Lekela

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

Prepared by:

Environics, SAE
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In association with

Nature Conservation Egypt NCE

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Abbreviations

BLI	BirdLife International
CRM	Collision Risk Model
GOE	Government of Egypt
EEAA	Egyptian Environmental Affairs Agency
EIA	Environmental Impact Assessment
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
UNDP	United Nations Development Program

Summary

This report presents the results of a monitoring study of soaring bird migration during the spring 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 spring 2016 ornithological studies conducted at the area.

The study was carried out between 20 February and 15 May 2017, for a period of 85 days, covering the full spring 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 that can be used in assessing potential risks from proposed wind energy developments in the area during the spring season, 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

Results from 2017 and 2016 indicate that the study area is located on the fringe of the globally important Red Sea / Rift Valley Flyway for migratory soaring birds, just north of the Gebel E Zeit bottle neck Important Bird and Biodiversity Area (IBA), and to the south of the Ain Sukhna IBA.

The study was carried out for a total period of 85 days. In total 170 observation sessions were carried out, totaling 810 observation hours, out of about 935 potential day light hours. The number of sessions and hours of observations was divided almost equally between the six vantage points.

There were no birds observed during 69 out of a total of 170 sessions, representing about 41% of the observation sessions.

In total 2,868 observations were made (of soaring and non-soaring birds, inside and outside the study sites), resulting in a grand total of 61,179 birds (very close to the grand total of 67,358 birds recorded in spring 2016), belonging to 66 species. Of these 12,205 non-soaring birds belonging to 42 species were recorded.

The total volume of soaring birds both inside the study sites and in the immediate surrounding area totaled 2,167 observations of soaring birds were made with a total of 49,181 birds belonging to at least 24 species, with an overall migration rate of 61 birds / hour. Of these 29,246 birds were recorded within the study area, while 19,728 birds were recorded in the adjacent zone.

Weather conditions

A total of 884 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 spring 2016.

The Average wind speed 5.9 m/second, with northerly winds dominating (86%) of the time. Visibility was > 5 km 74 % of the time; allowing good detection of birds well within the observation radius around each vantage point. About 25% of the time there was rather poor visibility of less than 5 km. The sky was 100% clear for 64% of the time. Completely over cast skies were noted during 3.6 % of the time. Negligible precipitation was detected.

Volume and diversity of soaring bird migration in the study area

Within the study area 1,996 observations were made of 29,246 soaring birds belonging to 27 species. Soaring bird migration was extremely stochastic, with volume fluctuating greatly from day-to-day. A maximum of 6,130 birds was noted on the 1st May. While there were no birds recorded during 41% of the observation sessions.

The most numerous species was the White Stork (23,714 birds representing 48 % of the total), followed by Steppe Buzzard (11,644 birds representing 23.6 % of the total), and Honey Buzzard (3,072 birds, representing 6% of the total). The remaining species combined made up about 20% of the total. Notably, the same seven species that contributed about 95% of the total recorded in spring 2016, contributed about 93% of the total in spring 2017.

The volume of migration, diversity of species and timing of migration fits closely with the results from spring 2016 and generally with results from previous literature and studies from the region.

Timing of migration

The migration followed a more or less typical pattern of gradual increase and gradual decline in numbers, although there was much fluctuation during the main migration season. There were no migrants during the first week of observations in February or much of the second week of May. The bulk of migration took place within seven weeks between the second week of March and the first week of May.

Flight altitude

Flight altitude is one of the most important factors in estimating collision risk for soaring birds. Average flight altitude of soaring birds within the study area was 187.8 meters above ground level (number of altitude records 8,362, range 0-700 m, Standard Deviation 136 m), which is slightly lower than the average in spring 2016, which was 211.7 m (Standard Deviation 133.8 m).

An estimated 6,164 birds were recorded within the Rotor Swept Height (RSH, representing about 21% of total birds. The vast majority of birds (76%) were recorded above 125 m, of these 6,540 birds flew between 200 – 300 m (representing 22%). While less than 3% of the birds were documented at or below 10 m, including birds that landed on the ground. Only 351 birds were recoded on the ground (1% of total birds). The number of birds flying through the RSH is the main factor in increasing collision risk estimates in the Collision Risk Model (CRM).

International significance

Five globally threatened soaring bird species were documented at the study site: Egyptian Vulture, Greater Spotted Eagle, Steppe Eagle, Imperial Eagle, and Pallid Harrier; all of which have been listed in the IUCN Red List (2017). Only the Steppe Eagle was found in internationally significant numbers, representing about 2.5 % of the species population.

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 about 103 birds, with a casualty rate of 0.8 birds / turbine / season.

Moreover, the CRM results predicts a casualty level for Steppe Eagle of 4 individuals / season. This is a notable figure that would need further assessment and monitoring. In spring 2016 the estimated seasonal casualties for Steppe Eagle was 0.08 individuals / season.

Four casualties belonging to active flying waterbirds and one passerine were documented on one transect within a stretch of less than 250 m under nearby power lines.

Conclusions

The results of the spring season study show that there are some potential risks to migratory soaring, particularly as several globally threatened species are involved. The study also suggests that there is a period of about seven weeks between the first week of March and the first week of May, where risk management and mitigation measures should be introduced.

The notable similarities between the results of springs 2017 and 2016 are very reassuring in terms of the stability and consistency of our methodology, and gives a greater degree of confidence in our results and predictions made in both 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 potential risk.

In conclusion, the outcome of the current study and of the 2016 studies at this site support that wind energy development and operation is possible throughout the greater part of the spring season with modest risks that can be managed or mitigated through a well planned monitoring and risk management effort.

Recommended risk management for the area include:

- Maintaining a pre-construction bird migration monitoring effort at least during the peak migration periods in both spring and autumn.

- Maintain the unattractiveness of the site to migrant birds. This is 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 or near the site.

- Reduction of risks from power lines through installing markers or underground power cables.

- Post-construction monitoring, particularly during the initial stages of operation to verify bird response predictions, and intervene if critical issues arise. 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 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 **must** be combined with a detailed monitoring effort to assess bird responses and document any casualties.

- Year 1 – 4 of operation: Implement a shut down on demand system. Shutdown on demand will require a constant monitoring effort and a clear set of triggers.

- 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

Thanks are due to Dr. Sherif Bahaa El-Din who prepared this report and all the field team members who spent long difficult hours with a high degree of professionalism to acquire the data used in the formulation of this report. Thanks are also due to the NCE staff, particularly Mr. Noor Noor and for the field support staff, particularly for Mr. M. Gad, for facilitating this study on the ground.

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 routes 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 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 spring season;
7. Recommend possible mitigation measures to reduce any risks identified.

The current study comes as a follow up to two earlier studies in the same area (but covering a much smaller sub set of the current study area, about on sixth of it), which took place in the autumn of 2015 and spring 2016. The outcomes of these earlier studies (particularly that of spring 2016) were very informative in evaluating the current study, and many comparative analysis were made throughout the report which help build a more robust picture of bird movements through the area of concern over time.

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 (Baha El Din 2014 and Baha El Din 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. TAs 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 en 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 the its closest neighboring point by between 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 RECREE 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 spring 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 spring 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.

Timing and duration of vantage point monitoring activities

The spring study period extended between 20 February and 15 May 2017 (85 days in order to cover the full extent of both the spring 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.

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 935 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.

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

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 will be documented on both forms and identified as such.

Data will be collected in half-hourly intervals. The following data will be 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 be 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 or Zephyrus wind meter, android application, in smart cell phones)
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.)

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.

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 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: Observers in one of the shelters during dusty conditions.

3.5 Attributes of the planned wind energy development

According to turbine and layout 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.

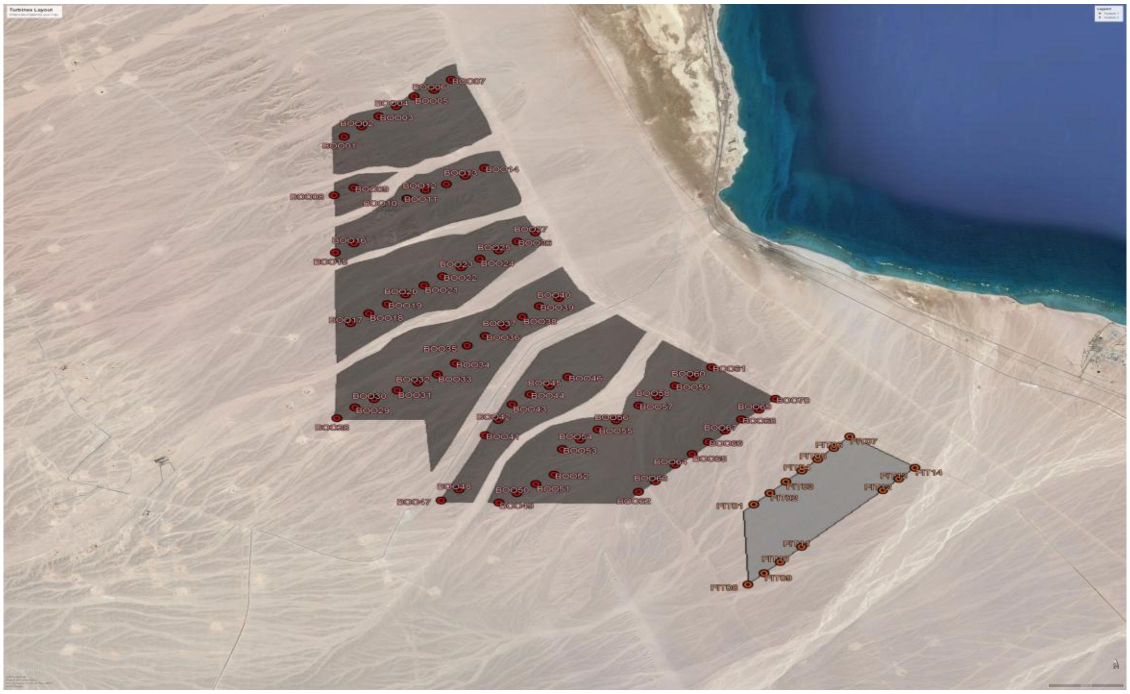

Figure 4: Turbine Layout.

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.

Figure 5: View from point 2 towards north. Note very flat landscape and blowing sand carried with the wind. Some annual grasses *Stipagrostis plumusa* are evident at a distance, an out come of last years rainfall.

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 6: Observer standing at one of the shelters constructed for the purpose of the study.

Figure 7: Wind measuring technique

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.

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).

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

This process seeks to estimate the 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 (e.g. width of blades, average speed of rotation, etc.). 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.

Collision avoidance rates

The CRM calculations assume that a bird flying through a wind farm and through the rotor swept zone behaves in a none 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

Dust storms at times hampered normal observation activities and field staff resorted under these most severe conditions to hide in side parked vehicles to avoid inhalation of suffocating dust.

Manual observation has its inherent limitation in the best of conditions. 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 inherent variability in visual based studies should be taken into account when evaluating results, or comparing between studies.

4. Results

The study was carried out between 20 February and 15 May 2017 for a total period of 85 days. In total 170 observation sessions were carried out, totaling 810 observation hours, out of about 935 potential day light hours, representing a coverage of about 87% 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	29	28	29	28	28	28
Number of observation hours	137	133.4	135.3	136.3	134.5	133.5

No birds were observed during 69 out of a total of 170 sessions, representing about 41% of the observation sessions (almost the same rate observed in spring 2016, which was 40%).

In total 2,868 observations were made (of soaring and non-soaring birds, inside and outside the study sites), resulting in a grand total of 61,179 birds (notably close to the total of 67,358 birds recorded in spring 2016), belonging to 66 species. Of these 12,205 non-soaring birds belonging to 42 species were recorded.

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	1,997	170	701	2,868
Number of birds	29,245	19,728	12,205	61,178
Number of species	24	13	42	66

4.1 Weather conditions

A total of 884 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 spring 2016.

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

Wind speed category	Number of records	% of records
0	7	0.8
0 to 3	121	13.6
3 to 6	364	40.9
6 to 9	281	31.6
9 to 12	77	8.6
12 to 16	39	4.4
Total	**889**	**100**

Wind velocity

Overall, wind speed was high as expected in this region, with an average of 5.95 m/second. For most of the time (72%) there were winds of between 3 and 9 m/second, while 14% of the time the wind speed was between 0 and 3 m/second. About 1% of the time there was no wind at all (0 wind speed was recorded on 6 separate days). Very high wind speeds of between 12 and 16 m/second were only encountered 4.4% of the time. The maximum wind speed recorded was 15.1 m/second (on 25 April 2017).

Wind direction

Northerly winds accounted for 86% of all records. Winds from the northwest were the dominant with about 46% of records; while northern winds accounted for about 29% of records. Southerly winds made up 8% of the records, while straight east and west winds had equal contributions of 2.5% each (see Table 7). As was the case in the spring of 2016, wind direction had a very detectable impact on the number of birds flying over the study area, as will be discussed below.

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

Wind direction	N	NE	E	SE	S	SW	W	NW	0	Total
Number of records	258	95	23	38	12	20	23	408	7	884
% of total	29.1	10.74	2.60	4.29	1.35	2.26	2.60	46.15	0.79	100

Visibility

Visibility can affect both the bird's ability to navigate and to avoid dangers, such as wind turbines and power lines; and also can affect the observer's ability to detect birds, and hence can affect the results of risk evaluation studies, such as this one.

