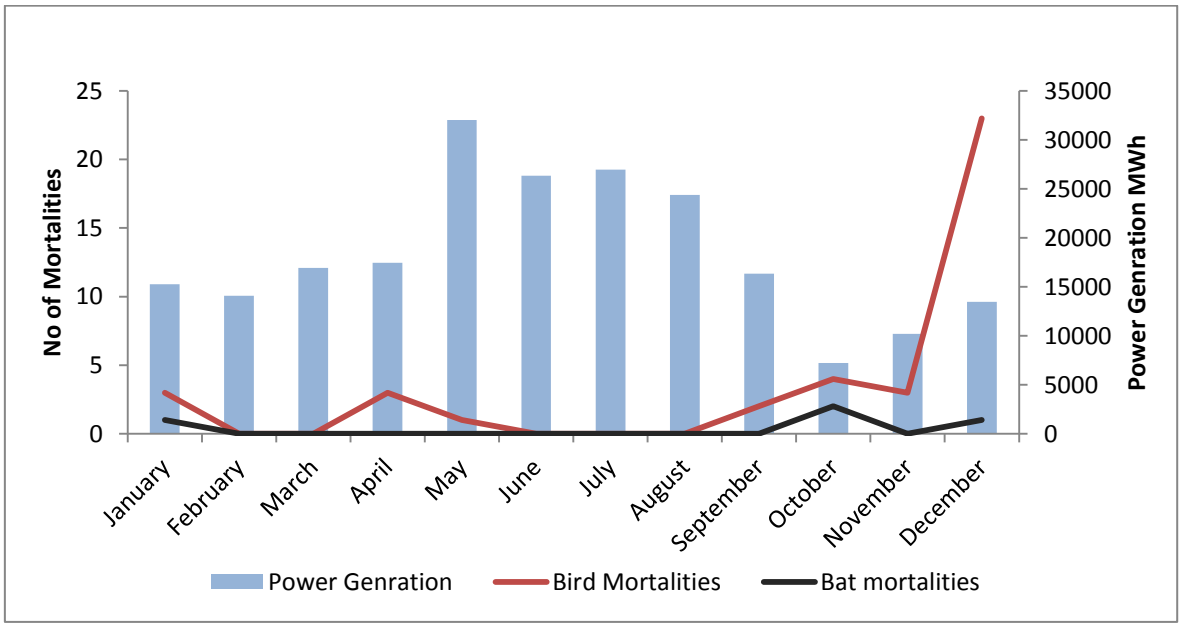


Figure 32 Monthly Power Genration and Bird Mortalities

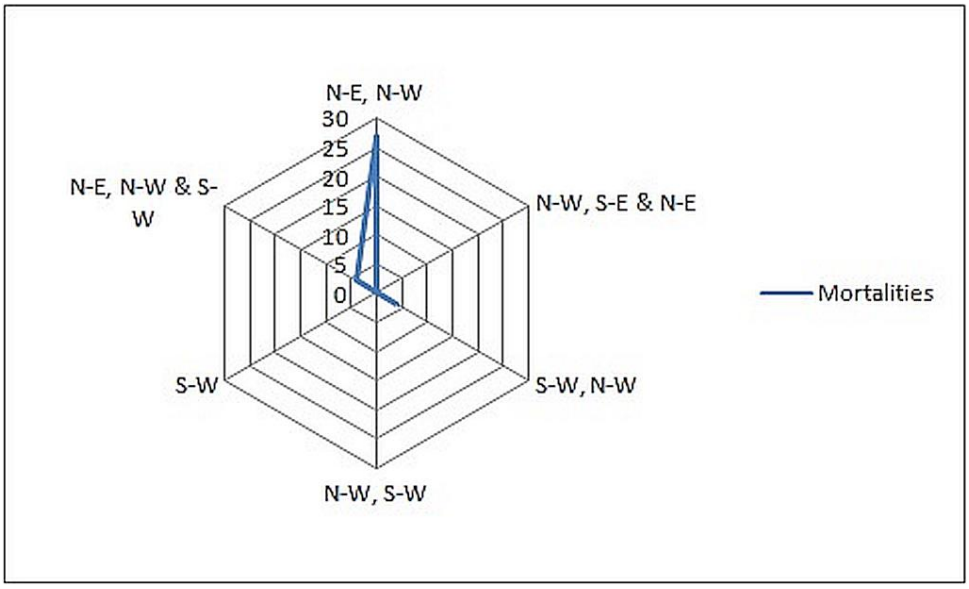


Figure 33 Wind direction and bird mortalities

4.8.4 LAND USE LAND COVER PATTERN AND BIRD COLLISIONS

The land use pattern varried in various season below each turbine within 100 m radius due to natural changes, Agricultural activities, and clearing activities. The landuse also varied in each turbine locations, overall barren area accounted for maximum 53% followed by Grass (24%), Shrub (11%) and Sorghum (6%). (Fig 29 & Fig 30) There was no significant difference between the land use pattern of turbine location with bird collition and without bird collision. However the tubine localities with bird mortality had more grass cover (24.7 %) and less barren land (50.5 %) than the turbine localities without mortalities (Grass cover - 18.37%, barren land - 54.6 %) (Fig 31).

