# Potential Impacts of Proposed Wind Turbines on Birds at Mampuriya, Puttalam

Final Report for the Senok Wind Power Private Limited

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Starting in December 2007, we studied the bird population in the area (South of Mampuriya) on a pilot scale and then initiated a detail study from September 2008 to May 2009 in the Mampuriya Site. This report though specifically covers the later dates, the conclusions and discussion is influenced by the former inquiry. We are confident of the results to the level of accuracy defined by the observational methods applied.

The 'risk of bird strikes', can be effectively minimized through sound mitigation and monitoring. The study has enabled the identification of this risk and the proposed mitigation and monitoring should enable the 'Wind Turbines' to meet the highest environment standards required.

We wish the venture all the success.

Prof. S. W. Kotagama
Professor of Environment Science
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## Introduction

As the demand for energy increases, attitude towards alternative energy amplified in recent past. One of the major alternatives among many others is wind energy generation. Hence, wind energy generation stations are being constructed across the world. Wind power has been used in many countries in Europe and the United States with a great deal of success. However, concerns have been raised about the possible environmental impact of these turbines on birds. Research in this area has focused primarily on mortality caused by birds striking turbine blades and associated wires. However, other aspects such as behavioural changes, disturbance to breeding, wintering or staging birds as a result of turbines have not been examined extensively.

With respect to avian mortality at wind power generating stations, the greatest concern has been for raptors and migrating passerines. The concern for raptors generally stems from the fact that many populations are small and thus even a few deaths can lead to declines (Morrison *et al.* 1998). Passerines which form the largest group of birds are also considered at risk because they are known to fly into human-made structures causing mass kills of thousands of individuals. While raptors and passerines are generally at greatest risk of injury or death from turbines, the impact of such structures on all bird species should be considered on a site-by-site basis since bird diversity and abundance are site specific.

The goal of this report is threefold:
1. Assess the bird diversity, abundance and potential effects of wind turbines;
2. Recommend ways of reducing potential impacts of turbines on birds based on published researches;
3. Recommend a program whereby potential effects of wind turbines on birds can be monitored.

## Methodology

Different methodologies were adapted to find out
1. Avifaunal richness and abundance of the area
2. Seasonal changes of the diversity and abundance
3. Diurnal changes of the diversity and abundance
4. Use of vertical space by the birds in the area
5. Flight paths crossing the project site
6. Collision risk at different locations

Establishing a sampling protocol, designing forms to collect field data, and selecting study plots were completed before starting the surveys. The field studies were designed to detect individual birds within the study plots and to characterize their specific activities. Each of these elements was tested in the field and refined as necessary before formal data collection began. Map 1 shows the locations identified for installations of turbines.

Surveys were conducted from September 2008 to May 2009 covering the migration season 2008/09.

Map 1: Selected locations for the establishment of turbines


## Birds inhabiting the area

Surveys were conducted along the coastal strip starting from the Norachcholai Coal Power Plant in North to nearly 10 km South in the site assigned to Senok Windpower(Pvt) Ltd.. Around 1000m from the coast to inwards which contains a mixture of habitats were subjected to the survey. No comprehensive survey was done in the area previously.

Two Important Bird Areas namely Puttalam lagoon IBA and Mundal Lake IBA are located close to project area. Further one marine sanctuary is also located in the area. However, project area does not belong to any of the conservation area either in full extent or partially.

Although the area is a mixture of habitats all of them are disturbed habitats that provide minimal facilities for the avifauna. Large portion of the surveyed area is covered by coconut plantations in various stages of growth. Coastal grasslands and beach area provides waders and sea birds, opportunities for them to feed. Further, cultivated areas of cash crop monocultures and home gardens form considerable portion in the area.

### Status

A total of 132 species were recorded during the survey period from September 2008 to May 2009 (Annex 1). This represents 48 families while majority belong to Lariidae (16 species), Accipitridae (15 species) and Ardeidae (11 species). Number of species recorded is a 26.8 % of country's known birds (492) of all forms including migrants and vagrants. Out of 132 species, 86 are breeding resident in the island however; breeding status in the project area is unknown. Number of migrant species recoded in the area was 32, while four species which are considered as vagrants to the island were also reported during the surveys. Another 10 species which have both resident and migrant populations in the island were also identified during the surveys. However, to separate these two populations and identify the breeding status of resident species in the area, surveys during the breeding period is essential.

## Commonness

Based on the number of observations made during the survey period in the migratory period, an index was developed to identify the commonness of the species in the survey area. If the number of observed days of a particular species out of total survey dates exceeds 80% it is categorised as a very common species. Accordingly, Common species (60-80%), uncommon species (40-60%), rare species (20-40%) and very rare species (0-20%) were identified. However, status of the species identified based on this index does not necessarily reflects the commonness of those species in the country. Results show that only 19 species are very commonly found in the project area. Numbers of species in each category are given in Table 1.

Table 1: Commonness of the species found in the project area

| Commonness | Number of Species |
|---|---|
| Very Common | 19 |
| Common | 12 |
| Uncommon | 8 |
| Rare | 11 |
| Very Rare | 82 |

## Bird Groups

This list of species identified through surveys includes: 35 species classified as waterbirds (seabirds and waterfowl), 16 species of raptor, 13 wader species and 68 species classified as passerines and other families. These bird groups exhibit different behaviours and habitat preferences, which should be considered when examining the possible impacts of the proposed wind energy site.

### *Waterbirds (including seabirds, waterfowl and waders)*

Seabirds spend much of their lives in marine environments, generally coming no further inland than the shore. However, almost all sea bird species (Terns and Gulls) found during the survey period showed high mobility between sea and the lagoon. This group of birds is the highest risk group identified during the survey. Since Puttalam lagoon provides important habitats for aggregating terns and gulls, it is important to identify their flight paths between sea and the lagoon

Waders are another group of aggregating birds, which shows high mobility between suitable habitats. Shallow coastal water bodies are considered ideal habitats as feeding grounds for the migrating waders. Since the Kalpitiya peninsula is full of coastal water bodies including Puttalam lagoon IBA, it is expected to have higher movement of waders in the area. Identified wader species except Lapwings and Thick-knees are highly mobile between suitable habitats, and observed so. However, during this migratory period, no large aggregations more than 100 birds of waders were observed along the coast.

### *Raptors*

Raptors are a high potential group of birds to have collision risk with wind turbines and therefore extensively studied all over the world. Among 16 species of raptors recorded in the project area, only two species namely Brahminy Kite and Shikra were very common, while all the others were rare or very rare. However, all these recorded species shows movements in all vertical layers, especially the space 30m above ground. The perching habit of raptors on tall trees or structures also makes them vulnerable to collision with wind turbines.

Only three species of nocturnal raptors were recorded during the surveys, however, few other species are likely to inhabit the area. Among the recorded species, Collard Scops Owl was common in the area, while two other species were very rare. However, these species are not categorised as highfliers.

### *Other birds*

Most of the passerine and other birds species occur in the project area are residents while few species of migrants were also reported. Among the species in this category, Barn Swallow, Blue-tailed Bee-eater, and Asian Palm Swift are important since those are very common and also use higher layers of the vertical space. Therefore, there is a high potential to have collision risk of these species. However, all these three species are swift in flying movements and therefore, it is believed that they will show high avoidance rate once turbines are in place. Common Myna, House Crow, Indian Roller, and Rock Pigeon are very common in the area and likely to move in the higher layers commonly.

### *Species of Special Conservation Concern*

No globally threatened species were recorded during the surveys. However, three species which are categorised as Nationally threatened species (IUCN & MENR 2007) are found in the project area. However, all these three species namely, Saunder's Tern (Critically Endangered), White-naped Woodpecker and Besra (Vulnerable) were very rarely recorded in the area. Further seven species that are categorised as near threatened in the national level, were also reported in the project area. Among these species Grey Francolin is the only species recorded very common during the study period. List of threatened and near threatened species recorded from the project area is annexed (Annex 2).