Visibility was reasonably good most of the time (74 % of the time), being greater than 5km; allowing good detection of birds well within the observation radius around each vantage point. About 25% of the time there was rather poor visibility of less than 5 km.

There were 20 days with relatively poor visibility, including dusty, or foggy conditions, or full-scale sand storms: The *khamasine* hot and dusty winds typical of this time of the year. Over all, these conditions occurred during 111 hours of observation, representing 12.5% of the study period. Strong sand storms occurred during 35 hours of observations over a period of five disjunct days, during which visibility of the observers was hampered significantly, and usually no birds were detected during such episodes. There are some indications also that increased mortality from collisions occurs during these adverse conditions (see results of the power line carcass surveys).

Table 8: Frequency distribution of visibility categories during the study period, spring 2017.

Visibility	0-5 km	5-10 km	10-15 km	> 15 km
Number of records	230	320	237	102
% of total	26	36	27	11

Cloud cover

The sky was completely clear for most of the study period (64% of the time), while there was some cloud cover (average 47% cloud cover) during the remainder of the time. Completely over cast skies were noted during 3.6 % of the time. Over cast conditions were sometimes associated with precipitation. Precipitation fell during 10 ten hours of observation on three separate days (22 February, 31 March and 13 April), mostly in the form of light rain, but on 22 February rain was relatively heavy.

Table 9: Frequency distribution of cloud cover during study period.

Cloud cover %	0	1-25	25-50	50-75	75-100
Number of hours	566	104	63	45	106
% of total time	64.03	11.76	7.13	5.09	11.99

4.2 Soaring bird migration in the study region

The study methodology indicated that two sets of data would be 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). 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.

The total volume of soaring birds both inside the study sites and in the immediate surrounding area totaled 2,167 observations of soaring birds were made with a total of 49,181 birds belonging to at least 24 species, with an overall migration rate of 61 birds / hour. Of these 29,246 birds were recorded within the project area, while 19,728 birds were recorded in the adjacent zone.

Only the birds recorded within the 2 km radius were used in CRM analysis.

Species composition

Notably, the same seven species that contributed about 95% of the total soaring birds recorded in spring 2016, contributed about 93% of the total in spring 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 surprisingly consistent, which sheds a good level of confidence in our ability to consistently detect and identify bird migration in the region.

The most numerous species was the White Stork (23,714 birds representing 48 % of the total), followed by Steppe Buzzard (11,644 birds representing 23.6 % of the total), and Honey Buzzard (3,072 birds, representing 6% of the total). The remaining species of soaring birds combined made up about 20% of the total.

Table 10: Number, frequency of the most numerous birds documented inside and outside the study site in spring of 2017 and 2016 (for comparison).

	Spring 2017				Spring 2016			
Species	**Number of birds**	**% of total**	**Number of obs.**	**% of total**	**Number of birds**	**% of total**	**Number of obs.**	**% of total**
White Stork	23,714	48.2	52	2.39	40,510	64.5	71	3.4
Steppe Buzzard	11,644	23.6	645	29.70	11,304	18	676	32.5
Steppe Eagle	2,550	5.1	335	15.42	2,199	3.5	336	16.1
White Pelican	1,165	2.3	6	0.28	1,775	2.8	17	0.8
Honey Buzzard	3,072	6.2	133	6.12	1,532	2.4	81	3.8
Black Kite	2,181	4.4	285	13.12	1,459	2.3	285	13.7
Levant Sparrowhawk	1,326	2.7	37	1.70	1,073	1.7	10	0.48
Total	45,652	92.8	1493	69	59,852	95.3	1476	71

The most frequently observed species was the Steppe Buzzard, with 645 observations, representing 30 % of all observations, with an average flock size of 18 birds. Steppe Eagle and Black Kite (with 335 and 285 observations consecutively) were the second and third most frequently observed species in the region (almost identical to spring 2016). On the other hand the White Stork, which was the most numerous species, represented only 2.4 % of all observations. The species is characterized by heavy passage in large flocks, during relatively short durations, with an average flock size of 456 birds. The overall average flock size was 31 birds.

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	2026	272	7.4	155	13	11.9	2181	285	7.7
Black Stork	50	17	2.9	8	2	4.0	58	19	3.1
Booted Eagle	76	62	1.2	0	0	0.0	76	62	1.2
Crane	811	4	202.8	127	4	31.8	938	8	117.3
Egyptian Vulture	30	23	1.3	0	0	0.0	30	23	1.3
G. Spotted Eagle	4	4	1.0	0	0	0.0	4	4	1.0
Honey Buzzard	1009	111	9.1	2063	22	93.8	3072	133	23.1
Imperial Eagle	10	9	1.1	0	0	0.0	10	9	1.1
Kestrel	112	76	1.5	1	1	1.0	113	77	1.5
Lesser Kestrel	9	6	1.5	0	0	0.0	9	6	1.5
Lesser Spotted Eagle	78	36	2.2	1	1	1.0	79	37	2.1
Levant Sparrowhawk	1277	35	36.5	49	2	24.5	1326	37	35.8
Long-legged Buzzard	38	25	1.5	0	0	0.0	38	25	1.5
Marsh Harrier	35	28	1.3	1	1	1.0	36	29	1.2
Montagu’s Harrier	35	31	1.1	0	0	0.0	35	31	1.1
Osprey	3	3	1.0	0	0	0.0	3	3	1.0
Pallid Harrier	12	12	1.0	0	0	0.0	12	12	1.0
Short-toed Eagle	336	201	1.7	4	3	1.3	340	204	1.7
Sparrowhawk	29	28	1.0	0	0	0.0	29	28	1.0
Spoonbill	32	1	32.0	0	0	0.0	32	1	32.0
Steppe Buzzard	11298	613	18.4	347	32	10.8	11644	645	18.1
Steppe Eagle	2507	319	7.9	43	16	2.7	2550	335	7.6
White Pelican	863	4	215.8	302	2	151.0	1165	6	194.2
White Stork	8029	35	229.4	15685	17	922.6	23714	52	456.0
Buzzard sp.	9	7	1.3	180	23	7.8	189	30	6.3
Eagle sp.	323	14	23.1	147	11	13.4	470	25	18.8
Falcon sp.	3	3	1.0	0	0	0.0	3	3	1.0
Harrier sp.	6	6	1.0	2	2	1.0	8	8	1.0
Raptor sp.	196	11	17.8	613	23	26.7	809	34	23.8
Total	29246	1996	14.7	19728	175	112.7	48973	2171	22.6

As can be noted in Table 11 birds observed outside the study area was composed primarily of large flocks (mostly of large species) that are easily detected and identified from a long distance. This is evidenced by the fact that the great majority of birds recorded outside the study site were composed of White Stork, which constituted 80% of the total. Smaller species that can be detected at closer range, such as Steppe Buzzard and Honey Buzzard, made the majority of birds detected within the study sites.

Flight orientation

The vast majority (93%) of all soaring birds recorded both inside and outside the study area flew in a northerly direction, which is the normal orientation in spring. About 24% headed strait north, 49% headed in a north-westerly direction and 21% headed in a north-easterly direction. Less than 4% of the birds were seen in southerly directions, probably in tactical response to adverse weather conditions.

General observations made during the spring of 2017 are similar to those made in spring 2016 in that they strongly suggest that the main migration flyway of soaring birds in the region is, most of the time or under prevailing weather conditions, located to the west of the study site along the Red Sea hills. Most birds seen at the study site or in its vicinity were seen heading either parallel to the coast or towards the Red Sea Mountains to the west during easterly winds. Much of the time soaring bird migration could be seen a few kilometers to the west of the study area near the foot hills of he Red Sea mountains, well outside the counting radius of our observation points.

Table 12: Distribution of bird numbers by orientation of flight for observations inside and outside the study site, spring 2017.

Flight direction	0	N	NE	E	SE	S	SW	W	NW
Number of birds	266	11,550	10,078	556	544	796	658	472	24,054
% of total	0.5	23.5	20.5	1.1	1.1	1.6	1.3	1.0	48.9
Number of obs.	3	286	202	33	62	17	61	63	1,444
% of total	0.1	13.4	9.4	1.5	2.9	0.8	2.8	2.9	67.4

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 detailed and focused analysis and understanding of the birds patterns of movement and behavior, and help provide an accurate assessment of risk within the target area.

Migration volume and intensity within the study area

During the study period 1,996 observations of soaring birds were made within the study area, totaling 29,246 birds, belonging to 24 species.

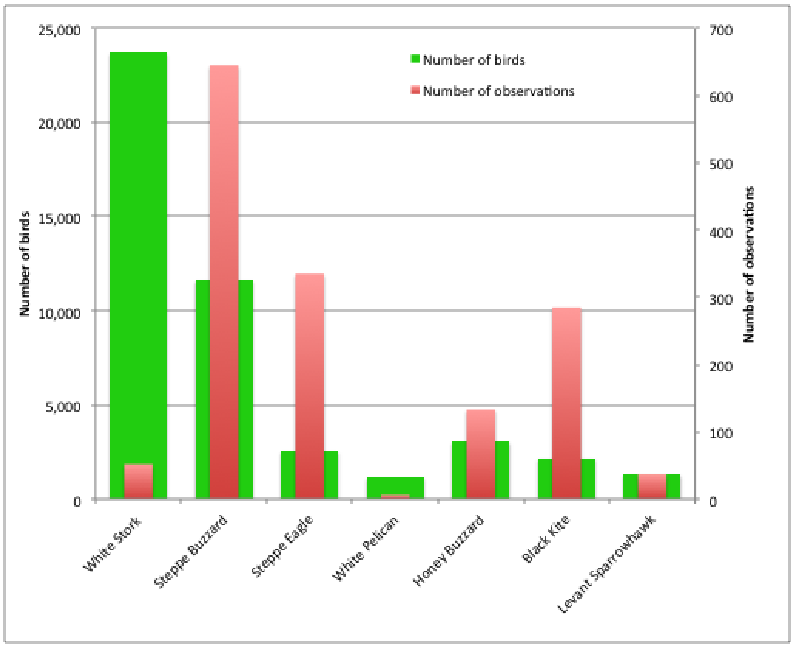

Figure 8: Comparison between number of birds and number of records of the seven most abundant soaring birds inside the study area, spring 2017.

Soaring bird migration was extremely stochastic (more so than in spring 2016), with volume varying greatly from day-to-day, and even from hour-to-hour. A maximum of 6,130 birds was documented on the 1st May. While there were no birds recorded during 69 out of a total of 170 sessions, representing about 41% of the observation sessions. Indeed migration usually occurred in a very focused temporal fashion in the form of bursts of migrants followed by long intervals of no migration. This fits the characterization of the study site as falling on the outskirts of the main migratory soaring birds. Similar characteristics were noted at Ras Zaafarana (Baha El Din & Baha El Din 1996), where migration only occurred very sporadically when weather conditions shifted from the normal patterns. This can be compared with locations along the main flyway, where migration is a daily (if not hourly) occurrence under normal conditions, with some variation in intensity.

Table 13: Migration intensity by week, showing peaks in March, April and May; and great variability from week to week.

Week	Number of birds	Number of observations	% of total	Average flock size
20-26 Feb	0	0	0.0	0
27 Feb- 5 Mar	1605	80	5.5	20.1
6-12 Mar	1389	228	4.7	6.1
13-19 Mar	719	168	2.5	4.3
20-26 Mar	6586	332	22.5	19.8
27 Mar-2Apr	3649	117	12.5	31.2
3-9 Apr	1108	158	3.8	7
10-16 Apr	5872	360	20.1	16.3
17-23 Apr	1482	232	5.1	6.4
24-30 Apr	77	15	0.3	5.1
1-7 May	6205	184	21.2	33.7
8-15 May	554	123	1.9	4.5
	29246	1997	100.0	14.6

Seasonal migration pattern

The 2017 spring season had a typical gradual start, with a very stochastic pattern of bird movement indicated by several high peaks in migration volume intermittent with low dips of no birds over six weeks between late March and early May, with an abrupt decline of migration after the first of May. About 85% of the total birds passed between 20 March and 1 May 2017. The largest daily total of migrants was on 1 May, with 6,130 birds and 146 observations, mostly made up of Steppe Buzzards.

There were no soaring birds recorded inside the study site during the first week of the study, with the first consistent passage recorded on the 28th of February. The number of birds declined sharply towards the end of the study and there were no birds during the last four days of the study period between 12 and 15 May. Indeed only 629 birds were observed during the last two weeks of the study (between 2-15 May), representing 2.2% of the total soaring birds documented inside the study site.

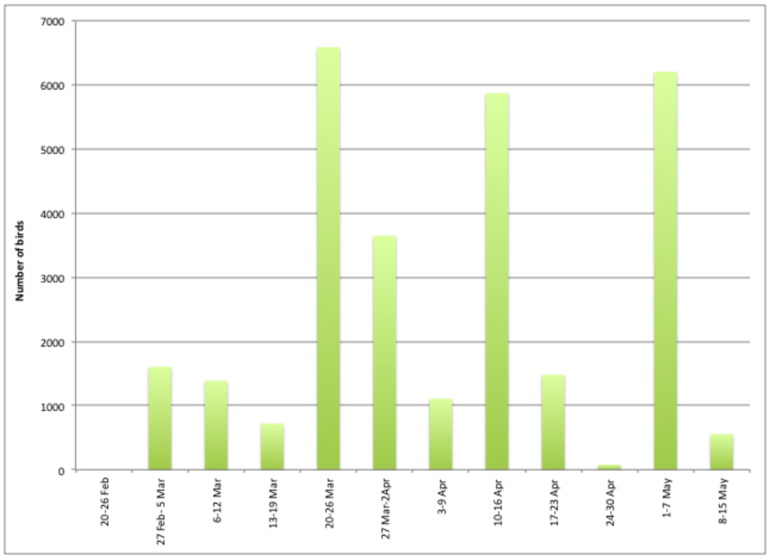

Figure 9: Migration volume per week during spring 2017.

