DEVELOPMENT OF SAN SOLAR PV FACILITY AND ASSOCIATED INFRASTRUCTURE, NORTHERN CAPE PROVINCE

Avifauna Baseline and Impact Assessment Report

May 2022

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EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of San Solar Energy Facility (Pty) Ltd to compile an avifauna impact assessment report for the proposed San Solar PV facility to be located on the Remaining extent of the Farm Wincanton 472, approximately 3km south of Kathu, Northern Cape Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the project area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species).

Baseline avian data was obtained from point count sampling techniques during two independent sampling sessions (February 2022 and May 2022).

Six prominent avifaunal habitat types were identified on the study area, and consisted of three structural variations of Kathu Bushveld, ephemeral pans, artificial livestock watering points and transformed areas consisting of build-up land and quarries. The highest number of bird species and bird individuals were observed from the artificial livestock watering holes and pans, as well as from Kathu Bushveld with a taller tree canopy. Approximately 152 bird species were expected to occur in the wider study area, of which 91 species were observed in the study area during two independent surveys. The expected richness included four threatened or near threatened species, 12 southern African endemics and 31 near-endemic species. These species occurred at low reporting rates (< 3% reporting rates), which suggests that these species are irregular visitors to the area, of which the critically endangered White-backed Vulture (*Gyps africanus*) was observed overhead on a farm adjacent to the study area, while a pair of endangered Martial Eagles (Polemaetus bellicosus) is known from a farm south of the study area. Eight southern African endemics and 24 near-endemic species were confirmed on the study area. A total of 34 collision-prone bird species have been recorded from the wider study area (*sensu* atlas data), of which 13 species were birds of prey and eight species were waterbird species.

The main impacts associated with the proposed PV solar facility included the following:

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction.
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or colliding with the panels (as they are mistaken for waterbodies).
- Collision with associated infrastructure (mainly overhead power lines).

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). However, the risk for certain waterbirds (e.g. shelducks) and sandgrouse species colliding with the PV infrastructure remained eminent due to the presence of surface water (e.g. inundated pans and artificial watering points) on the study area. Post-construction monitoring was recommended along with the installation of appropriate bird diverters and the relocation of artificial watering points to minimise the potential risk of collision trauma in birds.

No fatal-flaws were identified during the assessment, although it was strongly recommended that the proposed mitigation measures and monitoring protocols (e.g. post construction monitoring) be implemented during the construction and operational phase of the project.

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DECLARATION OF INDEPENDENCE

I, Lukas Niemand (Pachnoda Consulting CC) declare that:

- I act as the independent specialist in this application to Savannah Environmental (Pty) Ltd and San Solar Energy Facility (Pty) Ltd;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have no vested financial, personal or any other interest in the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Lukas Niemand (Pr.Sci.Nat)
31 May 2022

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 20 years of experience in ecological-related assessments and more than 15 years in the field of bird interactions with electrical and renewable energy infrastructure. He has conducted numerous ecological and avifaunal impact assessments including Eskom Transmission projects, hydro-electric schemes, solar farms and other activities in South Africa and other African countries.

1. INTRODUCTION

1.1 Project Description

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of San Solar Energy Facility (Pty) Ltd to compile an avifauna impact assessment report for a solar facility and associated infrastructure (herewith referred to as the "San Solar PV facility") with a contracted capacity of up to 100MW located on a site approximately 16km north west of Kathu in the Northern Cape Province (Figure 1). The study area[1] is situated within the Gamagara Local Municipality within the John Taolo Gaetsewe District Municipality. The site is accessible via the R380 provincial route which branches off the N14 National Road, approximately 3km south of Kathu.

The PV facility will be located on a 400ha development area[2], which will include the PV arrays, BESS and a 132kV facility substation to be connected via a Loop-in-Loop out (LILO) connection to the Umtu 132kV overhead power line (Figure 2). The infrastructure associated with this 100MW PV facility includes:

- PV modules and mounting structures
- Inverters and transformers
- Cabling between the panels, to be laid underground where practical.
- Battery Energy Storage System (BESS)
- Site and internal access roads (up to 8m wide)
- Laydown area
- Operation and Maintenance buildings including a gate and security building, control centre, offices, warehouse, and workshop areas for maintenance and storage.
- Grid connection solution including a 132kV facility substation to be connected via a Loop-in-Loop out (LILO) connection to the Umtu 132kV overhead power line (located ~1.5km south of the development area).