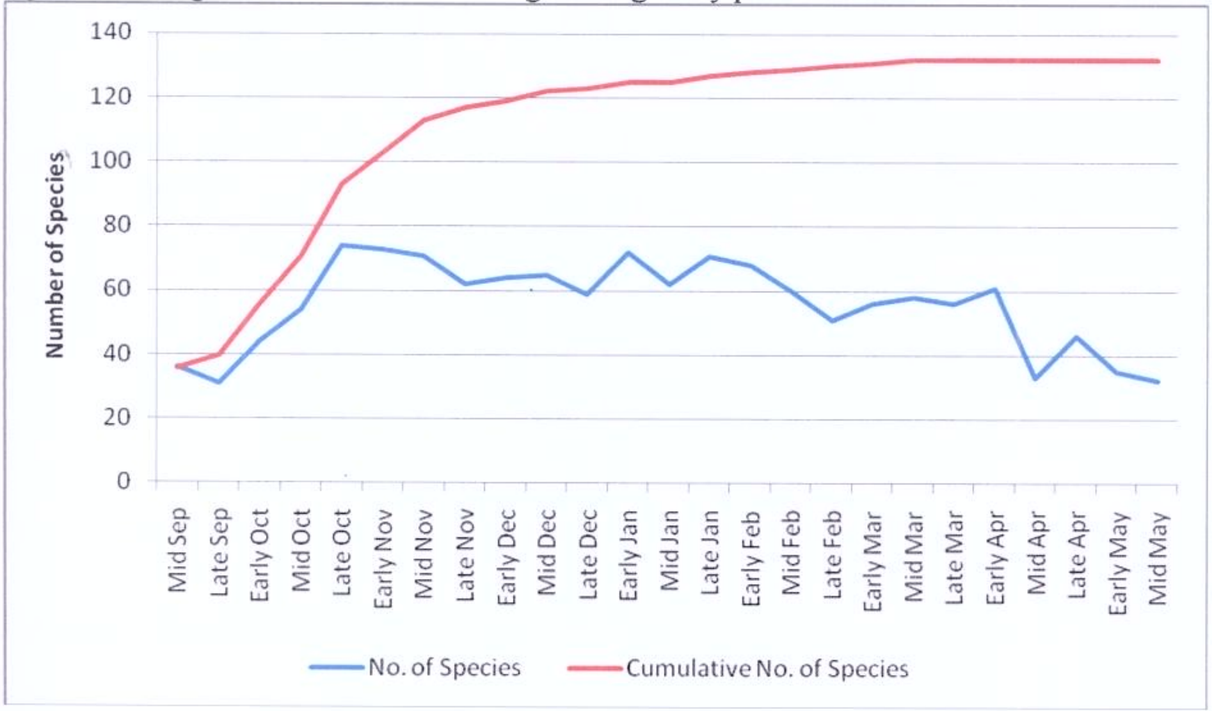
No Restricted Range species (Endemic species) recorded in the project area.

## Seasonal changes of the diversity and abundance

Results of the general surveys conducted in the area, showed a fluctuation of species richness throughout the period. Number of species that inhabit the area increased significantly during September and October, and thereafter continued with some fluctuations till February (Figure

1). After February, number of species recorded in the area started to drop and in May it was similar to the condition prevailed in September. The increase of number of species is caused by two ways, first by addition of migratory species which comes during September and October, then by addition of resident species due to favourable conditions especially the lowered wind speed in the area.

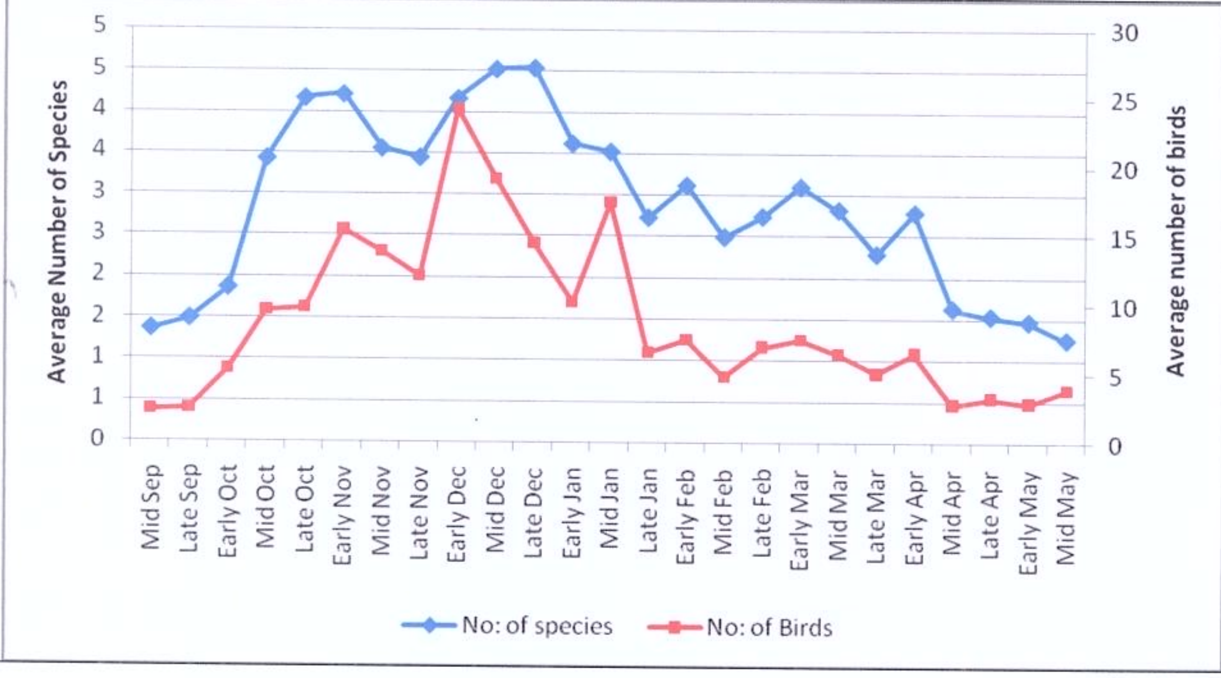
Figure 1: Change of avian richness during the migratory period 2008/09




Surveys were conducted at the locations where wind turbines are planned to establish to assess avifaunal composition of the selected location. Only the area swept by the rotors was considered for this survey, accordingly a total of eight locations surveyed for five minutes periods during the selected time blocks throughout the migratory period. Results of this study further confirm the above mentioned findings by showing higher diversity during the period from November to February (Figure 2). During February and March, both average number of species and number of birds recorded in a unit time period were settled in lower level compared to previous months. However, during April and thereafter, values dropped and became more or less similar to the condition prevailed during September last year.

Based on these observations it can be concluded that there is a high risk of bird collisions during the period from October to January, and less risk till April. Further, as the rotation do not occur at wind speeds or happens extremely slowly, thus the risk of bird strikes is minimal or zero. However, this conclusion was made based on the study carried out during a single migratory period and therefore this will not be applied to the all migratory seasons. It is known fact that many variables affect bird diversity and abundance especially for this kind of location where mixture of disturbed habitats present and high mobility of birds prevail. The need for continuous monitoring during operations is thus justified.

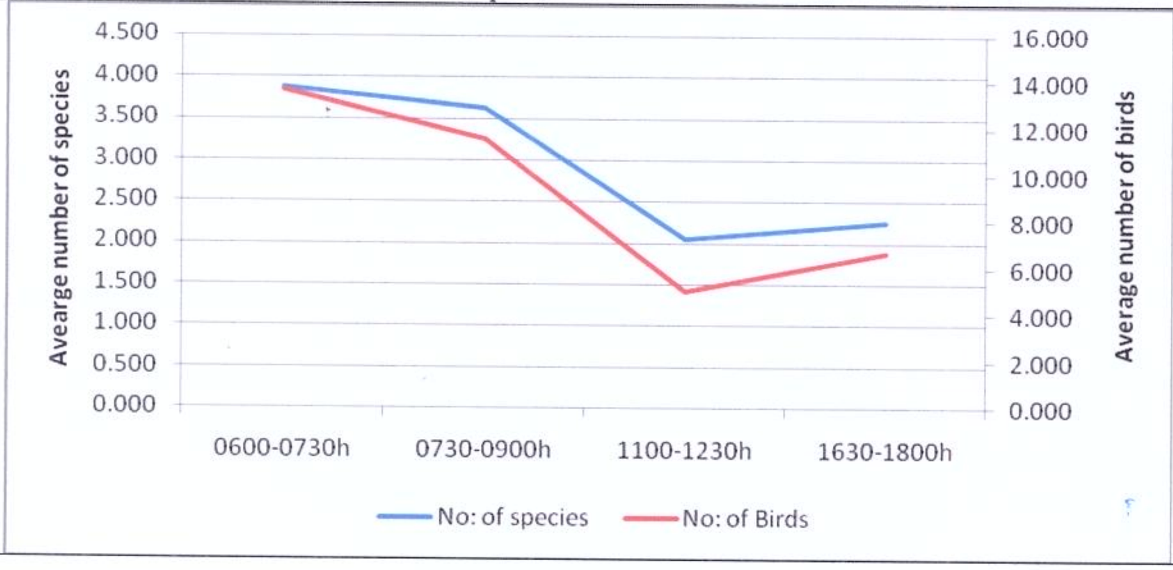
Figure 2: Average number of species and birds recorded at selected points




## Diurnal change of the bird composition

Diurnal change of bird composition was observed during the study period (Figure 3). Based on the results from point counts conducted at the selected locations of turbine construction, number of birds and number of species were higher in the mornings. Considerable drop of both average number of species and number of individuals were observed during the mid day and evenings. Hence it can be concluded that there is a higher bird collision risk in the mornings.