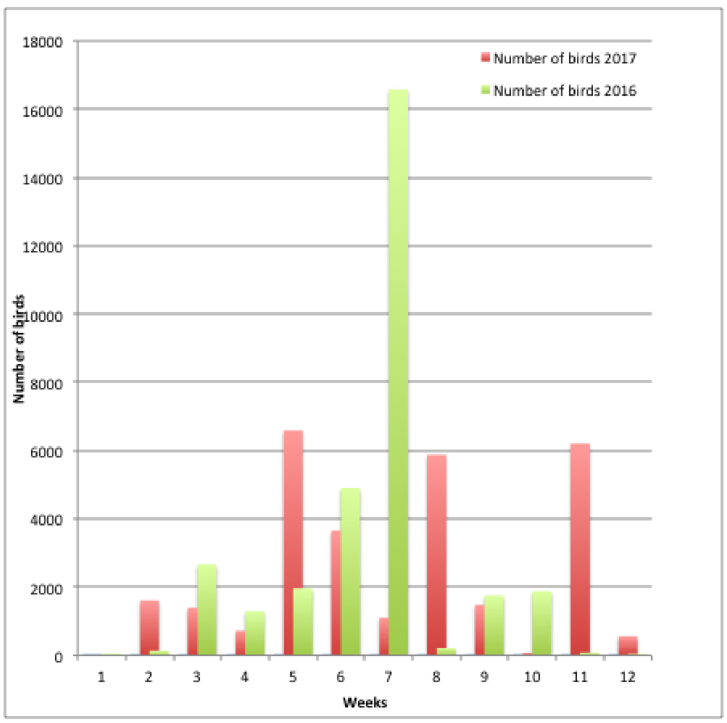

Figure 10: Variation in migration intensity by week, showing low activity early in the season, a peak in numbers in mid April, and great variability from week to week.

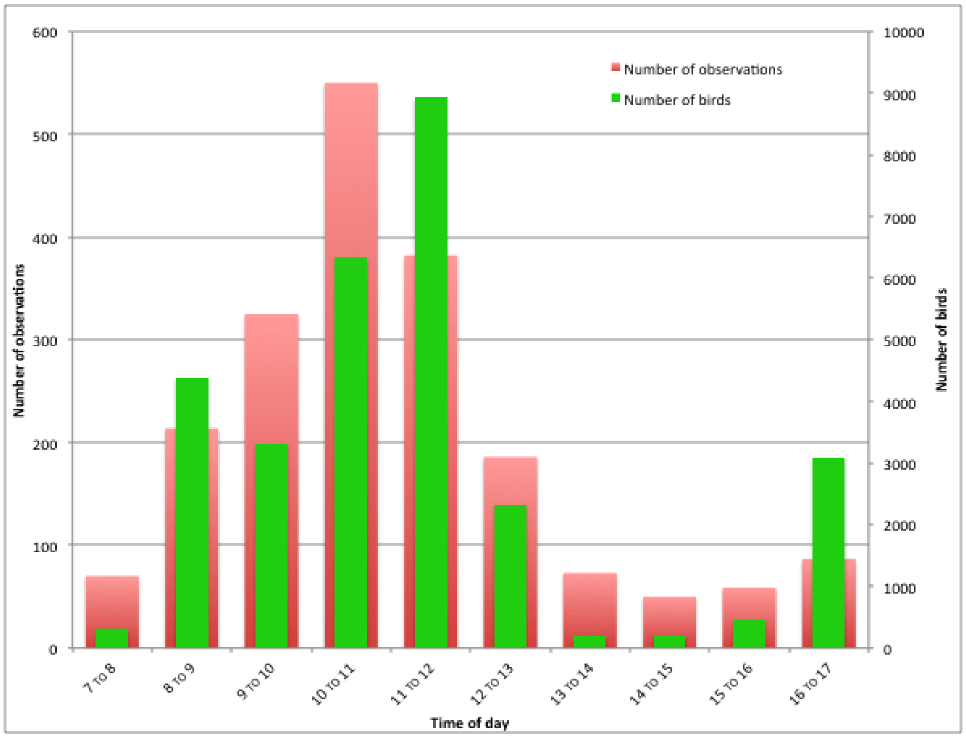

Figure 11: Bird and observation numbers by time of day showing daily migration pattern.

Daily migration pattern

Daily migration showed a pattern largely similar to that observed in spring 2016, with two during the observation day, the main peak in the late morning (between 11 and 12 AM), the other lesser peak was in the late afternoon (between 16 and 17 PM). It is worth noting however that the evening peak (shown in Fig. 11) was mainly (about 90%) composed of large flocks of Steppe Buzzard that passed between 16 and 17 PM on 12 April, and one large White Stork flock that passed on 1 May.

The majority of birds (79%) migrated before noon-time, with more than 30% of the total passing during the hour between 11 and 12 AM. A sharp drop in number of birds and observations is noted after noon-time, almost a fourfold drop; with a further sharp drop between 13 and 14 PM.

There is a general positive correlation between average flock and bird numbers, indicating that the bulk numbers of birds were composed of pulses of large flocks, rather than a constant flow of birds. Much of these large flocks of birds were mainly White Stork.

Bird occupancy at Rotor Swept Height (RSH), or the time spent by birds within the risk zone, had two peaks during the day, coinciding with early and mid morning and late afternoon, when thermals are weakened and bird flight altitude is lower (see Figures 11 and 12). It is interesting to note that occupancy was very low in the late morning when bird passage was the greatest due to the greater flight altitude of birds.

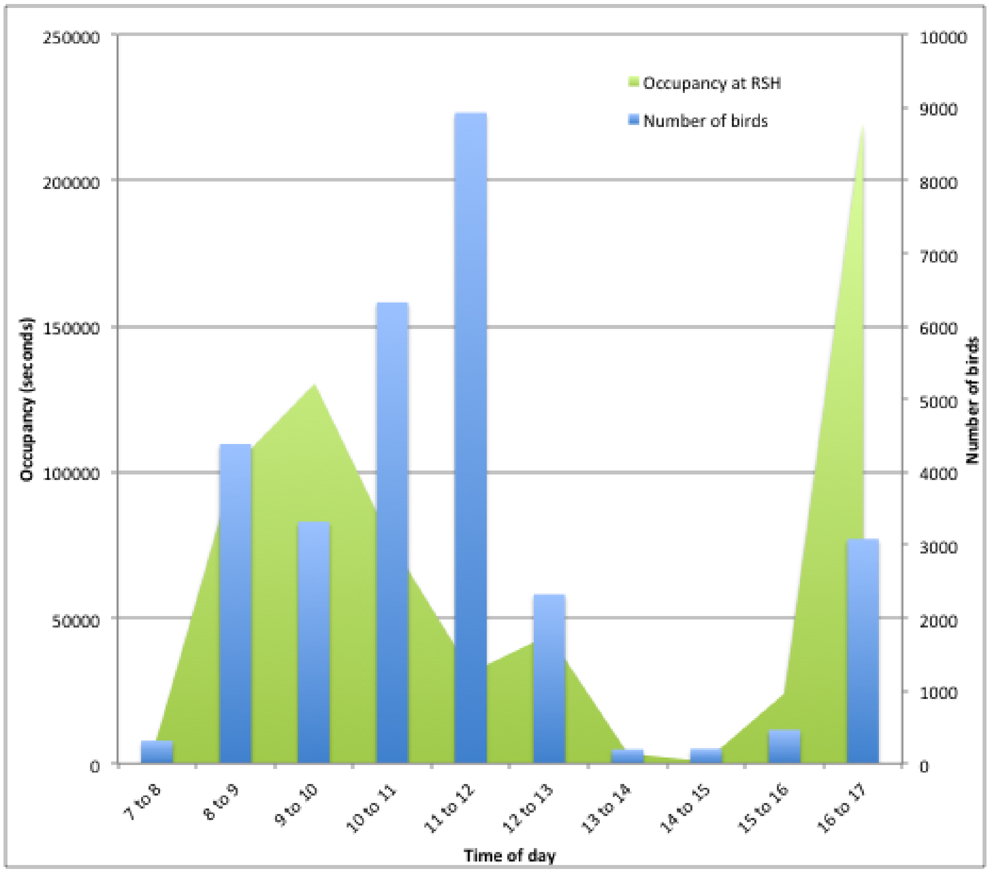

Figure 12: Comparison of bird occupancy at RSH and the total number of birds at different times of the day.

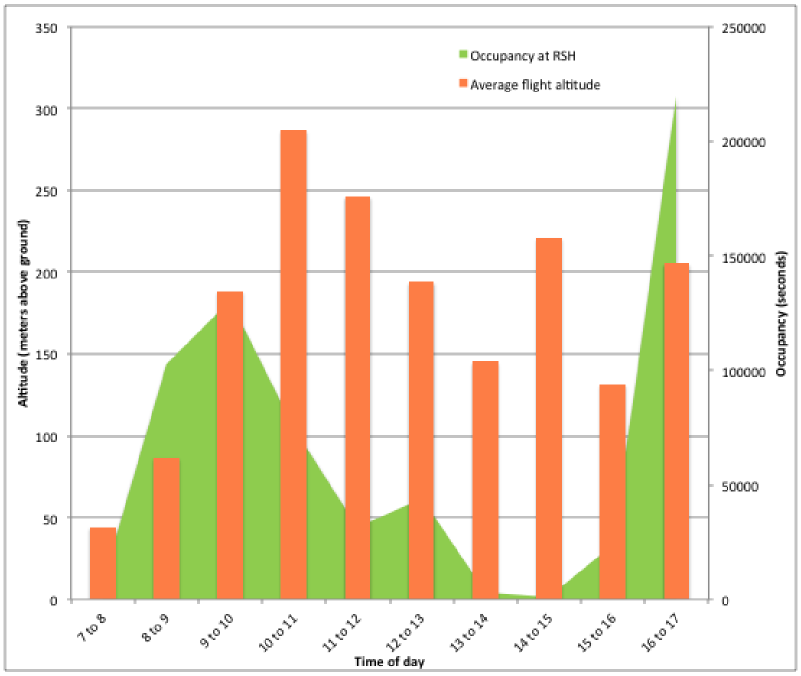

Figure 13: Comparison of bird occupancy at RSH and the average altitude of flight of all birds at different times of the day.

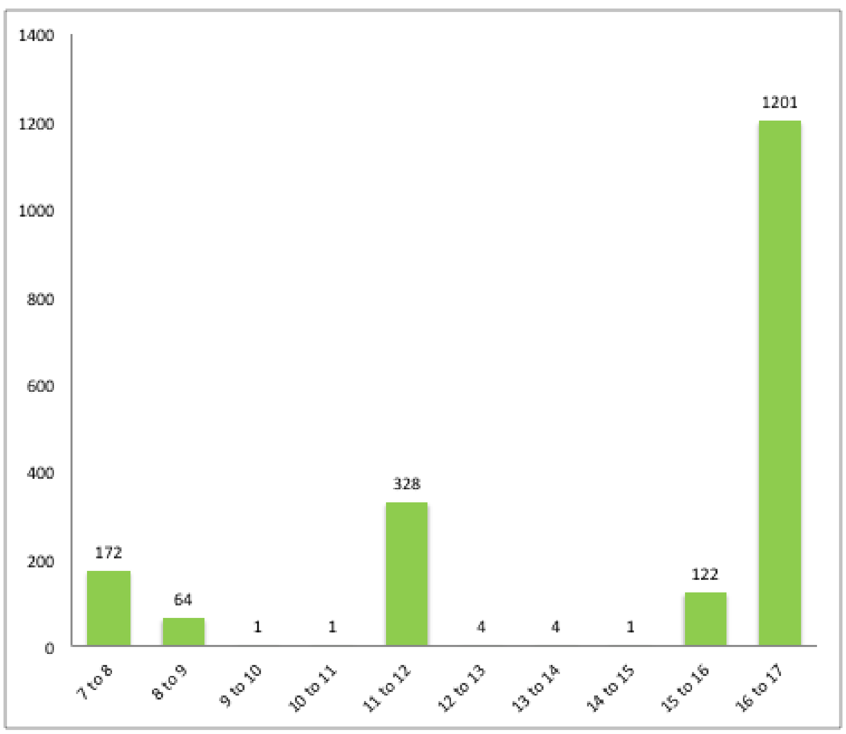

Figure 14: Distribution of resting and roosting birds throughout the day.

Species composition and diversity

There were 24 soaring bird species documented within the study area, slightly lower than spring 0f 2016, when there was 27 species recorded, this including Spoonbill a species not recorded in previous monitoring of the study area. The most abundant species were Steppe Buzzard (contributing 39% of all records), White Stork (27%), Steppe Eagle (9%), Black Kite (7%), Levant Sparrowhawk (4%), Honey Buzzard (3%) and White Pelican (3%). This composition is almost identical to that of spring 2016, with the exception that Steppe Buzzard was more abundant this spring (see Fig. 12).