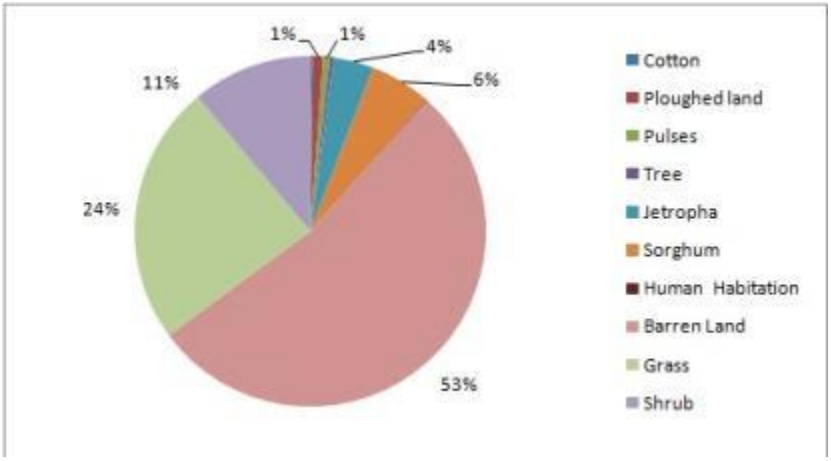


Figure 34.Overall land use pattern in all turbine locations

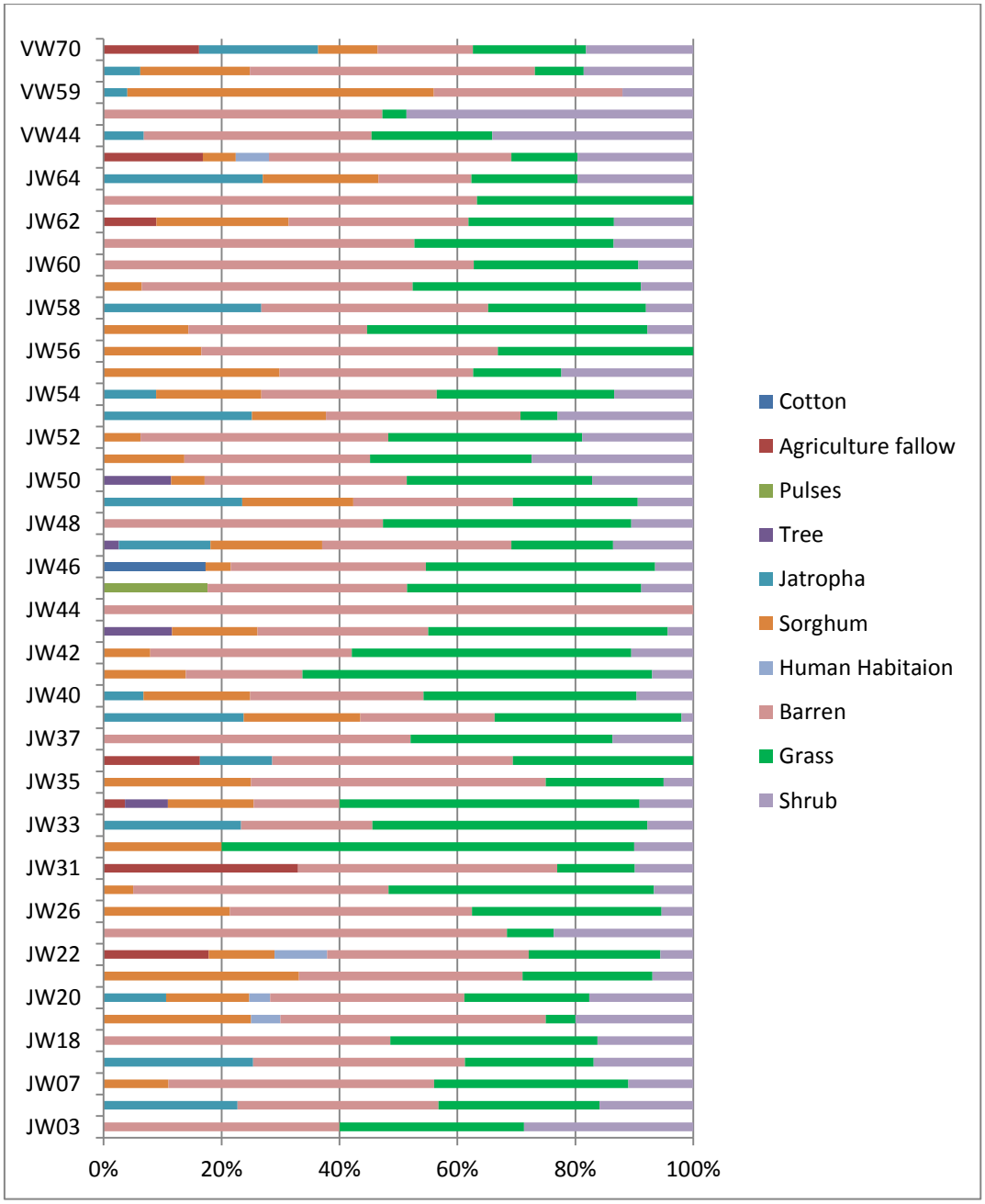


Figure 35. Land use pattern around turbine sites

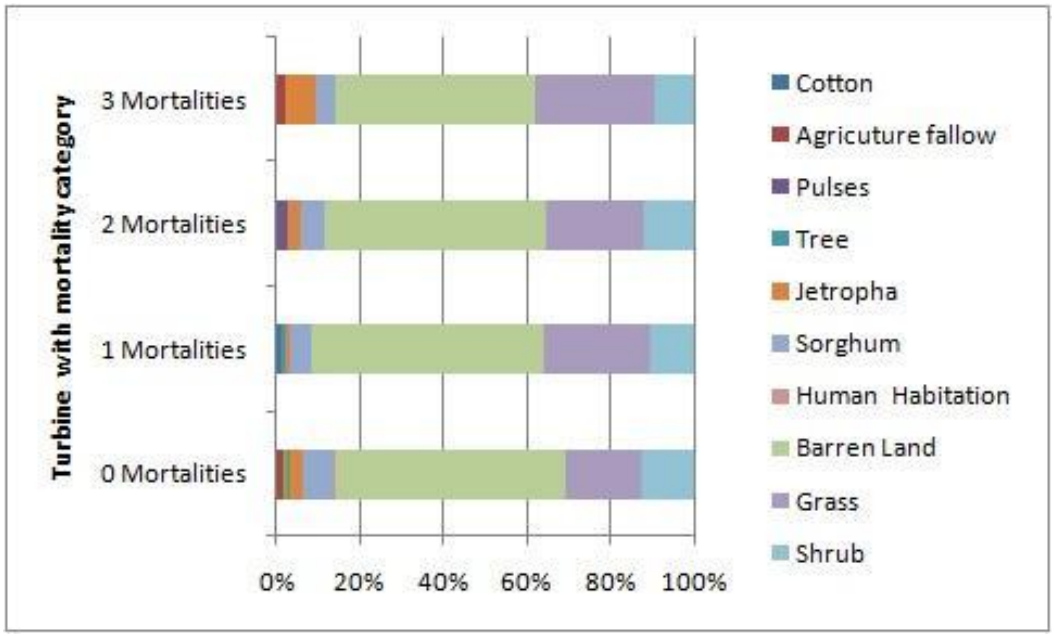


Figure 36.Land use pattern in turbine locations with and without mortalities

4.8.5 MORTALITY RATE ESTIMATION

The recorded mortality (during the carcass searches) of birds from collision with turbines at the Jangi wind farm during the entire study was 35 birds. The actual mortality rate was estimated using standard methods taking into account various factors affecting the detection of carcasses in the field such as removal of carcasses by scavengers.

To determine the average length of time that an avian carcass remains under the turbine before being removed from the study area by scavengers was calculated using standard methods. During the mortality surveys 10 bird carcasses were left in the field for the scavenger removal bias test. The length of time each individual carcass remained on the plot before being removed by scavenger was calculated as the number of days between the time the carcass was planted and the last search date it was observed. The mean length of time a carcass remained on a plot (T) was calculated based on the following equation Erickson et al, 2003.

$T = \sum ti / S$

Where ti is the length of time a carcass remained on site, S is the total number of carcasses planted for the study.

Here, T= 242/10 =24.2 days

The estimated number of total mortalities (m) during the study period was calculated using the following formula from Jhonson et al. (2003)

M= N x I x C / k x t x e

where **N** is the total number of turbines , **I** is the interval between searches in days, **C** is the total number of carcasses found **k** is the number of turbines sampled, **t** is the mean length of time carcasses remained on site before being scavenged, and **e** searcher efficiency

Estimated Total Bird Mortality from the farm for 3 years
(=(51 x 40 x 35) / (51 x 24 x 1) = 58.33
Estimated Annual Bird Mortality rate in the wind farm
(= 58.33/3) = 19.44 birds
∴ **Mean Annual Bird Mortality per turbine**
(= 19.44/51) = **0.38** birds/ turbine/ year

Similarly estimation of bat mortalities were also calculated using the same formula Erickson et al, 2003 and Jhonson et al. (2003)

Estimated Total Bat Mortality from the farm for 3 years
(=(51 x 40 x 4) / (51 x 3.75 x 1) = 42.66 Bats
Estimated Annual Bat Mortality rate in the wind farm
(= 42.66/ 3) = 14.22 Bats/ year
∴ **Mean Annual Bat Mortality estimate per turbine**
(= 14.22/ 51) = **0.28** Bats/turbine/year

5 DISCUSSION

The development of wind-energy is a vital component of the India-wide objective to increase the proportion of energy derived from renewable sources, thus helping to reduce the emission of greenhouse gases. However, considering the current pace and scale of wind power development proposals, the impacts on environment is a cause for concern and hence there is a pressing need for more information on the range of potential impacts of wind farms, from across landscapes and seasons. There are many studies from various parts of the world indicating that the wind farms can potentially have serious adverse effect on the environment and wildlife such especially through habitat disturbances, changing flight behavior of birds and most importantly causing mortality of birds and bats (Arnett *et al*. 2005; Jain 2005; Keil 2005; Kinglsley & Whittam 2005; Drewitt *et al*. 2006; Barclay *et al*. 2007). However there is very little documentation on the impacts of windfarms on birds from other parts of India (Pande et al, 2013).

The Jangi wind power project is located in an environmentally less sensitive area with no major forest or wildlife area involved. The present study reports the presence of diverse bird fauna that include several species of conservation importance. The high avian species-richness recorded is attributable to the presence of diverse habitat types and also to the closeness of the region to the Western edge of the Central Asian migratory flyway of birds. Although studies elsewhere have reported that birds especially migratory species do not prefer wind turbine sites (Villegas-Patraca 2012), around 70 migratory bird species were recorded in the present study area. Few species such as Black redstart, Blue throat, Booted warbler, Brahminy starling, Dusky craig Martin, Greater Coucal and Yellow throated sparrow were the only species found absent in the wind farm area compared to the control sites.

The wetlands in wind turbine sites supported relatively higher number of birds (48,588 individuals) than comparable area of control site wetlands (41,808 individuals). The wetlands of both turbine and control sites supported 82 species of birds each. However, species such as Black-necked Stork, Pacific Golden Plover, Whimbrel, Heuglin's Gull and Pallas's Gull were recorded only in the wetland of the turbine sites, while species such as Greater Scaup, Sarus Crane, Sanderling, Curlew Sandpiper and Citrine Wagtail were

recorded only in the wetland of the turbine sites. Overall, waterfowl were the dominant avifaunal group in the wetlands of turbine sites (31.5%), but in non-turbine sites wading birds (51.6%) was the dominant group.

The results suggest that wetland birds do not actively avoid the wetlands within the wind turbine sites. However, abundance of individual species differed between wetlands of turbine and non-turbine sites. For example, the Demoiselle Crane was most abundant species in both sites, but the abundance varied from wetland to wetland. Other than wind turbines, several factors such as wetland size, water availability, landscape structure, physico-chemical parameters of water, prey availability and migratory season may also influence the wetland birds distribution. The findings indicate that wetlands within wind turbine sites still have conservation value since diverse avifauna including threatened species were found to be using these wetlands.

Nesting pattern of birds varied between control and turbine site. The control site had more nests than turbine site. No nests of Globally threatened birds (IUCN Redlist) were found except for the precnce of near threatened Eurssian spoonbill nests in the turbine site. Most of the Raptors recorded in the study area are winter visitors, and only two nests of Raptors (Shikra) were located during studyperiod. Birds like Indian Robin, Red vented bulbul were found nesting very close (2 to 10 m) to the wind turbines. The results indicated that Common birds such as House crow, House Sparrow, Blue Rock Pegion, Black Ibis preferred non-turbine sites (control sites) for nesting, but there were no such significant preference for species of conservational importance. The results indicated that birds generlly tend to avoid turbine sites (wind farm area) for nesting purpose.

Although 173 species of birds recorded in the area, only 28% (49 species) of birds were found flying in the collision risk zone area of turbines. Bird species namely Common Tern, Greater flamingo, Short-toed snake eagle, White eared bulbul, Booted eagle, Common buzzard, Oriental white ibis, Black necked stork, Grey heron, Oriental honey buzzard, Common sandpiper, Greater spotted eagle and Montegu's Harrier, Spot billed duck, Shikra, Black ibis, White eyed buzzard, Glossy ibis, Common kestrel, Huglen's Gull, Eurasian spoon bill, Blue rock pigeon, Cattle egret, House crow, Western reef egret, Pond heron, River tern, Red wattled lapwing, Black shouldered kite, Eurasian collared dove and Northern pintail had used the collition risk zone for their flight activities for maximum compared to other species.