Figure 3: Diurnal variation of bird composition

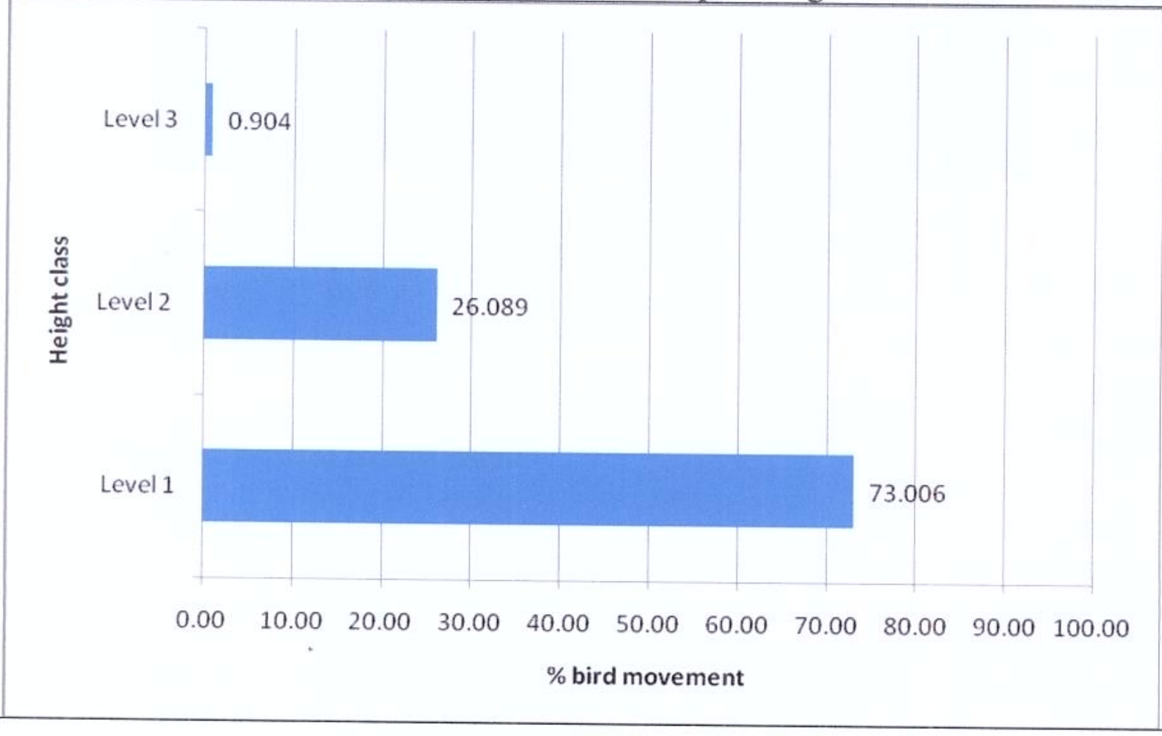


## Vertical stratification of bird movements

The locations where the wind turbines are to be established were surveyed to identify vertical stratification of bird movements. Horizontally, only the area swept by the rotors was considered for this survey and three levels of height were considered. Area below the rotors was considered as the lowest stratum (Level 1). Area swept by the rotors which is the important stratum in the vertical stratification (Level 2) and Stratum above the rotor levels (Level 3) were the other stratum considered. Heights of these strata were determined based on the specifications of the wing turbine 'Suzlon S 64-1250'. Bird movements per unit time were assessed throughout the study period. The height differences were based on visual estimates.

Based on the observations of 12,051 bird movements, 73% of the bird movements were below the level of rotors *i.e.* level 1 (Figure 4). Percentage of bird movements above the rotors was very minimal showing only 0.9%. However, most critical vertical stratum which is swept by the rotors had 26.089 % (3144 birds) bird movements during the migratory period. This is a considerable percentage if all the birds moved across collided on rotors.

Figure 4: Vertical stratification of bird movements as a percentage

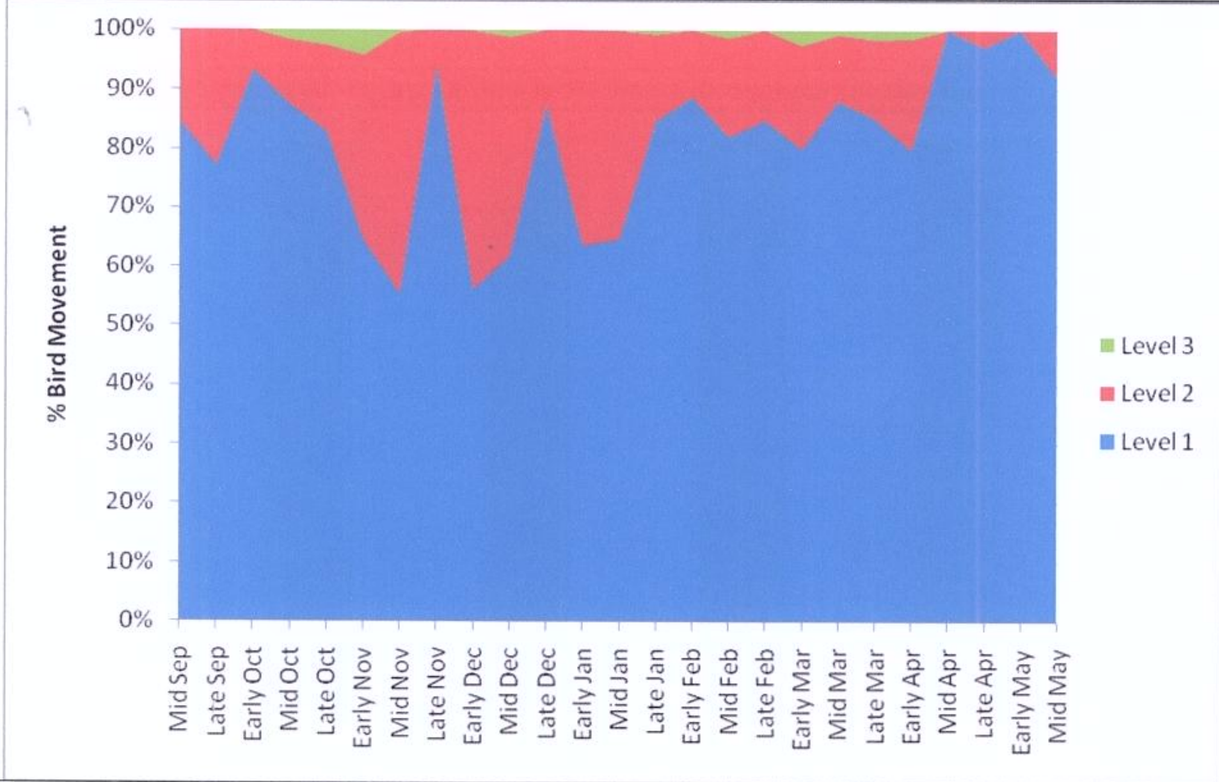



## Vertical stratification throughout the migratory period

However, percentages of bird movements vary with many parameters such as the time of the day, location, month and wind speed, etc. Change of vertical stratification throughout the study period was given in the figure 5. It clearly shows increment of bird movements through level 2 which is the critical level for bird collision, from mid October to early February period. This also shows the higher probability of bird collision in the said period compared to other months of the study period.