Steppe Buzzard was the most frequently observed species, with an average flock size of 18 birds. Most species (66%) were observed less than 100 times, while five species were observed more than 100 times, and one species only once. White Stork, White Pelican and Common Crane had the largest average flock size of over 200 birds.

Species richness peaked in April and remained constant in the middle of the season, notably declining towards the end and the start of the study period, corresponding with the overall decline in the volume of migrants.

Migration direction

Bird migration orientation during the spring is normally generally directed towards the north, where summer breeding grounds of most soaring migrants are located. The migration direction over and within our study area is 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.

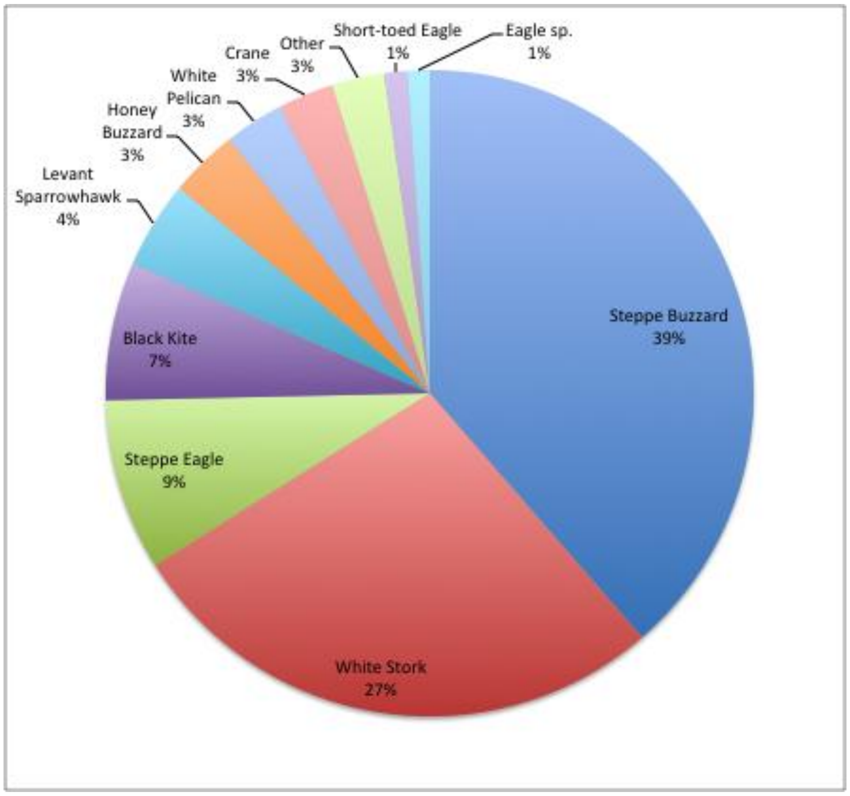

Figure 15: Pie chart of the soaring bird species that make up 1% or more of the total birds recorded within the study site.

The overall migration orientation was very similar to that documented in spring 2016. As was the case in spring 2016, 56% of the birds were documented in a north-westerly flight, with over 92% of all birds taking a northerly orientation (NW, N and NE). Most birds flying in a northerly orientation did so during south-easterly winds, often with low visibility. Only about 3% had a southerly flight orientation. The north-westerly direction of migration of many birds probably reflects birds aiming to return to the Red Sea mountains (where the main soaring bird flyway lies) after reaching the Gulf of Suez coast. Typically, birds flying along the Red Sea hills to the west of the project site, attempting to make the crossing eastwards over the Gulf of Suez multiple times (probably when visibility is good). But many will drift back towards the hills after approaching the Gulf of Suez and assessing the crossing difficulties; these are the most passive fliers that opt to remain on the west side of the gulf, and most will reach Suez and cross into Sinai there.

Table 14: Bird flight orientation inside the study site.

Flight direction	Number of birds	% of total	Number of observations	% of total
N	7569	25.9	270	13.5
NE	2908	9.9	179	9.0
E	398	1.4	21	1.1
SE	527	1.8	58	2.9
S	790	2.7	15	0.8
SW	152	0.5	57	2.9
W	222	0.8	59	3.0
NW	16329	55.8	1333	66.8
0	351	1.2	4	0.2
Total	29246	100	1996	100

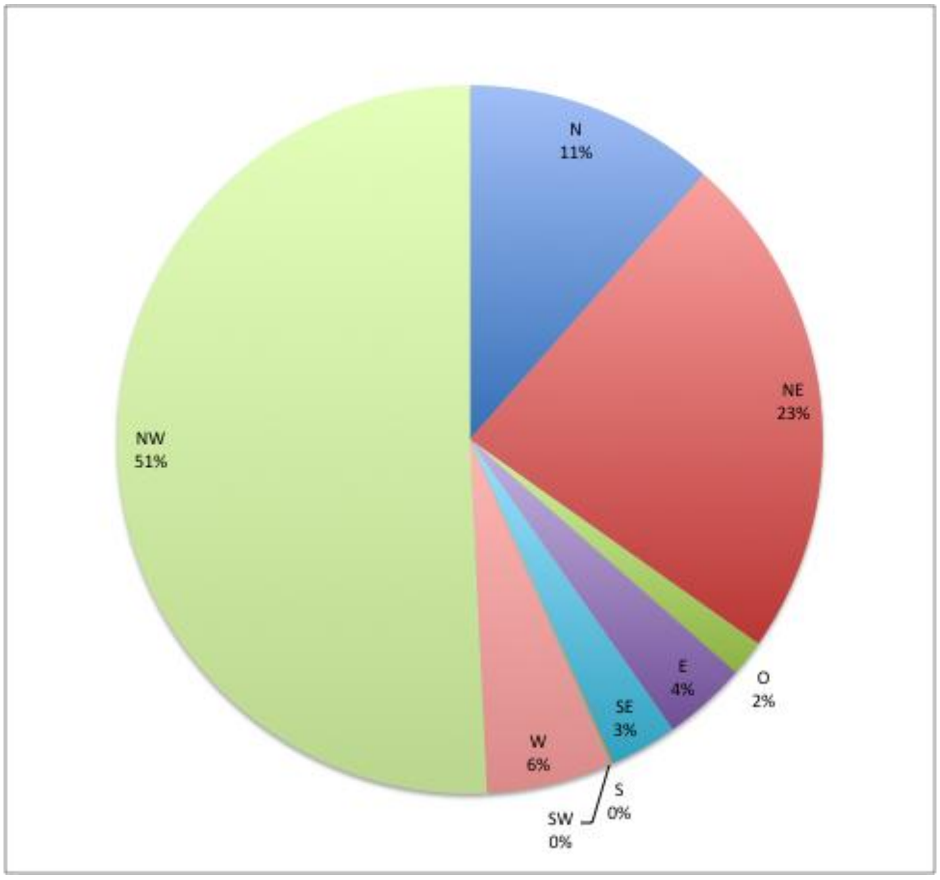

Figure 16: Distribution of birds according to flight direction within the study area.

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 3 minutes) of each bird or flock entering the study area, to provide an accurate assessment of the utilization of vertical space by birds within the study area.

During the current study, average flight through the study site was at a fairly high altitude, with the average altitude of 187.8 meters above ground level (number of altitude records 8362, range 0-700 m, Standard Deviation 136 m), which is slightly lower than the average in spring 2016, which was 211.7 m (Standard Deviation 133.8 m).

An estimated 8130 birds were recorded within the RSH (between 5 – 125 meters above ground), representing about 28% of total birds. The vast majority of birds (76%) were recorded above 125 m, of these 6,540 birds flew between 200 – 300 m (representing 22%). While less than 3% of the birds were documented at or below 10 m, including birds that landed on the ground. Only 351 birds were recoded on the ground (1% of total birds). The number of birds flying through the RSH is the main factor in affecting collision risk estimates in the CRM.

There is a strong negative relationship between altitude and occupancy within the study area (r=-0.9), which is to be expected as birds at lower altitudes usually spend considerable 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 were more often observed gliding rapidly across the study area. Birds at lower altitude might also be engaged in searching for resting sites or for food and water. This tendency for lower birds to have higher occupancy was also noted in the spring 2016 study. 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 and spent less than 75 seconds inside the study area (over 75% of total birds).

Table 15: 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	60	0.2	24	1.2	240
30	2712	9.3	298	14.9	260
45	12680	43.4	683	34.2	235
60	4330	14.8	510	25.6	195
75	2262	7.7	139	7.0	172
90	644	2.2	106	5.3	202
105	316	1.1	41	2.1	118
120	1857	6.3	59	3.0	165
135	131	0.4	11	0.6	120
150	81	0.3	17	0.9	61
165	14	0.0	2	0.1	97
180+	4159	14.2	106	5.3	115
	29246	100.0	1996	100.0	

Flight altitude is influenced by species-specific behavior to some extent. Harrier species are known as typically low flying species. As was the case in both autumn 2015 and spring 2016, Harriers had the lowest average flight altitude of 62 m. Falcons also had an average flight altitude that is below 100 meters. Eagles were the highest, with an altitude average above 180 m, while the most numerous species that made up the bulk of bird volume, such as White Stork, and Steppe Buzzard had a flight altitude average that ranged between 150 m for and 200 m.

Table 16: 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 observatio ns	% of total number of observations
0	351	1.20	218	2.61	4	0.20
0-10	459	1.57	496	5.93	80	4.01
10-125	6164	21.08	2761	33.02	589	29.51
125-200	4236	14.48	1724	20.62	247	12.37
200-300	6540	22.36	1539	18.40	417	20.89
300-400	6015	20.57	1341	16.04	392	19.64
400-500	4891	16.72	220	2.63	217	10.87
>500	590	2.02	63	0.75	50	2.51
Totals	29246	100	8362	100	1996	100

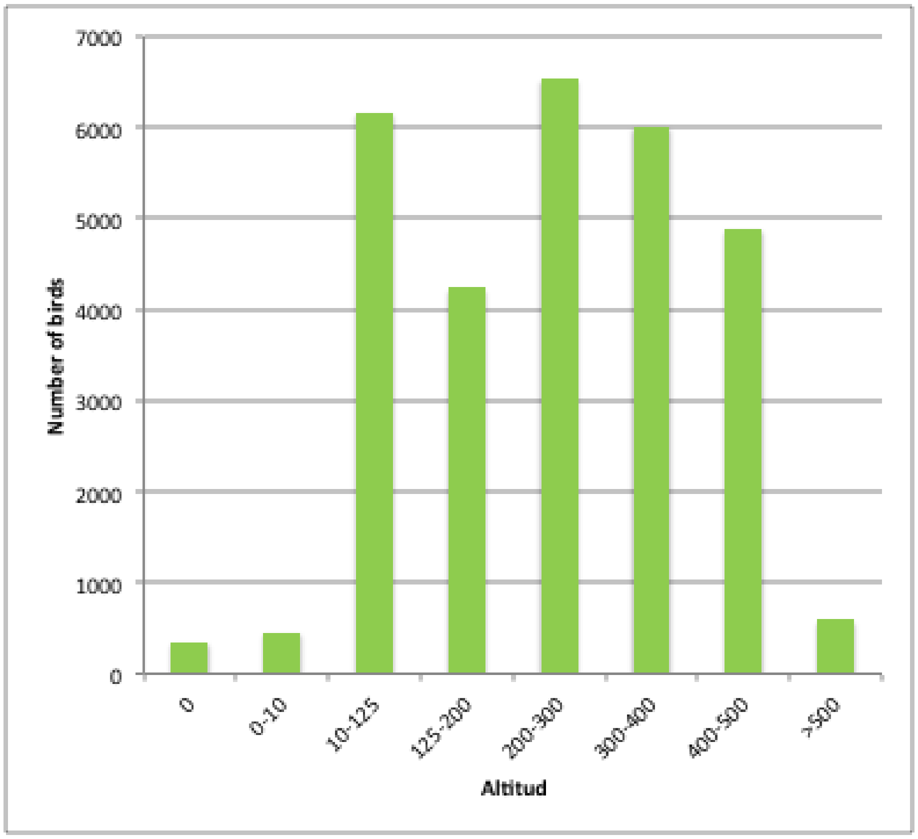

Figure 17: Frequency distribution of all birds documented in the study site according to altitude.

Table 17: Flight altitude by species inside the study site.

Species	Average altitude	Number of readings	Min. altitude	Max. altitude
Black Kite	179.6	1224	0	600
Black Stork	237.4	62	50	500
Booted Eagle	207.3	264	15	500
Common Crane	212.8	40	20	350
Egyptian Vulture	230.4	95	5	540
Greater Spotted Eagle	181.8	11	100	400
Honey Buzzard	213.9	521	20	600
Imperial Eagle	180	25	80	400
Kestrel	95.5	338	0	500
Lesser Kestrel	66.7	17	5	150
Lesser Spotted Eagle	255	163	40	500
Levant Sparrowhawk	159.4	137	0	350

Species	Average altitude	Number of readings	Min. altitude	Max. altitude
Long-legged Buzzard	283	136	20	500
Marsh Harrier	88.5	129	0	400
Montagu's Harrier	50	176	0	350
Osprey	205.5	9	100	400
Pallid Harrier	46.2	64	1	300
Short-toed Eagle	193.5	903	0	600
Sparrowhawk	112	112	1	400
Spoonbill	200	5	200	200
Steppe Buzzard	183.3	2381	0	600
Steppe Eagle	260	1128	0	700
White Pelican	99.5	23	0	350
White Stork	140.4	227	0	500

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

The length of time birds spend within the study area and particularly within the RSH can potentially increase risks from wind energy installations. Typically the movement of migratory birds across the Sahara, including the Egyptian desert is rapid due to the need to cross over these inhospitable habitats in as short a time as possible, combined (in spring) with the urgency of reaching breeding habitats as early as possible to have he best options in selecting the most optimal breeding grounds. Thus, under normal circumstances birds pass through at the maximum speed and the shortest route possible. 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.