In general, raptors, doves and some waterbirds had maximum chance of collisions where as passerines had very little probability of colliding with the turbine.

The estimated mean annual mortality rates per turbine at the Genting wind farm at Jangi was 0.38 for birds and 0.28 for bats. This is a very low mortality rate when compared with the reports from wind farms in various other parts of the world (Pedersen & Poulsen 1991; Muster *et al*. 1996; Howe *et al*. 2002; Everaert & Stienen 2007;Fiedler *et al*. 2007). For instance, the mean number of collision fatalities reported in different European wind farms varies between a few birds per turbine per year up to 64 birds per turbine per year (Langston & Pullan 2003).

Only single fruit bat colony with small population was recorded in the control site and no evidence of fruit bat mortalities caused by collition with turbines were recorded during the study period. Noctornal bat activity survey revealved that bat activity was comparatively less in turbine site than the non-turbine control sites, indicating possible avoidance of turbine site by bats. Only four instances of bat mortalities were recorded during the study period with an estimated bat mortality rate of 0.28 bats/ turbine/year which is very low. However, the low number of bat carcasses used for the scavenger removal rate tests (because of unavailability of bat carcasses for the test) might have slightly affected the accuracy of mortality rate estimations. Overall, the bat activities in the study area was low and there is no singnificant mortality risk from wind turbines to the bat population in the present context of Jangi wind farm.

6 RECOMMENDATIONS

Though it appears that there is only minimal impact on the avifauna and bats from the wind turbines based on the observations and estimates during the present study, following precautionary measures are recommended for further minimizing the chance of avian mortality in the wind farm.

- Switching off the lights below the turbines whenever not required at night to avoid attracting the insects and associated nocturnal birds and bats to the turbines
- Ensuring proper Insulation of electrical installations such as junctions on electric posts and transformers in order to avoid electrocution since many of the birds use these as perching sites.
- Further installation of turbines may be avoided in the area within 1 km radius of wetlands to further minimize the collision risk especially for migratory avifauna.
- Measures may be taken to create awareness among the villages in and around turbine site such as Jangi, Modpar, Godpar and Vandhiya for careful burial of the cattle carcasses to avoid the attraction of scavenging birds such as vultures into the turbine area.
- A participatory approach towards advocating and popularizing various measures in the human habitations located in and around the wind farm areas mainly for discouraging the feeding of pigeons and other human associated avifaunal species may be adopted. This can help minimize bird collision risk directly at the turbines, and also indirectly through avoiding the raptors getting attracted to the area.
- Vehicle movements in the turbine sites may be reduced and appropriately managed to minimize disturbances and road mortalities
- Seasonal bird counts and regular avifaunal mortality recordings following standard protocols (as followed during the present study) may be done on a long-term basis to understand the changes in the wind farm bird assemblages and their response to the wind farm operations in the long run.

7 REFERENCES

Ali, S. & S.D. Ripley (1969). Handbook of The Birds of India and Pakistan Together With Those of Bangladesh, Nepal, Bhutan and Sri Lanka—Volume 3. Oxford University Press, New Delhi.

Anderson, R., M.L. Morrison, K. Sinclair & D. Strickland (1999). Studying wind energy/bird interactions: a guidance document. National Wind Coordinating Committee. Washington, D.C., USA.

Arnett, E., W. Erickson, J. Kerns & J. Horn (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An assessment of fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Final Report.Bats and Wind Energy Cooperative.

Barclay, R.M.R., E.F. Baerwald & J.C. Gruver (2007). Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. *Canadian Journal of Zoology* 85:381-387.

Barlow, K. (1999). Expedition Field Techniques: BATS. Published by the Expedition Advisory Centre, Royal Geographical Society, and London.p. 69.

Bernardino , R Bispo , H Costa & M Mascarenhas (2013): Estimating bird and bat fatality at wind farms: a practical overview of estimators, their assumptions and limitations , New Zealand Journal of Zoology, 40:1, 63-74

Christensen, T.K., I. Clausager & I.K. Petersen (2003). Base-line investigations of birds in relation to an offshore wind farm at Horns Rev, and results from the year of construction. Report to National Environmental Research Institute. Roskilde, Denmark.

Cryan, P.M. & R.M.R. Barclay (2009). Causes of Bat Fatalities at Wind Turbines: Hypotheses and Predictions. *Journal of Mammalogy* 90(6): 1330-1340.

de Lucas, M., G. Janss & M. Ferrer (2004). The effects of a wind farm on birds in a migration point: the Strait of Gibraltar. *Biodiversity Conservation* 13:395-407.

Drewitt, A.L. & R.H.W. Langston (2006). Assessing the impacts of wind farms on birds.*Ibis* 148:29-42.

Drewitt, A.L. & R.H.W. Langston (2008). Collision effects of wind-power generators and other obstacles on birds. *Annals of New York Academy Sciences* 1134: 223-266.

Erickson ,W.P., Johnson, G. D, Strickland, M.D. &Kronner, K. (2000). Avian and bat mortality associated with the Vansycle wind project, Umatilla County, Oregon: 1999 study year. Technical report prepared by WEST Inc. for Umatilla County Department of Resource Services and Development, Pendleton, OR. 25 p.

Erickson, W. P., J. Jeffrey, K. Kronner, and K. Bay.(2003). Stateline Wind Project wildlife

monitoring annual report, results for the period July 2001 – December 2002. Technical report submitted to FPL Energy, Oregon Office of Energy, and the Stateline Technical Advisory Committee. Western EcoSystems Technology, Cheyenne, WY.

Erickson, W.P., G.D. Johnson & D.P. Young (2005).A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions.USDA Forest Service General Technical Report PSW-GTR-191, Washington, D.C., USA.

Erickson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, K.J. Sernka & R.E. Good (2001). Avian collisions with wind turbines: a summary of existing studies and comparisons to other sources of avian collision mortality in the United States. National Wind Coordinating Committee Resource document.62 pp.

Everaert, J. & E.W.M. Stienen (2007). Impact of wind turbines on birds in Zeebrugge (Belgium).*Biodiversity Conservation* 16: 3345-3359.

Farfán, M.A., J.M. Vargas & J. Duarte (2009). What is the impact of wind farms on birds: A case study in southern Spain? *Biodiversity Conservation* 18: 3743-3758.

Fiedler, J.K., T.H. Henry, R.D. Tankersley & C.P. Nicholson (2007). Results of bat and bird mortality monitoring at the expanded Buffalo Mountain Wind farm, 2005. Tennessee Valley Authority, Knoxville, Tennessee, USA.

Fuller, S., J. McLennan, J. Dowding, L. Barea & J. Craig (2009). Assessment of potential avian mortality at the proposed Taharoa Wind Farm, Taharoa Beach, Kawhia,

Waikato.Unpublished report to The Proprietors of Taharoa C, Department of Conservation and Waitomo District Council.

GAO. (2005). US Government Accountability Office, Wind power: Impacts on wildlife and government responsibilities for regulating development and protecting wildlife. Washington, DC: US Government Accountability Office, Report GAO-05-906.

Gaston, A.J. (1975). Estimating bird population.*Journal of the Bombay Natural History Society* 72: 271-283.

Gipe, P. (1995). Wind energy comes of age. John Wiley & Sons, Inc., NY.

Graham, T.L. & P.F. Hudak (2011). Potential Hazards of Wind Energy for Rare, Tereatened, and Endangered Birds and Batsin Texas. *International Journal of Environmental Research* 5(4): 917-922.

Grimmett, R., C. Inskipp & T. Inskipp (1998). Birds of Indian Subcontinent.Oxford University press, New Delhi, 384pp

Hoover, S.I. & M.L.Morrison (2005).Behavior of Red-tailed Hawks in a wind turbine development.*Journal of Wildlife Management* 69:150-159.

Howe, R.W., W. Evans & A.T. Wolf (2002). Effects of wind turbines on birds and bats in northeastern Wisconsin.University of Wisconsin-Green Bay, Green Bay, USA.

Huso, M (2010). An estimator of wildlife fatality from observed carcasses. Environmetrics 22: 318329.

Jain, A., Kerlinger, P., Curry, R., Slobodnik, L. (2007). Annual report for the Maple Ridge wind power project: post-construction bird and bat fatality study*2006. Final report.Syracuse, New York, Curry & Kerlinger, LLC. 53 p

Jain, A.A. (2005). Bird and bat behavior and mortality at a northern Iowa wind farm. Ph.D. Thesis. Iowa State University, Ames, Iowa, USA.

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepard, D. A. Shepard. & S. A. Sarappo. (2003). Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. Amer. Midl. Nat. 150:332-342.

Keil, M. & K.A. Motter (2005). The effects of wind farms on birds: a review. Technical report.Biology, Ecosystem Science and Management Program, University of Northern British Columbia, Prince George, B.C., Canada.

Kerns, J., Erickson W.P. &Arnett E.B (2005). Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. In: Arnett EB ed. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioural interactions with wind turbines. Final report submitted to the Bats and Wind Energy Cooperative. Austin, TX, Bat Conservation International. Pp. 2495

Kerlinger, P. (2001). Avian mortality study at the Green Mountain Windpower Project, Garrett, Somerset County, Pennsylvania - 2000-2001. Report to National Wind Power, McLean, VA, USA.