During the period of higher movements through level 2, it shows two huge drops. These drops were mainly because of high wind speeds that prevailed in those days. Correlation of bird movements with wind speed will be discussed later.

Figure 5: Vertical stratification of bird movements throughout the migratory period




**Diurnal change of vertical stratification**

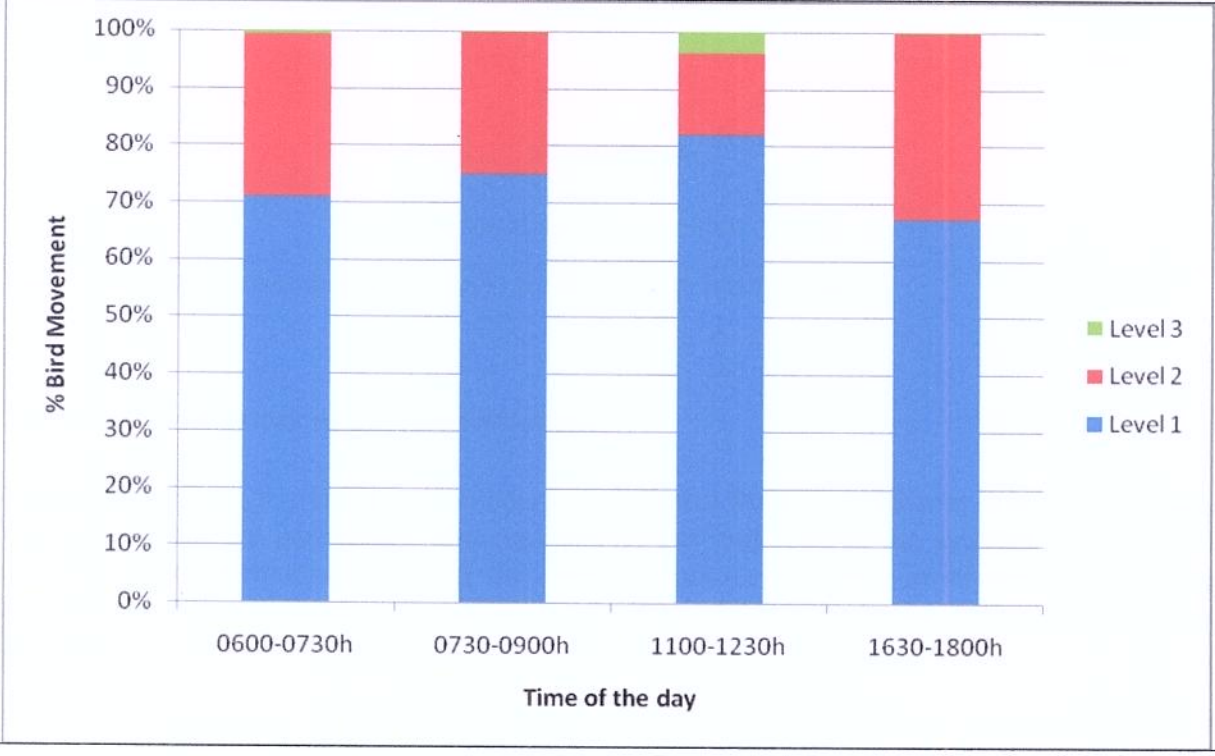
Change of the vertical stratification of bird movements throughout the day time was also observed (Figure 6). According to the results, more birds tend to use lower strata during the noon time. However, use of highest stratum went up in this period mainly because of soaring raptors and some other species. Bird movements were comparatively low at the level 2 during this period. However, use of critical stratum by birds increases during mornings and evenings, showing comparatively higher potential for bird collisions.

## Identification of Flight paths of birds

Surveys were conducted to identify flight paths that cross the project area. Based on the observations made along the study area, a flight path that crosses the development area was identified. Sea birds mainly terns and gulls use this flight path to move between the sea and the lagoon. Birds move along this flight path as individuals, pairs and most commonly as flocks sometimes up to 300-400 birds. This flight path covers the area that is planned to install four southernmost turbines. The flight path located at the place where the shortest distance between sea and lagoon and therefore birds can cross the land bridge easily.

However, high traffic along this flight path was observed only after November and before February. This coincides with the period where higher diversity and population size prevailed in the area. Based on the Observations of bird movements along the flight path, flocks of birds are more vulnerable to collide on turbines than pairs or single birds. However, to have a thorough conclusion on this matter, further studies are needed on the heights and consistency.

Figure 6: Vertical stratification of bird movements throughout the day time

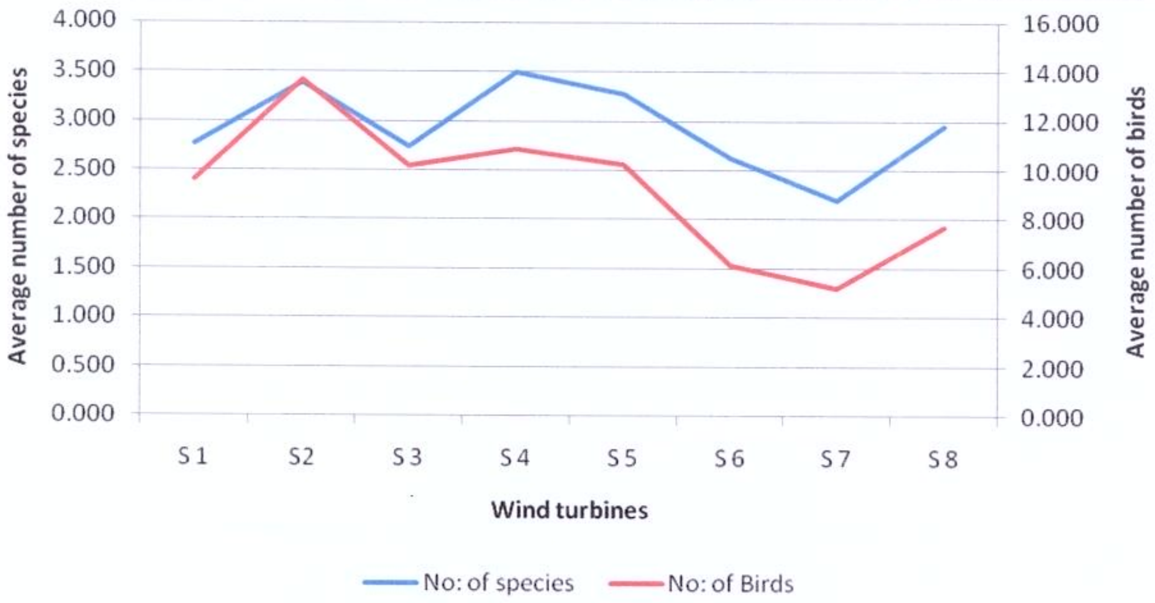



## Collision risk at different locations

Locations identified for the installations have different characteristics and therefore assessed separately for collision risk of birds. The habitats of the selected locations are either coconut plantations or coastal grasslands. After turbines were installed at these locations there will be more or less homogeneous habitat type in all locations.

However, differences of species composition in these locations were observed. Many factors such as the habitat type, wind speed, disturbances, flight paths, etc affect on the species composition. Figure 7 shows the average number of species and birds in a unit time period, in this case five minutes in the area covered by the rotors. Higher number of birds observed at southernmost turbines from S1 to S5. This is mainly because of the use of flight path between the sea and lagoon in peak months of the bird population.

Figure 7: Diversity of birds at locations selected for turbines




Note: Turbines are numbered (S1 –S8) from South to North (Map 1)

**Vertical Stratification at different locations**

Vertical stratification of bird movements was different from each other at selected locations. Figure 8 shows the percentage bird movements per unit time at the selected locations for installations of turbines. Based on the results it shows a strong correlation between the movements in lower strata and middle strata. When bird movements at the lower stratum goes down, it is increased at the second stratum which is swept by the rotors.

First four locations (S1 to S4) showed comparatively higher percentage of bird movements. It was more than 20% of the total bird movements at each location and S2 showed the highest value (40%).

When consider the average number of birds per unit time crossing the turbine, it was also high at above mentioned four locations (S1 –S4). Average numbers of birds crosses at the level of rotors were 3.54, 5.46, 3.32 and 2.31 for five minute periods at S1, S2, S3 and S4 respectively. Movement of more than two birds per five minutes across the rotors is a comparatively higher number (Figure 9).

