Lekela

Report on the autumn 2017 pre-construction ornithological monitoring at the Lekela wind energy development area, Ras Gharib, Gulf of Suez

Draft Report

Prepared by:

Environics, SAE
Environment & Development Advisors

In association with

Nature Conservation Egypt (NCE)

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Table of Contents

List of Table

List of Figure

Abbreviations

BLI	BirdLife International
CRM	Collision Risk Model
GOE	Government of Egypt
EEAA	Egyptian Environmental Affairs Agency
EIA	Environmental Impact Assessment
FS	Fixed Shutdown
IBA	Important Bird and Biodiversity Area
KFW	Kreditanstalt fur Wiederaufbau
MSB	Migratory Soaring Bird
NCE	Nature Conservation Egypt
NREA	New and Renewable Energy Authority
RSH	Rotor Swept Height
SOD	Shutdown on Demand
UNDP	United Nations Development Program

Summary

This report presents the results of a monitoring study of soaring bird migration during the autumn of 2017 at the Lekela prospective wind farm project sites north of the town of Ras Gharib on the Gulf of Suez, Egypt, and compares the overall outcomes of this study and that of autumn 2015 ornithological studies conducted at the area.

The study was carried out between 15 August and 5 November 2017, for a period of 83 days, covering the full autumn bird migration season in the Gulf of Suez region.

The objectives of the study were to gather systematic information about soaring bird migration at the study site during the autumn season that can be used in assessing potential risks from proposed wind energy developments in the area, as a contribution towards the environmental profiling and development approval process, as well as future mitigation planning at the site.

The methodology was composed of observer-based field monitoring of bird migration at the study site based at six fixed vantage observation points, all placed in a central position in each of the proposed development plots. The observation points had a radius of 2 km each, and were visited on a rotating schedule twice a week. Each point was manned by two observers, on two alternating morning and evening shifts, which covered the entire daylight hours. Birds were recorded according to location (vantage point, or position inside or outside the wind farm), time of day, altitude, species and number. Hourly weather records were documented.

In addition vehicle based transects were carried out to search for carcasses under existing power lines that fringe the study area from the east.

Results

The study was carried out between 15 August and 5 November 2017 for a total period of 83 days. In total 166 observation sessions were carried out, totaling 800 observation hours, representing a coverage of about 89% of available daylight time. The number of sessions and hours of observations was divided almost equally between the six vantage points

No birds were observed during 126 out of a total of 166 sessions, representing about 75% of the observation sessions, with no soaring birds being recorded during the last eight days of the study.

In total 954 observations were made (of soaring and non-soaring birds, inside and outside the study sites), resulting in a grand total of 31,386 birds (including 8,654 non-soaring birds). 5,259 birds were recorded in the adjacent zone, outside the 2km radius of observation. The total number of observation of soaring birds inside and outside the study sites was 704 observations, with a total of 22,732 birds belonging to at least 24 species, with an overall migration rate of 28 birds / hour. Of these 17,473 birds were recorded within the project area. Of these 582 observations of 17,473 birds belonging to 20 species were recorded within the project area, with an overall migration rate of 22 birds / hour; reaching an average of 72 birds / hour during the first three weeks of autumn migration.

The most numerous species was the White Stork (14,309 birds representing 63.4 % of the total), followed by Honey Buzzard (7,754 birds representing 34.4 % of the total), and White Pelican (183 birds, representing 0.8% of the total).

Weather conditions

Wind speed had an average of 8.23 m/second. Wind direction was highly consistent, with north and northwesterly winds dominating 89% of the time, and winds from the northeast accounting for about 10% of records. Average temperature during the study period was 30.6˚c, with a maximum of 41.4˚c and a minimum of 21.1˚c. Visibility was notably better than in spring 2017, being fairly good (> 5km) 70 % of the time; while, visibility was of lower quality (< 5km) about 17% of the time.

Volume and diversity of soaring bird migration in the study area

Within the study area 582 observations were made of 17,473 soaring birds belonging to 20 species.

The most abundant species were White Stork (contributing 56% of all records), and Honey Buzzard (contributing 32%), and White Pelican, Black Kite and Marsh Harrier (contributing 1% each). Honey Buzzard was the most frequently observed species (71% of all observations), with an average flock size of 17 birds. The second most frequently observed species was Marsh Harrier with 85 observations. All other species were observed less than 50 times, while there were six rare species only recorded once. This composition and proportional contributions of the main species is consistent with that of autumn 2015.

Timing of migration

The 2017 autumn season had an abrupt start, with 88.5% of the total birds passing between 15 August and 12 September 2017. The largest daily total of migrants was on 23 August, with 5,300 White Storks. No soaring birds were recorded during the first five days of the study. The first observation of soaring birds was of a flock of 2,000 White Storks on 20 August. The last observation made was on 28 October, with the last eight days of the study being devoid of soaring birds.

Movement through the study area was typically rapid and unidirectional, with most birds passing right across the area without stopping, slowing down or altering flight trajectory. The average occupancy of birds (flocks) within the study area was 1 minute (range 0.25 – 35 minutes), with an average occupancy in the RSH of 0.4 minutes (range 0-3 minutes). More than 99% of all birds spending less than 5 minutes within the study area.

Flight altitude

Flight altitude is one of the most important factors in estimating collision risk for soaring birds. The average flight altitude through the study site during the current study was 148.4 meters above ground level (number of altitude records 2187, range 0-500 m, Standard Deviation 109.5 m), An estimated 1217 birds were recorded within the RSH (between 5 – 125 meters above ground), representing about 7% of total birds. The vast majority of birds (93%) were recorded above 125 m, of these 2,354 birds flew between 200 – 300 m (representing 14% of the total). While less than 1% of the birds were documented at or below 5 m, including birds that landed on the ground. Only 15 birds were recoded landing on the ground throughout the duration of the study. The number of birds flying through the RSH is the main factor in increasing collision risk estimates in the CRM.

Observations of avian mortality

Seven carcass surveys were conducted under the existing 220 kv power lines that stretch along the eastern boundary of the study site between 17 August and 4 November 2017, with a total combined length of 84 km and about 7.5 hours of observations. Only 6 carcasses of white storks were detected, seemingly all from one large flock.

Conservation significance

Three globally threatened soaring bird species were documented at the study site: Pallid Harrier, Sooty Falcon, and Red-footed Falcon; all of which have been listed in the IUCN Red List (2017) as Near Threatened and Vulnerable. None of the threatened species were found in internationally significant numbers, nor were predicted to have any significant casualty levels by the CRM.

White Stork was the only species that occurred in globally important numbers exceeding the 1% population level, and for which significant risk could occur during the early autumn migration season.

Risk assessment

The outcome of the CRM predicts that the total potential casualty level from active wind turbines within the study area (an estimated total of 126 turbines) during the study period, would be between 54.04 (95% avoidance rate) and 21.62 (98% avoidance rate) birds, with a casualty rate of between 0.64 (95% avoidance rate) and 0.26 (98% avoidance rate) birds / turbine / season.

Conclusions

Results from 2017 and 2015 indicate that the study area is of importance for certain species along wider Red Sea / Rift Valley Flyway for migratory soaring birds.

In conclusion, the results from the current study and the 2015 study at this site support that wind energy development is possible throughout the greater part of the autumn season with low risks, except for a narrow window of risk between mid August and mid September, where risks must be managed or mitigated through a well planned monitoring and risk management effort.

Recommended risk management for the area include:

Despite the debatable findings of the RECREEE Strategic Study (Lahmeyer & Ecoda 2017) to regard the autumn season as being of no importance to bird migration and recommendations that no mitigation measures should be applied during this season (besides carcass surveys), our findings indicate that the early part of the autumn season (mid August – mid September) carries a significant risk to migratory soaring birds comparable to the spring season and deserve equal precautionary treatment, as indicated below and in agreement with many of the RECREEE proposed measures for spring.

Pre-construction

Maintain a pre / post construction bird migration monitoring effort during the peak migration period. Recommended monitoring period: 10 August – 15 September.

Establish a database to maintain monitoring results and continually analyze the cumulative data to produce more refined management recommendations (this should continue throughout the life time of the project and maintained by a trained specialist).

Design and construction

Maintain monitoring effort as above. A modified monitoring approach with a reduced effort can be applied, as knowledge is enhanced.

Strictly preserve the unattractiveness of the site to migrant birds. This can be achieved by rigorously banning any type of cultivation, or plantation of green areas in or around the site; prevention of garbage or other solid or liquid waste in the project site or in its vicinity (even inorganic wastes); strictly preventing any water or other liquids (including oils) from reaching the surface.

The management of risks from power lines differs from wind turbines, as shutdown options will not be applicable. For the existing power line visual interventions should be applied. For all internal grid, underground power cables should be installed.

It is important to harmonize and coordinate the design, installation and operation of multiple wind farms in the wider region; as well as coordinate monitoring and risk management efforts, including any Shut Down on Demand procedures.

Some further physical aspects to consider in the design stage include: Avoiding turbines with lattice towers, limiting maximum tip height of wind turbines to about 120 m, avoid lighting of wind turbines and painting turbine blades with bold and contrasting colors to increase blade visibility to birds.

Operation phase

Post-construction monitoring is critical, particularly during the initial stages of operation to verify bird response to predictions and intervene if critical issues arise. Confidence levels in risk assessment results will increase with cumulative knowledge and experience. This knowledge will be used to refine any shutdown or other risk management measures that need to be taken, and hence reduce long-term costs. The post construction monitoring effort must include a systematic carcass survey to assess actual mortality during operation.

Year 0 – 1 of operation: No shutdown should be implemented during the first full year of normal operation in order to provide a verifiable sample assessment of the full potential impact of the newly operational infrastructure on migrant soaring birds. This, however, must be combined with a detailed monitoring effort to assess bird responses and document any casualties. The results of the first year of un-interrupted operation would be then used in the detailed set up of subsequent shutdown on demand methodologies and standards.

Year 1 – 4 of operation: Implement a shut down on demand system based on the finding of previous years monitoring and the results of the first year of operation. Eventually, the shutdown system could include a fixed shutdown during the last two weeks of August (during the peak stork migration in Autumn), combined with shutdown on demand during seven weeks of peak migration in spring, as discussed above. Shutdown on demand will require a constant monitoring effort and a clear set of triggers (these have already been defined by the EEAA). The details of a shutdown system need an independent effort to establish a viable and practical system that takes into account, the biological aspects and also the cost, practical implementation aspects, potential consequences to the grid, and relationship with neighboring wind energy developments.

Year 4 and beyond: It is anticipated that a shutdown system (either fixed or on demand) and long term monitoring (composed of systematic carcass surveys and a sampling effort) will be required for the life-time of the project.

Acknowledgements

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1. Introduction

The western shoreline of the Gulf of Suez is the focus of a major wind energy development effort that is aimed at transforming the greater part of this landscape into a wind-harvesting field. With one of the world best wind productivity few other potential competing land uses the region is on a fast-track towards this rapid transformation.

Potential impacts on large populations of birds that tend to concentrate in globally important numbers is one of the main concerns for the future expansion and establishment of wind harvesting infrastructure in this region. Frequently significant mortality of birds (and bats), mainly due to collisions with the rotors of wind turbines and associated infrastructure, has been documented in several wind farms around the world. This issue has been highlighted by most of the major international lenders investing in wind energy today (e.g. World Bank and European Bank for Reconstruction and Development, etc.) as an important issue that needs to be addressed at most new wind energy developments throughout the world.

This is particularly the case in Egypt, where large areas with the greatest wind energy potential coincide with globally important migratory routs for soaring bird migration, where the potential conflict with birds has been one of the major environmental concerns with regards to wind energy development. This is particularly the case in the Gulf of Suez area, which has the best wind energy potential in Egypt and also includes some of the world’s most important bottlenecks for soaring bird migration.

The Gulf of Suez falls along the Red Sea-Rift Valley Flyway and has several recognized Important Bird and Biodiversity Areas (IBAs) including Gebel El Zeit, Suez, Ain Sukhna and the Qa plain (Baha El Din 1999), where hundreds of thousands of migratory soaring birds pass every autumn and spring. Significant proportion of the global populations of many species pass through the region. These birds are vulnerable during their passage, particularly when flying across the Gulf of Suez, due to the hyper arid conditions that prevail in this region.

The combination of other development and alterations to the natural environment can add even greater risks and pressures to these birds during their voyage through the region by reducing resting sites and increasing pollution, disturbance and hunting pressures.

Wind energy and bird interactions in the Gulf of Suez region are going to continue for a long time, and the risk factor to birds will always be present. It is imperative that there is a good understanding of this interaction in order to enable effective management of this risk and to mitigate potential negative impacts in an effective and efficient way that facilitates optimal energy productivity.

2. Monitoring and risk evaluation

Monitoring is important to ensure that risks posed to birds by wind energy developments are minimal, and to ensure that mitigation measures applied are effective. Since the advancement of the initial plans for wind energy development in the Gulf of Suez region, a multitude of ornithological studies have been conducted to evaluate the risks and develop potential mitigation measures that can be applied at various sites within the region.

Pre-construction Monitoring is part of the EIA process for wind farms as required by the EEAA, through which risks to birds are assessed. Without proper and technically sound pre-construction monitoring, there are unknown levels of risk that could be very costly to all concerned. Pre-construction monitoring provides a general assessment of what can be expected regarding bird migration for the area and the risks they face. Its collected records are imperative to select appropriate project sites, minimize risks to migratory birds and to design appropriate mitigation plans.

Wind energy development is known to potentially have serious negative impacts on birds. This is because of the large land area they cover, and their above ground infrastructure needed, such as wind turbines and power lines.

Some species like soaring birds are more likely to have a high risk from wind energy development. This is because they are usually large in size, slow in maneuverability and tend to concentrate in specific migration routes. In the mean time they are long-lived, with low natural mortality and low reproductive rates; which means that they are vulnerable at a population level. Many of these species are already threatened, or have small or declining populations; even small but sustained losses at wind farms could add significant mortality stress on the entire species population.

According to guidance paper from the Migratory Soaring Birds (MSB) project (2012) there are three main ways in which a wind farm development could affect bird populations:

1. Collision including collision with rotors, power lines and other infrastructure. The magnitude of the predicted collision rate should ideally be determined in the context of the background mortality rate for that species. A negligible magnitude impact would be predicted if the collision mortality was to represent an increase of less than 1% on the background mortality rate.
2. Direct habitat loss through displacement from an area in and around the wind farm development site that can be bird’s typical feeding or nesting area. Habitat fragmentation at a landscape scale may also be an issue.
3. Disturbance and barrier effects – Disturbance would have a real ecological impact if it resulted in reduced resource use by the birds and hence a reduction in carrying capacity. Disturbance effect can mean that habitats adjacent to the development are not utilized by birds, meaning that the impact of the development is greater than the development area itself. The

barrier effect of the turbines, which could affect birds' movement and increased energetic costs, also needs to be considered. The cumulative and barrier impacts of several adjacent wind developments could be significant. A single wind farm could have acceptable levels of bird casualties, with little impact on the overall bird population. However, if successive wind farms are established in the same region, the cumulative effect may have population level impacts. In a migratory flyway such as the Rift valley/Red Sea Flyway, the potential impacts, particularly the cumulative impacts produced by successive wind energy developments, can be serious.

This study is mostly focused on the first impact related to collision with wind turbines and other infrastructure.

Impacts on local bird habitats is most likely be minimal as natural habitats and associated avian fauna at the study site and surrounding region is poor and supports very scant populations of very few species that occur in very low density (as can be seen in the results in this and other similar studies in the region).

The disturbance and barrier impacts are also likely to be negligible for the same reasons.

2.1 Study objectives

The overall objective of the study is to provide an updated understanding of the phenology of bird movements and habitat utilization of primarily migratory soaring birds during the autumn season, in and around the prospective wind farm sites, and assess the possible levels of risk that they might be exposed to within the project area from future wind turbines and associated structures.

The operational objectives of the monitoring program are:

1. Collect detailed data on the migration patterns of birds through the project site and its vicinity;
2. Collect detailed data on the behavior (flight altitude, flight direction and patterns) and reactions of bird migration through the project site;
3. Collect detailed weather observations for the duration of the study in order to identify potential weather effects on migration;
4. Identify situations / locations when and where birds could be at high risk within the wind farm;
5. Collect data on any background (pre-existing) casualty rate of bird through the project site (if any);
6. Provide overall assessment of risk to migratory soaring birds from the wind farm during the autumn season;
7. Recommend possible mitigation measures to reduce any risks identified.

3. Methodology

The field methodology and data analysis used in the study followed to a large extent the guidelines outlined in the document "Environmental Impact Assessment Guidelines and Monitoring Protocols for Wind Energy Development Projects with a particular reference to Migratory Soaring Birds" (MSB Project 2013); which includes guidelines developed by the UNDP/BirdLife International Migratory Soaring Birds Project and adopted by the EEAA. These are generally the same methodologies employed by earlier studies in the Gebel El Zeit region, most recently by studies commissioned by NREA in autumn 2014, and spring 2015 (Ecoconserv 2014 and Ecoconserv 2015).

According to these guidelines preconstruction monitoring within the Gulf of Suez region should be intensive in nature due to the critical importance of the area for migratory soaring birds. The intensive approach was recommended to include a three-year monitoring-program, must be a combination of high-level radar-monitoring and high-level standardized visual observations for the entire spring and autumn migration seasons. The three-year requirement has since been downgraded to one year by the EEAA. In the absence of radar technology (due to security restrictions), the monitoring effort was dependent on manual observations. Although this departure from the Guidelines has been sanctioned by the EEAA, it does provide lower quality data than what radar observations would provide. This reduced quality of data should be kept in mind when interpreting results.

The methodology is composed of three primary components: 1) fixed vantage point observer-based visual field monitoring of bird migration at the study area; and 2) casualty surveys under existing power lines and other ad-hoc observations of mortality within and around the study area; 3) data analysis and reporting, including review of the available data from other previous and relevant studies.

In light of the absence of radar technology (due to security restrictions in Egypt) and the dependence on visual observations, the monitoring methodology and setup followed a precautionary approach maximizing the extent of survey effort as much as possible to compensate for inherent weaknesses in manual / visual based monitoring.

Figure 1: Polygon (green line) defining the general study area encompassing the six development plots (black line).

3.1 Fixed vantage observation points

Fixed vantage point monitoring was selected as the primary monitoring approach for this season as was the case in previous seasons in the earlier studies of the Lekela (Site 1). This is also the approach recommended by the EEAA guidance in light of the absence of radar technology.

The study area composed of six plots with an estimated combined area of 28.5 km^2. As the six plots are contiguous and form one concise land area; it was decided to treat the totality of plots as one integral site (the Study Area). The Study area is defined by a polygon has an estimated area of 60 km^2.

The study area was monitored through six fixed vantage points. These were utilized to conduct stationary observations at the project sites, each monitoring location was established at a central location within the perimeter of each of the six plots, each with a visual radius of roughly 2 km, which is a distance within which birds can be detected and identified with a good level of confidence (as indicated in EEAA guidance), and covers the whole area of each of the proposed wind farm plots (see Figure 2). Each observation point was separated from its closest neighboring point by 2.3 to 4.4 km. The corners of each of the plots were marked with small flags on the ground to help the observers visually identify the boundaries of each site in the field.