Kingsley, A. & B. Whittam (2005). Wind turbines and birds. A background review for environmental assessment. Environment Canada, Canadian Wildlife Service, Quebec.

Korner-Nievergelt, F., Korner-Nievergelt, P., Behr, O., Niermann, I., Brinkmann, R. & Hellriegel, B.(2011). A new method to determine bird and bat fatality at wind energy turbines from carcass searches. Wildlife Biology 17: 350363.

Langston, R.H.W. & J.D. Pullan (2002). Windfarms and Birds: An analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues. BirdLife Report, 37pp.

Langston, R.H.W. & J.D. Pullan (2003). Wind farms and birds: an analysis of the effects of wind farm on birds, and guidance on environmental assessment criteria and site selection issues. Report written by Birdlife International on behalf of the Bern Convention. Council Europe Report T, PVS/inf.

Leddy, K.L., K.F. Higgins & D.E. Naugle (1999). Effects of Wind Turbines on Upland Nesting Birds in Conservation Reserve Program Grasslands.*Wilson Bulletin* 111: 100-104.

Lekuona, J.M. & C. Ursua (2007). Avian mortality in wind power plants of Navarra (Northern Spain).*In*: de Lucas, M., Janss, G.F.E., Ferrer, M. (Eds.), Birds and Wind Farms. Quercus, Madrid.

Madders, M. & D.P. Whitfield (2006). Upland raptors and the assessment of wind farm impacts. *Ibis* 148:43-56.

Manville, A.M. (2009). Towers, turbines, power lines, and buildings – steps being taken by the U.S. Fish and Wildlife Service to avoid or minimize take of migratory birds at these structures. *In:* C.J. Ralph and T.D. Rich (eds). Proceedings 4th International Partners in Flight Conference, February 2008, McAllen, TX.

McLeish, T. (2002). Wind power. *Natural New England* 11:60-65.

Miller, A. (2008). Patterns of avian and bat mortality at a utility scaled wind farm on the southern high plains. Master Degree Thesis. Texas Tech University.

Naroj Rishad (2006) Birds of Prey of Indian Subcontinent **.**

NRC.(2007). National Research Council Environmental impacts of wind-energy projects. Washington, DC: National Academies Press.

Orloff, S. & A. Flannery (1992). Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas. Work performed by BioSystems Analysis, Inc., Tiburon, CA. Sacramento, CA: California Energy Commission.

Osborn, R.G., K.F. Higgins, R.E. Usgaard, C.D. Dieter & R.G. Neiger (2000). Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. *American Midland Naturalist* 143: 41-52.

Pande, S., A. Padhye, P. Deshpande, A. Ponkshe, P. Pandit, A. Pawashe, S. Pednekar, R. Pandit & P. Deshpande (2013). Avian collision threat assessment at 'Bhambarwadi Wind Farm Plateau' in northern Western Ghats, India. Journal of Threatened Taxa 5(1): 3504–3515

Pasqualetti, M., R. Richter & P. Gipe.(2004). History of wind energy.*In*: C. L. Cleveland (ed.). Encyclopedia of energy.Volume 6.Elsevier, New York, New York, USA. Pp. 419-433.

Pedersen, M.B. & E. Poulsen (1991). Impact of a 90m/2MW wind turbine on birds: Avian responses to the implementation of the Tjaereborg wind turbine at the Danish Wadden Sea. Danske Vildtundersøgelser Hæfte, Denmarks.

Percival, S.M. (2000). Birds and wind turbines in Britain. *Britain Wildlife* 12:8-15.

Percival, S.M. (2003). Birds and wind farms in Ireland: A review of potential Issues and Impact Assessment. Durham, UK.

Pettersson, J. & T. Stalin (2003). Influence of offshore windmills on migration birds in southeast coast of Sweden. Report to GE Wind Energy.

Phillips, J.F. (1994). The effects of a wind farm on upland breeding bird communities of Bryn Tytli, Mid Wales. 1993-1994. RSPB report to National Wind power Ltd.

Powlesland, R.G. (2009). Impacts of wind farms on birds: a review. Department of Conservation, Wellington, New Zealand.

Redlinger, R.Y., P.D. Andersen & P.E. Morthorst (2002). Wind Energy in the 21st Century: Economics, Policy, Technology and the Changing Electricity Industry. Palgrave Publishers, Basingstoke.

Shah, N., Bonny, P. and Goyal, S. P. (1995) Avifauna of Wild Ass Sanctuary, Gujarat. Pavo 33: 135-144.

Sharp, A. (2010). Briefing note on the effects of wind farms on bird and bat populations. Department of Environment and Heritage, Govt. of South Australia.

Shoenfeld, P.(2004). Suggestions regarding avian mortality extrapolation. Technical memo provided to FPL Energy. Davis, WV, West Virginia Highlands Conservancy.6 p.

Sovacool, B.K. (2009). Contextualizing avian mortality: A preliminary appraisal of bird and bat fatalities from wind, fossil-fuel, and nuclear electricity. Energy Policy 37: 2241-2248.

Thelander, C.G. & K.S. Smallwood (2007). The Altamont Pass wind resource area's effect on birds: a case history. *In*: de Lucas, M., Janss, G.F.E., Ferrer, M. (Eds.), Birds and Wind Farms. Quercus, Madrid.

Tingley, M.W. (2003). Effects of Offshore Wind Farms on Birds: "Cuisinarts of the Sky" or Just Tilting At Windmills? Bachelor Thesis, Harvard University, Cambridge, Massachusetts.

Villegas-Patraca, Rafael, Ian Macgregor-Fors , Teresa Ortiz-Martínez Clara E. Pérez-Sánchez , Leonel Herrera-Alsina , and Carlos Muñoz-Robles (2012) Bird-Community Shifts in Relation To Wind Farms: A Case Study Comparing a Wind Farm, Croplands, and Secondary Forests in Southern Mexico. The Condor, 114(4):711-719.

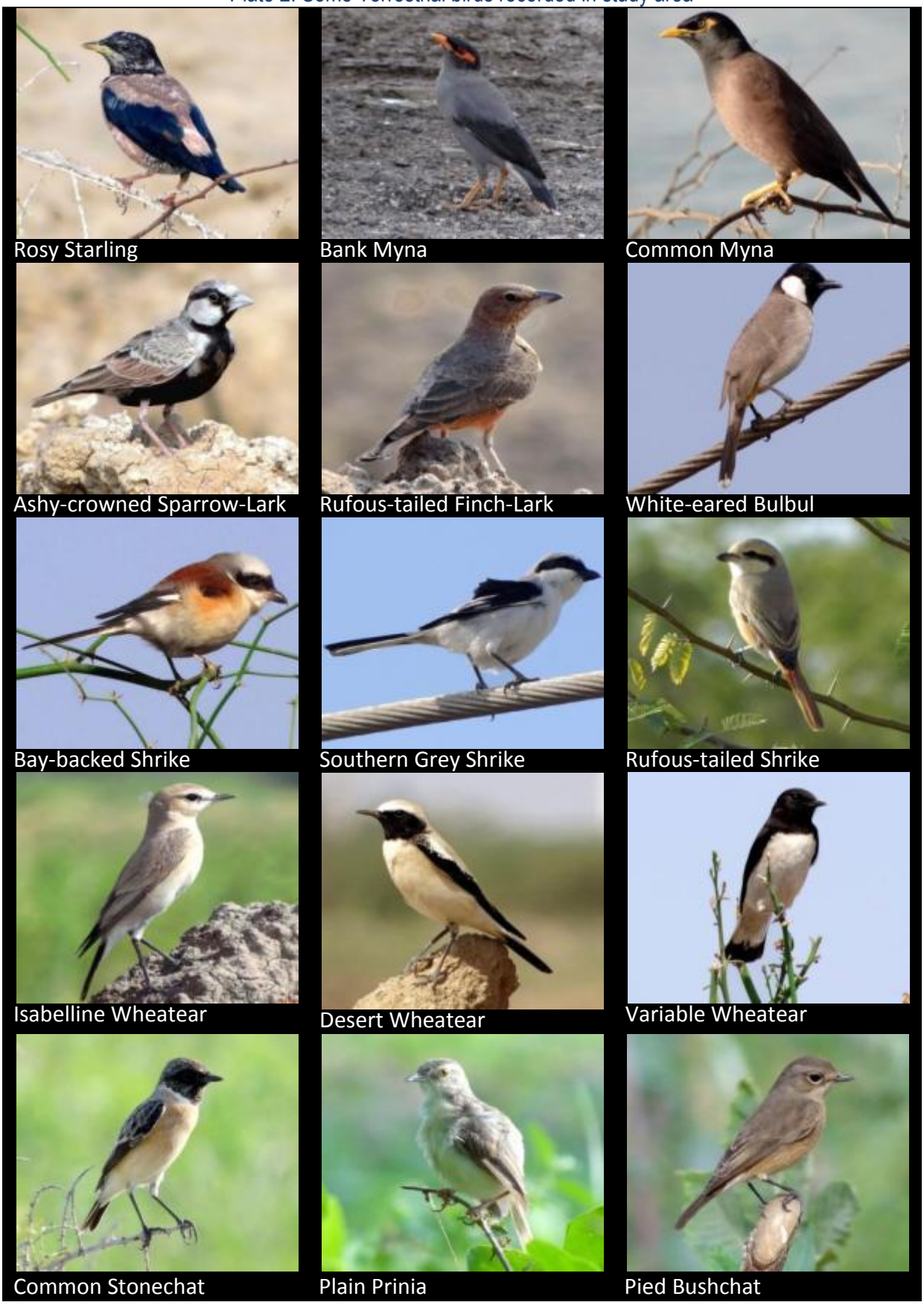
Walker, D., M. McGrady, A. McCluskie, M. Madders & D.R.A. McLeod (2005). Resident Golden Eagle ranging behaviour before and after construction of a wind farm in Argyll. *Scotland Birds* 25:24–40.