These higher values for bird numbers at the critical levels were mainly due to the existing flying path crossing these turbines. Based on these results it can be concluded that southernmost four turbines (S1, S2, S3 and S4) have higher risk of bird collisions since higher bird movement percentage is through the rotors.

Figure 8: Percentage bird movements in different heights at proposed turbines

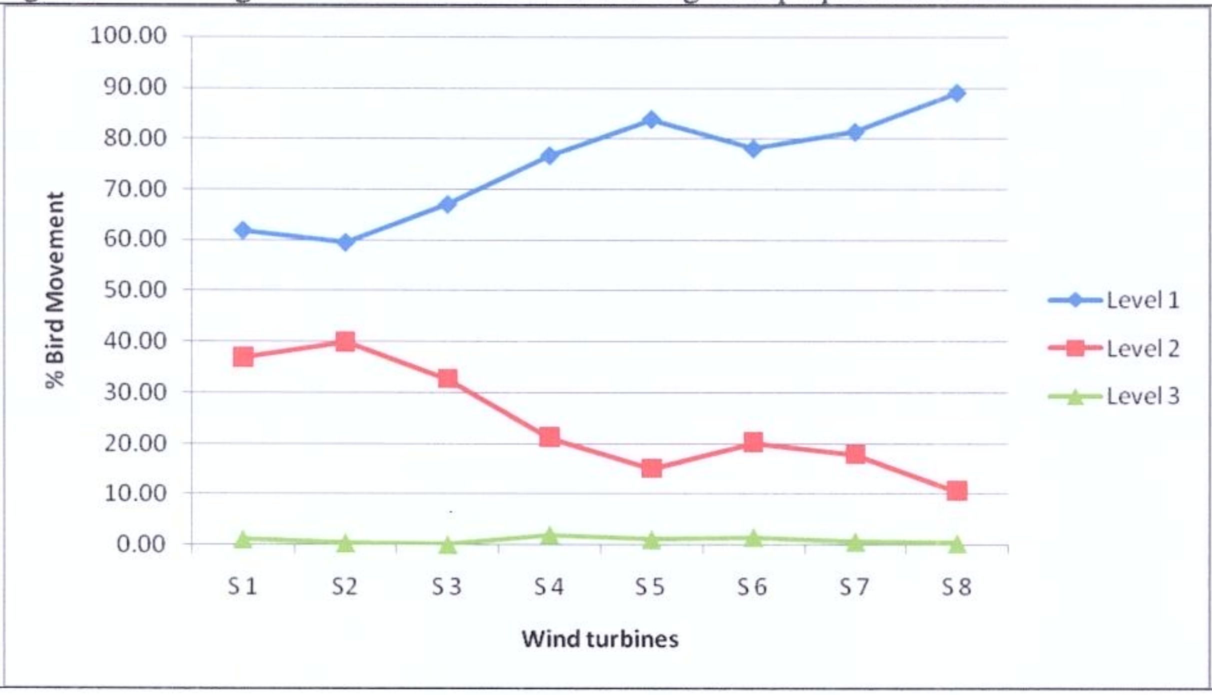
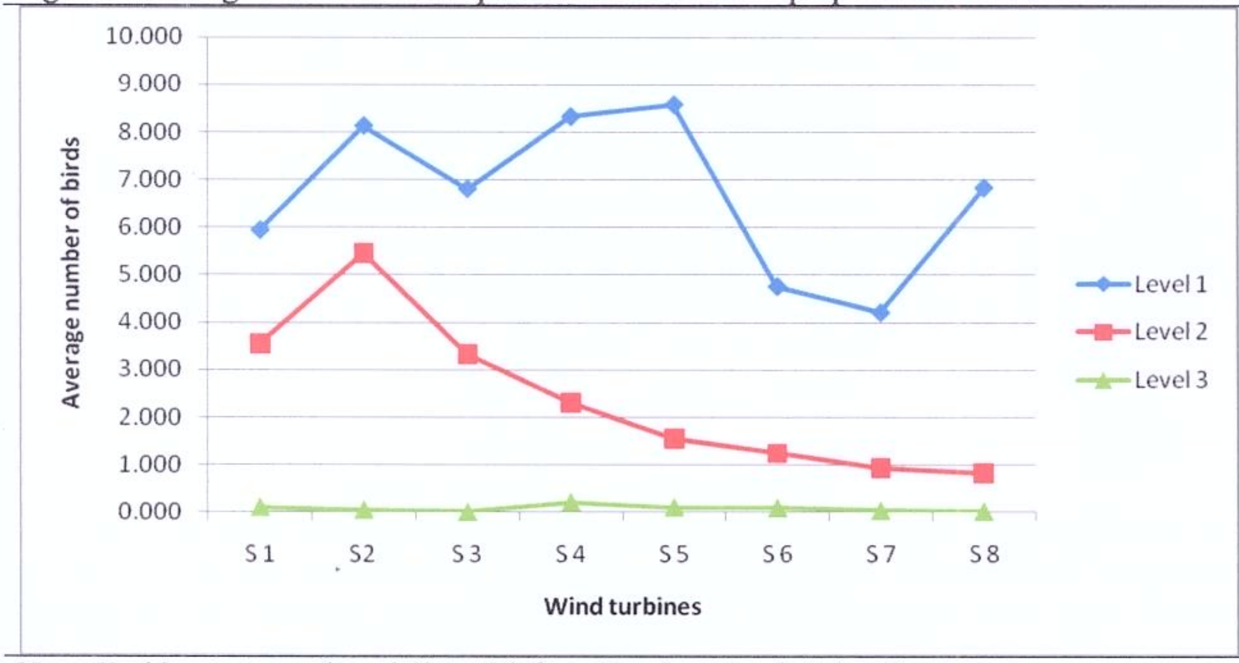



Figure 9: Average number of birds present at a unit time at proposed wind turbines

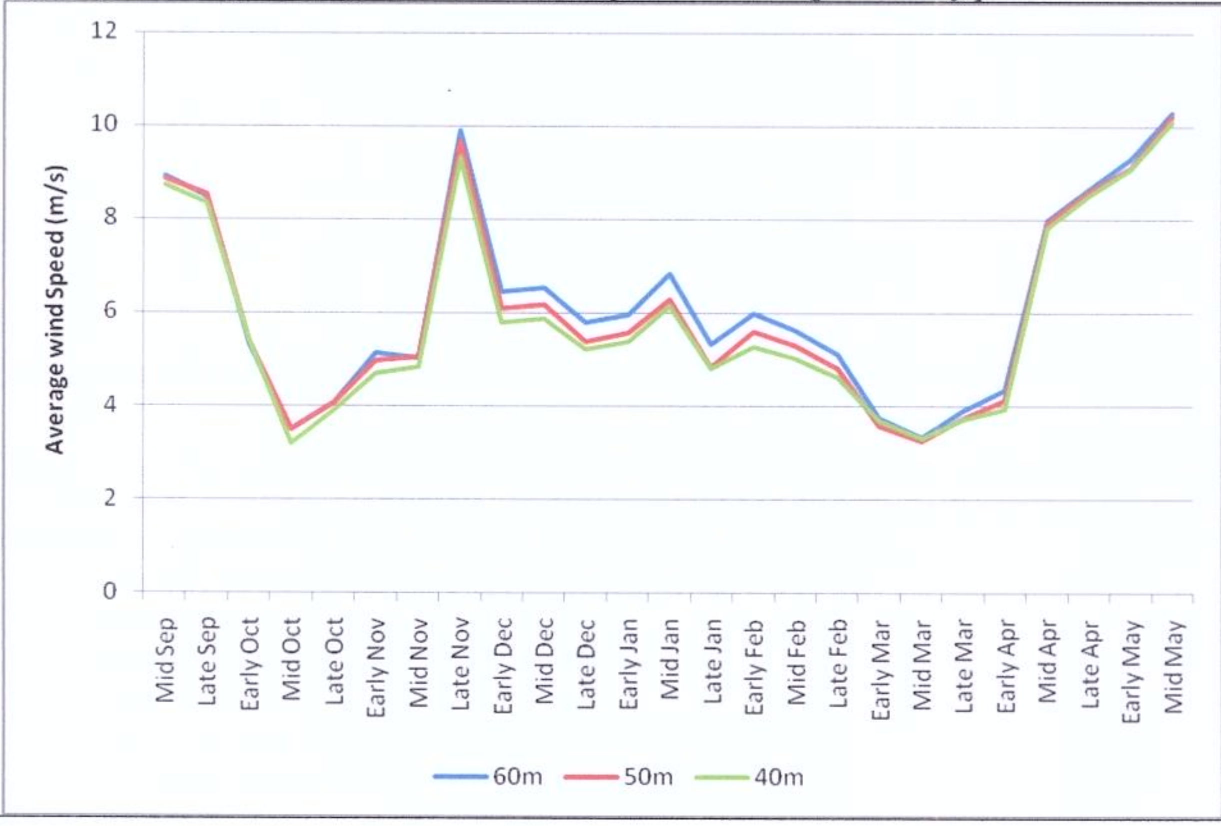



Note: Turbines are numbered (S1 –S8) from South to North (Map 1)