Figure 2: Map of the study site showing observation points and 2 km observation radius around each. The black lines delineate the wind energy development parcels. The red line shows the 2 km radius around each observation point. Ras Bakr is located SE of the study site. The Gulf of Suez occupies the right side of the map.

Table 1: Coordinates of the six observation points identified in Figure 2 above (excluding the RCREEE observation points)

Observation point	N	E
1	28°30'59.77"N	32°52'37.33"E
2	28°32'20.26"N	32°51'22.67"E
3	28°33'53.29"N	32°49'37.79"E
4	28°35'25.13"N	32°48'31.55"E
5	28°33'2.87"N	32°48'23.43"E
6	28°31'36.89"N	32°50'8.97"E

3.2 Observation techniques and routine

Visual observations were conducted during daylight hours on a daily basis for the entire duration of the autumn season. Two teams each made up of two qualified ornithologists conducted the timed observations. Field observations took place on two 5 hour shift basis, one starting at around 7 am and ending at noon and the other starting at noon and ending at around 5 pm. The team conducting the morning session was replaced by another fresh team for the afternoon session on a daily basis in order maintain the observer condition and optimal observation capacity. The two observers forming each team alternated roles every 15 minutes between scanning and counting, and data recording so as to help maintain optimal vigilance. Minor variations in the length of shift times were made according to sunrise and sunset times and other field conditions.

Observations at each of the six observation points took place every 2 - 3 days during morning and evening sessions as shown in the sample schedule (Table 2), which shows a six-day cycle within which each site would be observed once in both morning and evening sessions. Thus, during the course of the autumn study each site would be monitored about 14 times during either a morning or an evening session (roughly 7 sessions in each period). The distribution and timing of observation sessions is designed to maximize spatial and temporal representation of the entire study area.

Table 2: Sample schedule of observations, showing the distribution of monitoring effort amongst observation points during a week.

Day	Site no.	1	2	3	4	5	6
1	morning	X					
	evening			X			
2	morning				X		
	evening					X	
3	morning		X				
	evening						X
4	morning			X			
	evening	X					
5	morning					X	
	evening				X		
6	morning						X
	evening		X				
7	morning	X					
	evening			X			

At each observation point, observers made regular 360º scans of the sky with binoculars to detect any soaring bird movements. Two sets of observations were made: one of birds flying within each project site (< 2 km distance) and another of birds flying near and around (but not entering the project site being monitored) to the maximum possible visible range (probably about 3-5 km according to visibility and size of species, etc.). The detailed observations of birds entering the project sites are used to assess the collision risk to birds within each project site, and the total volume entering the risk zone.

The detailed observations of birds entering the project site were used in evaluating bird flight behavior within the study site, and assessing the proportion of these birds entering the risk zone (the rotor swept zone), which was used in the Collision Risk Modeling to assess the collision risk to birds within the project site, and the total volume entering the risk zone.

Observations of the wider context of the project site were used in assessing the total volume and pattern of migration in the region and the relative significance of the study area to the migration volume in the region.

Observations of the wider context of the project site were used in assessing the total volume and pattern of migration in the area at large and the relative significance of the study area to the migration in the region.

3.2.1 Timing and duration of vantage point monitoring activities

The autumn study period extended between 15 August and 5 November 2017 (85 days in order to cover the full extent of the autumn migratory seasons. According to methodologies developed by BirdLife International and adopted recently by the EEAA, it is necessary to cover the whole migration season during preconstruction risk evaluations for birds at wind farm sites. This is important to account for the possible seasonal variability in the migration pattern at the study site.

3.2.2 Daily observation period

Observations started daily after sunrise and ended at noon during morning sessions, and started at noon and ended before sun set during evening sessions, to cover as much of the daytime as possible (migratory soaring birds migrate only during day time, with very few exceptions). It is estimated that there was 901 hours of effective daylight during the study period,

As no radar is used in this study there was no assessment of nocturnal migration and all focus will be given to diurnal migrants.

3.2.3 Birds inside wind farm area

Birds detected entering this area are identified, counted, timed, their orientation and flight altitude is documented on 15 second intervals during their passage in the wind farm.

The following data were collected when birds were observed inside the study area:

1. Time
2. Number of birds
3. Bird species
4. Direction of flight
5. Altitude at 15-second intervals during the bird passage in the project site.
6. Behavior (e.g. direct passage, resting, feeding, roosting, etc.)
7. Photographic documentation whenever possible

3.2.4 Birds outside wind farm area

All visible birds detected in the vicinity of the project site from any direction were identified, counted, followed, and their flight direction, distance from project site and altitude estimated. Birds that were first detected outside the project site area and then enter the areas of concern were documented on both forms and identified as such.

Data was collected in hourly intervals. The following data was collected:

1. Number of birds
2. Bird species
3. Direction of flight
4. Altitude (using visual estimate)
5. Behavior (e.g. direct passage, resting, feeding, roosting, etc.)
6. Time
7. Distance from vantage point (using visual estimate)

Field sheets were designed to capture this and other data, which were entered into digital storage on a daily basis.

3.3 Weather observations

Weather observations were made at the start of each hourly observation session, including the following:

1. Wind speed (using Anemometer)
2. Wind direction (using compass)
3. Visibility being assigned to four categories: 1) < 5 km, 2) 5-10 km, 3) 10-15 km and 4) > 15 km. using land scape and/or stationary ground marks)
4. Special weather conditions (sand storms etc.)
5. Temperature (digital thermometer)

3.3.1 Opportunistic observations

Opportunistic observations outside the monitoring locations e.g. en route to the site or in areas adjacent to the site were documented whenever possible and used in circumstantial analysis.

3.3.2 Monitoring of mortality along existing power lines

Previous studies in the region have indicated that power lines could to be a significant cause of mortality for migrant soaring birds. In order to assess the possible impact of existing power lines nearby the study area, a car based transect was carried out roughly every ten days along the length of the existing high tension 220 kv power lines (east of the study site, see Figure 20) to assess risks of collision with power lines to birds.

The transect inspection was carried out from a slow moving vehicle usually in the morning by the resting (evening team). Observers looked from either side of the vehicle to note any bird remains (whole carcasses or feathers). Since our focus is on soaring birds, which are typically large in size and would normally stand out if lying on the barren desert floor from a considerable distance, the vehicle use for this type of transect was deemed efficient enough to provide a bottom-line reassurance that at least no large numbers of soaring birds were impacted by the existing power lines.

A standard set of data was collected when any casualty is found, including, number, species, age, date, age of carcass, likely cause of death, and photographic documentation.

3.4 Description of the study site

The six plots that are the subject of this study, described hereinafter as the study area, are about 28.5 km^2 in combined area. They are located along a north-west to south-east axis that is about 12.5 km long at its longest extent and 6.5 km at its widest. The six plots are located upon the coastal plain of the Gulf of Suez to the north west of the town of Ras Gharib.

The nature of the landscape at all six plots is monotonous and basically composed of a flat gravelly plain, dissected with a few shallow runnels (wadis), and located between Wadi Hawashiya and another large wadi, which have moderately sized drainage basins from the Red Sea hills draining into Ras Bakr on the Red Sea. The plots tend to get more undulating and with more topographic relief from south to north. With site one the flattest, and site 4 the most complex, with many small wadis and bluffs.

Vegetation cover within the site is modest (with many perennials apparent after the rains and floods of autumn 2016) and there are no known permanent natural sources of fresh water. The only prominent man made structures within close proximity to the study site is a 220 kv high tension power line that extends along the entire eastern boundary of the study area (13 km) and parallel to it, and at an average distance of about 300 m.

Figure 3: Habitat conditions in the surroundings of vantage point 3.

3.5 Attributes of the planned wind energy development

According to turbine and lay out specifications provided by the developer, there is planned to be a total of 84, 3.6 MW turbines (including 70 in the BOO component, and 14 in the FIT component). The hub height of each turbine will be 63 meters above ground, with a 114 m rotor diameter, 4 m maximum blade width, with a total turbine height of 120 m, and a rotor swept area of 10,207 m^2. We have adopted these specs for the purpose of Collision Risk Modeling. A conservative Rotor Swept Height (RSH) was regarded as between 5 and 125 meters above ground level.

The turbines are arranged in 12 longitudinal arrays, with a north-easterly orientation (more or less perpendicular to the prevailing north westerly wind direction in the region). The average distance between the 84 turbines along the axes of each array is about 0.36 km. The turbine density will be about 2.98 turbines per 1 km^2, based on an estimated total project area of 28 km^2.

Table 3: Area of each development plot with estimated number of wind turbines at each. Site 1 is the same covered by previous monitoring effort in 2015 – 2016 (Environics 2016).

Project site number	Approximate area (km^2)	Estimated number of wind turbines
1	3.76	17
2	4.87	14
3	4.62	11
4	3.16	14
5	5.88	15
6	5.84	13
Total	**28.13**	**84**

Besides the existing 220 kv power line that runs parallel to the eastern boundary of the site an unknown length of grid connection will be made from the project site to a substation to the north of the project site. The properties of this connection have not been decided yet.

3.6 Weather observations

Primary relevant weather condition parameters (wind speed, wind direction, visibility and any notes on special weather conditions like sand storms), were documented on an hourly basis. The Team leader made these records at any one of the two observation points he was present at.

1. Wind speed (using Anemometer);
2. Wind direction (using compass);
3. Visibility according to four categories: 1) < 5 km, 2) 5-10 km, 3) 10-15 km and 4) > 15 km. Using land scape and/or stationary ground marks);
4. Special weather conditions (sand storms, rain, etc.)

3.7 Equipment used

The field staff was equipped with a 10X40 binocular and spotting scope, and bird field guides. Anemometer and compasses were used to provide weather data. Simple shelters were constructed at each of the two vantage points to provide shade and cover from the wind. Two 4X4 trucks were used to transport the field teams from and to the observation points.

Figure 4: View from point towards northeast, facing the Gulf of Suez, which can be seen in the middle left side of the photograph, with the mountains of Sinai faintly apparent at a distance. This is where large numbers of White Stork would cross the Gulf and arrive at the African side to gain altitude on the costal plain.

3.8 Coverage and double counting

The monitoring technique provided spatial sampling of the study area across the six designated observation points. At any one time during the study period (within the daily monitoring schedule) one sixth of the entire study area (one observation point) was being monitored. The sampling procedure should provide a good representation of totality of the study site, plus provide enough differentiation between observation points (if there is any). Given the small geographic scale of the study area it was not likely that much differences would be encountered in the migration phenology within the study site, thus results from one observation point could generally be considered as representative of the entire study area. In the data analysis results needed to be adjusted for the sampling effort to provide predicted outcomes of the study that reflect the entire study area.

There was no potential for double counting during the current study as no simultaneous observations were carried out, and all counts were conducted at a single point eliminating any need to account for potential double counts.

3.9 Data analysis

The risk analysis conducted here, followed the Scottish Natural Heritage (SNH) Collision Risk Model (CRM) (SNH 2000, 2010), which is the standard CRM approach adopted by previous studies conducted in the Gebel El Zeit area. The SNH CRM is one of several approaches that seek to provide an estimate of the potential number of bird collisions likely to occur at a given wind farm.

The CRM involves three steps:

1. Estimation of the number of birds passing through the zone swept by the rotating turbine blades. This is calculated from data collected on bird flight activity and altitude in the wind farm, in addition to the size and proportions of the wind turbines used.
2. Assessment of the probability of a bird colliding, if it flies through an operational turbine, which varies according to species and wind turbine proportions.
3. Lastly, application of an avoidance rate, to take account of the bird's own abilities to avoid the moving turbine rotors.

An avoidance rate of 95% means that only 5% of the birds that enter the rotor swept zone are predicted to make contact with the moving rotors. The 95% avoidance rate was proposed by SNH as a precautionary avoidance rate, based on expert opinion and with little empirical evidence (SNH 2010). It has since been updated to 98%, based on data from the field, indicating that in most cases, avoidance rates are higher than 95%.

For this reason, two avoidance rates were applied in the CRM at 95% and 98% to represent a more or less conservative prediction measure of potential casualty levels.

3.9.1 Number of birds flying through the rotor swept zone

Estimation of numbers flying through the rotor swept height (and are as such exposed to risk of collision with the moving rotors) is based on the data collected from the field, which was stratified into altitudes above, below and within the rotor swept zone, also called the risk window, which lies between 5-125 meters above ground, according to the specs for the equipment to be used at the Lekela study site. Within this risk window the rotor swept zone is identified as the area swept by each turbine's rotor estimated at 10,207 m^2 per turbine (using the turbine size that is most likely to be utilized at the site, according to the data provided by the developer).

3.9.2 Calculation of collision risk "P" for birds passing through the rotor area

This process seeks to estimate a risk factor "P" for each species at a specific wind farm, according to biological parameters of the different bird species and the technical specs of the wind turbine rotors. SNH (2000) developed a model that calculates this "P" value for each species, taking into account important wind turbine parameters, including turbine diameter, blade width, number of blades and average speed of rotation. For this we adopted the turbine parameters provided by the developer. In addition, average biometrics of the species involved (from standard published references), including bird length, wingspan and standard flight speed were used to calculate the "P" value for each of the species occurring in the study area.

For the "P" for unspecified species or groups of birds (such as Buzzard sp.), the "P" value for the most common species of that group during the season was used to represent the most likely value for that group, in the case of buzzards it was the Honey Buzzard.

3.9.3 Collision avoidance rates

The CRM calculations assume that a bird flying through a wind farm and through the rotor swept zone behaves in a non-selective, linear manner (i.e. more or less like a projectile); but in fact birds do take considerable avoidance measures in most cases when and if they enter a wind farm, or get into close proximity to a wind turbine. These avoidance measures mean that the majority of the birds that are predicted to fly through the danger zone are likely to escape without direct harm (although some harm might be inflicted indirectly through the extra stress and disturbance caused by the avoidance measures).

Avoidance rates are developed through accumulating and comparing data on actual observed collisions with the predicted no-avoidance collision estimate. Avoidance rates for many species are still not known with accuracy, due to the rarity of collision monitoring data collected at operational wind farms.

We apply an avoidance rate of 98%, which is generally accepted for most species considered in the current study (SNH 2010). However, we also applied a more conservative rate of 95% collision avoidance rate to the CRM, as was applied in recent studies in the Ras Shukheir area (Al-Hasani 2014, Baha El Din 2014, Baha El Din 2015, Environics 2016), to better facilitate a broader perspective of comparison of results.

Observations made at each point were not conducted in parallel with other points, thus there was no probability of double counting.

3.10 Difficulties and limitations

Visual observation has its inherent limitation in the best of conditions. The inherent variability in visual based studies should be taken into account when evaluating results, or comparing between studies. Many of the critical measurements utilized in this study depend on experience of the observers and their ability to make sound judgment. From bird identification to estimation of numbers to the critical issue of assessing flight altitudes. Some errors are certainly encountered, but the intensive nature of the study and multiplicity of observers and their extensive expertise provides a great deal of assurance in the data (particularly the consistency observed between this season and previous seasons).

It is important to note here that visual observation, which is the sole tool used to document soaring bird migration in this study, is most likely biased towards detecting larger species, with contrasting colors (such as White Stork and Great White Pelican) and those that move in large flocks, which can be more easily seen from greater distances, than smaller darker species that migrate in looser formations, such as buzzards. The latter species are almost certainly under documented and reported. Without the use of radar, such errors would remain a factor that should be kept in mind when considering the results.

The highly stochastic nature of migration and high variability in bird volume makes result interpretation challenging. The fact that much of the volume of migration, particularly in the autumn, most likely comes in the form of huge flocks of storks renders the general results of the study at potential risk of distortion based on a singular event. For example the average flight altitude of a large flock of 10,000 storks can distort overall results of the study towards the values documented in a singular event. Despite this, results are remarkably consistent between different years.

4. Results

The study was carried out between 15 August and 5 November 2017 for a total period of 83 days. In total 166 observation sessions were carried out, totaling 800 observation hours, out of about 901 potential day light hours, representing a coverage of about 89% of available daylight time. The number of sessions and hours of observations was divided almost equally between the six vantage points as outlined in the proposed methodology, see Table 4 below.

Table 4: Observation effort at each vantage point.

	1	**2**	**3**	**4**	**5**	**6**
Number of observation sessions	28	27	28	28	28	27
Number of observation hours	134	128	137	135	138	128

No birds were observed during 126 out of a total of 166 sessions, representing about 75% of the observation sessions (more than that observed in autumn 2015, which was about 50%), with no soaring birds being recorded during the last eight days of the study.

In total 954 observations were made (of soaring and non-soaring birds, inside and outside the study sites), resulting in a grand total of 31,386 birds (including 8,654 non-soaring birds). The total number of soaring birds (22,732 birds) is extremely close to that recorded during the same time period in autumn 2015 (22,311 birds).

Table 5: Summary of observations within and outside the study area.

	Soaring birds inside study area	Soaring birds outside study area	Non-soaring birds	Total
Observations	582	122	250	954
Number of birds	17,473	5,259	8,654	31,386
Number of species	20	4	24	44

4.1 Weather conditions

A total of 800 hourly weather records were made throughout the study period, which included wind speed measurements, wind direction and visibility estimates. Overall, weather records are very consistent with those from autumn 2017.

Table 6: Frequency distribution of wind velocity records, autumn 2017.

Wind speed category (m/second)	Number of records	% of records
0	2	0.25
0 to 3	43	5.375
3 to 6	142	17.75
6 to 9	294	36.75
9 to 12	226	28.25
12 to 16	93	11.625
Total	**800**	**100**

4.1.1 Wind velocity

Wind speed was on average higher than any other season during our ornithological studies at the site, with an average of 8.23 m/second (greater than the 6.75 m/second recorded in autumn 2015). For much of the time (65%) there were winds of between 6 and 12 m/second, while only 5.4% of the time the wind speed was between 0 and 3 m/second. Zero wind velocity was only recorded during a single day, representing 0.25% of the time. Very high wind speeds of between 12 and 16 m/second were encountered 11.6% of the time. The maximum wind speed recorded was 15.9 m/second (on 23 September 2017).

4.1.2 Wind direction

Wind direction was highly consistent, with north and northwesterly winds dominating 89% of the time, with winds from the northeast accounting for about 10% of records. (see Table 7). This is very consistent with results from autumn 2015.

Table 7: Frequency distribution of wind directions at the study site, autumn 2017.

Wind direction	N	NE	E	SE	S	SW	W	NW	0	Total
Number of records	140	78	1	0	0	0	6	573	2	800
% of total	17.5	9.75	0.12	0	0	0	0.75	71.62	0.25	100

4.1.3 Temperature

Average temperature during the study period was 30.6˚c, with a maximum of 41.4˚c and a minimum of 21.1˚c. Temperatures between 30-35˚c was the most predominant occurring 38% of the study period; with cool temperature of less than 25˚c being the rarest (occurring towards the end of the study period) along with temperatures above 40˚c only occurring during 6% of the time (mainly during the early part of the study in August and September).

Table 8: Frequency distribution of temperature bands inside the study site, autumn 2017

Temperature	Number of records	% of total
20 -25˚c	1	0.17
25 - 30˚c	121	20.79
30 - 35˚c	222	38.14
35 - 40˚c	205	35.22
40 - 45˚c	33	5.67

4.1.4 Visibility

Over all, visibility was notably better than in spring 2017, being fairly good (> 5km) most of the time (70 % of the time); allowing good detection of birds well within the observation radius around each vantage point. While, visibility was of lower quality (< 5km) about 17% of the time, but still greater than the observation radius around the vantage points.