The development area is larger than the area needed for the construction of a 100MW PV facility and will provide the opportunity for the optimal placement of the infrastructure, ensuring avoidance of major identified environmental sensitivities by the development footprint[3].

[1] The study area is defined as the Remaining extent of the Farm Wincanton 472, which has the extent of ~ 1000ha.

[2] The development area is that identified area (located within the study area) where the San Solar PV facility would be located.

[3] The development footprint is the defined area (located within the development area) where the PV panel array and other associated infrastructure for San Solar PV will be planned to be constructed. This will be the actual footprint of the facility, and the area which would be disturbed.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the study area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species; sensu IUCN, 2022; Taylor et al., 2015; Marnewick et al., 2015).

A bird assessment is required as part of the Environmental Impact Assessment process to investigate the impacts of the proposed solar facility on the avian attributes at the study site and its immediate surroundings. The avifaunal attributes at the proposed PV facility will be determined by means of a desktop analysis of GIS based information, third-party datasets and a number of site surveys. It also provides the results from two independent pre-construction surveys as per the best practice guidelines of Jenkins *et al.* (2017).

The terms of reference are to:

- conduct a baseline bird assessment based on available information pertinent to the ecological and avifaunal attributes on the project area and habitat units;
- conduct an assessment of all information on an EIA level in order to present the following results:
  - typify the regional and site-specific avifaunal macro-habitat parameters that will be affected by the proposed project;
  - provide a shortlist of bird species present as well as highlighting dominant species and compositions;
  - provide an indication on the occurrence of threatened, near threatened, endemic and conservation important bird species likely to be affected by the proposed project;
  - provide an indication of sensitive areas or bird habitat types corresponding to the study area;
  - highlight areas of concern or "hotspot" areas;
  - identify and describe impacts that are considered pertinent to the proposed development;
  - highlight gaps of information in terms of the avifaunal environment; and
  - recommend additional surveys and monitoring protocols (*sensu* Jenkins et al., 2017).

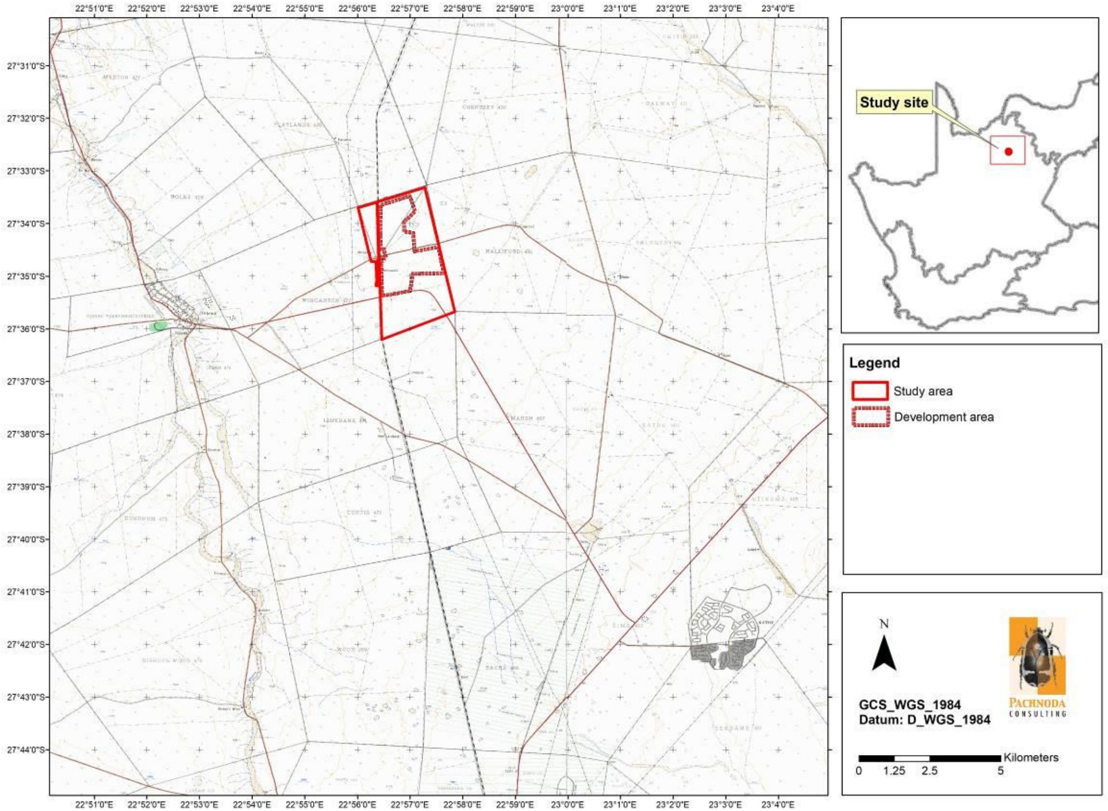


Figure 1: A topo-cadastral image illustrating the geographic position of proposed San solar PV study and development areas.