## Bird movements and the wind speed

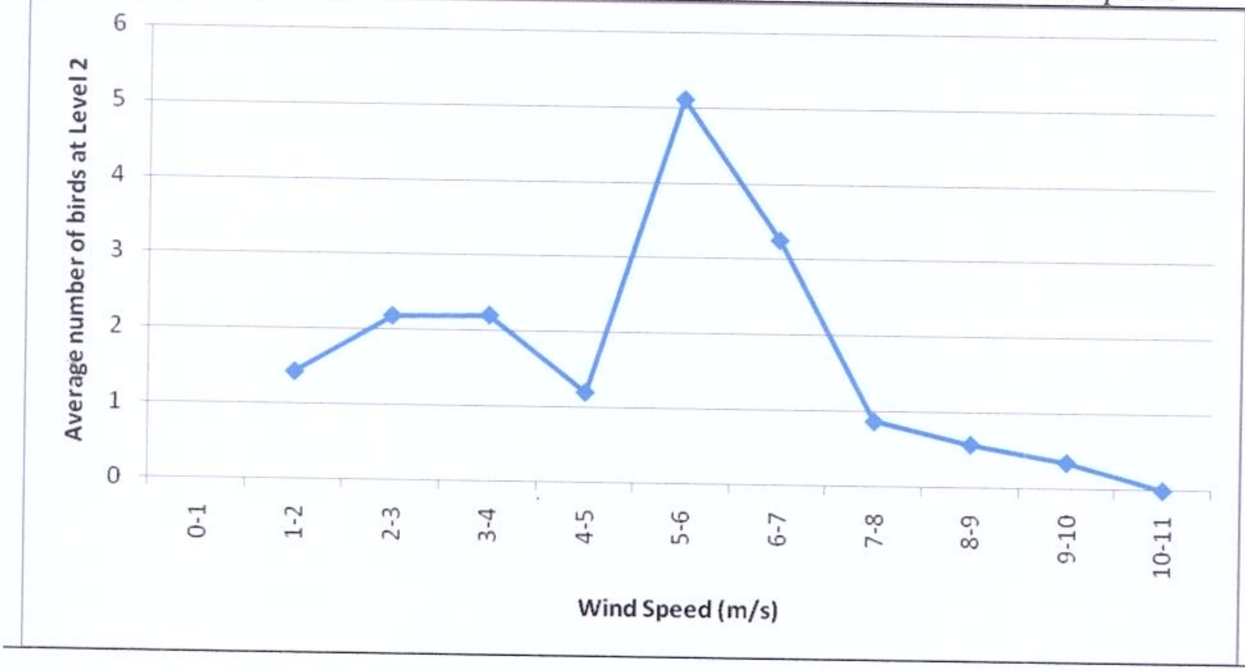
Based on the specification given for the Wind tower model Suzlon S 64 – 1250, which are to be installed at the project site, Cut-In wind speed is 3 m/s and Cut-Off wind speed is 22 m/s. Turbines reach its maximum performance at 14 m/s wind speed. Data obtained through the meteorological data testing tower, showed comparatively low wind speed during the study period. From October to March wind speed remained below 7 m/s, except for few days in late November where stormy condition prevailed. There were no significant differences between wind speeds at height levels above ground. However, slight differences were observed when the wind speed goes down.

Figure 10: Average wind speed at different height levels through the study period




Average wind speed during surveys ranged from 1 m/s to 11 m/s, and it went high as 16.m/s at only one survey session when stormy conditions prevailed. Average bird movement through the area swept by rotors showed fluctuations respective to the wind speed (Figure 11). High bird movement was observed between 5 m/s to 7 m/s wind speed, while it remain below 1, above the 7 m/s wind speed. Hence, it can be concluded that their is a minimal risk between 7-10 m/s wind speed and no risk above 10 m/s wind speed. However, there can be bird movements at the critical stratum at higher wind speeds above 10 m/s. Hence, it is advisable to monitor the situation during the high-wind period that coincides with the non-migratory period.

Figure 11: Average Number of bird movements through Level 2 at different wind speeds




## Methods of reducing bird mortality at wind energy facilities

Based on the studies carried out throughout the world, several methods have been identified to reduce bird collisions on turbines. Widely accepted and feasible methods to reduce bird collisions as proposed by some scientists (Strickland *et al.* 2001) are

- Paint the turbine blades to make them more visible to birds;
- Install anti-perching devices;
- Ensure that turbines are no taller than 100-150 m;
- Install bird flight "Diverters";
- Install warning devices that employ sound or visual cues;
- Use white strobe lighting (Gauthreaux and Belser 1999).

The proposed wind power site has already taken some precautionary steps to reduce bird mortality. The most important measure is the use of turbines of solid tubular design against lattice design, which is known to attract perching raptors and some nesting birds, thereby leading to injury or death. The proposed tower model Suzlon S 64 – 1250 to be installed at the site are also well below 150 m, and all wires are buried underground.

However, monitoring of bird mortality and bird behaviour at wind turbines is essential to carryout at least for one full year from its establishment. A draft monitoring protocol is annexed with this report (Annex 3). If mortality continues to appear to be a serious issue at certain windmill locations, the management should seriously consider reducing bird strikes by implementing some of the above mentioned measures and taking precaution through managing rotation times, considering peak bird movements.

## Monitoring Bird Mortality at Wind Energy Facilities

It is evident that every wind turbine site is unique and thus requires a distinctive protocol for monitoring bird mortality and bird movement across the wind farm. However, a number of factors should be common to all monitoring protocols (Morrison 1998, Anderson *et al.* 1999). These are:

- A measure of bird use; that is, how many birds pass by the turbines (or within a certain distance of the turbines) during a given time period
- A measure of bird mortality; that is, the number of carcasses found per unit area and/or search time.

Both of these variables should be assessed in order to identify changes in impact with season or site modifications. For example, if the number of mortalities recorded declines in a certain period, this could either be because the total use of the site by birds also declined due to another factor such as high wind, or because actual mortality due to turbines declined (while use of vertical space remained the same). It is impossible to draw conclusions about the impact of a site under varying conditions without both of these variables being measured (Anderson *et al.* 1999).

Most studies shows that it also benefit from a measure of bird use at a reference, or control, site located some distance from the turbines.

However, to conduct this kind of monitoring scheme, it is essential to have a skilled bird survey team, since identification of bird species and measuring distances and heights of bird movements need some credibility. This will require to have at least one officer dedicated for the task of assuring environmental safeguards. It would be necessary that this officer is competent in bird identification ( those in the area) too. Assistance could be provided by the Field Ornithology Group of Sri Lanka/ University of Colombo, in assisting this task.

A draft monitoring protocol is provided in Annex 3.

## Recommendations

- Locations S1, S2, S3 and S4 are considered significant for mitigation, and we suggest that installation must involve ‘painting of blades’ and ‘use of diverters’. These should be done with installation.
- All windmills should in the least contain the painting to distract and reduce any risk of strike.
- Monitoring must be part of the operational programme.