Generally no major incidents of very low visibility were recorded , where the visibility of birds or observers were severely impaired throughout the study period.

Table 9: Frequency distribution of visibility categories during the study period, autumn 2017.

Visibility	0-5 km	5-10 km	10-15 km	> 15 km	Totals
Number of records	137	393	171	99	800

% of total	17.125	49.125	21.375	12.375	100

4.2 Soaring bird migration in the study region

As indicated in the study methodology, two sets of data were collected: One of birds flying within each study site (within a 2 km radius from the observer) and another of birds flying outside and around the site (> 2km), to the maximum possible visible range (probably about 4-5 km according to visibility, etc.). Observations made outside the study area (i.e. > 2 km distance) are only included to give a general impression of the total volume of migration in the adjacent territory, and by doing so not missing or ignoring large movements that might be taking place in the immediate surroundings of the study area, which could potentially enter the target area under varying weather conditions, or according to other factors that might affect migration volume and behavior from season to season. Only the birds recorded within the 2 km radius were used in CRM analysis.

The total number of observation of soaring birds inside and outside the study sites was 704 observations, with a total of 22,732 birds belonging to at least 24 species, with an overall migration rate of 28 birds / hour. Of these 582 observations of 17,473 birds belonging to 20 species were recorded within the project area, while 5,259 birds were recorded in the adjacent zone, outside the 2 km radius of observation. The overall migration rate inside the study area was an average of 22 birds / hour, reaching an average of 72 birds / hour during the first three weeks of the study.

Similar the situation in the springs of 2017 and 2016, in autumn 2017 and 2015, the same seven species that contributed about 95% of the total soaring birds recorded, with the exception of a Black Stork, which was represented by a single large flock in 2015 but was absent in 2017. There are only modest variations in the contributions of each species to the total volume of migration, but in large the numbers and diversity is notably consistent amongst the years and seasons, which sheds a good level of confidence in our ability to consistently and accurately detect and identify bird migration in the region.

The most numerous species was the White Stork (14,309 birds representing 63.4 % of the total), followed by Honey Buzzard (7,754 birds representing 34.4 % of the total), and White Pelican (183 birds, representing 0.8% of the total).

Table 10: Number, frequency of the most numerous birds documented inside and outside the study site in autumn of 2017 and 2015 (for comparison).

	Autumn 2017				Autumn 2015			
Species	Number of birds	% of total	Number of obs.	% of total	Number of birds	% of total	Number of obs.	% of total
White Stork	14309	63.40	8	1.31	14131	63.34	17	2.04
Honey Buzzard	7754	34.35	431	70.66	5992	26.86	414	49.64
Black Stork	0	0.00	0	0.00	1000	4.48	1	0.12
White Pelican	183	0.81	2	0.33	504	2.26	8	0.96
Black Kite	123	0.54	38	6.23	0	0	0	0
Raptor sp.	63	0.28	14	2.30	239	1.07	118	14.15
Marsh Harrier	108	0.48	86	14.10	151	0.68	117	14.03
Crane	0	0.00	0	0.00	80	0.36	2	0.24
Kestrel	31	0.14	31	5.08	50	0.22	46	5.52
Total	**22571**		**610**		**22147**		**723**	

The most frequently observed species was Honey Buzzard, with 414 observations, representing 50 % of all observations, with an average flock size of 14 birds. Marsh Harrier and Kestrel (with 117 and 46 observations consecutively) were the second and third most frequently observed species in the region. In contrast, the White Stork, a species characterized by heavy passage in large flocks, made up 63% of the volume of birds, represented only 1.3 % of all observations, with an average flock size of 1,789 birds. The overall average flock size across all species was 37 birds.

Overall, the species composition and relative abundance of each species was very similar to that of autumn 2015 (as can be seen the table above), with a few species missing during autumn 2017 like Black Stork (which was represented in 2015 by a single flock of 1,000 birds) and Crane. On the other hand Black Kite was missing in the 2015 autumn study. These differences area expected however particularly amongst the less common species and due to the stochastic nature of migration.

Table 11: Totals, observation frequency and average flock size of all soaring bird species observed and documented inside and outside the study site.

Species	Inside wind farm			Outside wind farm			Totals inside and outside		
	No. birds	Obs.	Av. flock size	No. birds	Obs.	Av. flock size	No. birds	Obs.	Av. flock size
Black Kite	122	37	3.30	1	1	1	123	38	3.24
Crested Honey Buzzard	1	1	1				1	1	1
Eleonora's Falcon	2	2	1				2	2	1
Glossy Ibis	1	1	1				1	1	1
Hobby	1	1	1				1	1	1
Honey Buzzard	5578	333	16.75	2176	98	22.20	7754	431	17.99
Kestrel	31	31	1				31	31	1
Long-legged Buzzard	2	2	1				2	2	1
Marsh Harrier	107	85	1.26	1	1	1	108	86	1.26
Montagu’s Harrier	20	18	1.11				20	18	1.11
Osprey	2	2	1				2	2	1
Pallid Harrier	25	19	1.32				25	19	1.32
Peregrine	2	1	2				2	1	2
Red-footed Falcon	3	3	1				3	3	1
Short-toed Eagle	1	1	1				1	1	1
Sparrowhawk	1	1	1				1	1	1
Sooty Falcon	2	2	1				2	2	1
Steppe Buzzard	21	6	3.5				21	6	3.5
White Pelican	183	2	91.5				183	2	91.5
White Stork	11302	5	2260.4	3007	3	1002.33	14309	8	1788.63
Buzzard sp.				43	1	43	43	1	43
Eagle sp.	1	1	1				1	1	1
Falcon sp.	5	5	1	1	1	1	6	6	1
Harrier sp.	20	19	1.05	7	7	1	27	26	1.04
Raptor sp.	40	4	10	23	10	2.3	63	14	4.5
Total	17473	582	30.02	5259	122	43.11	22732	704	32.29

The number of birds observed outside the “study area” (i.e. outside the 2km observation radius at each point) is only limited by the visual ability of the observers to detect the birds. During this study they were composed primarily of a large flock of White storks that were easily detected and identified from a long distance, plus a moderate number of Honey Buzzards, which can be detected at a more modest distance. Smaller species are more difficult to detect at distances beyond the observation radius and are thus less likely to be recorded.

4.3 Monitoring results within the study area

This section only deals with the observations that have been made within the six study sites, in order to provide a more detailed and focused analysis and understanding of the patterns of movement and behavior of birds, and help provide an accurate assessment of risk within the target area.

Migration volume and intensity within the study area

A total of 582 observations of soaring birds were made within the study area, totaling 17,473 birds, belonging to 20 species. This is very comparable to the total of 15,891 birds and recorded inside the single study site in autumn 2015. In the current study the observation effort was similar to that in 2015, but it was spread over six sites in a wider geographic area, which theoretically means that the total volume of birds over the entire study area (including all six study sites) can potentially be six-time that actually observed in the field. In this case the estimated volume for the entire study area would be in the order of 105,000 birds. However, since birds enter the area of concern mostly from a singular direction and pass through the area rapidly (as is discussed below), it is prudent to only take into account only the four northern most sites, as accounting for birds in a second row site would be most likely double counting the same birds. In this case a more realistic estimate for an adjust total bird volume for the entire study area would be about 70,000 birds.

The maximum of 5,300 White Storks was documented on the 23nd of August, with 65% of the total volume passing on three days between 20 and 24 August 2017. Soaring bird migration was very stochastic, with volume varying greatly from day-to-day.

The bird migration intensity was highly variable and concentrated during only a few days of the season, with numbers varying greatly from day-to-day, with long periods with no birds at all. Much of the migration volume occurred in very focused temporal fashion in the form of a few bursts of migrants with long periods without any birds. In total there were 23 days during the study duration when no passage of soaring birds was documented inside the study site, representing about 28% of the study duration. In total there were 629 hours without birds out of the 800 observation hours, representing 79% of the study period. In fact birds were present inside the study area only during 10.06 hours, representing 1.25% of the of the study hours.

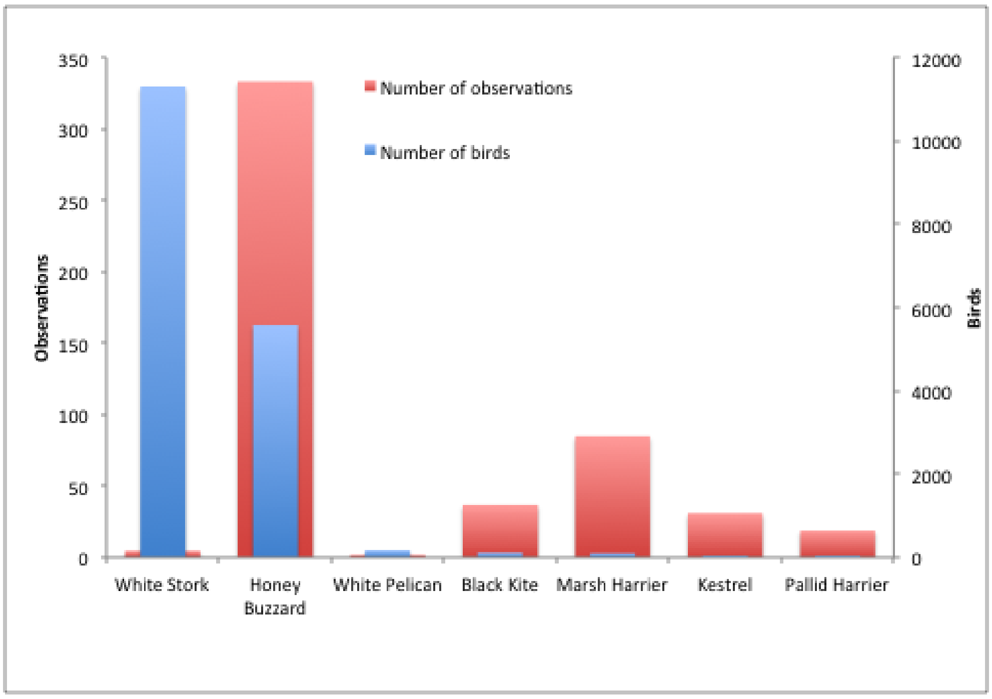


Figure 5: Comparison between number of birds and number of records of the seven most abundant soaring birds inside the study area, autumn 2017.

Table 12: Migration intensity by week, showing a single major peak in Late August, with a steep decline towards October and November.

Week	Number of birds	Number of observations	% of total	Average flock size
15-21 Aug	2000	1	11.45	2000
22-28 Aug	9480	23	54.26	412.17
29 Aug-5 Sep	1207	66	6.91	18.29
6-12 Sep	3323	207	19.02	16.05
13-19 Sep	1079	97	6.18	11.12
20-26 Sep	167	101	0.96	1.65
27 Sep-3 Oct	180	50	1.03	3.6
4-10 Oct	18	18	0.10	1
11-17 Oct	11	11	0.06	1
18-24 Oct	5	5	0.03	1
25-31 Oct	3	3	0.02	1
1-5 Nov	0	0	0.00	0
Totals	**17473**	**582**	**100**	

4.3.1 Seasonal migration pattern

As was the case with autumn 2015, the 2017 autumn season had an abrupt start, with 68% of the total volume of birds recorded during the initial 10 days of the study. This is a typical pattern during the autumn season throughout the region, including Gebel El Zeit and South Sinai. The main cause for this sudden start of migration is the explosive nature of the White Stork migration in the autumn, which forms the bulk of the migration volume, particularly in the early part of the season, in late August and early September, while Honey Buzzard contributed the smaller peak in numbers in mid-September.

About 88.5% of the total birds passed between 15 August and 12 September 2017.

The largest daily total of migrants was on 23 August, with 5,300 birds in one single flock of White Storks. No soaring birds were recorded inside the study site during the first five days of the study. The first observation of soaring birds was of a flock of 2,000 White Storks on 20 August. The last observation made was on 28 October of a single falcon sp., with the last eight days of the study being devoid of soaring birds.

The absence of migration during the first days of the study, followed by an abrupt high volume of White Storks is reassuring in the sense that it indicates that the current study did capture the very start of the autumn migration. In autumn 2015 there was a sense that the migration season had started prior to the study initiation on 16 August and it was recommended that subsequent autumn studies should be started a week earlier (Environics 2016).

White Stork is known to start its autumn migration over Egypt even in late July (cf. Goodman and Meininger 1989), but the bulk of migration takes place between mid August and mid September (Goodman and Meininger 1989, Shirihai 1996). It cannot be ruled out however that in some years stork migration might start some days earlier, or later, and given the huge volume of migration, it is recommended that the window of monitoring and precautionary measures be initiated on the 10th of August. Given the decline in number of migrants in the second part of September and during October and November (also observed during autumn 2015), it is recommended that the future monitoring and risk reduction measures be extended only to the 15th of September.

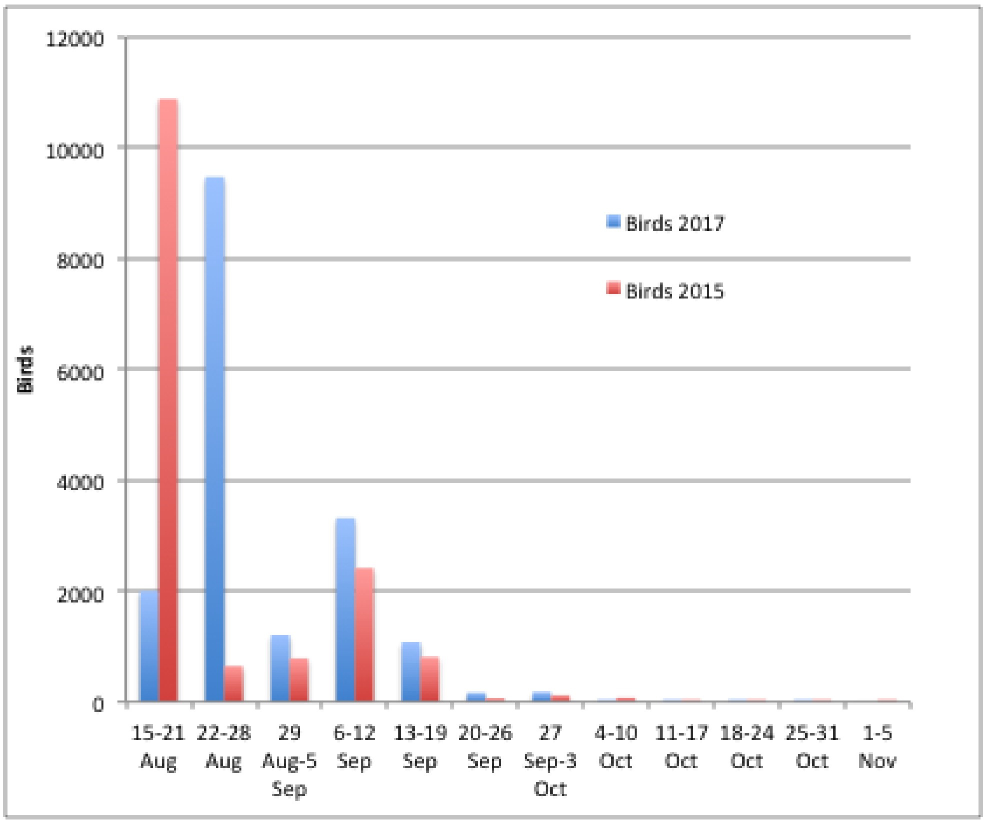


Figure 6: Comparison between soaring bird migration intensity per week in autumn 2017 and 2015.

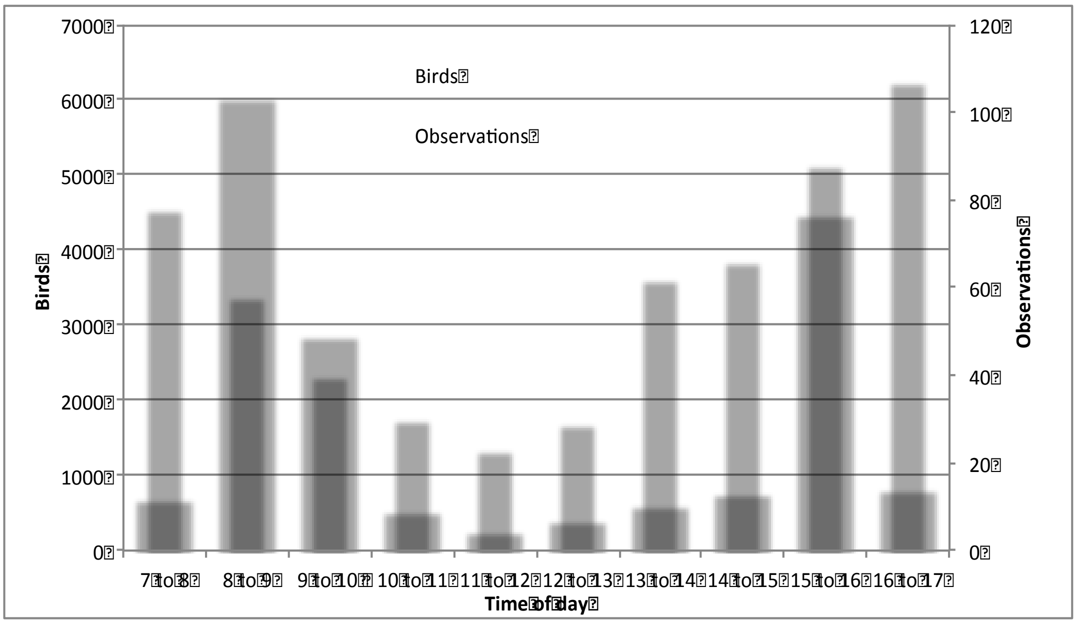


Figure 7: Bird and observation numbers by time of day showing daily migration pattern.

4.3.2 Daily migration pattern

The overall daily migration showed a bimodal pattern, with a major peak in the mid morning between 8 and 9 AM (35% of total birds); and a minor peak in the late afternoon, between 3 and 4 PM (26% of total birds). The majority of birds (60%) migrated before noon-time, with more than 50% of the total passing during the hours between 8 and 10 AM.

The bimodal daily migration pattern in 2017 contrasts with that in 2015, which showed a very large peak in numbers in the late afternoon between 4 and 6 PM, representing 63.4% of the total birds. This afternoon peak in bird numbers was due to very large flocks of White and Black Stork that were recorded on two separate days in August 2015. Indeed if these flocks were excluded the daily migration pattern would have had a typical bimodal pattern, with morning and an afternoon peaks (Environics 2015), as was the case in the current study. The bimodal daily migration pattern was also noted during the spring seasons of 2016 and 2017 (Environics 2017).

Bird occupancy at Rotor Swept Height (RSH), or the time spent by birds within the risk zone, had one major peak during the morning, roughly coinciding with the morning bird movement (see Figures 8 and 9). Birds passing through the late afternoon period spent less time within the RSH passing through the study area at greater speed. Figure 8 shows that average flight elevation in the late afternoon was lower than that in the morning, indicating that the low occupancy of the RHS is likely due to greater speed of migration rather than the birds occupying higher altitudes outside the RSH.