WWEA (World Wind Energy Association) (2014). World wind energy report 2014. Bonn, Germany, WWEA Head Office.

PLATES

Plate 1.View of wind turbines located in different landuse types

Plate 2. Some Terrestrial birds recorded in study area




White-throated Munia

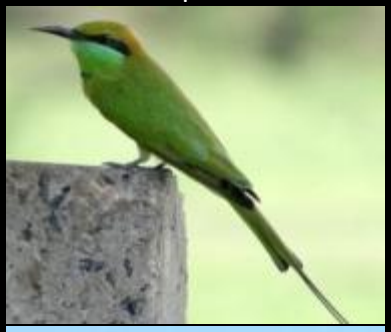

Streaked Weaver


Purple Sunbird


Common Hoopoe


Black Drongo


Crested Lark




Indian Roller


European Roller


Common Babbler


Eurasian Collared-Dove


Little Brown Dove


Rose-ringed Parakeet

Plate 3 Some Raptors recorded in the study area

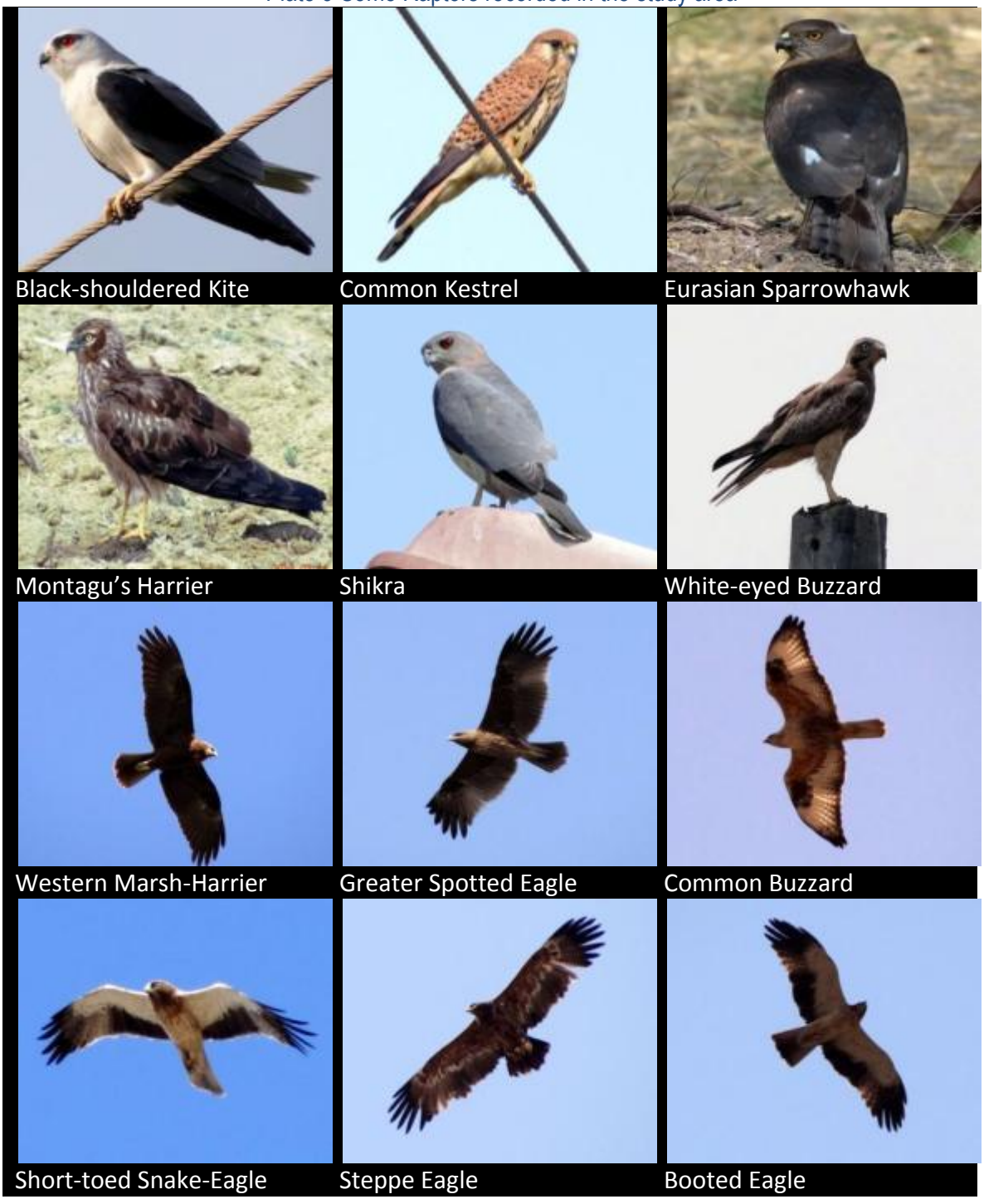


Plate 4 Some Wetland birds recorded from the area

Plate 5 Some bird and bat mortalities recorded at the wind farm

Blue Rock Pegion

Cattle Egret

Pallid Scops Owl

Eurasian Collared Dove

Greater Mouse Tail Bat

Common Kestrel

APPENDICES

Appendix 1. List of wetlands recorded in the study area

S. No	Area	Latitude (N)	Longitude (E)	Wetland category	Wetland type	Size (ha)
1	Jangi	23°13'27.36"	70°33'56.71"	Lake	Permanent	10.42
2	Jangi	23°13'31.52"	70°34'3.56"	Pond	Permanent	0.56
3	Jangi	23°13'23.40"	70°33'49.13"	Pond	Temporary	0.79
4	Jangi	23°13'23.40"	70°33'49.13"	Pond	Permanent	0.62
5	Bachau	23°14'9.84"	70°21'56.23"	Lake	Temporary	12.37
6	Bachau	23°16'42.43"	70°20'09.63"	Pond	Temporary	2.35
7	Bachau	23°17'16.57"	70°20'11.67"	Pond	Permanent	1.51
8	Surajbari	23°14'23.57"	70°40'21.48"	Lake	Permanent	9.08
9	Surajbari	23°13'53.47"	70°40'21.49"	Pond	Temporary	3.11
10	Shikarpur	23°14'27.23"	70°42'59.92"	Pond	Temporary	7.62
11	Shikarpur	23°14'32.28"	70°43'16.55"	Pond	Temporary	2.07
12	Vandhiya	23°14'38.23"	70°39'21.84"	Pond	Temporary	4.28
13	Vandhiya	23°14'45.47"	70°39'46.38"	Pond	Temporary	1.77
14	Vandhiya	23°13'03.97"	70°38'14.13"	Pond	Temporary	3.54
15	Vandhiya	23°13'18.34"	70°37'52.11"	Pond	Temporary	3.1
16	Vandhiya	23°13'59.55"	70°37'12.53"	Lake	Permanent	9.35
17	Lakhdhirgadh	23°11'50.55"	70°37'09.62"	Pond	Permanent	4.07
18	Lakhdhirgadh	23°11'42.66"	70°37'14.49"	Lake	Temporary	14.63
19	Lakhdhirgadh	23°12'10.48"	70°37'47.38"	Lake	Temporary	10.25
20	Modpar	23°13'18.93"	70°36'05.64"	Lake	Permanent	11.39
21	Modpar	23°13'22.33"	70°36'01.68"	Pond	Temporary	2.14
22	Modpar	23°12'59.10"	70°36'05.39"	Pond	Temporary	3.44
23	Lakhapar	23°12'15.40"	70°36'15.16"	Pond	Permanent	4.04
24	Ambliala	23°14'55.96"	70°29'33.83"	Lake	Permanent	9.15
25	Nava Katariya	23°16'53.92"	70°34'37.74"	Pond	Permanent	1.14
26	Nava Katariya	23°16'51.28"	70°34'27.19"	Pond	Temporary	0.84
27	Nava Katariya	23°17'21.48"	70°34'38.54"	Pond	Temporary	0.31
28	Nava Katariya	23°15'10.02"	70°35'10.57"	Lake	Temporary	8.81
29	Naransari	23°15'26.70"	70°40'10.84"	Pond	Temporary	2.43
30	Naransari	23°16'03.67"	70°43'35.43"	Pond	Temporary	1.62
31	Naransari	23°16'28.41"	70°43'06.38"	Pond	Temporary	0.95
32	Naransari	23°16'21.55"	70°44'17.44"	Pond	Temporary	1.02
33	Manaba	23°16'59.74"	70°44'42.07"	Pond	Permanent	2.17
34	Manaba	23°16'53.27"	70°45'36.47"	Pond	Temporary	0.73
35	Manaba	23°16'50.80"	70°45'53.31"	Pond	Temporary	1.32
36	Samakhiali	23°18'26.33"	70°30'23.64"	Lake	Permanent	9.84
37	Samakhiali	23°18'34.25"	70°30'25.60"	Pond	Permanent	1.36
38	Samakhiali	23°18'40.04"	70°31'09.33"	Pond	Permanent	0.77