## Acknowledgements

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# Annex

## Annex 1 - List of birds recorded in the project area

| Common name | Scientific name | Status | Commonness |
|---|---|---|---|
| Grey Francolin | *Francolinus pondicerianus* | BrR | VC |
| Indian Peafowl | *Pavo cristatus* | BrR | VR |
| Lesser Whistling-duck | *Dendrocygna javanica* | BrR | VR |
| Asian Openbill | *Anastomus oscitans* | BrR | VR |
| Black-headed Ibis | *Threskiornis melanocephalus* | BrR | VR |
| Yellow Bittern | *Ixobrychus sinensis* | BrR | VR |
| Cinnamon Bittern | *Ixobrychus cinnamomeus* | BrR | VR |
| Black Bittern | *Ixobrychus flavicollis* | BrR | VR |
| Black-crowned Night-heron | *Nycticorax nycticorax* | BrR | VR |
| Striated Heron | *Butorides striata* | BrR | VR |
| Indian Pond-heron | *Ardeola grayii* | BrR | VC |
| Cattle Egret | *Bubulcus ibis* | BrR | VC |
| Grey Heron | *Ardea cinerea* | BrR | VR |
| Purple Heron | *Ardea purpurea* | BrR | VR |
| Intermediate Egret | *Mesophoyx intermedia* | BrR | VR |
| Little Egret | *Egretta garzetta* | BrR | VR |
| Little Cormorant | *Phalacrocorax niger* | BrR | R |
| Indian Cormorant | *Phalacrocorax fuscicollis* | BrR | VR |
| Common Kestrel | *Falco tinnunculus* | BrR/M | R |
| Oriental Honey-buzzard | *Pernis ptilorhyncus* | BrR | VR |
| Black-winged Kite | *Elanus caeruleus* | BrR | VR |
| Black Kite | *Milvus migrans* | BrR | VR |
| Brahminy Kite | *Haliastur indus* | BrR | VC |
| White-bellied Sea-eagle | *Haliaeetus leucogaster* | BrR | VR |
| Crested Serpent-eagle | *Spilornis cheela* | BrR | VR |
| Western Marsh-harrier | *Circus aeruginosus* | M | VR |
| Pallid Harrier | *Circus macrourus* | M | VR |
| Pied Harrier | *Circus melanoleucos* | M | VR |
| Montagu's Harrier | *Circus pygargus* | M | VR |
| Shikra | *Accipiter badius* | BrR | VC |
| Besra | *Accipiter virgatus* | BrR | VR |
| Common Buzzard | *Buteo buteo* | M | VR |
| Booted Eagle | *Hieraaetus pennatus* | M | R |
| Changeable Hawk-eagle | *Spizaetus cirrhatus* | BrR | VR |
| White-breasted Waterhen | *Amaurornis phoenicurus* | BrR | R |
| Common Moorhen | *Gallinula chloropus* | BrR | VR |
| Eurasian Thick-knee | *Burhinus oedicnemus* | BrR | R |
| Black-winged Stilt | *Himantopus himantopus* | BrR | VR |
| Yellow-wattled Lapwing | *Vanellus malarbaricus* | BrR | VR |

| | | | |
|---|---|---|---|
| Red-wattled Lapwing | *Vanellus indicus* | BrR | VC |
| Common Ringed Plover | *Charadrius hiaticula* | M | VR |
| Little Ringed Plover | *Charadrius dubius* | BrR/M | VR |
| Kentish Plover | *Charadrius alexandrinus* | BrR/M | R |
| Lesser Sand Plover | *Charadrius mongolus* | M | UC |
| Greater Sand Plover | *Charadrius leschenaultii* | M | VR |
| Caspian Plover | *Charadrius asiaticus* | M | VR |
| Whimbrel | *Numenius phaeopus* | M | VC |
| Common Sandpiper | *Actitis hypoleucos* | M | VR |
| Sanderling | *Calidris alba* | M | VR |
| Brown-headed Gull | *Larus brunnicephalus* | M | UC |
| Black-headed Gull | *Larus ridibundus* | M | VR |
| Gull-billed Tern | *Sterna nilotica* | BrR/M | VC |
| Caspian Tern | *Sterna caspia* | BrR/M | VR |
| Lesser Crested Tern | *Sterna bengalensis* | M | UC |
| Great Crested Tern | *Sterna bergii* | BrR/M | C |
| Sandwich Tern | *Sterna sandvicensis* | M | VR |
| Roseate Tern | *Sterna dougallii* | M | VR |
| Black-naped Tern | *Sterna sumatrana* | Va | VR |
| Common Tern | *Sterna hirundo* | M | C |
| Little Tern | *Sterna albifrons* | BrR | C |
| Saunders's Tern | *Sterna saundersi* | BrR | VR |
| Sooty Tern | *Sterna fuscata* | M | VR |
| Whiskered Tern | *Chlidonias hybrida* | M | C |
| White-winged Tern | *Chlidonias leucopterus* | M | VR |
| Lesser Noddy | *Anous tenuirostris* | Va | VR |
| Pomarine Jaeger | *Stercorarius pomarinus* | Va | VR |
| Rock Pigeon | *Columba livia* | BrR | VC |
| Spotted Dove | *Stigmatopelia chinensis* | BrR | VC |
| Rose-ringed Parakeet | *Psittacula krameri* | BrR | C |
| Pied Cuckoo | *Clamator jacobinus* | BrR | VR |
| Common Hawk-cuckoo | *Cuculus varius* | BrR/M | VR |
| Lesser Cuckoo | *Cuculus poliocephalus* | M | VR |
| Grey-bellied Cuckoo | *Cacomantis passerinus* | M | VR |
| Drongo Cuckoo | *Surniculus lugubris* | BrR | VR |
| Asian Koel | *Eudynamys scolopaceus* | BrR | C |
| Greater Coucal | *Centropus sinensis* | BrR | VC |
| Barn Owl | *Tyto alba* | BrR | VR |
| Collared Scops-owl | *Otus bakkamoena* | BrR | C |
| Brown Hawk-owl | *Ninox scutulata* | BrR | VR |
| Indian Nightjar | *Caprimulgus asiaticus* | BrR | VR |
| Asian Palm-swift | *Cypsiurus balasiensis* | BrR | VC |
| Little Swift | *Apus affinis* | BrR | VR |
| Indian Roller | *Coracias benghalensis* | BrR | VC |

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|---|---|---|---|
| Stork-billed Kingfisher | *Pelargopsis capensis* | BrR | VR |
| White-throated Kingfisher | *Halcyon smyrnensis* | BrR | C |
| Common Kingfisher | *Alcedo atthis* | BrR | VR |
| Pied Kingfisher | *Ceryle rudis* | BrR | VR |
| Little Green Bee-eater | *Merops orientalis* | BrR | R |
| Blue-tailed Bee-eater | *Merops philippinus* | M | VC |
| Eurasian Hoopoe | *Upupa epops* | BrR | VR |
| Brown-headed Barbet | *Megalaima zeylanica* | BrR | VR |
| Black-rumped Flameback | *Dinopium benghalense* | BrR | VR |
| Greater Flameback | *Chrysocolaptes lucidus* | BrR | VR |
| White-naped Woodpecker | *Chrysocolaptes festivus* | BrR | VR |
| Indian Pitta | *Pitta brachyura* | M | VR |
| Ashy Woodswallow | *Artamus fuscus* | BrR | C |
| Brown Shrike | *Lanius cristatus* | M | C |
| Black-hooded Oriole | *Oriolus xanthornus* | BrR | VR |
| White-bellied Drongo | *Dicrurus caerulescens* | BrR | VR |
| Asian Paradise-flycatcher | *Terpsiphone paradisi* | BrR/M | VR |
| House Crow | *Corvus splendens* | BrR | VC |
| Jungle Crow | *Corvus levaillantii* | BrR | UC |
| Barn Swallow | *Hirundo rustica* | M | C |
| Red-rumped Swallow | *Hirundo daurica* | BrR/M | VR |
| Jerdon's Bushlark | *Mirafra affinis* | BrR | UC |
| Oriental Skylark | *Alauda gulgula* | BrR | VR |
| Ashy-crowned Sparrow-lark | *Eremopterix griseus* | BrR | VR |
| Zitting Cisticola | *Cisticola juncidis* | BrR | VC |
| Grey-breasted Prinia | *Prinia hodgsonii* | BrR | VR |
| Jungle Prinia | *Prinia sylvatica* | BrR | VR |
| Ashy Prinia | *Prinia socialis* | BrR | VR |
| Plain Prinia | *Prinia inornata* | BrR | R |
| Red-vented Bulbul | *Pycnonotus cafer* | BrR | VC |
| White-browed Bulbul | *Pycnonotus luteolus* | BrR | UC |
| Common Tailorbird | *Orthotomus sutorius* | BrR | VR |
| Blyth's Reed-warbler | *Acrocephalus dumetorum* | M | UC |
| Clamorous Reed-warbler | *Acrocephalus stentoreus* | BrR | VR |
| Yellow-billed Babbler | *Turdoides affinis* | BrR | VC |
| Common Myna | *Acridotheres tristis* | BrR | VC |
| Brahminy Starling | *Sturnus pagodarum* | BrR/M | VR |
| Rosy Starling | *Sturnus roseus* | M | VR |
| Indian Robin | *Saxicoloides fulicatus* | BrR | VR |
| Purple-rumped Sunbird | *Nectarinia zeylonica* | BrR | R |
| Purple Sunbird | *Nectarinia asiatica* | BrR | R |
| Long-billed Sunbird | *Nectarinia lotenia* | BrR | R |
| House Sparrow | *Passer domesticus* | BrR | UC |
| White-throated Munia | *Lonchura malabarica* | BrR | VR |