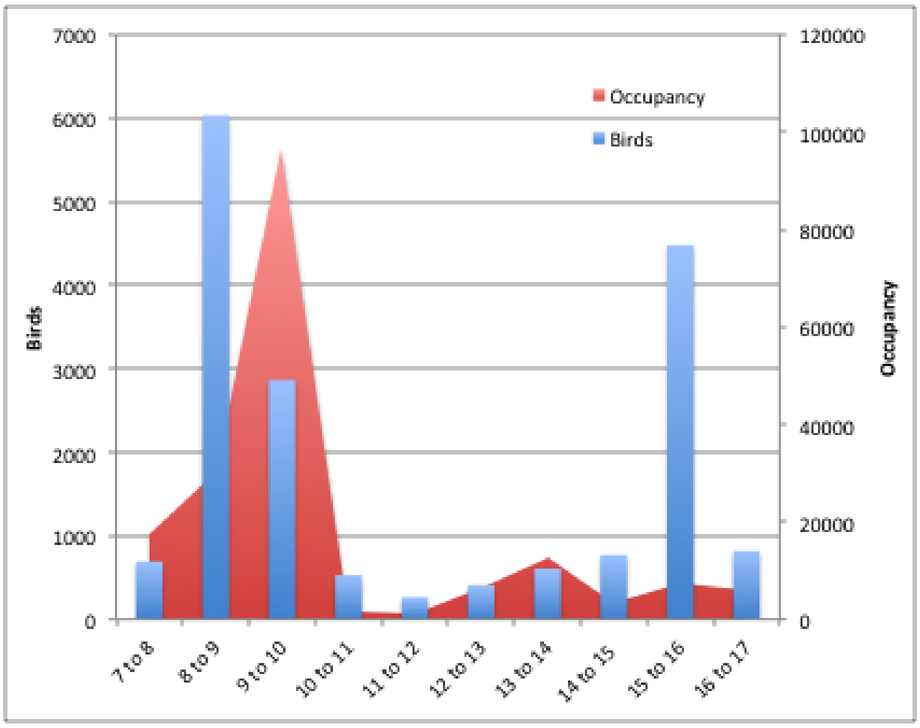


Figure 8: Comparison of bird occupancy at RSH and the total number of birds at different times of the day.

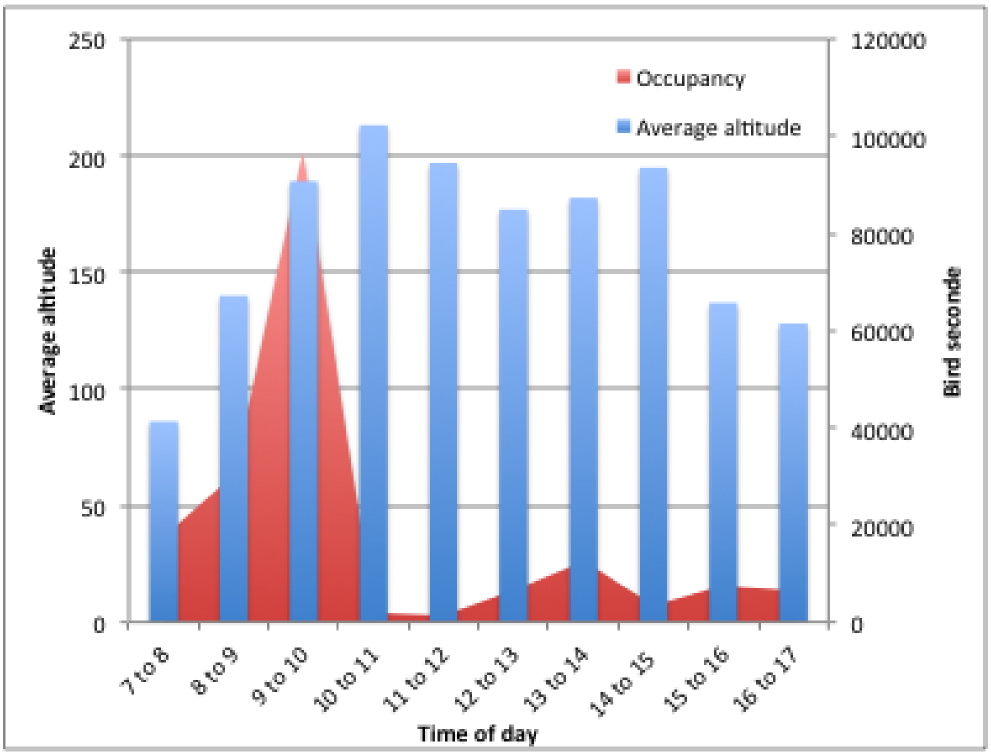


Figure 9: Comparison of bird occupancy at RSH and the average altitude of flight of all birds throughout the day.

4.3.3 Species composition and diversity

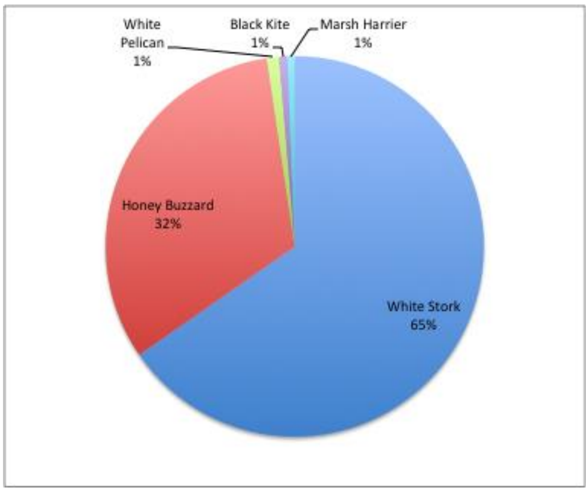
There were 20 soaring bird species documented within the study area, similar to the autumn of 2015, when 19 species were recorded.

The most abundant species were White Stork (contributing 56% of all records), and Honey Buzzard (contributing 32%), and White Pelican, Black Kite and Marsh Harrier (contributing 1% each). This composition and proportional contributions of the main species is very consistent with that of autumn 2015, with the exception of the presence of some numbers of Black Storks in 2015 (see Fig. 14).

Honey Buzzard was the most frequently observed species (71% of all observations), with an average flock size of 17 birds. The second most frequently observed species was Marsh Harrier with 85 observations (average flock size of 1.25 birds). All other species were observed less than 50 times, while there were six rare species only recorded once.

Most of the other species of soaring birds observed at the study site were relatively rare, with ten species being recoded less than ten times. Diversity notably declined towards the end of the study period, corresponding with the overall decline in the numbers of migrants, while the greatest species richness was noted during the month of September.

There was a complete lack of any eagles or vultures, which are highly passive soaring birds that avoid any sea crossings, with the exception of one Short-toed Eagle. These species cross into Africa either further north at Suez or much further south over Bab El Mandab in Yemen. This phenomena is well known and is characteristic of the autumn season in this part of the flyway. This is in contrast with the spring season, when eagles, vultures and Steppe Buzzards are a more dominant component of the migratory stream.



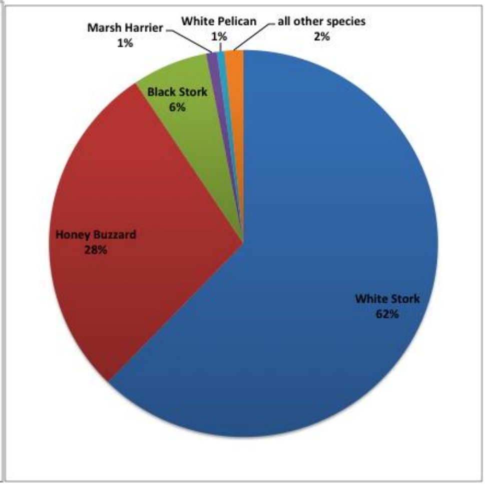


Figure 10: Pie chart of the soaring bird species that make up 1% or more of the total birds recorded within the study site. Autumn 2017 to the left and 2015 to the right.

4.3.4 Flight orientation

In autumn bird migration is naturally oriented southwards towards the wintering grounds in Sub-Saharan Africa. However, at the local level migration orientation might be influenced by several factors, most importantly the local topography, local wind regimes, visibility, and the intrinsic migration and flight phenology of the various species involved.

Migration orientation in autumn is much more consistent than in the springs of 2016 and 2017, which is likely due to the more stable wind regimes that blow more consistently from the north or northwest. Practically all soaring birds recorded both inside and outside the study area flew in a southerly direction (99%), with about 29% headed straight south, 62% headed in a southwesterly direction and 8% headed in a southeasterly direction.

The observations made during the 2017 autumn season are almost identical with those from autumn 2015, when 98% of the total volume of birds flew in a southerly direction, with a greater (94%) southwesterly component.

The observations made during autumn of 2015 and 2017 indicate that the greatest volume of birds passing through the study area originate from across the Gulf of Suez, and land either at the western shoreline of the Gulf just to the east of the project area or a little to the north of it (this applies particularly to the storks and Honey Buzzard). Most storks and other highly passive migrants tend to head southwest and try to cross the coastal plain towards the Red Sea

Mountains for better thermal uplift; in the case of the storks and Pelicans aiming for the Nile Valley beyond that. While other species such as harriers and falcons often drift in a broad front along the coastal plain.

Table 13: Bird migration orientation inside the study site.

Flight direction	Number of birds	% of total	Number of observations	% of total
N	1	0.01	1	0.17
NE	1	0.01	1	0.17
E	3443	19.70	160	27.44
SE	555	3.18	40	6.86
S	0	0.00	0	0.00
SW	13439	76.91	380	65.18
W	34	0.19	1	0.17
NW	0	0.00	0	0.00
Totals	17473	100	583	100

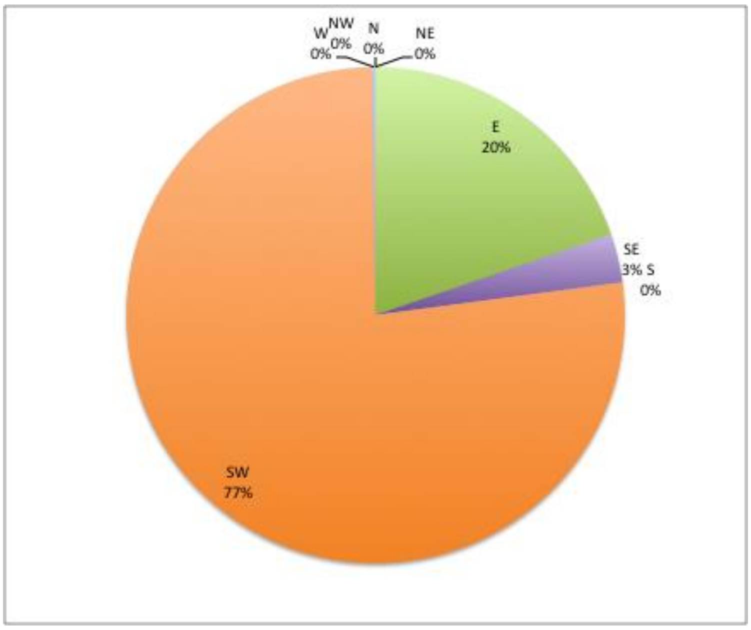


Figure 11: Distribution of birds according to flight direction within the study area.

4.3.5 Migration altitude

Migration altitude is one of the most important factors in assessing risk to soaring birds at wind energy facilities. Birds flying within the Rotor Swept Height (RSH), which is between 5 – 125 meters above ground are considered to be exposed to the risk of collision with wind turbine rotors and other associated infrastructure. The study methodology called for regular monitoring of bird altitude within the study area through timed altitude recordings (every

15 seconds for a total duration of 3 minutes) of each bird or flock entering the study area, to provide as accurate as possible an assessment of the utilization of vertical space by birds within the study area.

The average flight altitude through the study site during the current study was 148.4 meters above ground level (number of altitude records 2187, range 0-500 m, Standard Deviation 109.5 m), which is somewhat greater than the average altitude reported in autumn 2015 of 109.7 meters above ground level (number of altitude records 3,038, range 0-450 m, Standard Deviation 91.8 m) (Environics 2016).

An estimated 1217 birds were recorded within the RSH (between 5 – 125 meters above ground), representing about 7% of total birds. The vast majority of birds (93%) were recorded above 125 m, of these 2,354 birds flew between 200 – 300 m (representing 14% of the total). While less than 1% of the birds were documented at or below 5 m, including birds that landed on the ground. Only 15 birds were recoded landing on the ground throughout the duration of the study.

There was a general weak negative relationship between altitude and occupancy within the study area (r=-0.04); i.e. that birds at lower altitude are slower in passage than those higher up. This was predicted in spring 2017 (Environics 2017) as a consequence of birds at lower altitudes usually spending longer time attempting to gain altitude by engaging in active soaring; which involves birds searching for thermals and spiraling upward with hot air updrafts. Birds at higher altitudes are more often observed gliding rapidly across the study area. This tendency for lower birds to have higher occupancy was also noted in the autumn 2015 study (Environics 2016), where a similarly weak negative relationship between altitude and occupancy was found. The greater occupancy of lower altitudes potentially increases the risks per bird flying below 125 m within the study area. However the greater exposure to risk of birds at lower altitudes is partly compensated for by the fact that most birds flew over 125 m.

Table 14: Distribution of bird volume according to occupancy of different altitudes.

Time inside (seconds)	Number of birds	% of total birds	Number of observations	% of total observations	Average altitude
15	1	0.01	1	0.17	150
30	834	4.77	141	24.19	196
45	2473	14.15	186	31.90	165
60	1523	8.72	132	22.64	138
75	4502	25.77	49	8.40	141
90	376	2.15	36	6.17	130
105	133	0.76	9	1.54	110
120	35	0.20	10	1.72	83
135	1	0.01	1	0.17	256
150	1	0.01	1	0.17	10
165	1	0.01	1	0.17	332
180+	7593	43.46	16	2.74	119
	17473	100	583	100	153

Harriers are well known as typically low flying species had the lowest average flight altitude of 68 m above ground level. Falcons also had an average flight altitude that is about 100 meters (however, this might be due to difficulty detecting these smaller sized birds at higher altitudes). All other species had an average altitude above 125 m, including the most numerous species: White Stork (156 m) and Honey Buzzard (181 m).

Table 15: Summary of altitude records inside the study site (meters above ground).

Altitude band (meters)	Number of birds	% of total number of birds	Number of altitude records	% of total altitude records	Number of bird obs.	% of total number of Obs.	Occupancy (bird seconds)
0-10	36	0.21	141	6.44	32	5.49	2775
10-125	1198	6.86	886	40.49	219	37.56	294315
125-200	12462	71.32	390	17.82	94	16.12	1687305
200-300	2354	13.47	506	23.13	154	26.42	127020
300-400	1304	7.46	246	11.24	77	13.21	75780
400-500	114	0.65	13	0.59	4	0.69	6840
>500	5	0.03	6	0.27	3	0.51	150
Totals	17473	100	2188	100	583	100	

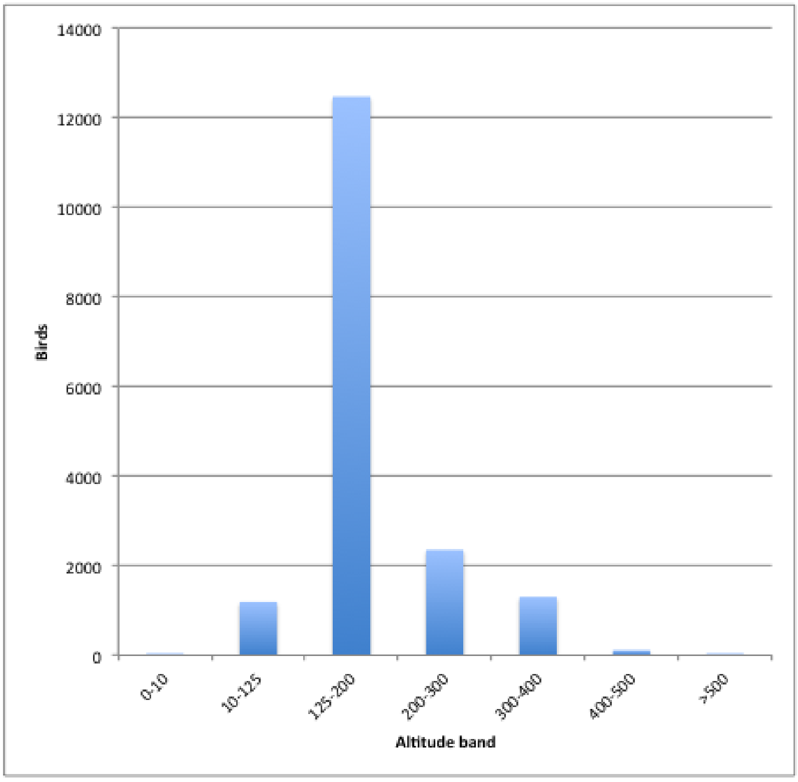


Figure 12: Frequency distribution of all birds documented in the study site according to altitude.

Table 16: Flight altitude by species inside the study site.

Species	Average altitude	Number of readings	Min. altitude	Max. altitude
Black Kite	184	135	5	500
Crested Honey Buzzard	200	4	150	250
Eleonora's Falcon	121	7	10	350
Glossy Ibis	400	1	400	400
Hobby	10	4	10	10
Honey Buzzard	181	1208	0	500
Kestrel	84	134	0	350
Long-legged Buzzard	159	11	40	300
Marsh Harrier	87	303	0	350
Montagu's Harrier	72	69	0	350
Osprey	220	5	100	300
Pallid Harrier	46	78	1	200
Peregrine Falcon	400	2	400	400
Red-Footed Falcon	66	11	150	30
Short-toed Eagle	300	5	200	400
Sooty Falcon	17	17	1	50
Sparrowhawk	250	2	250	250
Steppe Buzzard	213	28	100	350
White Pelican	135	15	80	350
White Stork	156	44	60	250

4.3.6 Turnover, urgency of migration and time spent within the wind farm

Although the urgency for breeding that is associated with the spring season is not present during the autumn, bird movement across the Sahara, including the Egyptian desert is rapid due to the need to cross over the inhospitable desert habitats in as short a time as possible. Thus, under normal circumstances birds pass through at the maximum speed and the shortest route possible. This is evident by the rapid passage of soaring birds through the study area. However, different factors such as adverse weather conditions, the health state of the birds and presence of attractions (such as artificial water sources or cultivations) on the ground are factors that can affect the speed of movement of birds through the region.

Movement through the study area was typically rapid and unidirectional, with most birds passing right across the area without stopping, slowing down or altering flight trajectory. The average occupancy of birds (flocks) within the study area was 1 minute (range 0.25 – 35 minutes), with an average occupancy in the RSH of 0.4 minutes (range 0-3 minutes). More than 99% of all birds spending less than 5 minutes within the study area. Migration in autumn 2015 had the same general aspect of turnover (Environics 2016).

The length of time birds spend within the study area (particularly within the RSH) can potentially increase risks from unwanted interactions with wind energy installations. Rapid movement through the study site is positive with regards to limiting risks to soaring migrants, however it has implications also for potential mitigation measures in the future under the operational phase (see recommendations section).

Table 17: Time spent within the wind farm by recorded migrant soaring birds.