The speed of movement of birds through the study area was similar to that in spring 2016, with an average occupancy time of 1.5 minutes (range 0.25 – 17 minutes), with about 68% of all birds spending a minute or less, and 95% of all birds spending three minutes or less within the study area. About 5% spent more than five minutes in the study site.

In general this 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.

Table 18: 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	15452	52.8	1005	50.4
1-3 min	9635	32.9	885	44.3
3-5 min	2860	9.8	77	3.9
5-15 min	1292	4.4	26	1.3
15 min - 1h	7	0.0	3	0.2
Total	**29246**	100	**1996**	100.0

Roosting, resting and feeding behavior within the wind farm

There were some indications of roosting and resting of soaring bird species within the study area during the study period. In total there were 57 observations involving either landing for short periods or roosting within the study area, totaling 1,898 birds representing 2.9% of the total birds recorded. The average time on the ground was 3.8 minutes. This is somewhat higher than the total of 571 birds recorded in spring 2016. The greater majority of these birds were White Storks (76% of resting / roosting birds), mostly contributed by two large flocks of the species which landed on April 12th and May 1st totaling 1,300 birds. As can be seen in Figure 13, the majority of the roosting / resting birds were documented either in the early morning or in the late afternoon (indication of potential roosting in the study area), with the exception of a single flock of 300 White Storks that was observed landing for a short while 11 AM on12 April.

The significance of any landing behavior including roosting, resting behavior or feeding (and drinking) is that birds could potentially get into close contact with wind energy installations. It is unlikely in the current state of environmental conditions at the study area that feeding and drinking would be a significant factor that tempts birds to land. From the current set of observations (and those from spring 2016), it is also the impression that the study area is not an important roosting or resting site for soaring birds, at least during the spring season.

Effects of weather conditions on bird migration

Soaring birds are highly dependent on weather conditions for their regular flight and movement. Wind direction, speed, and visibility, and to some extent temperature are all factors that affect the way soaring birds move, the altitude they assume, and direction they take. The typical migration pattern 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, the response of soaring birds could be unpredictable.

Wind direction

Studies of soaring bird migration throughout the world have shown a direct link between wind direction and the migration of soaring birds, and thus on the volume of birds at any specific point along their migratory routs. At the study site wind direction was probably the weather component that had the greatest effect on the migration patterns of soaring birds in the region.

As was the case in spring 2016, the correlation between the prevalence of different wind direction regimes (the number of hours) and the number of passing birds was relatively weak (r= 0.3), which suggests a strong influence of wind direction on the volume of birds independent of duration. This is also further confirmed by the greater abundance of birds at specific wind regimes, which are often uncommon or rare, as discussed below.

The greatest number of birds (10,482 birds, representing 35.8% of the total birds) passed during relatively short periods of north-easterly winds, which made up 11% of wind direction records. Winds with easterly elements contributed over 50% of the total birds, although they made up only 18% of wind records. In contrast with the spring of 2016, south-easterly winds contributed only 10% of birds (over 60% in 2016), showing that there are some variation in the response of birds to wind direction from year to year, but providing more evidence that easterly winds have the greatest potential to bring soaring birds through the study area.

When the bird numbers were normalized by division over the number of records, winds from the south had the greatest influence on the number of birds per unit of time, contributing 25% of the normalized number of birds , while making up only 1.25% of wind records.

North and north-westerly winds were the dominant wind regime making up about 75% of all wind records, however only 30% of birds passed under this wind regime; representing only 5% of the adjusted number of birds, which is reflected in the low density of birds during the prevailing north-westerly wind regime in the study area.

There is a notable and consistent association between winds from the east and large influx of birds through the study site, and it is important to note the timing and duration of this wind regime. Easterly winds occurred between February and May and lasting for a total 156 hours. These winds were often associated with hot temperatures, dusty conditions, and low visibility (particularly in April and May). This combination of conditions and high intensity of migration are likely to significantly increase risks to migratory soaring birds, indicating that special attention should be paid to easterly, and southerly winds (as also suggested in spring 2016).

Observations from this season and from spring 2016 indicate that wind direction is likely to be the single most important factor influencing the occurrence and intensity of migration of birds at the study site. However, there seems to be inter-seasonal variability in both the wind regimes (at least at the local level), and the response of birds to these variable conditions. Moreover, the spring season is characterized by sudden and frequent shifts in wind direction, which can reach almost 180 degrees within the hour, which explains the unpredictability of the migration. This suggests that it is important to maintain a monitoring effort to better understand the phenology of migration at the local level and hence enhance risk predictions and management.

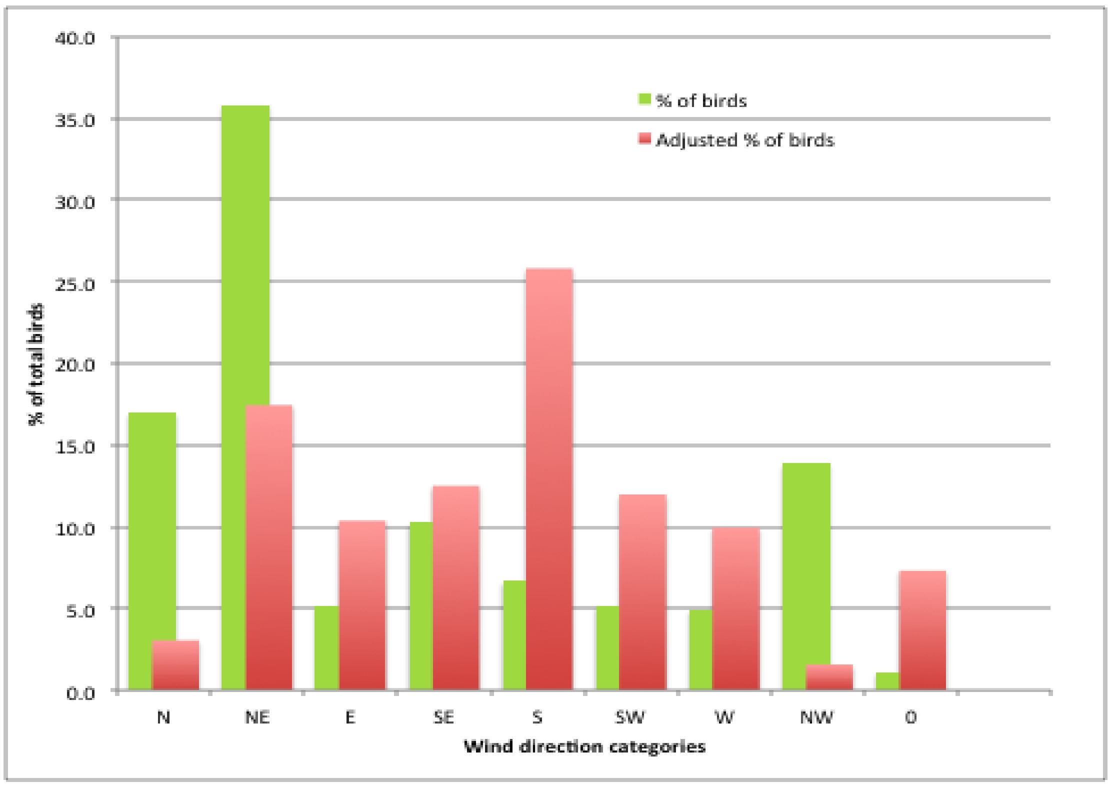

Figure 18: Relationship between wind direction and the number of birds entering the study site. The green columns show the actual percentage of birds for each wind direction, while the red columns shows percentages adjusted according to availability of each wind direction.

Table 19: Bird numbers according to wind direction.

Wind direction	Number of records	% of total	Number of birds	% of total	Adjusted number of birds / record	% of total
N	258	29.1	4960	17.0	19	3.0
NE	95	10.74	10482	35.8	110	17.4
E	23	2.6	1510	5.2	66	10.4
SE	38	4.29	3000	10.3	79	12.5
S	12	1.35	1949	6.7	162	25.8
SW	20	2.26	1515	5.2	76	12.0
W	23	2.6	1445	4.9	63	9.9
NW	408	46.15	4060	13.9	10	1.6
0	7	0.79	324	1.1	46	7.3
Total	884	100	29245	100.0	631	100.0

Table 20: Bird numbers according to wind speed category.

Wind speed category	Number of records	Number of birds	Adjusted number of birds
0	7	2506	358
0 to 3	121	12567	104
3 to 6	364	11906	33
6 to 9	281	2202	8
9 to 12	77	58	1
12 to 16	39	6	0
Total	**889**	**29245**	**504**

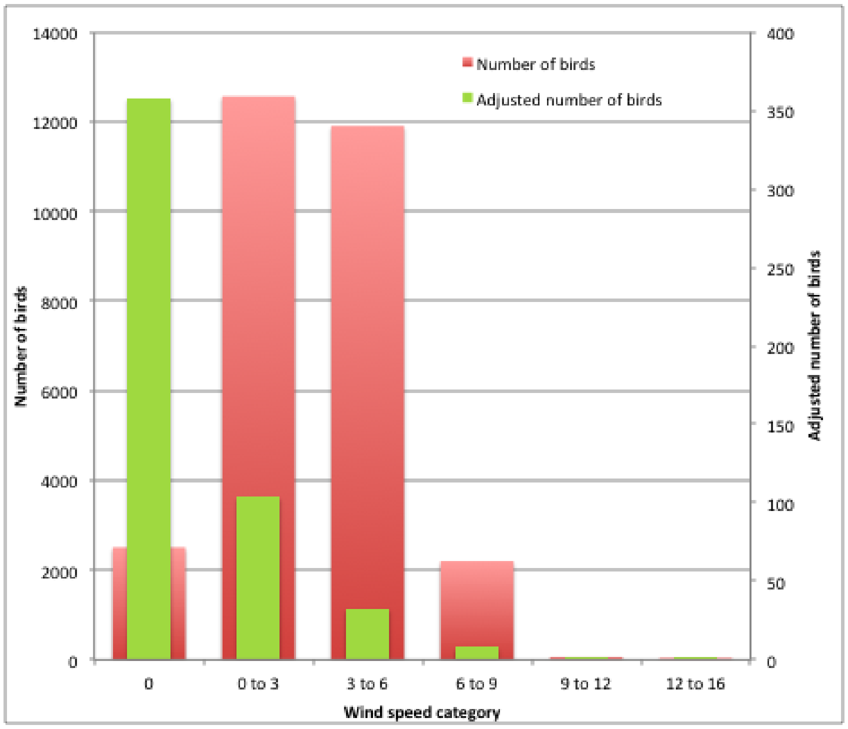

Figure 19: Relationship between wind velocity and bird migration volume. Number of birds was normalized by division over the number of records of each wind speed category, to provide a better representation of the relationship between wind velocity and bird volume not influenced by the frequency of each wind speed category.

Wind velocity

The average wind velocity during the study period was 5.9 m/second (range 0-15.1 m/second). There was a general trend for more birds to pass through during periods of lower wind velocity, with about 42% of the total birds passing through when wind speeds ranged between 3 – 6 m/second, which was the second most dominant wind speed representing 25% of all wind speed records (see Table 20). There was a modest negative correlation between the number of birds and wind speed (r= - 0.6), but when the number of birds was normalized by division over the number of records at each wind speed category, the negative correlation was more significant (r= - 0.8); suggesting fairly strong influence of wind velocity on bird movement in the area. Thus, it would be anticipated that larger numbers of birds would pass through the study area at lower wind velocity, and lower number of birds at greater wind velocity.

Visibility

The frequency of visibility categories in both spring 2017 and spring 2016 were very similar, with moderate visibility (5-10 km) being the most prevailing, occurring about 36% of the time (in 2017) and 43% of the time in spring 2016. Indeed the greatest proportion of birds (61%) passed through during the poorest visibility.

The correlation between the number of birds and visibility cannot be interpreted in isolation from other weather factors. While it is most likely that birds would prefer to fly during clear conditions (which is probably the case along the main fly way along the Red Sea Mountains), birds are driven to fly through the study area during atypical easterly winds and often during adverse conditions. This would mean that large numbers of birds would pass through the study area, despite poor visibility conditions, increasing risk of collision with wind energy infrastructure.

This apparent association between spring time easterly sand storm (known as *khamasine*) and large influx of soaring birds was noted in the spring of 2016 also, and should be noted with concern; as such low visibility events combined with strong winds and hot temperature could raise the risk of bird collisions with wind energy infrastructure.