39	Samakhiali	23°18'44.86"	70°31'18.55"	Pond	Permanent	1.28
40	Chhadavada	23°16'36.13"	70°27'08.29"	Lake	Permanent	12.06
41	Chhadavada	23°15'01.65"	70°25'43.37"	Pond	Temporary	2.4
42	Vondh	23°17'09.91"	70°23'40.20"	Lake	Permanent	8.68
43	Vondh	23°16'50.45"	70°24'27.52"	Pond	Permanent	6.26
44	Ram Dev Peer	23°18'15.03"	70°26'22.93"	Pond	Permanent	1.29
45	Ram Dev Peer	23°18'15.80"	70°26'28.40"	Pond	Temporary	0.25
46	Juna Katariya	23°17'16.44"	70°36'36.69"	Pond	Temporary	2.21
47	Juna Katariya	23°17'44.53"	70°37'05.95"	Lake	Temporary	9.66
48	Laliana	23°16'6.57"	70°32'26.62"	Lake	Permanent	10.51

Appendix 2.Standardized data sheet used for avifaunal survey

Date	Start	End	Observer	Transect	Sky	Notes

S. No.	Species	No. of birds	Angular distance (m)	Behavior	Notes

Appendix 3.Standardized data sheet used for bat roost-site survey

S. No.	Species	Location of roosting site	Lat. & Lon.	Roost-site (if tree, species name)	Estimated population	Surrounding ecosystem

Appendix 4. Standardized data form used for investigation of bird and bat mortality

Date	Start	End	Observer	Temp.	Wind	Sky	Notes

S. No.	Species	Sex	Age	Tower	Direction	Distance	Time	Substrate	GPS

Physical Condition at time of find: **Complete / Partial / Feather Spot**

Describe injuries:

Scavenging: **Yes / No**

Possible Scavengers:

Carcass Condition: **Fresh / Decomposing – early / Decomposing – late / Desiccated**

Eyes: **Round/fluid filled / Dehydrated / Sunken / Empty**

Estimated time of death: **Last night / 2 – 3 days / 4– 7 days / 7 – 14 days / > 2 weeks / > month**

Photo ID No.:

Additional Notes:

Appendix 5. List of avifuana recorded in the study area.

No	Family	Common Name	*Scientific Name*	IUCN	Migratory Status	IWPA
1	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	LC	R	IV
2	Podicipedidae	Great-crested Grebe	*Podiceps cristatus*	LC	WM	IV
3	Pelecanidae	Dalmatian Pelican	*Pelecanus crispus*	VU	LM	IV
4	Phalacrocoracidae	Little Cormorant	*Phalacrocorax niger*	LC	R	IV
5	Phalacrocoracidae	Indian Shag	*Phalacrocorax fuscicollis*	LC	LM	IV
6	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	LC	LM	IV
7	Phalacrocoracidae	Darter	*Anhinga melanogaster*	NT	R	IV
8	Ardeidae	Little Egret	*Egretta garzetta*	LC	R	IV
9	Ardeidae	Western Reef-Egret	*Egretta gularis*	LC	R	IV
10	Ardeidae	Grey Heron	*Ardea cinerea*	LC	R	IV
11	Ardeidae	Large Egret	*Casmerodius albus*	LC	R	IV
12	Ardeidae	Median Egret	*Mesophoyx intermedia*	LC	R	IV
13	Ardeidae	Cattle Egret	*Bubulcus ibis*	LC	R	IV
14	Ardeidae	Little Green Heron	*Butorides striatus*	LC	LM	IV
15	Ardeidae	Purple Heron	*Ardea purpurea*	LC	LM	IV
16	Ardeidae	Indian Pond Heron	*Ardeola grayii*	LC	R	IV
17	Ardeidae	Black-crowned Night Heron	*Nycticorax nycticorax*	LC	R	IV
18	Ciconiidae	Painted Stork	*Mycteria leucocephala*	NT	R	IV
19	Ciconiidae	Asian openbill stork	*Anastomus oscitans*	LC	LM	IV
20	Ciconiidae	Black-necked Stork	*Ephippiorhynchus asiaticus*	NT	LM	IV
21	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	LC	R	IV
22	Threskiornithidae	Oriental White Ibis	*Threskiornis melanocephalus*	NT	R	IV
23	Threskiornithidae	Black Ibis	*Pseudibis papillosa*	LC	R	IV
24	Threskiornithidae	Eurasian Spoonbill	*Platalea leucorodia*	LC	R	IV
25	Phoenicopteridae	Greater Flamingo	*Phoenicopterus ruber*	LC	LM	IV

26	Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*	LC	R	IV
27	Anatidae	Comb Duck	*Sarkidiornis melanotos*	LC	R	IV
28	Anatidae	Eurasian Wigeon	*Anas penelope*	LC	WM	IV
29	Anatidae	Spot-billed Duck	*Anas poecilorhyncha*	LC	R	IV
30	Anatidae	Northern Shoveller	*Anas clypeata*	LC	WM	IV
31	Anatidae	Northern Pintail	*Anas crecca*	LC	WM	IV
32	Anatidae	Gargany	*Anas querquedula*	LC	WM	IV
33	Anatidae	Common Teal	*Nettapus coromandelianus*	LC	WM	IV
34	Anatidae	Common Pochard	*Aythya ferina*	LC	WM	IV
35	Anatidae	Tufted Pochard	*Aythya fuligula*	LC	WM	IV
36	Anatidae	Greater Scaup	*Aythya marila*	LC	WM	IV
37	Accipitridae	Black-shouldered Kite	*Elanus caeruleus*	LC	R	I
38	Accipitridae	Eurasian Griffon	*Gyps fulvus*	LC	WM	I
39	Accipitridae	Short-toed Snake Eagle	*Circaetus gallicus*	LC	R	I
40	Accipitridae	Western Marsh-Harrier	*Circus aeruginosus*	LC	WM	I
41	Accipitridae	Pallid Harrier	*Circus macrourus*	NT	WM	I
42	Accipitridae	Montagu's Harrier	*Circus melanoleucos*	LC	WM	I
43	Accipitridae	Shikra	*Accipiter badius*	LC	R	I
44	Accipitridae	Eurasian Sparrow Hawk	*Accipiter nisus*	LC	WM	I
45	Accipitridae	White-eyed Buzzard	*Butastur teesa*	LC	R	I
46	Accipitridae	Common Buzzard	*Buteo buteo*	LC	WM	I
47	Accipitridae	Oriental honey Buzzard	*Xxx*	LC	WM	I
48	Accipitridae	Long-legged Buzzard	*Buteo rufinus*	LC	WM	I
49	Accipitridae	Greater Spotted Eagle	*Aquila nipalensi*	VU	WM	I
50	Accipitridae	Steppe Eagle	*Aquila clanga*	LC	WM	I
51	Accipitridae	Booted Eagle	*Hieraaetus pennatus*	LC	WM	I
52	Falconidae	Laggar Falcon	*Falco jugger*	LC	R	IV

53	Falconidae	Common Kestrel	*Falco tinnunculus*	LC	WM	IV
54	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	LC	R	IV
55	Phasianidae	Common Quail	*Cturnix coturnix*	LC	R	IV
56	Phasianidae	Indian Peafowl	*Pavo cristatus*	LC	R	I
57	Rallidae	Demoiselle Crane	*Grus virgo*	LC	WM	IV
58	Rallidae	Sarus Crane	*Grus antigone*	LC	LM	IV
59	Rallidae	Common Crane	*Grus grus*	LC	WM	IV
60	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	LC	R	IV
61	Rallidae	Purple Moorhen	*Porphyrio porphyrio*	LC	R	IV
62	Rallidae	Common Moorhen	*Gallinula chloropus*	LC	R	IV
63	Rallidae	Common Coot	*Fulica atra*	LC	R	IV
64	Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	LC	R	IV
65	Charadriidae	Pacific Golden-Plover	*Pluvialis fulva*	LC	WM	IV
66	Charadriidae	Grey Plover	*Pluvialis squatarola*	LC	WM	IV
67	Charadriidae	Little Ringed Plover	*Charadrius dubius*	LC	R	IV
68	Charadriidae	Kentish Plover	*Charadrius alexandrines*	LC	WM	IV
69	Charadriidae	Lesser Sand Plover	*Charadrius mongolus*	LC	WM	IV
70	Charadriidae	Yellow-wattled Lapwing	*Vanellus malabaricus*	LC	R	IV
71	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	LC	R	IV
72	Scolopacidae	Common Snipe	*Gallinago gallinago*	LC	WM	IV
73	Scolopacidae	Black-tailed Godwit	*Limosa limosa*	NT	WM	IV
74	Scolopacidae	Whimbrel	*Numenius phaeopus*	LC	WM	IV
75	Scolopacidae	Eurasian Curlew	*Numenius arquata*	NT	WM	IV
76	Scolopacidae	Spotted Redshank	*Tringa erythropus*	LC	WM	IV
77	Scolopacidae	Common Redshank	*Tringa totanus*	LC	WM	IV
78	Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*	LC	WM	IV
79	Scolopacidae	Common Greenshank	*Tringa nebularia*	LC	WM	IV