Time scale	Number of birds	% of total	Number of observations	% of total
< 1 min	3308	18.93	328	56.36
1-3 min	6571	37.61	238	40.89
3-5 min	7482	42.82	12	2.06
5-15 min	4	0.02	3	0.52
15 min - 1h	108	0.62	1	0.17
Total	**17473**	100.00	**582**	100.00

4.3.7 Roosting, resting and feeding behavior within the wind farm

Unlike previous studies in the area, there were only very few indications of roosting and resting of soaring bird species during the study period. In total there were 8 observations involving landing for short periods within the study area, totaling 13 birds belonging to four species (Honey Buzzard, Kestrel, Marsh Harrier and Montagu’s Harrier) recorded. There were no indications of roosting observed. The average time on the ground was 3.9 minutes.

This is certainly lower than the total of 204 birds belonging to 11 species recorded in autumn 2015. Such variation in bird behavior at the local level is anticipated, and could be in response to local factors, such as increased disturbance on the ground, or favorable conditions that favor rapid movement and limited need for landing.

4.3.8 Effects of weather conditions on bird migration

Soaring birds are highly affected by weather conditions during their flight and movement. Wind direction, speed, and visibility, and to some extent temperature are all factors that may affect the way soaring birds move; the altitude they assume, and direction they take.

The known migration patterns of soaring birds in the Gulf of Suez area is a product of migration phenology, topography and the prevailing climate in the region. Soaring bird movement patterns through the Gulf of Suez region have evolved around its complex geography and specific climatic features, characterized by the strong northerly winds that dominate throughout much of the year. However, when weather anomalies occur such as during strong southerly sand storms (*Khamasine*), which occur during spring, the response of soaring birds could be unpredictable. In autumn the local climate is less unpredictable and this us usually reflected in more stable bird migration regimes.

4.3.9 Wind direction

Almost 99% of wind during the current study had a northerly origin, with about 80% coming from the northwest, while there were no periods with winds from the east or the south, which appears to be the pattern for the region during the autumn season as is also supported by the results from the autumn 2015 study.

The largest number of birds (16,274 birds, representing 93% of the total birds) passed during the prevailing northwesterly winds, which made up 80% of wind direction records. Winds straight from the north occupied about 17% of the study period, producing only 6% of the total birds. In autumn 2015 the situation was slightly different; with 62% of total number of birds passed during periods when winds came straight from the north, followed by northwesterly winds, with 20% of the total.

This greater contribution of birds from northwesterly winds as compared to north winds, might suggest an effect from westerly winds on migration intensity. When the bird numbers were adjusted by division over the number of wind records, the contribution of winds from the northwest was reduced to 63% of the total volume, while the contribution of northeast winds increased from 2% to 16%, which also suggests a particularly strong response to northeasterly winds (although they only occupied less than 1% of the study period).

The correlation between the prevalence of different wind direction regimes (the number of hours) and the number of passing birds was strongly positive (r=0.99), which is similar to that in autumn 2015 (r= 0.67), but is inconclusive in light of the prevalence of only one or two wind patterns during the study period. Under such unimodal circumstances the effects of wind orientation on migration intensity are less pronounced and difficult to assess, compared with the spring season, which typically witnesses wide and rapid shifts in wind direction, which are translated to very pronounced effects on migration patterns. Another factor that probably contributes to a dampened effect of wind orientation on migration is the fact that birds in autumn fly with tailwinds pushing them rapidly through the region; while in spring birds face the prevailing winds almost head on, with greater impact on their navigation and orientation.

Unlike in the spring, wind direction in autumn does not seem to play the same predictive role in terms of bird migration volume, not because it does not have the same influence on the birds, but rather because the wind regimes in autumn are more stable than in spring, with fewer significant shifts in direction that may produce predictable impacts on bird migration phenology at the local level.

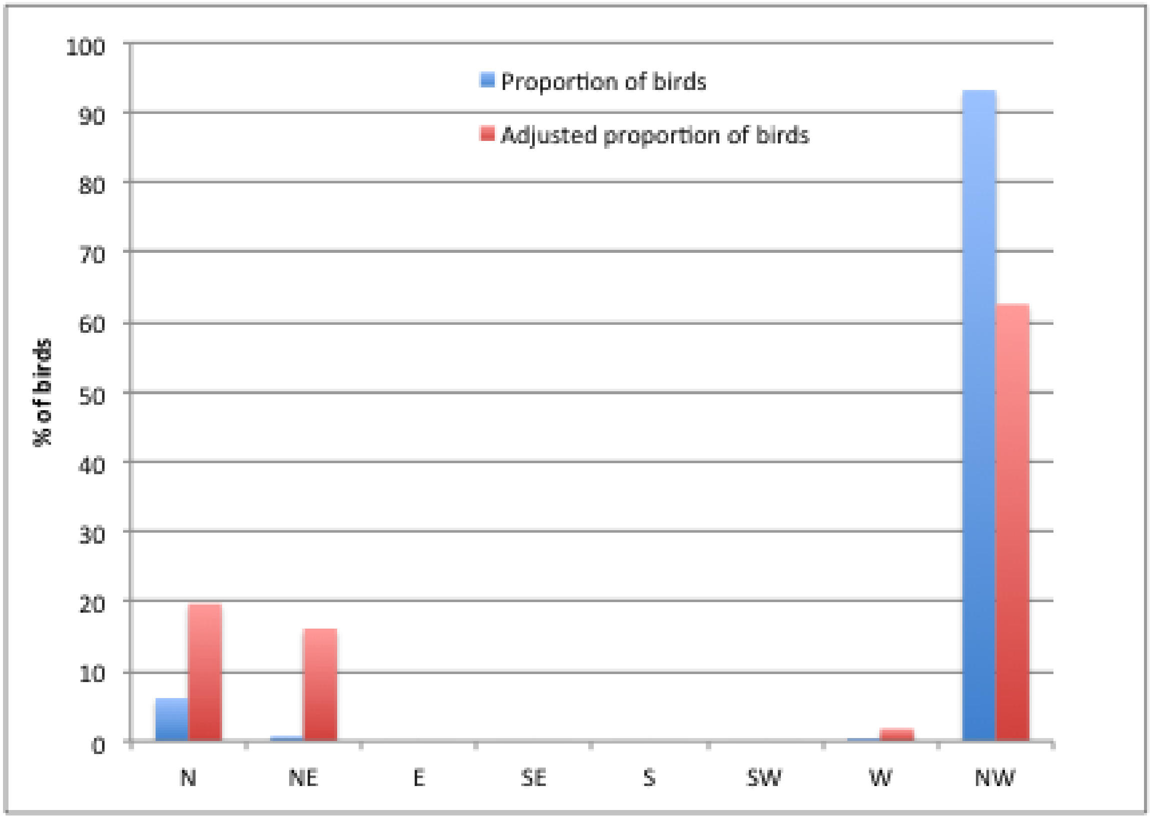


Figure 13: Relationship between wind direction and the number of birds entering the study site. The blue columns show the actual percentage of birds for each wind direction, while the red columns shows percentages adjusted according to availability of each wind direction.

Table 18: Bird numbers according to wind direction.

Wind direction	Number of records	% of total	Number of birds	% of total	Adjusted % of birds
N	97	16.67	1072	6.14	19.64
NE	13	2.23	122	0.70	16.07
E	0	0.00	0	0.00	0.00
SE	0	0.00	0	0.00	0.00
S	0	0.00	0	0.00	0.00
SW	0	0.00	0	0.00	0.00
W	5	0.86	5	0.03	1.79
NW	467	80.24	16274	93.14	62.50
Total	582	100	17473	100	100

Table 19: Bird numbers according to wind speed category.

Wind speed category	Number of wind records	% of total	Number of birds	% of total	Adjusted number of birds	Adjusted % of birds
0 to 3	18	3.09	202	1.16	11	9.56
3 to 6	38	6.53	149	0.85	4	3.34
6 to 9	172	29.55	1621	9.28	9	8.03
9 to 12	213	36.60	7134	40.83	33	28.53
12 to 16	141	24.23	8367	47.89	59	50.55
Total	**582**	**100**	**17473**	**100**	**117**	**100**

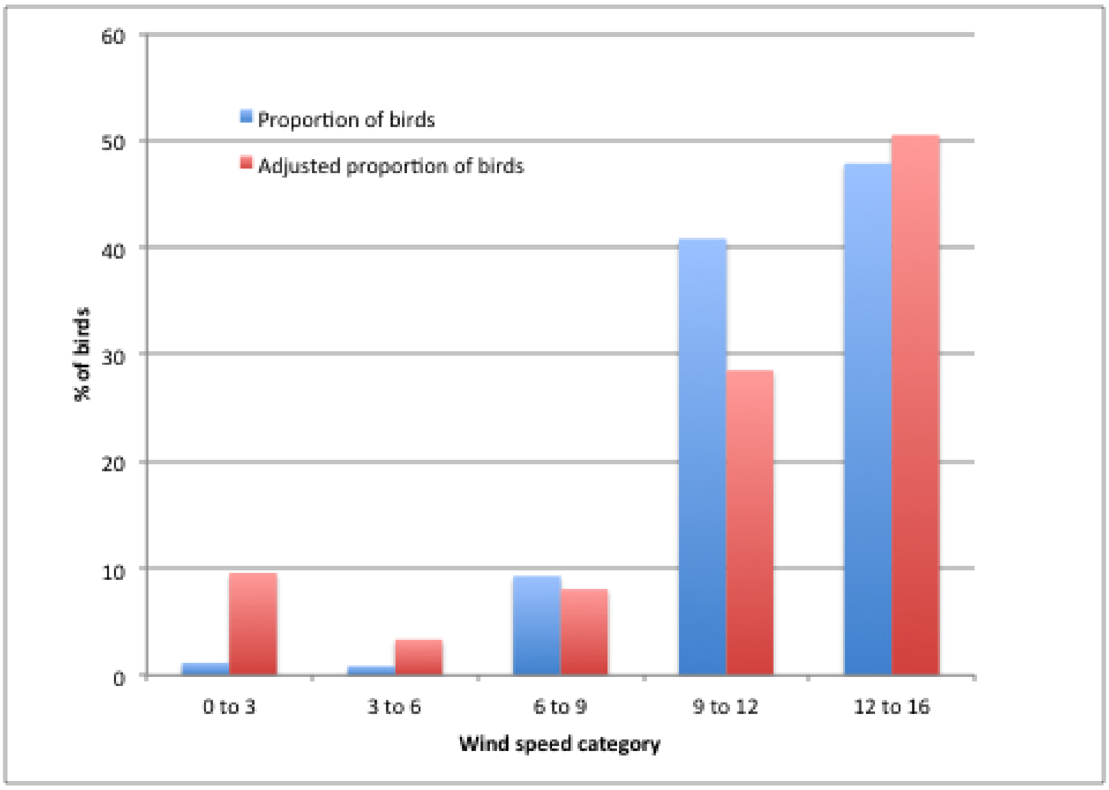


Figure 14: Relationship between wind velocity and bird migration volume. Number of birds was adjusted or normalized by division over the number of records of each wind speed category, to provide a better representation of the relationship between wind velocity and bird volume not influenced by the frequency of each wind speed category.

4.3.10 Wind velocity

The average wind velocity during the study period was 8.4 m/second (range 0-15.9 m/second), somewhat higher than the average of 6.75 m/second recorded in autumn 2015 (Environics 2016). About 89% of the migration volume passed during periods of high wind velocity with winds of between 9-16 m/second (which represented about 61% of total wind records, see Table 19). In autumn 2015 although the wind speed category between 9-12 m/s was recorded only about 9% of the time, the volume of birds passing through at that wind speed represented 64% of the total birds. These repeated results support the idea that the largest volume of passage occurs at periods of higher wind velocity (from the prevailing northwesterly orientation); which represents a favorable tail wind that propels migrants in their southerly direction. In contrast in spring 2016 and 2017 the evidence indicated that there was an inverse relationship between wind velocity and bird numbers (i.e. low wind velocity from the prevailing northerly orientation=more birds), which makes sense as the migration direction in spring is towards the north, thus birds are mostly facing adverse northerly winds, hence the influx of birds during strong southerly winds, which acts as a propelling tail wind in spring.

There was a modest positive correlation between the number of birds and wind speed (r= 0.7), the magnitude of this relationship was lower (r=0.5) when the number of birds was normalized by division over the number of records at each wind speed category, supporting the idea that wind velocity has an important effect on bird movement in the area, independent of the prevalence of the different wind regimes.

4.3.11 Visibility

About 64% of the birds recorded inside the study site passed during periods with fairly good visibility of between 5-10 km, which was the most prevailing occurring about 53% of the time.

As with previous studies in the study area, the correlation between the number of birds and visibility is not conclusive and there is no clear relationship between visibility and the number of birds recorded and its not clear if poor visibility affects the ability of observers to detect birds or if it affects the ability of birds to move, but probably affects both (Environics 2016, 2017). However, it is most likely that birds would prefer to fly during clear conditions; the generally good visibility (> 5 km) dominating at the site (> 93% of the time) is a positive factor that is likely to contribute to lower possible collision risks with rotors and power lines, or other infrastructure.

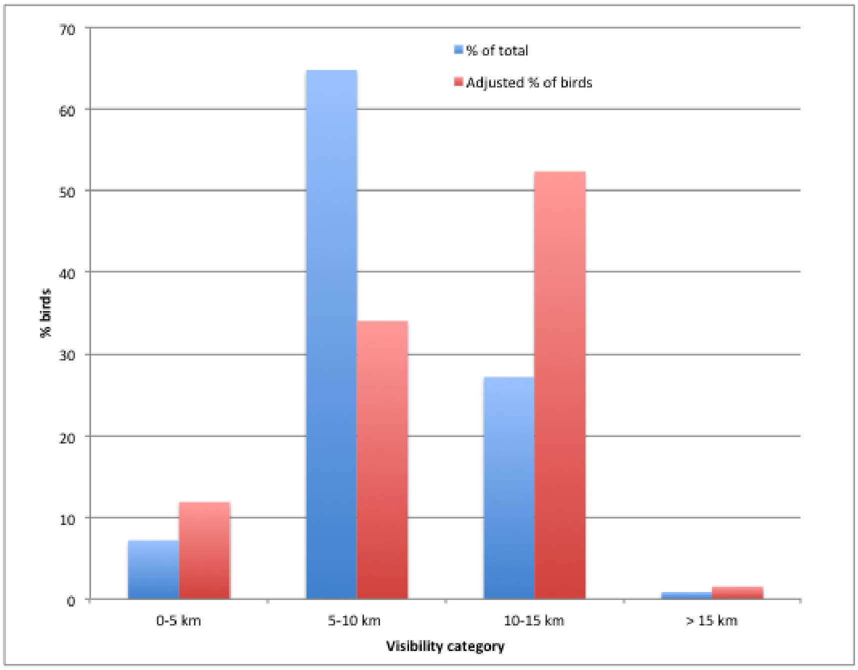


Figure 15: Relationship of visibility and number of birds.

Table 20: Number of birds according to visibility category.

Visibility	Number of birds	% of total	Frequency of visibility records	% of total	Adjusted number of birds	Adjusted % of birds
0-5 km	1255	7.18	98	16.84	13	11.86
5-10 km	11321	64.79	308	52.92	37	34.03
10-15 km	4749	27.18	84	14.43	57	52.35
> 15 km	148	0.85	92	15.81	2	1.49
Totals	17473	100	582	100	108	100.00

4.3.12 Temperature

Soaring birds depend on thermal updrafts that are generated when landmasses are heated up by the sun, and thus have a strong thermal dependence in their flight phenology. However, our data show no linear association between temperature and the number of birds (r = -0.001).

Overall the temperatures were moderate during the study period, with temperature average of 33.2 ^{o}c . Higher temperatures occurred earlier during the study with the average of 34 ^{o}c in August, 33 ^{o}c in September, 29 ^{o}c in October and 26 ^{o}c in November 2017.

Table 21: Frequency distribution of birds and temperature bands at the study site, autumn 2017.

Temperature	Number of birds	% of total	Number of records	% of total
20 -25	1	0.01	1	0.17
25 - 30	6492	37.15	121	20.79
30 - 35	4119	23.57	222	38.14
35 - 40	6519	37.31	205	35.22
40 - 45	342	1.96	33	5.67

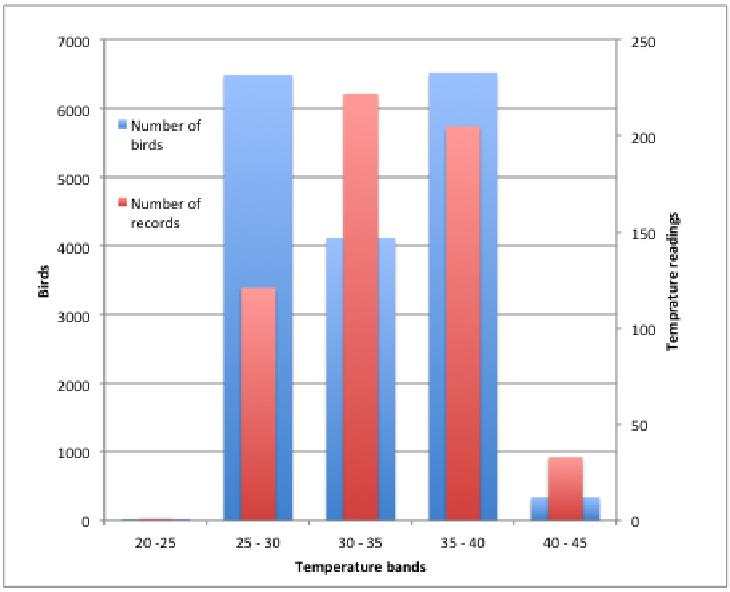


Figure 16: Relationship of temperature and number of birds

4.3.13 Spatial aspects of migration within the study area

The six observation points utilized in assessing the study area (each representing a project site) are organized along the Gulf of Suez, roughly forming a triangular shape, with its wide base along the Gulf coast (about 15 km); while its north south axis is about 9 km, and its east west axis is about 8km. The distances between observation points averaged around 2.5 km, with a maximum east- west distance between points 1 and 5 is 7 km, and the greatest north – south distance between points 1 & 4 is 8.25 km.

There was a rather pronounced differentiation between the six observation points along a northeast to southwest axis, with the greatest volume of birds recorded in the southeastern corner of the project area, and the smallest volume in the northwest corner. The trend was a gradual decrease in numbers (see Table 22) from vantage point 1 (4,898 birds) in the southeast, to vantage point 4 (496 birds), the northern most point in the study. About 84% of all birds were documented at vantage points 1,2 and 6, which also had the largest average flock size. This is unlike the spring season when there was no clearly discernible pattern (potentially due to the variable wind regime and more complex movement patterns of birds). The more intensive study of site 1 during autumn 2015 indicated an increase in numbers of birds on an east to west axis. This was evident at a similar scale to the current study (where vantage points A & B were separated by only 2.8 km). In contrast the current study the largest numbers of birds were observed more towards the southeastern portion of the study area.

It is possible that the morphology of the coast and its orientation might lead birds to concentrate more at the three southern most vantage points.

Table 22: Distribution of bird volume and altitude records between the six observation points. For comparison, the last column represents the results from autumn 2015 (i.e. roughly the same location as observation point 1) after being equalized for observation effort.