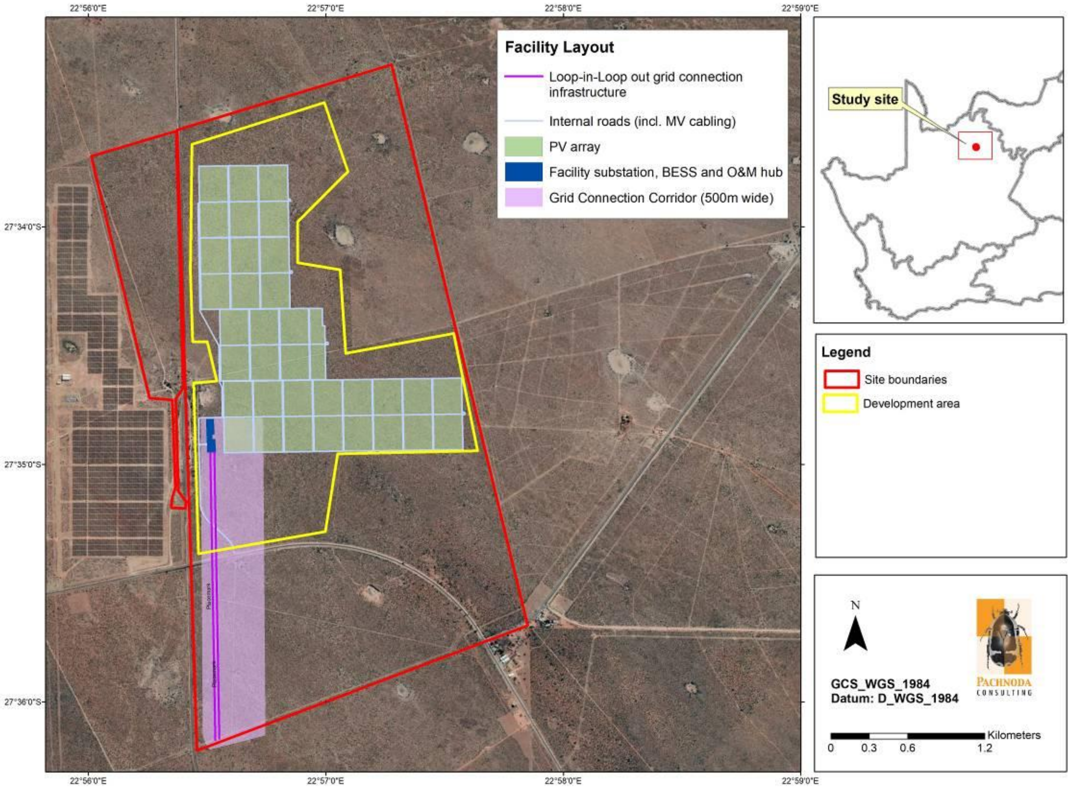


Figure 2: A satellite image illustrating the geographic position of the proposed San Solar PV facility and associated infrastructure.

1.3 Scope of Work

The following aspects form part of the Scope of Work:

- A desktop study of bird species expected to occur (e.g. species that could potentially be present), as well as species recorded in the past (e.g. SABAP1);
- A baseline survey of observed bird species according to ad hoc observations and two sampling surveys;
- A list of bird species historically recorded within the relevant quarter degree grid in which the study site occurs (SABAP1);
- Any protected or threatened bird species recorded in the past within the relevant quarter degree grid, their scientific names and colloquial names, and protected status according to IUCN red data lists; and
- The potential of these protected or threatened species to persist within the study area.

The following aspects will be discussed during this avifaunal assessment:

- Collision-prone bird species expected to be present and or observed;

- A list of the dominant bird species;
- A list of observed and expected threatened and near threatened species (according to IUCN red data list);
- Possible migratory or nomadic species;
- Potential important flyways/ congregatory sites and/or foraging sites; and
- Avian impacts associated with the PV solar facility.