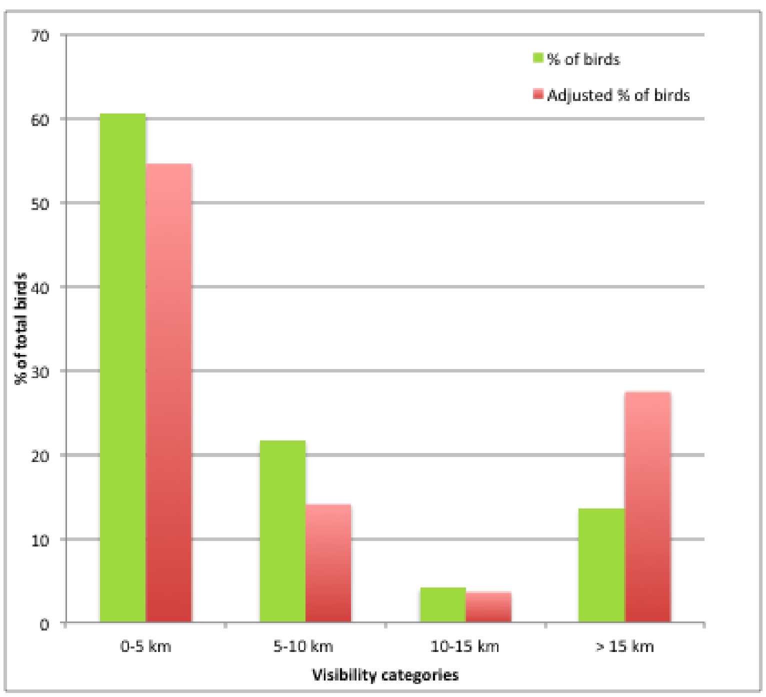

Figure 20: Relationship of visibility and number of birds.

Table 21: Number of birds according to visibility category.

Visibility	Number of birds	% of total	Frequency of visibility records	% of total
0-5 km	17719	61	230	26
5-10 km	6355	22	320	36
10-15 km	1219	4	237	27
> 15 km	3952	14	102	11
	29245	100	889	100

Spatial aspects of migration within the study area

The six observation points utilized in assessing the study area (each representing a project site) are stacked 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 in a 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.

Spatial differentiation between the six observation points was not very clear and did not appear to follow a clearly discernible pattern (at least with the limited data we have), with one exception. The earlier more intensive study of site 1 during autumn 2015 and spring 2016 suggested 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 the current study the two points at the western extremity of the study area (observation points 4 & 5) held the largest numbers of birds. Over 56% of all birds were documented at points 4 & 5, which also had the largest average flock size. The increased intensity of migration of soaring birds inland or westwards towards the Red Sea Mountains in this region, was also indicated by previous studies (c.f. Ecoda 2013).

On the other hand the third largest record of birds was at the eastern most point (point 1), with about 16% of all birds. Points 2, 3 and 6, located more or less in the center of the study area had the lowest numbers of birds (see Table 22).

Table 22: Distribution of bird volume and altitude records between the six observation points. For comparison, the last column represents the results from spring 2016 (i.e. roughly the same location as observation point 1) after being equalized for observation effort.

Observation point	1	2	3	4	5	6	Totals	Spring 2016
Number of birds	4600	2539	2964	11044	5400	2699	29246	5267
% of total	15.7	8.7	10.1	37.8	18.5	9.2	100	
Number of observations	439	246	245	454	386	226	1996	300
Average flock size	10.5	10.3	12.1	24.3	14.0	11.9	14.7	17
Average altitude	169.7	158.3	166.6	154.1	252.3	240		211
Range	0-550	0-500	0-700	0-600	0-540	0-700		0-700
Number of altitude records	1698	1208	1100	1799	1612	941	8358	1047
Number of birds at RSH	1877	426	2139	1433	1812	443	8130	1391
CRM Predicted casualties at 95% avoidance rate	26	6	29	20	26	7	114	22

Although the greatest average altitudes were at points 5 & 6, the number of birds at RSH (and hence collision risk) were at points 3 & 1. Generally, there did not appear to be a meaningful pattern in the distribution of flight altitudes between observation points or sites.

Birds flying at points 1,2,3 & 4 (all coastal sites located along the Gulf coast) predominantly had a north-western orientation (> 66%); while at points 5 & 6 (whish are further inland from the coast) north and north-easterly flight orientation made up some 75% of the total birds. Point 6 had the greatest number of east flying birds (14%) out of all points. The easterly orientation of flight at points 5 & 6 seems to coincide with strong easterly winds, once birds reach the coast (at points 1,2,3 & 4) they tend to take a more northerly and north westerly orientation in parallel with the coastline.

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

Flight direction	N		NE		E		SE		S		SW		W		NW		0		Total
Obs. site	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%	
1	186	2	89	3	0	0	329	62	760	96	3	2	25	11	3208	20	0	0	4600
2	661	9	50	2	6	2	96	18	26	3	21	14	6	3	1674	10	0	0	2540
3	275	4	6	0	2	1	11	2	3	0	9	6	57	26	2400	15	200	57	2963
4	3459	46	20	1	0	0	32	6	0	0	73	48	43	20	7291	45	126	36	11044
5	1496	20	2327	80	4	1	6	1	0	0	40	26	86	39	1441	9	0	0	5400
6	1492	20	416	14	386	97	53	10	1	0	6	4	1	0	319	2	25	7	2699
Total	7569	100	2908	100	398	100	527	100	790	100	152	100	218	100	16333	100	351	100	29246

4.4 Non-soaring bird species

The non-soaring birds recorded within the study area during the study period included a grand total of 12,185 birds belonging to 41 non soaring bird species. This represents a little over double the number documented in the spring of 2016. Such fluctuations in migrant numbers on an annual basis is common, and could be exacerbated by local weather conditions and observer bias.

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.

Migrant species

Almost 78% of the non-soaring bird species that have been recorded at the study area were spring migrants that pass rapidly through the region and normally do not stop or alight for short periods to rest (if at all). This spring the European Bee-eater made up just over 50% of all the migrant non-soaring birds documented. Barn Swallow made up about 20%, Short-toed Lark made up 15% and the Great Cormorant made up 10%. A similar composition of spring migrants was noted in the spring of 2016 (with some differences in proportion of migration) mostly composed of Great Cormorants, Barn Swallows, martins and Bee-eaters.

Table 24: Migrant bird species recorded at the study area. Spring 2017.

Species	Number of birds	Number of observations	Average flock size
Barn Swallow	1988	189	11
Blue-cheeked Bee-eater	25	3	8
Collared Pratincole	5	2	3
Common Quail	2	2	1
Common Swift	41	5	8
Common Wheatear	2	2	1
Common Whitethroat	1	1	1
Crag Martin	7	2	4
Cream-colored Courser	1	1	1
Dove sp.	1	1	1
Eurasian Hoopoe	3	1	3
European Bee-eater	5432	70	78
Great Cormorant	1105	11	100
House Martin	41	16	3
Lark sp.	16	2	8
Lesser White-throat	7	7	1
Meadow Pipit	7	2	4
Olivacious Warbler	7	2	4
Pallid Swift	2	1	2
Passarine sp.	26	4	7
Red-rumped Swallow	111	11	10
Rock Thrush	1	1	1
Rufous Bush Robin	1	1	1
Ruppell's Warbeler	1	1	1
Sand Martin	41	7	6
Short-toed Lark	1583	86	18
Spotted Flycatcher	1	1	1
Turtle dove	4	4	1
Whinchat	2	2	1
Whiskered Tern	22	2	11
Willow Warbler	1	1	1
Yellow Wagtail	18	9	2
	10505	450	301

Winter visitors

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 five species that might winter in the general vicinity of the study area were noted, totaling 11 individuals. The small volume and diversity of wintering birds is not surprising given the limited suitable habitat within the study site.

Table 25: Winter bird species recorded at the study area. Spring 2017.

Species	Number of birds	Number of observations	Average flock size
Desert Wheatear	3	3	1
Great Grey Shrike	1	1	1
Isabelline Wheatear	2	2	1
Tawny Pipit	1	2	1
White Wagtail	4	3	1
	11	11	5

Resident avifauna

Seven potentially resident and locally breeding bird species were encountered during the study period. Four of these: Brown-necked Raven, Rock Dove, Crowned Sandgrouse and Spotted Sandgrouse were recorded in spring of 2016 within Site 1. Some species that were not recorded previously (though anticipated in 2016) were documented in this season (namely the Bar-tailed Desert Lark). The expansion in potential resident bird diversity can be partly attributed to the larger study area in 2017, but also could be due to improved habitat conditions due to the good rains that were enjoyed in the region during the autumn of 2016. These rains must have improved local ephemeral vegetation and seed banks throughout the region and thus attracted nomadic birds that respond rapidly to such rain episodes. This is also evident in the beefed up numbers of sandgrouse and larks as compared with the previous spring.

Table 26: Resident bird species recorded at the study area. Spring 2017.

Species	Number of birds	Number of observations	Average flock size
Bar-tailed Lark	16	4	4
Brown-necked Raven	15	10	2
Collared Dove	2	1	2
Crowned Sandgrouse	264	35	8
Desert Lark	16	10	2
Rock Dove	14	8	2
Sandgrouse sp.	675	89	8
Spotted Sandgrouse	667	84	8
	1669	241	34

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 at the proposed wind energy facilities is that to soaring birds is that of collision with the moving rotors of wind turbines that are to be established at the study site. The impact from collision with power lines is also taken into consideration.

The impact on birds due to habitat loss is seen as minimal due to sparse 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 and disturbance are of the project (in isolation from other adjoining projects) will be very minimal due to the limited scale of the project area, the lack of local vital habitats for feeding or resting of soaring birds and to some extent the distance of the study site from critical bottle necks and the main migration flyway for soaring birds. But it is important to keep in mind that developing adjacent plots could create serious barrier and other landscape impacts, which can only be assessed in a strategic scale taking into account all other developments in the region. 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 seasonal 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 spring 2016 study of the Lekela project (Site 1).

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).

In the current study, 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 (20 February – 15 May 2017), would be about between 114 and 46 birds (at the avoidance rates of 95% and 98%, see Table 27 below), with a casualty rate of 1.4 – 0.5 birds / turbine / season (according to turbine specs and number provided by developer).

The predicted casualty levels for spring 2017 (at the 95% avoidance rate) are somewhat higher than that predicted for spring 2016 (1.4 birds / turbine / season). In fact the predicted casualty levels for site 1 (same study site as in spring 2016) are remarkably similar though slightly higher than in 2016 (24 birds / season in 2017, as compared with 22 birds / season in spring 2016).

Similar to the results of the 2016 spring study, three species are predicted to make up 96% of the total estimated casualties: White Stork (57 birds, representing more than 50% of the total estimated casualties); Steppe Buzzard (37 birds, representing about 29% of total); Black Kite (7 birds, representing 6% of total); and Steppe Eagle (about 4 birds, representing some 4% of total). White Pelican did not appear this year as a significant risk due to low numbers at RSH. 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 27: Summary of the outputs of the CRM model including collision estimates at 95% and 98% avoidance rates for the duration of the study period.

Site	P collision	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6			Totasl for all sites			Adjusted	
		Birds at RSH	Casualties at avoidance rate		Birds at RSH	Casualties at avoidance rate		Birds at RSH	Casualties at avoidance rate		Birds at RSH	Casualties at avoidance rate		Birds at RSH	Casualties at avoidance rate		Birds at RSH	Casualties at avoidance rate		Total birds at RSH	Casualties at avoidance rate		Casualties at avoidance rate	
Species			95%	98%		95%	98%		95%	98%		95%	98%		95%	98%		95%	98%		95%	98%	95%	98%
Black Kite	0.2	200	0.45	0.18	110	0.25	0.10	44	0.10	0.04	95	0.22	0.09	9	0.02	0.01	33	0.07	0.03	491	1.11	0.45	6.57	2.63
Black stork	0.22	11	0.03	0.01							9	0.02	0.01							20	0.05	0.02	0.29	0.12
Booted Eagle	0.19	10	0.02	0.01							7	0.02	0.01	3	0.01	0.00	3	0.01	0.00	23	0.05	0.02	0.30	0.12
Buzzard sp.	0.2				1	0.00	0.00													1	0.00	0.00	0.01	0.01
Common Crane	0.24										1	0.00	0.00				60	0.16	0.07	61	0.17	0.07	0.98	0.39
Eagle sp.	0.19	1	0.00	0.00				4	0.01	0.00	1	0.00	0.00	1	0.00	0.00				7	0.02	0.01	0.09	0.04
Egyptian Vulture	0.19	3	0.01	0.00				2	0.00	0.00				2	0.00	0.00				7	0.02	0.01	0.09	0.04
Falcon sp.	0.18							3	0.01	0.00										3	0.01	0.00	0.04	0.01
G. Spotted Eagle	0.19							1	0.00	0.00										1	0.00	0.00	0.01	0.01
Harrier sp.	0.2	1	0.00	0.00	1	0.00	0.00										1	0.00	0.00	3	0.01	0.00	0.04	0.02
Honey Buzzard	0.2							13	0.03	0.01	115	0.26	0.10	49	0.11	0.04				177	0.40	0.16	2.37	0.95
Imperial Eagle	0.19	2	0.00	0.00							1	0.00	0.00							3	0.01	0.00	0.04	0.02
Kestrel	0.18	21	0.04	0.02	3	0.01	0.00	9	0.02	0.01	17	0.03	0.01	10	0.02	0.01	25	0.05	0.02	85	0.17	0.07	1.02	0.41
Lesser Kestrel	0.18	3	0.01	0.00										1	0.00	0.00	1	0.00	0.00	5	0.01	0.00	0.06	0.02
Lesser Spotted Eagle	0.19	8	0.02	0.01				8	0.02	0.01	8	0.02	0.01	2	0.00	0.00				26	0.06	0.02	0.33	0.13
Levant Sparrowhawk	0.21							14	0.03	0.01	6	0.01	0.01	1	0.00	0.00				21	0.05	0.02	0.29	0.11
Long-legged Buzzard	0.18							2	0.00	0.00	1	0.00	0.00	2	0.00	0.00	1	0.00	0.00	6	0.01	0.00	0.07	0.03
Marsh Harrier	0.22				2	0.00	0.00	18	0.04	0.02	4	0.01	0.00	2	0.00	0.00	1	0.00	0.00	27	0.07	0.03	0.40	0.16
Montagu's Harrier	0.2	4	0.01	0.00	6	0.01	0.01	7	0.02	0.01	9	0.02	0.01	2	0.00	0.00				28	0.06	0.03	0.37	0.15
Osprey	0.19													1	0.00	0.00				1	0.00	0.00	0.01	0.01
Pallid Harrier	0.2	2	0.00	0.00	2	0.00	0.00	1	0.00	0.00	3	0.01	0.00				2	0.00	0.00	10	0.02	0.01	0.13	0.05
Short-toed Eagle	0.19	34	0.07	0.03	24	0.05	0.02	9	0.02	0.01	8	0.02	0.01	9	0.02	0.01	14	0.03	0.01	98	0.21	0.09	1.26	0.50
Sparrowhawk	0.21	8	0.02	0.01				1	0.00	0.00	5	0.01	0.00	1	0.00	0.00	2	0.00	0.00	17	0.04	0.02	0.24	0.10
Steppe Buzzard	0.2	434	0.98	0.39	160	0.36	0.15	1659	3.76	1.51	504	1.14	0.46	12	0.03	0.01	14	0.03	0.01	2783	6.31	2.52	37.24	14.90
Steppe Eagle	0.19	109	0.23	0.09	99	0.21	0.09	4	0.01	0.00	53	0.11	0.05	77	0.17	0.07	4	0.01	0.00	346	0.75	0.30	4.40	1.76
White Pelican	0.3													5	0.02	0.01	0	0.00	0.00	5	0.02	0.01	0.10	0.04
White Stork	0.22	1026	2.56	1.02	18	0.05	0.02	340	0.85	0.34	586	1.46	0.58	1623	4.05	1.62	282	0.70	0.28	3875	9.67	3.87	57.07	22.83
Totals		**1877**	**4.47**	**1.79**	**426**	**0.96**	**0.38**	**2139**	**4.93**	**1.97**	**1433**	**3.38**	**1.35**	**1812**	**4.47**	**1.79**	**443**	**1.09**	**0.44**	**8130**	**19.29**	**7.72**	**113.83**	**45.53**