Observation point	1	2	3	4	5	6	Total	Autumn 2015
Number of birds	4898	7140	1736	496	568	2635	17473	2648
% of total	28.03	40.86	9.94	2.84	3.25	15.08	100	
Number of observations	106	169	130	45	59	73	582	108
Average flock size	46.21	42.25	13.35	11.02	9.63	36.10	30.02	24.5
Average altitude	140	181	133	180	127	159	148	110
Number of altitude records	341	566	487	194	453	254	2295	506
Number of birds at RSH	462	201	809	108	112	2088	3780	243
Birds /hour	37	56	13	4	4	21	22	
Records/hour	0.79	1.32	0.95	0.33	0.43	0.57	0.73	

The lowest average flight altitude was at point 5, while the greatest was at point 4; but the largest number of birds at RSH (and hence increased collision risk) was at point 6 (2,088 birds), representing 55% of all birds flying at RSH during the study (largely contributed by one large flock of 2,000 White Storks). The largest rate of migration was at point 2 with 56 birds /observation hour (1.32 records/hour), while the lowest was at points 4 and 5 (4 birds/hour and 0.33 records/hour and 4 birds /hour and 0.43 records/hour, respectively).

Generally, there does not appear to be a meaningful pattern in the distribution of flight altitudes between observation points or sites, except that there is an apparent increase in migration volume in the southern part of the study area, which might reflect a localized event or it might prove to be a pattern subject to further investigation.

Table 23: Distribution of flight orientation amongst the six observation points.

Flight direction	N		NE		E		SE		S		SW		W		NW		Total
Obs. site	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	
1							1	0.2	419	12.2	4478	33.3					4898
2			1	100			214	38.5	740	21.5	6151	45.8	34	100			7140
3	1	100					151	27.2	159	4.6	1425	10.6					1736
4							9	1.6	25	0.7	462	3.4					496
5								0.0	22	0.6	546	4.1					568
6							180	32.4	2078	60.4	377	2.8					2635
Total	1	100	1	100	0	0	555	100	3443	100	13439	100	34	100	0	0	17473

4.4 Non-soaring bird species

The non-soaring birds recorded within the study area during the study period included a total of 8,654 birds belonging to 32 non-soaring bird species. Over all the total volume of non-soring migrants in 2017 is about six fold of that in 2015; much of this is contributed by a few large flocks of duck species; and about double the number of species documented in the autumn of 2015.

Soaring birds are typically the main concern with regards to risks from wind energy development in this region. Non-soaring birds are mostly composed of smaller and more maneuverable species, which typically migrate in broad fronts and do not concentrate in globally important concentrations in our region. Moreover previous studies of migration in the Saharan ecosystem have shown most passerines to fly at great altitudes well above the wind energy infrastructure. Birds that land within the hyper arid Saharan ecosystem represent a fraction of the total migrants passing non-stop overhead. Thus their potential exposure to wind energy development is relatively small under normal conditions.

4.4.1 Migrant species

The volume and diversity of migrant non-soaring birds can vary and fluctuate from year to year more than that of soaring birds, as the former is much less confined by the topography or to a lesser extent weather factors than the latter. This means that non-soaring birds are much more random and widespread in their migration phenology. This can be seen in the differences in numbers and species of observed in both autumn 2015 and 2017.

Figure 17: One of the large flocks of Garganey observed over the study site on 25 September 2017. Photo Ali Dora.

Almost 88% of the non-soaring bird species that have been recorded at the study area were autumn migrants that pass rapidly and briefly through the region and normally do not stop or only seldom alight for short periods to rest. During autumn 2017, Garganey and other duck species made up about 60% of the migration volume, passing over and near the site in fairly large flocks. The autumn migration of Garganey is well documented around the Isthmus of Suez, where over 200,000 birds have been accounted for along the North Sinai shoreline heading south towards the Gulf of Suez, whence they either follow the Red Sea coastline southwards or cut across the desert towards sub-Saharan wintering grounds.

Table 24: Non-soaring bird species recorded at the study area. Autumn 2017.

Species	Birds	Observations
Barn Swallow	73	13
Bee Eater sp.	61	3
Black-eared Wheater	1	1
Blue-cheecked Bee-Eater	25	1
Brown-necked Raven*	10	5
Cattle Egret	20	1
Chiffchaff **	2	1
Cormorant	109	4
Crowned Sandgrouse*	106	10
Desert Lark*	14	5
Duck sp.	1629	9
Eastern Orphan Warbler	1	1
European Bee Eater	70	3
Garganey	3500	1
Isabelline Wheatear **	5	3
Meadow Pipit	1	1
Pipit sp.	1	1
Redstart	2	2
Reed Warbler	1	1
Sandgrouse sp. *	318	17
Sea bird sp.	200	1
Short-toed Lark	4	1
Spotted Flycatcher	1	1
Spotted Sand grouse *	2451	145
Tree pipit	1	1
Wagtail species	26	2
Wheatear	4	4
White Wagtail **	13	8
Willow Warbler	3	2
Yellow Wagtail	2	2
Total	**8654**	**250**

* Resident breeding species. ** Species that might winter locally.

4.4.2 Winter visitors

Given the limited suitable habitat within the study site winter visitors are generally uncommon or even rare in this part of the Eastern Desert of Egypt. There is only typically a handful of bird species that might utilize this habitat during the winter season in very small numbers. During this study three species that might winter in the general vicinity of the study area were noted: Chiffchaff, Isabelline Wheatear and White Wagtail, totaling 20 individuals (see Table 24).

4.4.3 Resident avifauna

The vast majority of the non-soaring birds at the study area are transient migrants; only four species that are resident breeders of the region were recorded during the current study period: Brown Necked Raven, Crowned Sandgrouse, Desert Lark and Spotted Lark. Not all of the four species might breed within the study area, but might do so in adjoining desert areas and enter the area of concern for either food or shelter. For example the Brown-necked Raven might not have appropriate nesting sites with the area.

Three further potential local breeders were also documented in the spring of 2017 these are: Rock Dove, Collard Dove and Bar-tailed Desert Lark.

5. Risk assessment

The guidance provided by the EEAA identifies three main ways in which a wind energy development could negatively impact bird populations (Migratory Soaring Birds Project, 2012):

- Collision with rotors, power lines and other infrastructure;
- Habitat loss;
- Disturbance and barrier effects.

In the context of this study, the main source of risk that is considered herein is that of collision with the moving rotors of wind turbines that are to be established at the study site. Potential collision with power lines is also taken into consideration.

The impact on birds due to habitat loss is seen as minimal due to sparse and unproductive nature of the local habitats and its poor native avifauna, combined with a lack of specific foci for bird life and the abundance of the same habitats outside the project area. Although the combined impact of all wind developments along the entire Gulf of Suez coast will certainly have a large impact at the landscape level that will affect local bird populations through a huge swath of territory. The mitigation of such large scale issues can only be made on a wider more strategic level that would take into consideration the entire region.

Impacts of barrier effects of the project (in isolation from other adjoining projects) will be minimal due to the limited scale of the Lekela project area. But it is important to keep in mind that developing adjacent plots could create significant barrier and other landscape impacts, which can only be assessed in a strategic scale taking into account all other developments in the region, Lahmeyer & Ecoda (2017) provide some proposals in this respect. Moreover, the development of other land uses in the adjacent region could have equally significant influence on the degree of risk within the study site; e.g. if a water treatment plant or cultivations are established next to the current site, this could seriously alter risk predictions as a result of attracting large numbers of birds to lower elevations.

Thus, the risk assessment focuses on the potential collision of migratory soaring birds with wind turbine rotors, which are operational within an altitudinal band ranging between 5-125 meters above the ground (the RSH). The main emphasis in the risk evaluation process is on the volume of birds that enters the RSH, the time spent within this zone, and also the species of birds involved. The latter has significance in terms of the size and likely behavioral responses of the birds involved, but also has significance in terms of the conservation importance of these birds, and the likely impact of any casualty levels on global populations.

Part of the complexity of risk assessment for migrant soaring birds is the global scale of the issue, while the spring and autumn studies provide a snap-shot evaluations of the situation at a very localized level (mainly spatially but also temporally) within the study site, implications of these risks have a potentially much wider impact on global populations that disperse to other much wider landscapes, where they a critical role in other ecosystems. For this reason it is important to take into consideration global population size of concerned species, their conservation status, as well as the potential long-term cumulative impact of any local mortality.

5.1 Collision Risk Modeling

The Collision Risk Modeling (CRM) process addresses risks from collision with the moving rotors of the wind turbines, which is perceived as the most significant risk to migrating birds at wind energy facilities. There are a few CRM approaches in application around the world; they all attempt to predict with the greatest possible truthfulness the potential collision risks from wind turbines to birds, through mathematical modeling. In this study we applied the Scottish Natural Heritage SNH CRM (SNH 2010), which is the approach adopted by earlier studies conducted for NREA in 2014 and 2015 (Baha El Din 2014, 2015) and in spring 2014 (MSB Project, 2014), as well as in the autumn 2015 and spring 2016 and 2017 studies of the Lekela project area.

All the available models tend to be linear in nature and treat migratory birds, more or less, as projectiles that fly through the airspace in straight lines. This does not normally take into account the behavioral and avoidance responses of birds when confronted with the turbines in the field. Studies indicate that behavioral avoidance is quite high in birds, reducing collision potential by up to 99%. To help account for the behavioral avoidance responses by birds, the current CRM model applies two avoidance rates ranging between a conservative 95% avoidance rate and a more realistic avoidance rate of 98%.

Despite advances and refinements in modeling, it is always difficult to predict natural processes, particularly with still limited data from the field, particularly from the Middle East region. Moreover, the model does not take into account the effects of local landscape, migration urgency, and the prevailing weather conditions (which can significantly affect the presumed avoidance efficiency of birds).

CRM has been applied in many but not all of the ornithological risk assessment studies in the Gulf of Suez. For example, the RECREEE strategic study (Lahmeyer & Ecoda 2017) of the Ras Gharib wind energy development area (of which the Lekela sites are a part of) did not apply any modeling for the interpretation of its data, but rather made qualitative expert based evaluation of risk, proclaiming that the CRM produces estimates "lack a reasonable basis" without further explanation. It is important that CRM results cannot be treated as the sole tool for risk evaluation, but rather as a gauging tool that may provide a basic sense of magnitude of risk that can be anticipated. Certainly, the empirical results of post-construction monitoring and carcass surveys would provide more factual data that can be used in risk management after wind energy infrastructure is in place.

5.2 Results of the CRM

For the current study period, the outcome of the CRM predicts that the total potential casualty level from active wind turbines (without any mitigation measures) within the study area (a total of 84 turbines) during the study period (15 August – 5 November 2017), would be about between 54 and 22 birds (at the avoidance rates of 95% and 98%, see Table 25 below), with a casualty rate of 0.64 – 0.25 birds / turbine / season (according to turbine specs and number provided by developer). The predicted casualty levels for autumn 2017 (at the 95% avoidance rate) are somewhat lower than that predicted for autumn 2015 (0.64 birds / turbine / season; versus 0.83 birds / turbine / season in 2015).

The main difference between autumn 2105 and 2017 is the presence in 2015 of a significant number of Black Storks, which were not recorded in the current study, and hence the occurrence of predicted casualties by the CRM. Otherwise the results of the CRM in both studies are fairly similar. In 2017 four species make up 96% of the predicted casualties: White Stork (55% of total casualties), Honey Buzzard (35%), White Pelican (4%) and Marsh Harrier (2%). In 2015 Honey Buzzard was predicted to have the greatest casualties totaling 48%, while White Stork was in second place (27%), Black Stork in third place (21%) and Marsh Harrier I fourth (2%). The stochastic nature of migration means that in some years one species might be more abundant than another, or fly at a higher altitude and thus are not exposed to the same risk they are exposed to in other years. In 2015 White Pelican did not appear as a significant risk due to low numbers at RSH, but in 2017 it was amongst the top species exposed to risk. The predictions do reflect seasonal / annual changes and shifts in bird numbers and species compositions at the local level, but still reflect a considerable consistency.

Table 25: Summary of the outputs of the CRM model including collision estimates at 95% and 98% avoidance rates for the duration of the study period.* Adjusted for observation effort, as study only covered one sixth the area of the project at any one time. .

Species	*P.* collision	Total birds observed	Total birds at RSH	% birds passing at RSH	Estimated collisions during study period			
					95% risk	95% risk adjusted*	98 % risk	98 % risk adjusted*
Black Kite	0.2	122	68	55.74	0.15	0.91	0.06	0.36
Crested Honey Buzzard	0.2	1	0	0.00	0.00	0.00	0.00	0.00
Eleonora's Falcon	0.18	2	1	50.00	0.00	0.01	0.00	0.00
Glossy Ibis	0.2	1	0	0.00	0.00	0.00	0.00	0.00
Hobby	0.18	1	1	100.00	0.00	0.01	0.00	0.00
Honey Buzzard	0.2	5578	1426	25.56	3.23	19.08	1.29	7.63
Kestrel	0.18	31	21	67.74	0.04	0.25	0.02	0.10
Long-legged Buzzard	0.18	2	1	50.00	0.00	0.01	0.00	0.00
Marsh Harrier	0.22	107	74	69.16	0.18	1.09	0.07	0.44
Montagu's Harrier	0.2	20	13	65.00	0.03	0.17	0.01	0.07
Osprey	0.19	2	1	50.00	0.00	0.01	0.00	0.01
Pallid Harrier	0.2	25	24	96.00	0.05	0.32	0.02	0.13
Peregrine	0.18	2	0	0.00	0.00	0.00	0.00	0.00
Red-footed Falcon	0.18	3	2	66.67	0.00	0.02	0.00	0.01
Short-toed Eagle	0.19	1	0	0.00	0.00	0.00	0.00	0.00
Sparrowhawk	0.18	1	1	100.00	0.00	0.02	0.00	0.01
Sooty Falcon	0.21	2	0	0.00	0.00	0.00	0.00	0.00
Steppe Buzzard	0.2	21	17	80.95	0.04	0.23	0.02	0.09
White Pelican	0.3	183	108	59.02	0.37	2.17	0.15	0.87
White Stork	0.22	11302	2002	17.71	5.00	29.47	2.00	11.79
Eagle sp.	0.19	1	0	0.00	0.00	0.00	0.00	0.00
Falcon sp.	0.18	5	5	100.00	0.01	0.06	0.00	0.02
Harrier sp.	0.2	20	13	65.00	0.03	0.17	0.01	0.07
Raptor sp.	0.18	40	1	2.50	0.00	0.01	0.00	0.00
Total		**17473**	**3779**	**21.63**	**9.16**	**54.04**	**3.66**	**21.62**

5.3 Observations of avian mortality

Seven carcass surveys were conducted under the existing 220 kv power lines that stretch along the eastern boundary of the study site between 17 August and 4 November 2017, with a total combined length of 84 km and about 7.5 hours of observations.

The first casualties were detected on 24 August, composed of 5 White Storks found immediately under the power lines between vantage point 1 and point 2. The birds were clustered within a short distance from each other and were of the same age (since dead), indicating that they all were part of the same flock, which presumably slammed into the power lines. The casualties were fresh and estimated to be a day old, probably part of the very large flock of 5,300 White Storks that was recorded on the 23rd of August at point 2.

In the subsequent survey of the power lines on 31 August one further White Stork casualty was detected in the same area between point 1 and point 2. The bird casualty was rather old, estimated to be about 10 days old (since dead), and most likely was part of the same group that was killed a few days earlier, as it was in the same area. The bird was only detected on the subsequent visit.

No other bird casualties or evidence of bird mortality were detected in the other five surveys of the power lines.

In total then there were 6 casualties, all White Storks, all probably died on the same in a single collision incident with the power lines, between point 1 and point 2. In autumn 2015 one White Stork and one Garganey Duck casualties were found along the same stretch of power line. In spring 2017 old White Stork remains were also found under the power lines near point 2. These repeated observations of casualties along the same stretch of power line raise the possibility that there might be certain lengths of the power lines that are more troublesome than others.

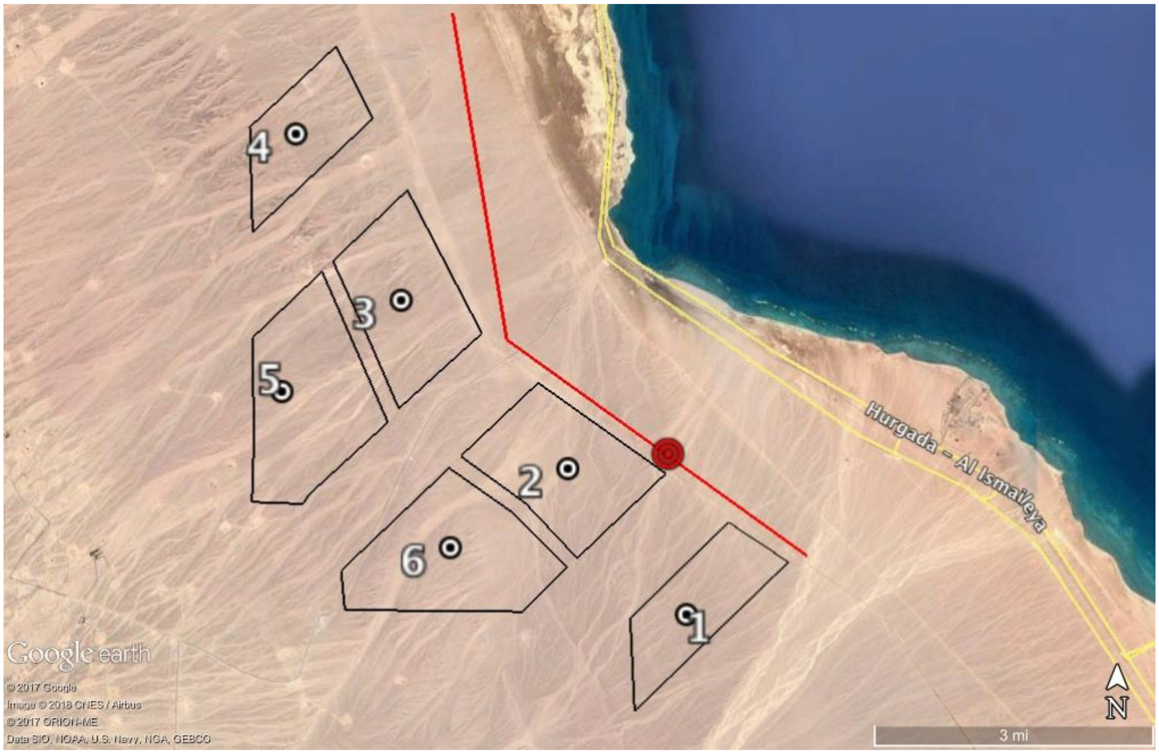


Figure 18: Carcass survey route (red line), and location of casualties recorded (red spot).

Figure 19: Remains of four White Storks found on 24 August 2017 between observation point 1 and 2 (two distant storks can be seen in the upper left side of the photograph). Photo Bassim Rabea.

Figure 20: Casualties found on 24 August 2017 were collected and later removed to prevent confusion during, subsequent surveys. Photos Bassim Rabea.

In the autumn of 2014, carcass monitoring at the KFW funded 200 MW wind farm at Ras Shukheir (Baha El Din 2014) revealed that 22 out of 24 casualties found were caused by power lines. A similar trend was also found in the spring of 2015 at the same site (Baha El Din 2015).

The regular occurrence of casualties along existing power lines during both spring and autumn migration indicate that they do pose a real and sustained risk to migratory soaring birds, which might be as great as that is posed by turbine rotors.

Table 26: Summary of carcass surveys made during autumn 2017 under the existing 220 kv power line.