2. METHODS & APPROACH

The current report places emphasis on the avifaunal community as a key indicator group on the proposed study area, thereby aiming to describe the conservation significance of the ecosystems in the area. Therefore, the occurrence of certain bird species and their relative abundances may determine the outcome of the ecological sensitivity of the area and the subsequent proposed layouts of the solar facility infrastructure.

The information provided in this report was principally sourced from the following sources/observations:

- relevant literature – see section below;
- observations made during two site visits corresponding to the austral wet and dry seasons (07 - 11 February 2022 and 10 - 13 May 2022); and
- personal observations from similar habitat types in proximity to the study area (Pachnoda Consulting 2017).

2.1 Literature survey and Database acquisition

A desktop and literature review of the area under investigation was commissioned to collate as much information as possible prior to the detailed baseline survey. Literature consulted primarily makes use of small-scale datasets that were collected by citizen scientists and are located at various governmental and academic institutions (e.g. Animal Demography Unit & SANBI). These include (although are not limited to) the following:

- Hockey *et al*. (2005) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities of selected bird species that could be present on the study area.
- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2022) and the regional conservation assessment of Taylor *et al.* (2015).
- Distributional data was sourced from the South African Bird Atlas Project (SABAP1) and verified against Harrison et al. (1997) for species corresponding to the quarter-degree grid cell (QDGC) 2722DB (Dibeng). The information was then modified according to the prevalent habitat types present on the development area. The SABAP1 data provides a "snapshot"

of the abundance and composition of species recorded within a quarter degree grid cell (QDGC) which was the sampling unit chosen (corresponding to an area of approximately 15 min latitude x 15 min longitude). It should be noted that the atlas data makes use of reporting rates that were calculated from observer cards submitted by the public as well as citizen scientists. It therefore provides an indication of the thoroughness of which the QDGCs were surveyed between 1987 and 1991;

- Additional distributional data was also sourced from the SABAP2 database (http://www.sabap2.birdmap.africa). The information was then modified according to the prevalent habitat types present on the study area. Since bird distributions are dynamic (based on landscape changes such as fragmentation and climate change), SABAP2 was born (and launched in 2007) from SABAP1 with the main difference being that all sampling is done at a finer scale known as pentad grids (5 min latitude x 5 min longitude, equating to 9 pentads within a QDGC). Therefore, the data is more site-specific, recent and more comparable with observations made during the site visit (due to increased standardisation of data collection). The pentad grids relevant to the current project are 2730_2255 and 2735_2255 (although all eight pentad grids surrounding grid 2730_2255 were also scrutinised) (Figure 3).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World Bird List v. 12.1), unless otherwise specified (see www.worldbirdnames.org as specified by Gill et al, 2022). Colloquial (common) names were used according to Hockey *et. al.* (2005) to avoid confusion;
- The best practice guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa were also consulted (Jenkins *et al.,* 2017).