| | | | |
|---|---|---|---|
| Scaly-breasted Munia | *Lonchura punctulata* | BrR | VR |
| Richard's Pipit | *Anthus richardi* | M | C |
| Paddyfield Pipit | *Anthus rufulus* | BrR | VR |
| Blyth's Pipit | *Anthus godlewskii* | M | VR |
| Grey-necked Bunting | *Emberiza buchanani* | Va | VR |

Status: BrR – Breeding Residents, M – Migrant, Va – Vagrant
Commonness: VC- Very Common, C – Common, UC – Uncommon, R – Rare, VR – Very Rare

**Annex 2 - Nationally Threatened species recorded in the project area**

| Species | Threat Status |
|---|---|
| Saunder's Tern | Critically Endangered |
| White-naped Woodpecker | Vulnerable |
| Besra | Vulnerable |
| Grey Francolin | Near Threatened |
| Greater Flameback | Near Threatened |
| Common Hoopoe | Near Threatened |
| Common Hawk Cuckoo | Near Threatened |
| Barn Owl | Near Threatened |
| Eurasian Thick-Knee | Near Threatened |
| Black-shouldered Kite | Near Threatened |
| Clamorous Reed Warbler | Near Threatened |

## Annex 3 - Draft bird monitoring protocol

The goal of this study is to determine the effects of eight wind turbines proposed at Mampuriya, on birds breeding, staging or migrating in the area. Currently, very little is known about the type and abundance of birds using this area, other than the results obtained through the baseline survey. The protocol is standardized so that results can be compared among potential and existing wind power facilities.

We highly recommend that a service provider with significant bird identification experience be hired to conduct the protocol during key periods of migration and breeding, and that employees at the proponent company be trained to do so for future monitoring work.

The number and species of birds at the project area will differ seasonally, within a season, and according to weather conditions and other environmental factors. For this reason, it is important to make every attempt to monitor the site at all times of year, for two to five years. Most wind test sites in the world are monitored every two weeks (Anderson *et al.* 1999). After completion of full one year monitoring programme and based on the results obtained, frequency of monitoring for future years can be adjusted.

The objectives of this monitoring programme are:
1. Determine use of space by birds (*bird utilization rate* – Number of birds observed per unit time and area) at each turbine and at a control site located at some distance from the turbines;
2. Determine *bird mortality rate* (Number of carcasses found per unit area) at these same points;
3. Using the above two variables, calculate *bird collision risk* (mortality/utilization) at each point;
4. Compare bird collision risk at turbines and controls;
5. Identify annual periods of high and low risk;
6. Determine the influence of weather on passage rate and mortality risk.

### Methods

Each of the eight turbines should be considered a single survey point. Each turbine should also be compared with a control point located about 300 m (or some other chosen distance) away, with the condition that the habitat should be similar between the turbine point and the control point. The control point should not be established either fully or partially on a water body. Control points should be marked for easy reference and geo-referenced with a GPS for future use. This paired design should allow comparison of bird utilization and mortality rates immediately surrounding the turbines, and some distance (300 m) away from the turbines. However, 300 m may be suitable to determine impacts on small birds, but may not be suitable for birds such as raptors that range large distances.

Each of the eight points should be surveyed at least three times a month from October to April where high bird density and diversity prevails. However, monitoring frequency can be reduced to once in every two weeks from May to September. Surveys should start at first light *i.e.* 0600h, so that dead bodies are more likely to be found before they are scavenged. Additional counts should be conducted following drastic weather changes such as storms during the migration seasons.

Draft data sheet is attached herewith. After data on environmental factors such as wind speed, cloud cover, etc. have been recorded, a 5-minute point count should be conducted wherein all birds that are staying or flying (e.g. within 45 m of) the turbine (for the control point, within 45 m of the center of the point) should be recorded. For each bird, the following variables should be recorded (from Morrison 1998):

1. Species (if known). If not known, each bird seen should simply be recorded by group. (Eg. Terns)
2. Behaviour (flying, gliding, soaring, walking, perching, etc).
3. If flying, gliding or soaring, the vertical zone of movement. Three suggested zones (after the baseline survey) are:
    Level 1) not in the area swept by the rotors but below the bottom tip of the blade;
    Level 2) within the area swept by the rotors;
    Level 3) out of and well above the top of the blade.

At the control point, the bird's location should be recorded in reference to the heights associated with the above zones

Once all eight survey points have been surveyed for bird activity, the points should be revisited and an area of 50 m radius around each tower (and the center of control point) should be searched for dead or injured birds. It is important that these searches occur on the same day as the point counts. It is possible to have two different observers conducting the point counts and the carcass counts at the same time. The carcass searches will take longer to complete, as all tall grass clumps, shrubs and openings to animal burrows should be searched thoroughly (Morrison 1998). If the carcasses cannot be identified, they should either be collected (requires a permission from the Department of Wildlife Conservation) or photographed for future identification.

Either way, each carcass should be removed from the search zone after photographing or identification to avoid re-finding it on a later survey. For each carcass found, the observer should record its identity (to species if possible), the condition of the carcass, the estimated time of death (or time since death), the probable cause of death, and justification for why this cause was chosen. The distance and direction from the base of the turbine (or the center of the control point) should also be noted (and geo-referenced with a GPS if possible). Most carcasses are scavenged within about five days of dying (Kostecke *et al.* 2001), so clearly not all birds killed at the turbines will be found by this method. It is advisable to conduct a separate study to determine carcass persistence rates at the study site at some point in the year (see Anderson *et al.* 1999).

Observers may discover live birds that have been injured due to potential turbine collisions. These birds should be examined to determine the cause of injuries (need to be done by professional), and the physical abnormalities should be described on the data forms (Anderson *et al.* 1999). Sample data forms are included at the end of this Appendix.

### Analyses

The bird utilization rate (Number of birds observed/unit time) and bird mortality rate (Number of dead birds/point) can be calculated for each turbine and control point. Utilization rate can also be calculated separately for each passage zone (Level 1-3). An index of risk can then be calculated as the ratio of mortality to utilization. This ratio can be compared for turbine and control sites, to see if the area immediately around turbines is considered to be more dangerous than the area at some distance from the turbines. Habitat differences between turbine and control points must be taken into account (by measuring standard habitat variables at each point). This ratio can also be compared across the season to determine if risk is higher during the migration, breeding, or wintering seasons, and across various weather conditions to determine if risk is higher during periods of low visibility, storm conditions, etc.

**Sample data Sheet – For Point Counts**

| | | | | | |
|---|---|---|---|---|---|
| **Date** | | **Point No:** | | **Time started** | |
| **Observer** | | **Assistant** | | **Cloud Cover** | |
| **Wind** | Mild | Low | Average | Strong | Very strong |
| **Weather** | Cloudy | Sunny | Rainy | Misty | |
| | | | | | |
| **Species** | **No: of birds** | **Height Level** | **Distance to tower** | **Flight Direction** | **Flight Pattern** |
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**Sample data Sheet – For Carcass Search**

| Date | | Point No: | | Time started | |
|---|---|---|---|---|---|
| Observer | | Assistant | | | |
| | | | | | |
| Species | ID procedure | Distance and direction to turbine | Carcass condition | Estimated time of death | Probable cause of death |
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| Comments: | | | | | |

Identification Procedure: Collected, or Photographed, Reference of specimen if collected
Carcass condition: As whole, scavenged, skeleton, cluster of feathers or other (describe in comments section).
Cause of death: As turbine strike, shooting, poisoning, predatory attack or unknown.