80	Scolopacidae	Green Sandpiper	*Tringa ochropus*	LC	WM	IV
81	Scolopacidae	Wood Sandpiper	*Tringa glorioles*	LC	WM	IV
82	Scolopacidae	Terek Sandpiper	*Xenus cinereus*	LC	WM	IV
83	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	LC	WM	IV
84	Scolopacidae	Little Stint	*Calidris minuta*	LC	WM	IV
85	Scolopacidae	Sanderling	*Calidris alba*	LC	WM	IV
86	Scolopacidae	Curlew Sandpiper	*Calidris ferruginea*	LC	WM	IV
87	Scolopacidae	Ruff	*Philomachus pugnax*	LC	WM	IV
88	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	LC	R	IV
89	Recurvirostridae	Pied Avocet	*Recurvirostra avosetta*	LC	WM	IV
90	Burhinidae	Great Stone Plover	*Esacus recurvirostris LC*	LC	LM	IV
91	Laridae	Pallas's Gull	*Larus ichthyaetus*	LC	WM	IV
92	Laridae	Heuglin's Gull	*Larus heuglini*	LC	WM	IV
93	Laridae	Common Tern	*Sterna hirundo*	LC	WM	IV
94	Laridae	River Tern	*Sterna aurantia*	NT	R	IV
95	Laridae	Little Tern	*Sterna albifrons*	LC	LM	IV
96	Laridae	Gull-billed Tern	*Gelochelidon ninotica*	LC	WM	IV
97	Laridae	Brown headed Gull	*Chroicocephalus brunnicephalus*	LC	WM	IV
98	Laridae	Whiskered Tern	*Chlidonias hybridus*	LC	R	IV
99	Pteroclididae	Chestnut-bellied Sandgrouse	*Pterocles exustus*	LC	R	IV
100	Columbidae	Blue Rock Pigeon	*Columba livia*	LC	R	-
101	Columbidae	Little Brown Dove	*Streptopelia senegalensis*	LC	R	IV
102	Columbidae	Spotted Dove	*Streptopelia chinensis*	LC	R	IV
103	Columbidae	Red Collared-Dove	*Streptopelia tranquebarica*	LC	R	IV
104	Columbidae	Eurasian Collared-Dove	*Streptopelia decaocto*	LC	R	IV
105	Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*	LC	R	IV
106	Cuculidae	Asian Koel	*Eudynamys scolopacea*	LC	R	IV

107	Cuculidae	Greater Coucal	*Centropus sinensis*	LC	R	IV
108	Cuculidae	Sirkeer Malkoha	*Phaenicophaeus leschenaultii*	LC	R	IV
109	Strigidae	Pallid Scoops-Owl	*Otus brucei*	LC	WM	IV
110	Strigidae	Spotted Owlet	*Athene brama*	LC	R	IV
111	Picidae	Eurasian Wryneck	*Jynx torquilla*	LC	WM	IV
112	Apodidae	House Swift	*Apus affinis*	LC	R	IV
113	Alcedinidae	Lesser Pied Kingfisher	*Ceryle rudis*	LC	R	IV
114	Alcedinidae	White-breasted Kingfisher	*Halcyon smyrnensis*	LC	R	IV
115	Alcedinidae	Small Blue Kingfisher	*Alcedo atthis*	LC	R	IV
116	Meropidae	Small Bee-eater	*Merops orientalis*	LC	R	IV
117	Coraciidae	European Roller	*Coracias garrulous*	NT	PM	IV
118	Coraciidae	Indian Roller	*Coracias benghalensis*	LC	R	IV
119	Upupidae	Common Hoopoe	*Upupa epops*	LC	R	IV
120	Alaudidae	Ashy-crowned Sparrow Lark	*Eremopterix grisea*	LC	R	IV
121	Alaudidae	Common-crested Lark	*Galerida cristata*	LC	R	IV
122	Alaudidae	Rufous-tailed Finch-Lark	*Ammomanes phoenicurus*	LC	R	IV
123	Alaudidae	Great Hoopoe-Lark	*Alaemon alaudipes*	LC	R	IV
124	Hirundindae	Red-rumped Swallow	*Hirundo daurica*	LC	R	IV
125	Hirundindae	Dusky Crag Martin	*Hirundo concolor*	LC	R	IV
126	Hirundindae	Common Swallow	*Hirundo rustica*	LC	WM	IV
127	Hirundindae	Wire-tailed Swallow	*Hirundo smithii*	LC	WM	IV
128	Motacillidae	White Wagtail	*Motacilla alba*	LC	WM	IV
129	Motacillidae	Large Pied Wagtail	*Motacilla maderaspatensis*	LC	WM	IV
130	Motacillidae	Citrine Wagtail	*Motacilla citreola*	LC	WM	IV
131	Motacillidae	Yellow Wagtail	*Motacilla flava*	LC	WM	IV
132	Motacillidae	Grey Wagtail	*Motacilla cinerea*	LC	WM	IV
133	Motacillidae	Paddy-field Pipit	*Anthus rufulus*	LC	R	IV

134	Pycnonotidae	White-eared Bulbul	*Pycnonotus leucotis*	LC	R	IV
135	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	LC	R	IV
136	Laniidae	Rufous-tailed Shrike	*Lanius isabellinus*	LC	WM	IV
137	Laniidae	Bay-backed Shrike	*Lanius vittatus*	LC	R	IV
138	Laniidae	Rufous-backed Shrike	*Lanius schach*	LC	R	IV
139	Laniidae	Southern Grey Shrike	*Lanius meridionalis*	LC	R	IV
140	Turdinae	Bluethroat	*Luscinia svecica*	LC	WM	IV
141	Turdinae	Indian Robin	*Saxicoloides fulicata*	LC	R	IV
142	Turdinae	Black Redstart	*Phoenicurus ochruros*	LC	WM	IV
143	Turdinae	Common Stonechat	*Saxicola torquata*	LC	WM	IV
144	Turdinae	Pied Bushchat	*Saxicola caprata*	LC	WM	IV
145	Turdinae	Variable Wheatear	*Oenanthe picata*	LC	WW	IV
146	Turdinae	Desert Wheatear	*Oenanthe deserti*	LC	WW	IV
147	Turdinae	Isabelline Wheatear	*Oenanthe isabellina*	LC	WW	IV
148	Turdinae	Indian Chat	*Cercomela fusca*	LC	WW	IV
149	Timaliinae	Common Babbler	*Turdoides caudatus*	LC	R	IV
150	Sylviinae	Jungle Prinia	*Prinia sylvatica*	LC	R	IV
151	Sylviinae	Ashy Prinia	*Prinia socialis*	LC	R	IV
152	Sylviinae	Greenish Leaf Warbler	*Phylloscopus trochiloides*	LC	WM	IV
153	Sylviinae	Booted warbler	*Iduna caligata*	LC	WM	IV
154	Sylviinae	Rufous fronted prinia	*Prinia buchanani*	LC	R	IV
155	Sylviinae	Grey breasted prinia	*Prinia hodgsonii*	LC	R	IV
156	Sylviinae	Plain Prinia	*Prinia inornata*	LC	R	IV
157	Sylviinae	Common Tailorbird	*Orthotomus sutorius*	LC	R	IV
158	Nectariniidae	Purple Sunbird	*Nectarinia asiatica*	LC	R	IV
159	Estrildidae	Black-headed Munia	*Lonchura Malacca*	LC	R	IV
160	Estrildidae	White-throated Munia	*Lonchura malabarica*	LC	R	IV

161	Passeridae	Yellow throated Sparrow	*Petronia xanthocollis*	LC	R	IV
162	Passeridae	House Sparrow	*Passer domesticus*	LC	R	IV
163	Ploceidae	Baya Weaver	*Ploceus philippinus*	LC	R	IV
164	Ploceidae	Streaked Weaver	*Ploceus manyar*	LC	R	IV
165	Sturnidae	Brahminy Starling	*Sturnus pagodarum*	LC	R	IV
166	Sturnidae	Rosy Starling	*Sturnus roseus*	LC	WM	IV
167	Sturnidae	Common Myna	*Acridotheres tristis*	LC	R	IV
168	Sturnidae	Bank Myna	*Acridotheres ginginianus*	LC	R	IV
169	Dicruridae	Black Drongo	*Dicrurus macrocercus*	LC	R	IV
170	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*	LC	R	IV
171	Corvidae	Indian Treepie	*Dendrocitta vagabunda*	LC	R	IV
172	Corvidae	House Crow	*Corvus splendens*	LC	R	V
173	Corvidae	Jungle Crow	*Corvus macrorhynchos*	LC	R	IV

Appendix 6 List of Wetland and wetland associated birds recorded during the study period and their conservation status

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
Order: PODICIPEDIFORMES						
Family: Podicipedidae						
1	Little Grebe *Tachybaptus ruficollis*	Open water	R	LC	Sch. IV	
2	Great Crested Grebe *Podiceps cristatus*	Open water	WM	LC	Sch. IV	
Order: PELECANIFORMES						
Family: Pelecanidae						
3	Dalmatian Pelican *Pelecanus crispus*	Open water	LM	VU		Appendix I
Family: Phalacrocoracidae						
4	Little Cormorant *Phalacrocorax niger*	Open water	R	LC	Sch. IV	
5	Indian Shag *Phalacrocorax fuscicollis*	Open water	LM	LC	Sch. IV	
6	Great Cormorant *Phalacrocorax carbo*	Open water	LM	LC	Sch. IV	
Family: Anhingidae						
7	Darter *Anhinga melanogaster*	Open water	R	NT	Sch. IV	
Order: CICONIIFORMES						
Family: Ardeidae						
8	Little Egret *Egretta garzetta*	Wading birds	R	LC	Sch. IV	