Date	Time start	Species	Species	Number of individuals	Condition
17/8/2017	7:15	7:45	No bird	0	
24/8/2017	6:30	7:00	White Stork	5	Dead, one day old
31/8/2017	7:26	8:01	White Stork	1	Dead, ten days old
9/10/2017	7:00	8:00	No bird	0	
27/9/2017	7:00	8:00	No bird	0	
13/10/2017	7:00	8:10	No bird	0	
4/11/2017	16:00	17:00	No bird	0	

5.4 Conservation Significance of predicted risk

Three globally threatened soaring bird species were documented at the study site (see Table 27): Pallid Harrier, Sooty Falcon, and Red-footed Falcon; all of which have been listed in the IUCN Red List (2017) as Near Threatened and Vulnerable.

None of the threatened species were found in internationally significant numbers (i.e. > 1% of the estimated population of the species, see Table 27).

Table 27: Threatened migratory soaring birds found at the Lekela study site and its immediate vicinity during autumn 2017, and their conservation status (IUCN 2017).

Species	Number of birds	Flyway population estimate*	% of Global population	Predicted collisions at wind farm during study* period	Conservation status
Pallid Harrier	25	36,000	0.07	0.32	NT
Red-footed Falcon	3	550,000	0.00	0.02	NT
Sooty Falcon	2	22,500	0.01	0	VU

* at the 95% adjusted risk avoidance level

Besides the globally threatened species only one species occurred in internationally significant numbers within the wind farm area (exceeding 1% of the flyway population of a species), which is the White Stork, with 2.5% of its world population passing through the study area. The situation in the autumn of 2015 was very similar, with White Stork occupying the top rank in terms of global significance and predicted level of casualties.

The level of mortality predicted by the CRM does not approach the 1% level. However, the CRM does not take into account cumulative impacts of such a loss., nor does it account for the chronic nature of this potential loss of birds can have long-term significant negative impacts on the global populations of the concerned species (this is particularly true with long-lived species with low reproductivity, which is the case with most soaring birds). The overall risk can be further compounded when other neighboring wind farms are developed in adjoining territory and the footprint of wind farms in the entire region is multiplied, as the ability for soaring birds to avoid or circumvent wind energy infrastructure will be greatly reduced (and hence the need to maintain safe flight corridors between turbine arrays or wind farms at a strategic level).

Table 28: International significance of the most numerous species, occurring in significant numbers, i.e. representing >1% of its flyway population documented during autumn 2017.

Species	Total number of birds	Flyway population estimate*	% of flyway population	Predicted casualties**
White Stork	11302	450,000	2.50	29.47
Honey Buzzard	5578	675,000	0.82	19.09
White Pelican	183	40,000	0.46	2.17
Black Kite	122	200,000	0.06	0.91
Marsh Harrier	107	885,000	0.01	1.09

* Flyway population estimates come from different sources, including the BirdLife Soaring Birds Sensitivity Tool, (2017), IUCN Red Data Book (IUCN 2017), and Wetlands International. Species in bold face / italics were found in internationally significant numbers (>1% of population).

** at the 95% adjusted risk avoidance level

5.5 Comparison with results from autumn 2015 and other relevant studies in the region

It was not possible to meaningfully compare the current results with those of the RECREEE Strategic Study (Lahmeyer & Ecoda (2017) due to methodological differences, including a lower observation effort of 1.2 hours/site/day verses 1.6 hours/site/day during the current study. But most importantly the Lahmeyer & Ecoda (2017) study only had a limited coverage of the autumn season, as that study started on the 10th of September to the 10th of November 2016, essentially missing the most important part of the autumn season. As shown in in Figure 21 and Table 29 below, a large peak in numbers recorded prior to the first of September is documented by three studies that covered the second half of August. The other three studies started later in the season (including Lahmeyer & Ecoda 2017) and as a consequence missed the bulk of autumn migration Also note the generally similar pattern of numbers amongst the three studies conducted in the Ras Gharib area during the period from mid-September onwards.

As a consequence the conclusions of the RECREEE Strategic Study with regards to the autumn season in particular are disputable. Their statement regarding the autumn migration season "Neither a single FiT-plot nor the whole project area is of particular importance for migrating birds in autumn" is inaccurate in the light that migration during the first three weeks in autumn reaches a comparable rate of migration (72 birds / hour, this study) as it does in spring (109 birds / hour in spring 2017 (Lahmeyer & Ecoda 2017), only for a narrower window of time. More over the Lahmeyer & Ecoda (2017) assessment is based on incomplete data as they only covered a period where only less than 10% of the migration volume of the autumn season takes place. These statements regarding autumn migration are unexplained given the acknowledgement made in the same report that "it is not possible to derive a complete picture of autumn migration and to assess the importance of the project area for large soaring birds" as a result of the limited coverage of the autumn season. Similarly the recommended risk management and mitigation measures for the autumn season have some significant shortcomings that are discussed below, because of their relevance to the Lekela project site.

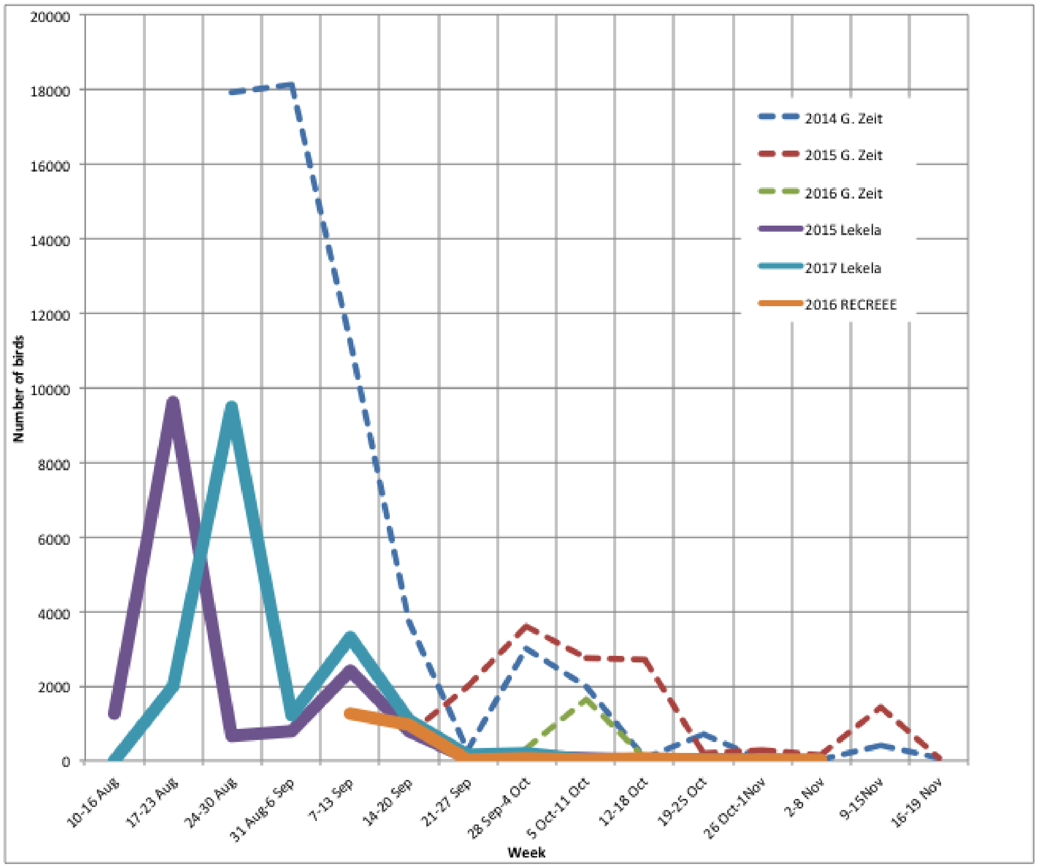


Figure 21: Comparison between the number of birds recorded during autumn season ornithological studies at the southern Gulf of Suez

G.Zeit 2014 (Ecoconserve 2015), 2015 (Ameaster 2016) and 2016 (Baha El Din 2016) at the 240 MW wind farm at Gebel El Zeit (dotted lines); and the autumn of 2015 (Environics 2016) and this study (2017) at the Lekela study site ; plus the RECREEE Strategic Study (Lahmeyer & Ecoda 2017).

Table 26: Comparison of bird numbers recorded during five autumn season studies in the southern Gulf of Suez. Shaded areas of the table indicate duration of each study.

Study reference	Ecoconserv (2015)	Ameaster (2016)	Baha El Din (2016)	Environics (2016)	Current study
Location	G. Zeit	G. Zeit	G. Zeit	R. Gharib	R. Gharib
Study year	2014	2015	2016	2015	2017
Date / week	Aug 24-19 Nov	Sep 17-14 Nov	Sep 26-Nov 1	Aug16-Nov 5	Aug 15-Nov 5
10-16 Aug				1281	0
17-23 Aug				9603	2000
24-30 Aug	17900			649	9480
31 Aug-6 Sep	18128			789	1207
7-13 Sep	11236			2420	3323
14-20 Sep	3747	700		811	1079
21-27 Sep	269	2000		64	167
28 Sep-4 Oct	3012	3600	340	117	180
5 Oct-11 Oct	1974	2750	1655	75	18
12-18 Oct	70	2700	50	40	11
19-25 Oct	710	200	35	32	5
26 Oct-1Nov	26	300	115	9	3
2-8 Nov	17	150		1	0
9-15Nov	393	1450			
16-19 Nov	60	50			
Total	57542	13900	2195	14610	17473

On the other hand, there is an overall good similarity between the results of this study and those of the autumn 2015. Table 30 summarizes the results for both years, in 2015 the study was singularly focused on site 1 (covered by observation point 1 in the current study), while in 2017 the study effort was spread on a much wider area, but the observation effort was the same in both years, thus the results are very comparable despite the different spatial coverage of each.

When adjusted for effort the total number of birds at site 1 in autumn 2017 would have been 29,388 birds (compared with an actual total of 15,891 birds in autumn 2015). The range of species and relative contribution of each to the overall volume of birds, as well as flight patterns and altitudinal preferences are all remarkably similar in both years, with some exceptions like the presence of Black Stork in 2015 (however this was a single large flock). The level of predicted casualties is also very close in both years with a total of 0.64 casualties / turbine / season in 2017 and 0.83 casualties / turbine / season in 2015 (at the 95% avoidance rate).

Generally, the similarities between the results of autumn 2017 and 2015 are remarkable and very reassuring in terms of the stability and consistency of our methodology. This consistency in outcomes was also noted during the 2017 and 2016 spring season studies, and gives a high degree of confidence in our results and predictions made in all years. The value of continued monitoring becomes evident with time and can help provide practical mitigation measures through improving our understanding of risk and narrowing down the window of risk.

When comparing with the results of other risk assessment studies in the region specifically in the in adjoining at Gebel El Zeit area we also find a broad consensus, when comparing the casualty levels predicted by the current study. There is a general agreement in the main migration pattern, timing, species composition and timing of migration throughout the region during the autumn season. Essentially the results produced at the Lekela study area in 2015 and 2017 are very representative or characteristic of the autumn migration through the southern portion of the Gulf of Suez. Similarly the CRM results proposed by ENBICON (2014) for autumn 2013 at the ItalGen site at Gebel El Zeit, and by Baha El Din (2014, 2017) for autumn 2014 and 2016, and Ameaster (2016) for autumn 2015 at the nearby KFW funded 200 kw wind farm area at Ras Shukheir all correspond to a large extent with the results from autumn 2015 and 2017 at the Lekela study site (see Table 31).

Table 27: Comparison of results for autumn 2015 and 2017. Both results represent the same observation effort, and an avoidance rate of 95%.

	Autumn 2017				Autumn 2015			
Species	**Total birds**	**Birds at RSH**	**% birds passing at RSH**	**Estimated collisions**	**Total birds**	**Birds at RSH**	**% birds passing at RSH**	**Estimated collisions**
Black Kite	122	68	55.74	0.15	15	11	73.3	0.03
Black Stork	0	0	0.00	0.00	1000	1000	100	3.02
Crested Honey Buzzard	1	0	0.00	0.00	0	0	0.00	0.00
Eleonora's Falcon	2	1	50.00	0.00	1	1	100	0.00
Glossy Ibis	1	0	0.00	0.00	0	0	0.00	0.00
Hobby	1	1	100.00	0.00	0	0	0.00	0.00
Honey Buzzard	5578	1426	25.56	3.23	4491	2964	66	6.72
Kestrel	31	21	67.74	0.04	40	16	40	0.04
Lanner Falcon	0	0	0.00	0.00	2	2	100	0.01
Lesser Kestrel	0	0	0.00	0.00	7	2	28.6	0.01
Levant Sparrowhawk	0	0	0.00	0.00	1	1	100	0.00
Long-legged Buzzard	2	1	50.00	0.00	0	0	0.00	0.00
Marsh Harrier	107	74	69.16	0.18	141	105	74.5	0.30
Montagu’s Harrier	20	13	65.00	0.03	34	19	55.9	0.06
Osprey	2	1	50.00	0.00	7	7	100	0.01
Pallid Harrier	25	24	96.00	0.05	21	10	47.6	0.03
Peregrine Falcon	2	0	0.00	0.00	4	2	50	0.01
Red-footed Falcon	3	2	66.67	0.00	4	2	50	0.01
Sooty Falcon	2	0	0.00	0.00	7	2	28.6	0.01
Sparrowhawk	1	1	100.00	0.00	5	2	40	0.01
Short-toed Eagle	1	0	0.00	0.00	0	0	0.00	0.00
Steppe Buzzard	21	17	80.95	0.04	33	7	21.2	0.02
White Pelican	183	108	59.02	0.37	100	0	0.00	0.00
White Stork	11302	2002	17.71	5.00	9880	1249	12.6	3.78
Buzzard sp.	0	0	0.00	0.00	7	6	85.7	0.01
Eagle sp.	1	0	0.00	0.00	0	0	0.00	0.00
Falcon sp.	5	5	100.00	0.01	20	8	40	0.02
Harrier sp.	20	13	65.00	0.03	15	7	46.7	0.02
Raptor sp.	40	1	2.50	0.00	40	3	7.5	0.01
Total	**17473**	**3779**	**21.63**	**9.16**	**15891**	**5435**	**34.2**	**14.13**

Table 28: Comparison of different collision risk predictions made for the autumn season from the Gulf Suez.

Project site	**Lekela 95% avoidance**	**Lekela 98% avoidance**	**Lekela**	**KFW 200 MW site**			
Location	Ras Gharib		R. Gharib	Gebel Zeit			
Study	Current study		1	2	3	4	5
Date	2017	2017	2015	2013	2014	2015	2016
Total casualties	54.04	21.62	14.13	164.66	112.07	112.07	112.07
Number of turbines	84	84	17	100	100	100	120
Casualties / turbine	0.64	0.26	0.83	1.65	1.17	1.16	0.36

Sources: $_1$ Environics (2016), $_2$ Al Hassani (2014), $_3$ Ecoconserv (2015), $_4$ Ameaster (2016), $_5$ Baha El Din (2016).

6. Conclusions and recommendations

The most important findings of the study:

The study site is located along an important migratory route for soaring birds in autumn. The 2015 and 2017 studies confirm that the study location is on a globally important flyway for certain migratory soaring birds during the autumn season, supporting important concentrations of birds. In the autumn the very passive soaring birds take a more northerly rout into Africa at Suez, while the largest proportion of less passive species entre Africa via Bab El Mandab between Yemen and Djibouti. The Gulf of Suez remains of international importance for storks, pelicans and Honey Buzzards in the main part.

Migration volume decreases sharply after mid-September. In the current study and all studies conducted in the region in the autumn season show that the intensity and volume of soaring bird migration declined sharply after the second week of September. Composition of species and timing of migration is in agreement with previous established knowledge (e.g. Goodman and Meininger 1989, Bruderer et. Al 1994, Agris and Baha El Din 1999, DECON and Fitchner 2007, Baha El Din 2015), with an abrupt and short peak of stork movement in mid-August, followed by a less dramatic movement of Honey Buzzards in the early part of September.

The bulk of migration takes place from mid-August to mid-September. Almost 90% of the total migrants were documented before mid-September. The period between mid-septembers to the middle of November is of lesser importance for bird migration in terms of volume. Observations made between 20 September and 5 November contributed only 2.2% of the total birds observed during the entire study period.

There is a clear dichotomy in the soaring bird pattern during the earlier and latter parts of autumn in the Gebel El Zeit region. The phenology of bird migration changes quite significantly around the middle of September, from an almost mono-specific migration made up of huge and sudden pulses of birds between mid-August till mid-September, to a diverse migration stream that is more of a trickle and less of a series of sudden volume event. This contrast calls for quite a different way in looking at risk management in each case, and also calls for the proper sampling of this most critical period of the autumn migration.

The nature of migration in the early part of autumn dominated by huge pulses of White Storks flying at low level could cause catastrophic type of incidents, where large numbers of birds are damaged in a very short period of time. The current study shows that over 50% of all anticipated mortality would be made up of White Storks.

The window of risk for migratory soaring birds in autumn is fairly narrow, extending between mid-august to mid-September. This window can slid a few days earlier or later in different years. Further monitoring at the location will improve predictability of bird movements in the region and increase confidence in identifying the highest risk times with greater accuracy.

About 1,217 birds were recorded within the RSH (between 5 – 125 meters above ground), representing about 7% of the total volume of birds recorded inside the study site. This excludes about 93% of the birds from collision risk. Estimates of casualties predicted by the CRM at the study site from active wind turbines (without any mitigation measures) during autumn 2017 would have been about between 54 and 22 birds (at the avoidance rates of 95% and 98%), with a casualty rate of 0.64 –by the CRM are mostly of non-threatened species, mostly White Stork and Honey Buzzard (both classified as Least Concern by IUCN (2017).

Only the White Stork that occurred in internationally significant numbers within the study area, in addition to three globally threatened soaring bird species have been documented: Pallid Harrier, Sooty Falcon and Red footed Falcon (none of these though occurring in internationally significant numbers).

Generally the CRM results should be taken as indicative only, as comparative empirical results from casualty surveys carried out in parallel with migrant monitoring and CRM analysis at Gebel El Zeit have either shown that CRM estimates are either too high (Baha El Din 2015) or too low (Baha El Din 2017). The differences however between empirical observations and predicted estimates were not huge, and carcass search studies have to a large extent shown the value of the CRM in predicting casualties and in providing a sense of scale and nature of the risks to be expected (in terms of numbers and species involved); which is an excellent outcome, which has great value for planning purposes, despite the great uncertainty that risk assessment of this type of natural resources can face

Predicting levels of risk into the future is difficult, as there are many factors that could affect risk levels during operations that might not have been taken into account in the CRM model. Minor factors could alter risks greatly (such as disturbance, development patterns in adjacent areas, weather patterns, etc.). Moreover, the soaring bird migration in the region could vary greatly within and between years; this means that predictions based on a small sample of observation seasons is relatively weak, but increases in robustness with increased monitoring effort.

Six bird casualties found under the existing power lines. Even though these casualties were caused by collision with power transmission infrastructure, they do indicate that bird mortality is a real risk in the study area and the rest of the region. These casualties also indicate that not only should risk assessment consider wind turbines, but also other infrastructure that can pose an equally high risk to birds. These collective factors should certainly be considered in any strategic or cumulative risk assessment of the region. Also the timing and target species suggest that risk management focus in autumn should be focused on the migration of White Storks in late August and early September.