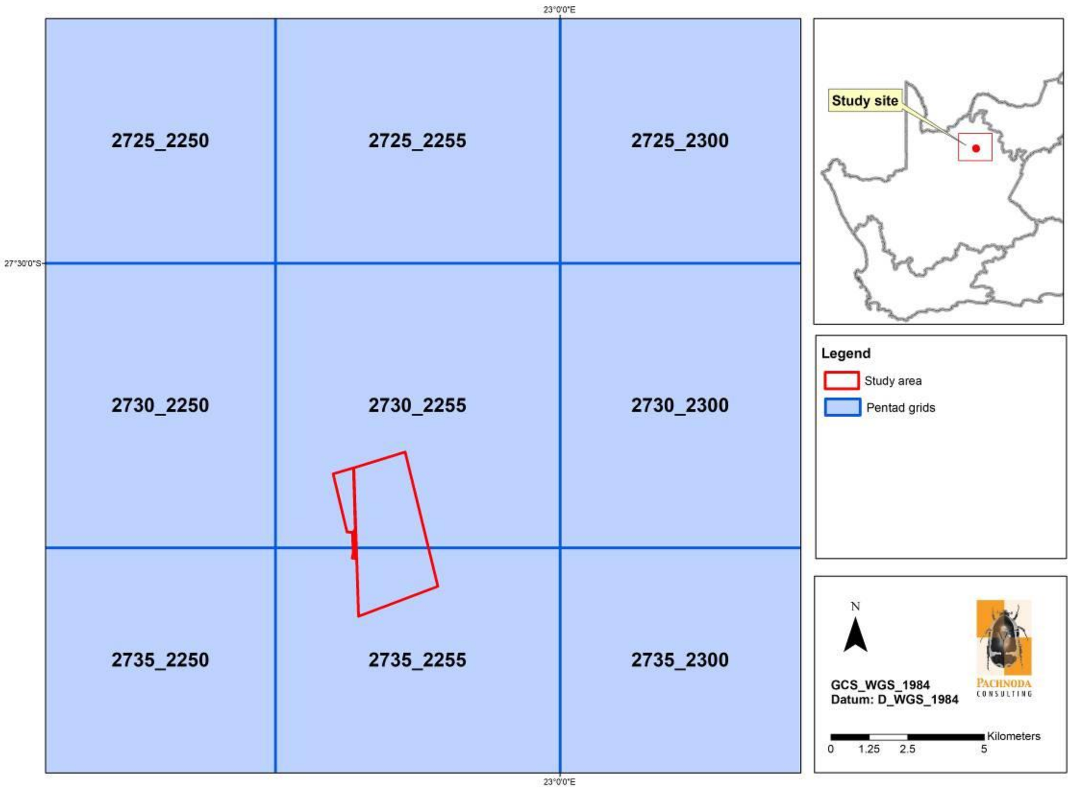


Figure 3: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study site was surveyed during two independent site visits representing a wet season (February 2022) and an early dry season survey (May 2022).

The baseline avifaunal survey was conducted by means of the following survey techniques:

2.2.1 Point Counts

Bird data was collected by means of 25 point counts (as per Buckland et al. 1993) from the study area. Data from the point counts has been analysed to determine dominant and indicator bird species (so-called discriminant species), relative densities and to delineate the different bird associations present.

The use of point counts is advantageous since it is the preferred method to use for skulking or elusive species. In addition, it is the preferred method to line transect counts where access is problematic, or when the terrain appears to be complex (e.g. mountainous). It is considered to be a good method to use, and very efficient for gathering a large amount of data in a short period of time (Sutherland, 2006). The spatial position of each point count is illustrated in Figure 4. The spatial placement of the point counts was determined through a stratified random design which ensures coverage of each habitat type and/or macro-habitat (Sutherland et al., 2004).

Therefore, the sampling approach was adapted so that all the bird species seen within approximately 50m from the centre of the point were recorded (resulting in an area of 0.78 ha) along with their respective abundance values (a laser rangefinder was used to delineate the area to be surveyed at each point). Each point count lasted approximately 20 -30 minutes, while the area within the 50m radius of homogenous habitat was slowly traversed to ensure that all bird species were detected and or flushed (as proposed by Watson, 2003). To ensure the independence of observations, points were positioned at least 200 m apart. Observations were not truncated, and in order to standardise data collection, the following assumptions were conformed to (according to Buckland *et al.*, 1994):

- All birds on the point must be seen and correctly identified. This assumption is in practice very difficult to meet in the field as some birds in the nearby vicinity may be overlooked due to low visibility or were obscured by vegetation (e.g. graminoid cover). Therefore, it is assumed that the portion of birds seen on the point count represents the total assemblage on the point.
- All birds must be recorded at their initial location. All movements of the birds are random and therefore natural in relation to the movements of the observer. None of the birds moved in response to the presence of the observer, and birds flying past without landing were omitted from the analysis.
- In other words, no bird is recorded more than once.

2.2.2 Random (ad hoc) surveys

To obtain an inventory of bird species present (apart from those observed during the point counts), all bird species observed/detected while moving between point counts were identified and noted. Particular attention was devoted to suitable roosting, foraging and nesting habitat for species of conservation concern (e.g. threatened or near threatened species). In addition, the fly patterns of large non-passerine and birds of prey were recorded, as well as the locality of collision-prone birds.

2.2.3 Analyses

Data generated from the point counts was analysed according to Clarke & Warwick (1994) based on the computed percentage contribution (%) of each species, including the consistency (calculated as the similarity coefficient/standard deviation) of its contribution. Hierarchical Agglomerative Clustering (a cluster analysis-based group-average linkages; Clarke & Warwick 1994) was performed on calculated Bray-Curtis coefficients derived from the data. A cluster analysis is used to assign "species associations" between samples with the aim to objectively delineate groups or assemblages. Therefore, sampling entities that group together (being more similar) are believed to have similar compositions.