Comparison with results from spring 2016

There is an overall pronounced similarity between the results of this study and those of the spring of 2016, which took place at one of the current study's sites; site 1 (covered by observation point 1). There is a strong correlation between the totals observed of each species in both seasons (r=0.8). Table 28 summarizes the results from the same site from both years, but results for 2017 were not adjusted for observation effort. In 2016 the observation effort was all focused at site 1, so coverage was more or less 100% of the site. In 2017 the observation effort at that site represents only about one sixth of the effort in 2016.

When adjusted the total number of birds at site 1 in 2017 would have been 28,273 birds (compared with an actual total of 31,607 birds in 2016). 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 (these similarities are highlighted discussed throughout the previous discussions of migration phenology above). The level of predicted casualties is also very close in both years with a total of 22 casualties in 2016 and 24 casualties in 2017 (at the 95% avoidance rate).

These notable similarities between the results of springs 2017 and 2016 are very reassuring in terms of the stability and consistency of our methodology, and gives a greater degree of confidence in our results and predictions made in both 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.

There is a broad consensus, when comparing the casualty levels predicted by the current study and in spring 2016 with those in adjoining at Gebel El Zeit ENBICON (2014) for spring 2013 at the ItalGen site at Gebel El Zeit, and by Baha El Din (2015) for spring 2015 at the nearby KFW funded 200 kw wind farm area at Ras Shukheir, as can be seen in Table 29. There is overall agreement in the distribution of predicted casualty levels amongst species; with a broad agreement between all three studies on the higher risk levels for White Stork, White Pelican, Honey Buzzard and Steppe Buzzard. There is also a great similarity amongst the studies with regards to the overall level of casualties and the seasonal rate of casualties per turbine / season, roughly estimated around one bird/season/turbine.

Table 28: Comparison of results for Site 1 from spring 2016 and spring 2017. Note that results from 2017 are not adjusted for observation effort (roughly one sixth of observation effort). Both results presented for avoidance rate of 95%.

	2016				2017			
Species	**Total birds**	**Birds at RSH**	**% at RSH**	**Est. casualties**	**Total birds**	**Birds at RSH**	**% at RSH**	**Est. casualties**
Black Kite	1400	247	17.64	0.62	563	200	35.52	0.45
Black stork	286	26	9.09	0.07	20	11	55.00	0.03
Booted Eagle	418	8	1.91	0.02	30	10	33.33	0.02
Buzzard Sp.	73	4	5.48	0.01	0	0	0	0
Crane	26	26	100	0.07	0	0	0	0
Eagle sp.	22	19	86.36	0.04	10	1	10	0
Egyptian Vulture	25	1	4	0	4	3	75	0.01
Eleonora's Falcon	1	1	100	0	0	0	0	0
Falcon sp.	11	5	45.45	0.01	0	0	0	0
G. Spotted Eagle	14	1	7.14	0	1	0	0	0
Harrier sp.	11	4	32	0.01	1	1	100	0
Honey Buzzard	1391	338	24.3	0.77	62	0	0	0
Imperial Eagle	11	3	27.27	0.01	3	2	66.67	0
Kestrel	88	46	52.27	0.09	31	21	67.74	0.04
Lanner Falcon	1	0	0	0	0	0	0	0
Lesser Kestrel	1	0	0	0	7	3	42.86	0.01
L. Spotted Eagle	107	14	13.08	0.03	21	8	38.10	0.02
L. Sparrowhawk	73	0	0	0	3	0	0	0
L. l. Buzzard	26	5	19.23	0.01	2	0	0	0
Marsh Harrier	46	35	76.09	0.08	3	0	0	0
Mon. Harrier	38	12	31.58	0.03	5	4	80	0.01
Osprey	5	1	20	0	0	0	0	0
Pallid Harrier	26	11	42.31	0.03	2	2	100	0
Peregrine	1	0	0	0	0	0	0	0
Raptor sp.	5	2	40	0	59	0	0	0
Short-toed Eagle	307	40	13.03	0.09	114	34	29.82	0.07
Sooty Falcon	1	0	0	0	0	0	0	0
Sparrowhawk	21	11	52.38	0.02	9	8	88.89	0.02
Steppe Buzzard	10004	1704	17.03	3.66	2556	434	16.98	0.98
Steppe Eagle	1706	55	3.22	0.12	206	109	52.91	0.23
White Pelican	1078	886	82.19	2.64	0	0	0	0
White Stork	14384	4705	32.71	13.48	1080	1026	95.00	2.56
Total	**31607**	**8210**	**25.98**	**21.91**	**4792**	**1877**	**39.17**	**4.47**

Table 29: Comparison of different collision risk predictions made for the spring season from the Gulf Suez.

Study	This study 95% avoidance	This study 98% avoidance	Lekela***	KFW 200 MW site**	ItalGen* site
Location	R. Gharib	R. Gharib	R. Gharib	G. Zeit	G. Zeit
Date	2017	2017	2016	2015	2013
Total casualties	114	46	22	122	104
Number of turbines	84	84	17	100	100
Casualties / turbine	1.4	0.5	1.2	1.2	1

Sources: *ENBICON Public presentation Hurghada, January 2014, ** Baha El Din (2015), *** Environics (2016).

5.2 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 11 March and 14 May, with a total combined length of 91 km and about seven hours of observations.

In total four birds carcasses were found all on the morning of 21 March, following a day of sand storms. Three of these of these birds belonged to three different species from the Family Rallidae (Moorhen, Little Crake, and Spotted Crake); a group of wading waterbirds with long legs and usually cryptic and reclusive habits, which typically migrate at night at low altitudes. In addition to one Short-toed Lark. No species of rails or moorhens have been recorded at the study site during normal monitoring hours probably due to the nocturnal habits of the concerned species.

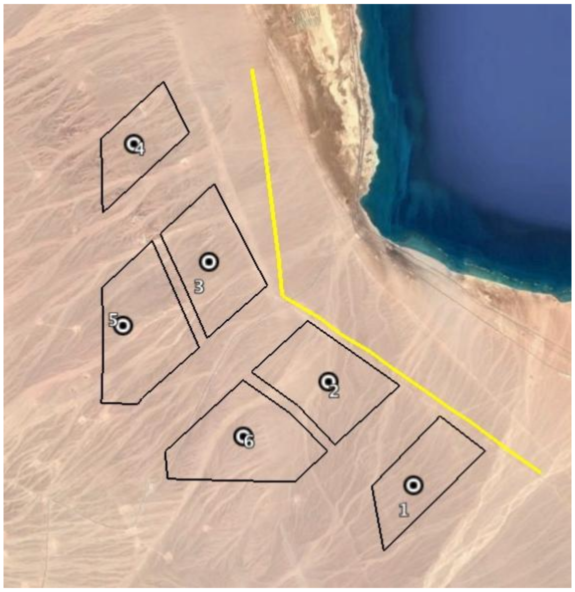

Figure 21: Carcass survey route (yellow line).

Figure 22: Old White Stork remains found near observation point 2. Photo Tamer Attala

Moorhen

Little crake

Spotted Crake

Short-toed Lark

Figure 23: Casualties found on 21 March 2017 under the 220 kv power line. Photos Bassim Rabea.

All the birds found were partly desiccated indicating that they are not very fresh and about 2-3 days old. They were all found within a stretch of 250 m right under the power lines between 7 and 8 am. All evidence suggest that these birds were impacted by the power line during the night of the 18th of March, when there was very sandy conditions, strong winds and low visibility.

The finding of these birds clearly confirms that there certainly another dimension of bird migration that is not covered by diurnal visual observations, and that can only be documented by radar. However, these migrants occur in low densities and fly on a broad front, where by its unlikely that wind energy infrastructure would have significant impact on their global populations.

No evidence of bird mortality under the power lines was evident during all other six surveys conducted. Skeletal remains of one adult White Stork, which are probably at least two or more years old, were found 400 m east of observation point 2, and could have potentially been a casualty of collision with the 220 kv power line; the locality being only 700 m west of the power line down wind from the prevailing wind direction.

Table 30: Summary of carcass surveys made during spring 2017 under the existing 220 kv power line.

Date	Time start	Species	Number of individuals	Condition
3/11/17	12:42	No bird	0	
3/21/17	7:10	Little Crake	1	2-3 days old
3/21/17	7:10	Moorhen	1	2-3 days old
3/21/17	7:10	Spotted Crake	1	2-3 days old
3/21/17	7:10	Short-toed Lark	1	2-3 days old
4/2/17	7:20	No bird	0	
4/13/17	7:15	No Birds	0	
4/24/17	6:55	No Birds	0	
5/4/17	7:20	No Birds	0	
5/14/17	7:00	No Birds	0	

5.3 Conservation Significance of predicted risk

Five globally threatened soaring bird species were documented at the study site (see Table 31): Egyptian Vulture, Greater Spotted Eagle, Steppe Eagle, Imperial Eagle, and Pallid Harrier; all of which have been listed in the IUCN Red List (2017). In addition, one non-soaring species, Meadow Pipit (considered Near Threatened) was observed inside the study site.

Only the Steppe Eagle was documented in internationally significant numbers (i.e. > 1% of the estimated population of the species, see Table 32). The 2,507 Steppe Eagles recorded at the study area represent about 2.5 of the species population. Moreover the CRM results predicts a casualty level for Steppe Eagle of 4 individuals / season. This is a notable figure that would need further assessment and monitoring, particularly given the Endangered status of the species and its current decline in global populations. In spring 2016 the estimated seasonal casualties for Steppe Eagle was 0.08 individuals / season.

The higher predicted casualty level this season was due to a larger number of Steppe Eagles flying lower during adverse weather conditions (sand storms). These conditions are of particular concern, as the combination of low flight, strong winds and low visibility could lead to high casualties amongst all species. Steppe Eagle should be highlighted as a species of special concern at the study site, and a precautionary approach in risk evaluation and management should be applied, with a target of zero casualties.

Table 31: Threatened migratory soaring birds found at the Lekela study site and its immediate vicinity during spring 2017, and their conservation status (IUCN 2017).

Species	Total birds	Flyway population estimate*	% of Global population	Predicted collisions	Red List classification
Egyptian Vulture	30	30000	0.1	0.08	Endangered
Greater Spotted Eagle	4	13200	0.0	0.01	Vulnerable
Imperial Eagle	10	15000	0.1	0.03	Vulnerable
Steppe Eagle	2507	100000	2.5	3.96	Endangered
Pallid Harrier	12	15000	0.1	0.11	Near Threatened

Besides the globally threatened species, seven species occurred in internationally significant numbers within the wind farm area (exceeding 1% of the flyway population of a species). These are: White Stork, White Pelican, Steppe Buzzard, Short-toed Eagle, Steppe Eagle, Levant Sparrowhawk and Booted Eagle. As would be expected the most abundant species at the study site contributed about 95% of all casualties predicted by the CRM, with White Stork contributing 55% alone.