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
9	Western Reef-Egret *Egretta gularis*	Wading birds	R	LC	Sch. IV	
10	Grey Heron *Ardea cinerea*	Wading birds	R	LC	Sch. IV	
11	Purple Heron *Ardea purpurea*	Wading birds	LM	LC	Sch. IV	
12	Large Egret *Casmerodius albus*	Wading birds	R	LC	Sch. IV	
13	Median Egret *Mesophoyx intermedia*	Wading birds	R	LC	Sch. IV	
14	Cattle Egret *Bubulcus ibis*	Wading birds	R	LC	Sch. IV	
15	Indian Pond-Heron *Ardeola grayii*	Wading birds	R	LC	Sch. IV	
16	Little Green Heron *Butorides striatus*	Wading birds	LM	LC	Sch. IV	
17	Black-crowned Night-Heron *Nycticorax nycticorax*	Wading birds	R	LC	Sch. IV	
Family: Ciconiidae						
18	Painted Stork *Mycteria leucocephala*	Wading birds	R	NT	Sch. IV	
19	Asian Openbill-Stork *Anastomus oscitans*	Wading birds	LM	LC	Sch. IV	
20	Black-necked Stork *Ephippiorhynchus asiaticus*	Wading birds	R	NT	Sch. IV	
Family: Threskiornithidae						
21	Glossy Ibis *Plegadis falcinellus*	Wading birds	R	LC	Sch. IV	
22	Oriental White Ibis *Threskiornis melanocephalus*	Wading birds	R	NT	Sch. IV	
23	Black Ibis *Pseudibis papillosa*	Wading birds	R	LC	Sch. IV	

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
24	Eurasian Spoonbill *Platalea leucorodia*	Wading birds	R	LC	Sch. I	Appendix II
Order: PHOENICOPTERIFORMES						
Family: Phoenicopteridae						
25	Greater Flamingo *Phoenicopterus ruber*	Wading birds	LM	LC	Sch. IV	Appendix II
Order: ANSERIFORMES						
Family: Anatidae						
26	Lesser Whistling-Duck *Dendrocygna javanica*	Waterfowl	R	LC	Sch. IV	
27	Comb Duck *Sarkidiornis melanotos*	Waterfowl	LM	LC	Sch. IV	Appendix II
28	Eurasian Wigeon *Anas Penelope*	Waterfowl	WM	LC	Sch. IV	
29	Spot-billed Duck *Anas poecilorhyncha*	Waterfowl	R	LC	Sch. IV	
30	Northern Shoveller *Anas clypeata*	Waterfowl	WM	LC	Sch. IV	
31	Northern Pintail *Anas acuta*	Waterfowl	WM	LC	Sch. IV	
32	Garganey *Anas querquedula*	Waterfowl	WM	LC	Sch. IV	
33	Common Teal *Anas crecca*	Waterfowl	WM	LC	Sch. IV	
34	Common Pochard *Aythya farina*	Waterfowl	WM	LC	Sch. IV	
35	Tufted Pochard *Aythya fuligula*	Waterfowl	WM	LC	Sch. IV	
36	Greater Scaup *Aythya marila*	Waterfowl	WM	LC	Sch. IV	

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
Order: GRUIFORMES						
Family: Gruidae						
37	Sarus Crane *Grus antigone*	Wading birds	LM	VU	Sch. IV	Appendix II
38	Demoiselle Crane *Grus virgo*	Wading birds	WM	LC	Sch. IV	Appendix II
39	Common Crane *Grus grus*	Wading birds	WM	LC	Sch. IV	Appendix II
Family: Rallidae						
40	White-breasted Waterhen *Amaurornis phoenicurus*	Waterfowl	R	LC	Sch. IV	
41	Purple Moorhen *Porphyrio porphyrio*	Waterfowl	R	LC	Sch. IV	
42	Common Moorhen *Gallinula chloropus*	Waterfowl	R	LC	Sch. IV	
43	Common Coot *Fulica atra*	Waterfowl	R	LC	Sch. IV	
Order: CHARADRIIFORMES						
Family: Jacanidae						
44	Pheasant-tailed Jacana *Hydrophasianus chirurgus*	Waterfowl	R	LC	Sch. IV	
Family: Charadriidae						
45	Pacific Golden-Plover*Pluvialis fulva*	Shorebirds	WM	LC	Sch. IV	
46	Little Ringed Plover *Charadrius dubius*	Shorebirds	R	LC	Sch. IV	
47	Kentish Plover *Charadrius alexandrines*	Shorebirds	WM	LC	Sch. IV	

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
48	Lesser Sand Plover *Charadrius mongolus*	Shorebirds	WM	LC	Sch. IV	
49	Yellow-wattled Lapwing *Vanellus malabaricus*	Wading birds	R	LC	Sch. IV	
50	Red-wattled Lapwing *Vanellus indicus*	Wading birds	R	LC	Sch. IV	
Family: Scolopacidae						
51	Common Snipe *Gallinago gallinago*	Shorebirds	WM	LC	Sch. IV	
52	Black-tailed Godwit *Limosa limosa*	Shorebirds	WM	NT	Sch. IV	
53	Whimbrel *Numenius phaeopus*	Shorebirds	WM	LC	Sch. IV	
54	Eurasian Curlew *Numenius arquata*	Shorebirds	WM	NT	Sch. IV	
55	Spotted Redshank *Tringa erythropus*	Shorebirds	WM	LC	Sch. IV	
56	Common Redshank *Tringa tetanus*	Shorebirds	WM	LC	Sch. IV	
57	Marsh Sandpiper *Tringa stagnatilis*	Shorebirds	WM	LC	Sch. IV	
58	Common Greenshank *Tringa nebularia*	Shorebirds	WM	LC	Sch. IV	
59	Green Sandpiper *Tringa ochropus*	Shorebirds	WM	LC	Sch. IV	
60	Wood Sandpiper *Tringa glareola*	Shorebirds	WM	LC	Sch. IV	
61	Terek Sandpiper *Xenus cinereus*	Shorebirds	WM	LC	Sch. IV	
62	Common Sandpiper *Actitis hypoleucos*	Shorebirds	WM	LC	Sch. IV	
63	Sanderling *Calidris alba*	Shorebirds	WM	LC	Sch. IV	

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
64	Little Stint *Calidris minuta*	Shorebirds	WM	LC	Sch. IV	
65	Curlew Sandpiper *Calidris ferruginea*	Shorebirds	WM	LC	Sch. IV	
66	Ruff *Philomachus pugnax*	Shorebirds	WM	LC	Sch. IV	
Family: Recurvirostridae						
67	Black-winged Stilt *Himantopus himantopus*	Shorebirds	R	LC	Sch. IV	
68	Pied Avocet *Recurvirostra avosetta*	Shorebirds	WM	LC	Sch. IV	
Family: Burhinidae						
69	Great Stone-Plover *Esacus recurvirostris*	Shorebirds	LM	LC	Sch. IV	
Family: Laridae						
70	Heuglin's Gull *Larus heuglini*	Open water	WM	LC	Sch. IV	
71	Pallas's Gull *Larus ichthyaetus*	Open water	WM	LC	Sch. IV	
72	Brown-headed Gull *Larus brunnicephalus*	Open water	WM	LC	Sch. IV	
73	Gull-billed Tern *Gelochelidon nilotica*	Open water	WM	LC	Sch. IV	
74	River Tern *Sterna aurantia*	Open water	R	NT	Sch. IV	
75	Common Tern *Sterna Hirundo*	Open water	WM	LC	Sch. IV	
76	Whiskered Tern *Chlidonias hybridus*	Open water	R	LC	Sch. IV	
Order: FALCONIFORMES						

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
Family: Accipitridae						
77	Western Marsh-Harrier *Circus aeruginosus*	Raptor	WM	LC	Sch. I	Appendix II
78	Greater Spotted Eagle *Aquila clanga*	Raptor	WM	VU	Sch. I	Appendix II
79	Steppe Eagle *Aquila nipalensis*	Raptor	WM	LC	Sch. I	Appendix II
Order: CORACIIFORMES						
Family: Alcedinidae						
80	Small Blue Kingfisher *Alcedo atthis*	Open water	R	LC	Sch. IV	
81	White-breasted Kingfisher *Halcyon smyrnensis*	Open water	R	LC	Sch. IV	
82	Lesser Pied Kingfisher *Ceryle rudis*	Open water	R	LC	Sch. IV	
Order: PASSERIFORMES						
Family: Hirundinidae						
83	Common Swallow *Hirundo rustica*	Passerine	R	LC	Sch. IV	
84	Wire-tailed Swallow *Hirundo smithii*	Passerine	LM	LC	Sch. IV	
85	Red-rumped Swallow *Hirundo daurica*	Passerine	R	LC	Sch. IV	
Family: Motacillidae						
86	White Wagtail *Motacilla alba*	Passerine	WM	LC	Sch. IV	
87	Large Pied Wagtail *Motacilla maderaspatensis*	Passerine	R	LC	Sch. IV	

No	Common Name	Guild	Status	Conservation Status		
				IUCN	IW(P)A	CITES
88	Citrine Wagtail *Motacilla citreola*	Passerine	WM	LC	Sch. IV	
89	Yellow Wagtail *Motacilla flava*	Passerine	WM	LC	Sch. IV	