Perhaps one of the most notable outcomes of the current study is the consistency of its results with those from autumn 2015. This was also the case amongst the spring 2016 and spring 2017 studies. This overall uniformity is very reassuring in terms of the stability and dependability of our methodology, and gives a greater degree of confidence in our results and predictions made in both years. The value of continued monitoring over time becomes evident with such results and in the long run can help provide practical mitigation measures through improving our understanding of risk and narrowing down the window of risk.

In conclusion, the results from the current study and the 2015 study at this site support that wind energy development is possible throughout the greater part of the autumn season with low risks, except for a narrow window of risk between mid-August and mid-September, where risks must be managed or mitigated through a well-planned monitoring and risk management effort (potentially including shutdown on demand or fixed shutdown options).

6.1 Recommendations

Based on the findings of the RECREEE Strategic Study (Lahmeyer & Ecoda 2017), that the Ras Gharib region has "no particular importance for migrating birds in autumn", it concluded that collision risk for migrating birds in autumn are "assessed as a minor impact when considering an individual wind farm"; hence, no management or mitigation measures was required for the autumn season, subject to verification with carcass surveys. As the Lekela study area is encompassed within the geographic scope of the Strategic Study, and its recommendations has relevance to its operations in its development area it is prudent to take into consideration these recommendations.

As indicated earlier in this report the conclusions and recommendations of the RECREEE Strategic Study (Lahmeyer & Ecoda 2017) with regards to the autumn season are based on incomplete coverage of the autumn migration season, missing the most important period of the season which occurs in the second part of August and early September, where over 90% of the migration volume was documented in 2017. While, it is clear that the autumn season is less significant for bird migration in the autumn than in spring, there is indeed a narrow temporal window of significant migration during autumn that should not be ignored by all means.

We recommend a precautionary approach when dealing with risks originating from difficult to quantify natural phenomenon, with high variability, such as bird migration. Wind energy development at the study area must be paired with a scientifically sound bird monitoring system that is designed to build a professional knowledge base of this natural phenomenon, so as to enable the efficient and effective management of risk to birds from the industry's infrastructure and its operation. Initially this would guide the infrastructural planning and help develop effective mitigation measures. This will improve risk management and narrow down interventions, hence increasing efficiency of operation and reduce potential loss of energy generation potential at the site. The assurance offered by fairly consistent results of several ornithological studies within roughly the same geographic area, makes the case in this respect.

Risk management measures should be developed, adopted and modified gradually according to improved understanding of risks at the site and its modes of operation. Initially there can be more precautionary measures, possibly involving fixed shutdown (FS) periods, combined with monitoring, then ultimately devolving to a shutdown on demand (SOD) system that responds to the four triggers that have been adopted by the EEAA (presence of threatened species, flocks of 10+ birds of target species, imminent collision risk and occurrence of sand storms). In all cases this should be combined with monitoring (including detailed carcass surveys) to assess risks and effectiveness of any shutdown and refine its parameters, making it more efficient, including the length of the risk window, which is likely to become much smaller with more available data. Throughout this process there is a critical need for data streamlining, maintenance and knowledge buildup and accumulation, which would facilitate better factual management of the risk to birds on the long run.

Lahmeyer & Ecoda (2017) proposed a set of risk management measures and steps for the preconstruction, construction, operational and decommissioning phases of wind energy projects, for the wider Ras Gharib region. These include a set of rational and typical measures applied to wind energy developments worldwide with regards to risk reduction to birds. These measures are largely in line with proposals made based on the spring 2017 study findings (Environics 2017) and the results of the current study, most of which were already reflected in earlier recommendations or have been integrated in the recommendations below when deemed relevant, keeping in mind that the recommendations are mainly targeting the autumn season specifically.

6.1.1 Pre-construction

Maintain a pre / post construction bird migration monitoring effort during the peak migration period. Recommended monitoring period: 10 August – 15 September.

Establish a database to maintain monitoring results and continually analyze the cumulative data to produce more refined management recommendations (this should continue throughout the life time of the project and maintained by a trained specialist).

6.1.2 Design and construction

Maintain monitoring effort as above. A modified monitoring approach with a reduced effort can be applied, as knowledge is enhanced.

Strictly preserve the unattractiveness of the site to migrant birds. This can be achieved by rigorously banning any type of cultivation, or plantation of green areas in or around the site; prevention of garbage or other solid or liquid waste in the project site or in its vicinity (even inorganic wastes); strictly preventing any water or other liquids (including oils) from reaching the surface.

The management of risks from power lines differs from wind turbines, as shutdown options will not be applicable. For the existing power line visual interventions should be applies. For all internal grid underground power cables should be installed.

It is important to harmonize and coordinate the design, installation and operation of multiple wind farms in the wider region; as well as coordinate monitoring and risk management efforts, including any SOD procedures.

Some further physical aspects to consider in the design stage include: Avoiding turbines with lattice towers, limiting maximum tip height of wind turbines to about 120 m, avoid lighting of wind turbines and painting turbine blades with bold and contrasting colors to increase blade visibility to birds.

6.1.3 Operation phase

Post-construction monitoring is critical, particularly during the initial stages of operation to verify bird response to predictions and intervene if critical issues arise. Confidence levels in risk assessment results will increases with cumulative knowledge and experience. This knowledge will be used to refine any shutdown or other risk management measures that need to be taken, and hence reduce long-term costs. The post construction monitoring effort must include a systematic carcass survey to assess actual mortality during operation.

Year 0 – 1 of operation: No shutdown should be implemented during the first full year of normal operation in order to provide a verifiable sample assessment of the full potential impact of the newly operational infrastructure on migrant soaring birds. This, however, must be combined with a detailed monitoring effort to assess bird responses and document any casualties. The results of the first year of un-interrupted operation would be then used in the detailed set up of subsequent shutdown on demand methodologies and standards.

Year 1 – 4 of operation: Implement a shut down on demand system based on the finding of previous years monitoring and the results of the first year of operation. Eventually, the shutdown system could include a fixed shutdown during the last two weeks of August (during the peak stork migration in autumn), combined with shutdown on demand during seven weeks of peak migration in spring, as discussed above. Shutdown on demand will require a constant monitoring effort and a clear set of triggers (these have already been defined by the EEAA). The details of a shutdown system need an independent effort to establish a viable and practical system that takes into account, the biological aspects and also the cost, practical implementation aspects, potential consequences to the grid, and relationship with neighboring wind energy developments.

Year 4 and beyond: It is anticipated that a shutdown system (either fixed or on demand) and long term monitoring (composed of systematic carcass surveys and a sampling effort) will be required for the life-time of the project.

7. References

Agris, C. and Baha El Din, M. (1999). Observations of bird migration through southern Sinai with insights on migration strategies. Report to NCS.

Al Amar Consulting Group (2009). Gulf of El Zayt 220 MWe Wind Power Plant Project, Environmental and Social Impact Assessment. Prepared fro JICA / NREA.

Al-Hasani I (2014) Gabel Al-Zayt Wind farm Project (200 MW): post-construction monitoring for non-operational wind farm, Spring Survey (April 4 – May 15, 2014). Report prepared for Egyptian Environmental Affairs Agency (EEAA) & BirdLife International/UNDP/GEF Migratory Soaring Birds Project.

Ameaster (2016) Gabel Al-Zayt Wind farm Project (200 MW): Post-construction monitoring for autumn season (September 17 - November 14, 2015). Report prepared for New and Renewable Energy Authority (NREA) –Egypt. Unpublished draft report.

Baha El Din S.M. and Baha El Din, M. (1996). Spring migration of birds at Ras Zaafarana, Egypt, with reference to risk from planned wind energy developments. Report submitted to the Danish Embassy in Cairo.

Baha El Din, S. M. (1999). The Important Bid Areas of Egypt. BirdLife International.

Baha El Din, S.M. (2015a). Sensitivity Atlas of Migratory Soaring Birds in Egypt. Publication of the MSB Project, UNDP/ BirdLife / EEAA /NCE.

Baha El Din, S. M. (2015b). Final report on the spring 2015 post construction ornithological monitoring at the 200 MW KFW funded wind farm at Gebel El Zeit. Report presented to NREA.

Baha El Din, S. (2016). Report on the 2016 autumn post construction ornithological monitoring at the 200 MW KFW funded wind farm at Gebel El Zeit.

Baha El Din, S. M. (2017). Review of autumn bird migration monitoring at Gebel El Zeit: 2014-2016. Report for EEAA.

Biebach, H. (1995). Stopover of migrants flying across the Mediterranean Sea and the Sahara. Isr. J. Zool. 41: 387–392.

Bergen, F. (2007). Ornithological Investigation on Bird-Wind Power Interactions at a Wind Farm near Zafarana, Egypt. Report to DECON - Deutsche Energie-Consult Ingenieurgesellschaft mbH & New and Renewable Energy Authority (NREA).

Bergen, F. (2007). Ornithological Expert Opinion as part of the Feasibility Study for a large wind farm at Gulf of Zayt Report prepared for: DECON.

Bergen, F. and Fritz G.B.R. (2013). Environmental and Social Impact Assessment for an Area of 300 km2 at the Gulf of Suez Non-Technical Summary. Prepared by the Joint Venture Lahmeyer International GmbH, Bad Vilbel and Ecoda

Berthold, P., van den Bossche, W., Fiedler, W. Gorney, E., Kaatz, M., Leshem, Y., Nowak, E., and Querner, U. (2001). Der Zug des Weißstorchs (Ciconia ciconia) eine besondere zugform auf grund neuer ergebnisse. Journal für Ornithologie 142: 73–92.

Bijlsma , R.G. (1987). Bottleneck areas for migratory birds in the Mediterranean region. ICBP Study Report No. 18, Cambridge.

Bijlsma, R.G. (1983). The Migration of raptors near Suez, Egypt, autumn 1981. Sandgrouse, 5, 19-44.

Bijlsma, R.G. (1983). the migration of raptors near Suez, Egypt, autumn 1981. Sandgrouse 5: 19–44.

British Trust for Ornithology (2012). Best Practice Guidance for Wind Farm Development for the Conservation of Birds in the Rift Valley – Red Sea Flyway.

Bruderer, B, S Blitzblau & D peter. (1994). Migration and flight behaviour of Honey Buzzards *Pernis apivorus* in southern Israel observed by radar. Ardea 82: 111–122.

Bruun, B. (1985). Spring migration of raptors at Suez compared to Elat. Dutch Birding 7: 6–11.

Christensen, K. D. and Jensen, F. P. (2002). Atlas of bird migration at the Gulf of Suez, Egypt. Report prepared by Ornis Consult Ltd., for DANIDA.

Christensen, K.D. and Jensen, F.P. (2002). Atlas of bird migration at the Gulf of Suez, Egypt. Ornis Consult/Ministry of foreign affairs/Danida, Copenhagen.

DECON and Fitchner (2007a). Feasibility Study for a Large Wind Farm at Gulf of Zayt. Ornithological Field Monitoring Report. Prepared for KfW-Entwicklungsban / NREA.

DECON and Fitchner (2007b). Feasibility Study for a Large Wind Farm at Gulf of Zayt. Ornithological Investigations Summary of Findings Report. Prepared for KfW-Entwicklungsban / NREA.

DECON and Fitchner (2008). Environmental Impact Study 200 MW Wind Farm at the Gulf of El Zayt. Prepared for KfW-Entwicklungsban / NREA.

Ecoda (2011). Environmental and Social Impact Assessment Study 1,000 MW Wind Farms at the Gulf of Suez. Prepared for KfW-Entwicklungsban/ NREA.

ENBICON (2014). Public presentation of the results of ornithological impact assessment of a 100-200 MW wind-farm project at Italgen Phase 2 area Gebal El Zayt, Egypt 2013.

ENBICON (2014). Ornithological impact assessment of a 100-200 MW wind-farm project at Italgen Phase 2 area Gebal El Zayt, Egypt 2013.

Ecoconserv (2015). Bird Migration at the 200 MW (KfW) Windfarm in Gabal El Zeit, Egypt (Autumn 2014 Season). Report to New and Renewable Energy Authority (NREA). Cairo.

Environics (2016) Report on the spring 2016 pre-construction ornithological monitoring at the Lekela project site, Ras Gharib, Gulf of Suez. Unpublished Report.

Goodman, S. M., Meininger, P.L., Baha El Din, S.M., Hobbs, J.J., & Mullié, W.C. (1989). The Birds of Egypt. Oxford University Press, Oxford

Grieve, A. (1996). Spring raptor movements at Gebel El Zeit, Egypt. Sandgrouse 18(1): 61–63.

Hilgerloh, g, Pegram, G. and Schreiber, A. (2011). The influence of wind conditions and topography on soaring migrants near the southern Gulf of Suez. Sandgrouse 33: 139–148.

Hilgerloh, G, Weinbecker, J. & Weiss, I. (2009). The timing of spring passage of soaring birds at Zait Bay, Egypt. Sandgrouse 31:26–35.

Hilgerloh, G. (2009). The desert at the Zait Bay/Egypt: a critical bird migration bottleneck area of global importance. Bird Conservation International 19: 338–352.

Hilgerloh, G. (2011). The desert at the Zait Bay/Egypt: a critical bird migration bottleneck area of global importance—ERRATUM. Bird Conservation International 21: 362–363.

IUCN (2017). IUCN red list of threatened animals. http://www.iucnredlist.org.

Lahmeyer & Ecoda (2017). Strategic and Cumulative Environmental and Social Assessment Active Turbine Management Program (ATMP) for Wind Power Projects in the Gulf of Suez, 2nd Draft Report (D-5-2) on the Strategic Environmental and Social Assessment.

Megalli, M. (2011). Migratory soaring bird arrivals coastal southwest Sinai, spring 2006. Sandgrouse 33: 179–180.

Megalli, M. and Hilgerloh, G. (2013). The Soaring Bird Spring Migration Bottleneck at Ayn Sokhna, Northern Gulf of Suez, Egypt. Sandgrouse, 35 28-35.

MSB Project (2012). UNDP / BirdLife Migratory Soaring Birds Project, Wind Energy Guidance for Developers and Consultants. http://migratorysoaringbirds.undp.birdlife.org/sites/default/files/factsheet%20Wind%20Farm%20Developer%20new%20logo%20PR.pdf.

MSB Project (2013). Environmental Impact Assessment Guidelines and Monitoring Protocols for Wind Energy Development Projects along the Rift Valley/Red Sea Flyway with a particular reference to wind energy in support of the conservation of Migratory Soaring Birds (MSB). UNDP / BirdLife/ EEAA.

Mortensen, N.G., J.C. Hansen, J. Badger, B.H. Jørgensen, C.B. Hasager, L. Georgy Youssef, U. Said Said, A. Abd El-Salam Moussa, M. Akmal Mahmoud, A. El Sayed Yousef, A. Mahmoud Awad, M. Abd-El Raheem Ahmed, M. A.M.

Sayed, M. Hussein Korany, M. Abd-El Baky Tarad (2005). Wind Atlas for Egypt, Meas- urements and Modeling 1991-2005. New and Renewable Energy Authority, Egyptian Meteorological Authority and Risø National Laboratory. ISBN 87-550- 3493-4. 258 pp.

NABU (2005). Protecting birds from power-lines, Nature and environment No. 140, Council of Europe Publishing.

Porter, R.F. (2006). Soaring bird migration in the Middle East and north east africa: the bottleneck sites. In: UNDP/BirdLife International. Mainstreaming conservation of migratory soaring birds into key productive sectors along the Rift Valley/Red Sea flyway. UNDP Project Document, Annex 2.
IUCN (2015). The IUCN Red List of Threatened Species Version 2015-4. <www.iucnredlist.org>. Downloaded on 19 November 2015.

Loss, S. R., Will, T., & Marra, P. P. (2014). Refining Estimates of Bird Collision and Electrocution Mortality at Power Lines in the United States. PLoS ONE, 9(7), e101565. http://doi.org/10.1371/journal. pone.0101565

Korner-Nievergelt, F., Pius Korner-Nievergelt, Oliver Behr, Ivo Niermann, Robert Brinkmann, and Barbara Hellriegel (2007). A new method to determine bird and bat fatality at wind energy turbines from carcass searches. Wildlife Biology, 17(4): 350-363.

Scottish Natural Heritage (SNH) (2000) WINDFARMS AND BIRDS: Calculating a theoretical collision risk assuming no avoiding action. Available from: http://www.snh.gov.uk/docs/C205425.pdf

Scottish Natural Heritage (SNH) (2010) Use of avoidance rates in the SNH wind farm collision risk model. Available from: http://www.snh.gov.uk/docs/B721137.pdf

Shirihai, H, Yosef, R Alon, D. Kirwan, G.M. & Spaar, R. (2000). Raptor migration in Israel and the Middle East. A summary of 30 years of field research. International Birding & Research Center in Eilat, Israel.

Shirihai, H. (1996). The Birds of Israel. Academic Press.

Wimpfheimer, D., Bruun, B, Baha El Din, S.M. and Jennings, M.C. (1983). The migration of birds of prey in the northern Red Sea area. The Holy Land Conservation Fund, New York.

Zegula, T. (2012). Environmental Issues and Wind Energy Development in Egypt. Ecoda Environmental Consulting presentation; Cairo – September 11th, 2012.

Annex 1
List of all birds observed during Autumn 2017 at the study site and its vicinity

English name	Scientific name
Barn Swallow	*Hirundo rustica*
Black Kite	*Milvus migrans*
Black-eared Wheatear	*Oenanthe hispanica*
Blue-cheeked Bee-eater	*Merops superciliosus*
Brown-necked Raven	*Corvus ruficollis*
Cattle Egret	*Bubulcus ibis*
Common Buzzard	*Buteo buteo*
Common Wheatear	*Oenanthe oenanthe*
Crowned Sandgrouse	*Pterocles coronatus*
Garganey	*Anas querqudela*
Glossy Ibis	*Plegadis falcinellus*
Desert Lark	*Ammomanes deserti*
Eastern Orphan Warbler	*Sylvia crassirostris*
Eleonora's Falcon	*Falco eleonorae*
Eurasian Kestrel	*Falco tinnunculus*
Eurasian Sparrowhawk	*Accipiter nisus*
European Bee-eater	*Merops apiaster*
Great Cormorant	*Phalacrocorax carbo*
Great White Pelican	*Pelecanus onocrotalus*
Honey Buzzard	*Pernis apivorus*
Isabelline Wheatear	*Oenanthe isabellinus*
Marsh-Harrier	*Circus aeruginosus*
Meadow Pipit	*Anthus pratensis*
Montagu's Harrier	*Circus pygargus*
Osprey	*Pandion haliaetus*
Peregrine	*Falco peregrinus*
Pallid Harrier	*Circus macrourus*

English name	Scientific name
Redstart	*Phoenicurus phoenicurus*
Red-rumped Swallow	*Hirundo daurica*
Reed Warbler	*Acrocephalus scirpaceus*
Short-toed Lark	*Calandrella brachdactyla*
Spotted Sandgrouse	*Pterocles senegallus*
Tree Pipit	*Anthus trivialis*
White Stork	*Ciconia ciconia*
White Wagtail	*Motacilla alba*
Willow Warbler	*Phylloscopus trochilus*
Yellow Wagtail	*Motacilla flava*