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 (Ameaster 2016). The differences however between empirical observations and predicted estimates were not huge, and to a large extent show the value of the CRM in predicting casualties and in in providing a sense of scale and nature of the risks to be expected; which is an excellent outcome despite the great uncertainty that risk assessment of this type of natural resources can face

The CRM also does not take into account the cumulative impacts of such a loss on populations. 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 32: International significance of the most numerous species, occurring in significant numbers, i.e. representing >1% of its flyway population documented during spring 2017.

Species	Total number of birds	Flyway population estimate*	% of flyway population	Predicted casualties
Black Kite	2026	200000	1.0	6.21
Levant Sparrowhawk	1277	20000	6.4	0.17
Short-toed Eagle	336	35000	1.0	1.06
Steppe Buzzard	11298	380000	3.0	29.96
Steppe Eagle	2507	100000	2.5	3.96
White Pelican	863	40000	2.2	0.08
White Stork	8029	450000	1.8	55.75

* 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).

6. Conclusions and recommendations

Several factors indicate that the study area clearly does not fall along the main Red Sea / Rift Valley Migratory Soaring Birds Flyway during spring, but rather is situated along its fringe.

One of these factors is the very intermittent nature of migration in the area, and the long periods devoid of birds (more than 50% of the time). This was the case in both the spring of 2017, as well as in spring of 2016. Bird migration is normally evident on a daily basis (or even on an hourly basis) along the main trunk of the flyway or at bottlenecks, with some variations in intensity according to weather conditions. Another factor is the relatively low total number of birds observed during spring (29,246 birds in 2017 and 31,607 birds in 2017), which is much smaller than totals observed during spring in locations further south in the Gebel El Zeit (Ecoda 2013, Baha El Din 2014, ENBICON 2014), or further north at Suez and Ain Sukhna (e.g. Baha El Din 1999, Wheimpfheimer et al 1983, Brunn 1985, Goodman and Meininger 1989).

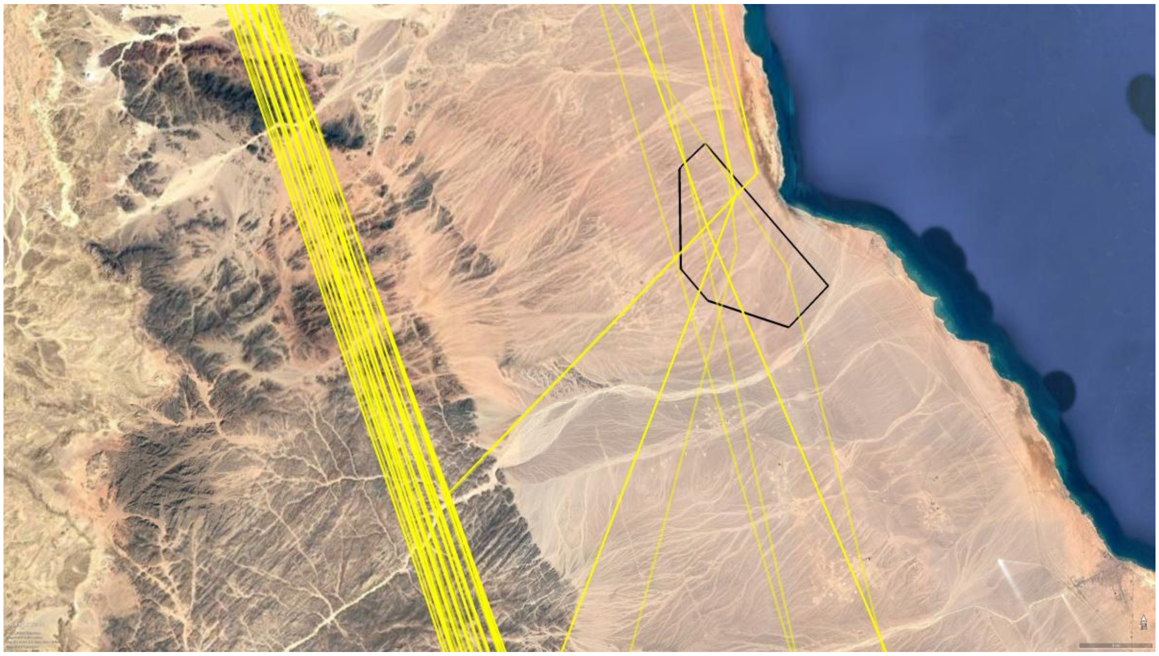

Figure 24: Schematic map of the project area (polygon with black outline) showing relative intensity of migration during spring season. Yellow lines represent general simplified migration passage of migratory soaring birds in the region surrounding the project area. This graphic presentation shows the main migration route over the Red Sea mountains to the west of the project site.

Ecoda (2013) indicated spatial differences in migration intensity amongst eight observation points utilized by that study, where there was a general tendency for the number of birds to decline towards the east. This was also confirmed by observations of the field team, who noted that most of the migration was taking place to the west of the Lekela site towards the Red Sea hills. Thus, it appears that there is a spatial differentiation in migration intensity in an east to west trend, between the Gulf of Suez coast towards the Red Sea hills, with the greatest intensity occurring along the foot hills of the mountains, where the strongest up draughts would occur.

A similar pattern was noted at the Zaafarana wind farm area (Baha El Din and Baha El Din 1996), where the main migration route was located some 15 km inland along the Red Sea mountain peaks, while the coastal plain was almost devoid of any soaring migrants. In the Ras Gharib case however the coastal plain is much narrower, and the Gulf of Suez is at its narrowest, allowing for frequent good visibility of the Sinai mountains. This attracts some birds to attempt the crossing of the gulf during advantageous weather conditions. This is also supported by the observation of soaring migrants arriving at Al Tor on the Sinai side at sea level after crossing the gulf waters in spring 2016 (Ahmed Waheed, pers. com.).

As was the case in spring 2016, the international importance of the area was confirmed. Seven species occurred in internationally significant numbers within the study area: White Stork, White Pelican, Steppe Buzzard, Steppe Eagle, Short-toed Eagle, Levant Sparrowhawk and Black Kite. In addition five globally threatened soaring bird species have been documented: Egyptian Vulture, Greater Spotted Eagle, Steppe Eagle, Imperial Eagle, and Pallid Harrier. Most of these species are the same as those noted in 2016.

Unlike the autumn season, when soaring bird migration through the southern section of the Gulf of Suez region tends to have a very clear peak in late August and early September (because of the massive pulse of White Storks that comes through at that time), then tends to steadily and rapidly decline into October. In spring the migration volume is scattered over a longer period of time. About 85% of the total birds passed through between 20 March and 1 May 2017, with three peaks noted between mid March and early May. The highly stochastic nature of migration in this season was reflected by the complete lack of birds during 40% of the observation sessions, or about 50% of the time.

As indicated in the 2016 study the spring window of risk can be more confidently narrowed down to the period between the first week of March and the first week of May. And as indicated previously this window will slip a few days in either directions in different years. More monitoring at the location will improve predictability of bird movements in the region.

Perhaps one of the most important outcomes of the current study is the consistency of its results with those from the spring of 2016. 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.

Amongst the important similarities between 2017 and 2016 (which are also highlighted within the results above) is the notable and consistent influence of wind direction on the volume of birds passing through the study area. The greatest number of birds in both seasons came with uncommon easterly winds, while northerly winds, which dominated most of the time, had only a small fraction of the migration volume. In fact, the greatest concentrations of birds were noted during or just after *Khamasine* storms, with strong hot south-easterly winds and low visibility. These results confirm that this weather pattern should be one of the main triggers for potential shutdown, and other risk reduction measures.

An estimated 6164 birds were recorded within the RSH, representing about 21% of total birds, which is slightly higher than the 13% recorded in 2016. This excludes about 80% of the birds from collision risk, but probably explains the slightly higher prediction of casualties by the CRM. The CRM predicts a level of casualties of about 103 birds in total amongst the six sites, ranging between 5 to 26 casualties per site, or about 0.8 casualties per turbine. Site 5 had the highest casualty level, while site 2 had the lowest. There are no indications that would suggest specific features of any of the sites that might lead to such differentiation in casualty rates. In most likelihood, these differences are a result of the natural variability in migration at the local level. Only long term monitoring would be able to discern predictable patterns that lead to increased casualties.

The casualties predicted by the CRM are mostly of non-threatened species, mostly White Stork and Steppe Buzzard (both classified as Least Concern by IUCN 2017); however a predicted casualty level of 4 Steppe Eagles is noteworthy as the species is classified as Endangered (IUCN 2017). Although the CRM predictions should be considered as indicative only, the passage of substantial and internationally significant numbers (> 1% of population) of Steppe Eagles and other species like White Stork through the study area does justify a precautionary approach to wind energy development in the area, and calls for a careful, systematic and sustained monitoring effort both pre and post construction of any wind energy facilities.

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.

The limited level of casualties found under the existing power lines indicate that mortality due to collision with power lines is likely to be low during the spring season under normal weather conditions.

In conclusion, the results from the current study and the 2016 studies at this site support that wind energy development is possible throughout the greater part of the spring season with modest risks that can be managed or mitigated through a well planned monitoring and risk management effort.

Recommendations

Wind energy development at the study area should be paired with a bird monitoring plan that enhances understanding of migration at the site, which would guide the infrastructure planning and help develop effective mitigation measures. This will improve risk management and narrow down interventions and potential loss of energy generation potential at the site. The assurance made by the results of two consecutive studies at roughly the same site, makes the case in this respect.

Potential risk management measures that can be adopted and modified gradually according to improved understanding of risks at the site. Initially they can be more precautionary possibly involving fixed shutdown periods, combined with monitoring, then ultimately devolving to a shutdown on demand system that responds to specific triggers that are agreed upon between the developer, the EEAA and NREA. In all cases this should be combined with monitoring to assess effectiveness of 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.

Recommended risk management measures include:

Pre-construction

Maintain a pre construction bird migration monitoring effort at least during the peak migration periods in both spring and autumn. A modified monitoring approach with a reduced effort can be applied.

Establish a database to maintain monitoring results and continually analyze the cumulative data to produce more refined management recommendations.

Design and construction

Maintain monitoring effort.

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 or near the site (even inorganic); strictly preventing any water or other liquids (including oils) from reaching the surface.

The management of risks from power lines will be different from wind turbines, as shutdown options will not be applicable, but rather a combination of visual and design interventions (including the option of installing underground power cables) can be considered during the design and construction phase.

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 the 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 (e.g. during the last two weeks of August (during the peak stork migration in Autumn), combined with shutdown on demand (e.g. 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 (some have been already defined by the EEAA, to which we can add local weather triggers such as *khamaseen* dust storms in spring). The details of a shutdown system needs 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. (2014). Final report on the autumn 2014 post construction ornithological monitoring at the 200 MW KFW funded wind farm at Gebel El Zeit. Report presented to NREA.

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.

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.

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.

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 I: List of all birds observed during spring 2017 at the study site and its vicinity

English name	Scientific name
Barn Swallow	*Hirundo rustica*
Black Kite	*Milvus migrans*
Black Stork	*Ciconia nigra*
Blue-cheeked Bee-eater	*Merops superciliosus*
Brown-necked Raven	*Corvus ruficollis*
Collared Pratincole	*Glareola pratincola*
Common Swift	*Apus apus*
Common Buzzard	*Buteo buteo*
Common Crane	*Grus grus*
Common Quail	*Coturnix coturnix*
Common Whitethroat	*Sylvia communis*
Comon Wheatear	*Oenanthe oenanthe*
Crag Martin	*Hirundo rupestris*
Cream-colored Courser	*Cursorius cursor*
Crowned Sandgrouse	*Pterocles coronatus*
Desert Wheatear	*Oenanthe deserti*
Eleonora's Falcon	*Falco eleonorae*
Eurasian Hoopoe	*Upupa epops*
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*
House Martin	*Delichon urbica*
Isabelline Wheatear	*Oenanthe isabellinus*
Lanner Falcon	*Falco biarmicus*
Lesser Whitethroat	*Sylvia curruca*

English name	Scientific name
Lesser Kestrel	*Falco naumanni*
Levant Sparrowhawk	*Accipiter brevipes*
Little Crake	*Porzana parva*
Little Egret	*Egreta garazeta*
Marsh-Harrier	*Circus aeruginosus*
Meadow Pipit	*Anthus pratensis*
Montagu's Harrier	*Circus pygargus*
Moorhen	*Gallinuula chloropus*
Olivacious Warbler	*Hippolais pallida*
Osprey	*Pandion haliaetus*
Pallid Harrier	*Circus macrourus*
Pallid Swift	*Apus pallidus*
Pallid Swift	*Apus pallidus*
Red-rumped Swallow	*Hirundo daurica*
Red-rumped Swallow	*Hirundo daurica*
Rock Dove	*Columba levia*
Rock Thrush	*Monticola saxatilis*
Rueppell's Warbler	*Sylvia rueppelli*
Rufous Bush Robin	*Cercotrichas galactotes*
Sand Martin	*Riparia riparia*
Short-toed Lark	*Calandrella brachdactyla*
Spoonbill	*Platalea leucorodia*
Spotted Crake	*Porzana porzana*
Spotted Flychatcher	*Muscicapa striata*
Spotted Sandgrouse	*Pterocles senegallus*
Tawny Pipit	*Anthus campestris*
Turtle Dove	*Streptopelia turtut*
Whinchat	*Saxicola rubetra*
Whiskered Tern	*Chlidonias hybrida*
White Stork	*Ciconia ciconia*

English name	Scientific name
White Wagtail	*Motacilla alba*
Willow Warbler	*Phylloscopus trochilus*
Yellow Wagtail	*Motacilla flava*