The species richness and diversity of each bird association was analysed by means of richness measures (such as the total number of species recorded (S) and Shannon Wiener Index) were calculated to compare the associations with each other.

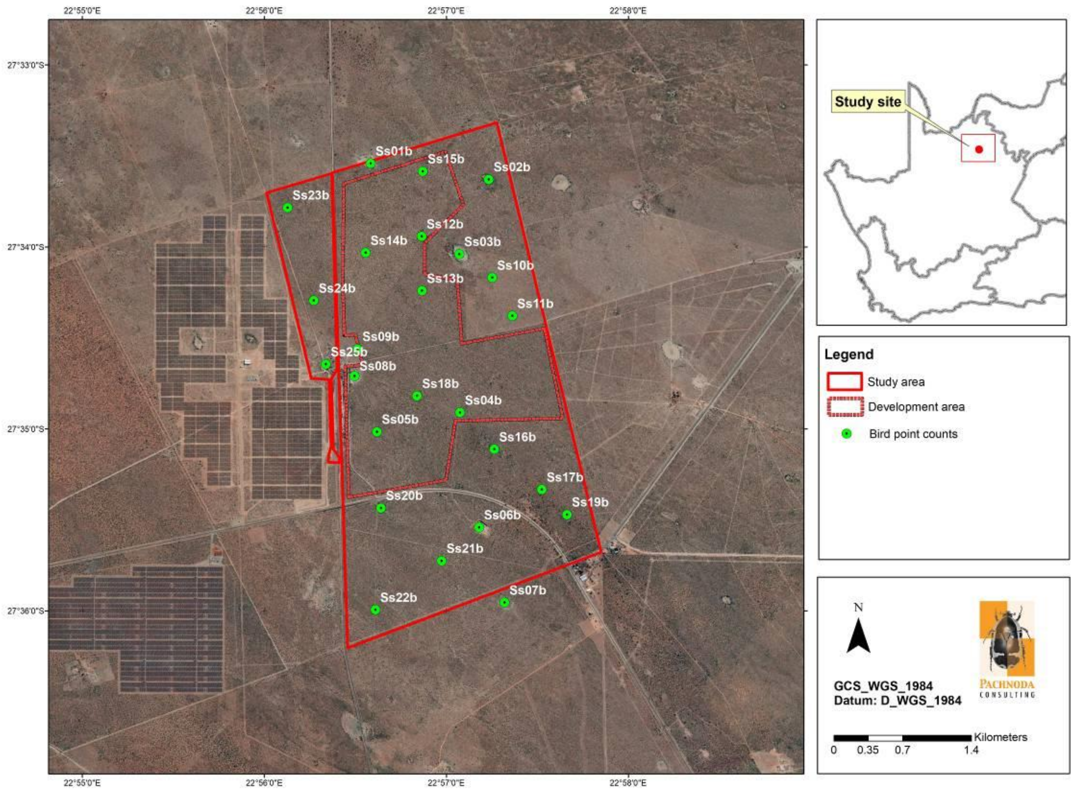


Figure 4: A map illustrating the spatial position of 25 bird point counts located within the study area.

2.3 Sensitivity Analysis

A sensitivity map was compiled based on the outcome of the baseline results.

The ecological sensitivity of any piece of land is based on its inherent ecosystem service (e.g. wetlands) and overall preservation of biodiversity.

2.3.1 Ecological Function

Ecological function relates to the degree of ecological connectivity between systems within a landscape matrix. Therefore, systems with a high degree of landscape connectivity amongst one another are perceived to be more sensitive and will be those contributing to ecosystem services (e.g. wetlands) or the overall preservation of biodiversity.

2.3.2 Avifaunal Importance

Avifaunal importance relates to species diversity, endemism (unique species or unique processes) and the high occurrence of threatened and protected species or ecosystems protected by legislation.

2.3.3 Sensitivity Scale

- *High* – Sensitive ecosystems with either low inherent resistance or low resilience towards disturbance factors or highly dynamic systems considered important for the maintenance of ecosystem integrity. Most of these systems represent ecosystems with high connectivity with other important ecological systems OR with high species diversity and usually contain high numbers of threatened, endemic or rare bird species. These areas should preferably be protected;
- *Moderately high* - Untransformed or productive habitat units (which can also be artificial) which contain high bird numbers and/or bird richness values. These areas are often fragmented OR azonal, and hence of small surface area that are often surrounded by habitat of moderate or low sensitivity. These habitat units also include potential habitat for threatened species. Development is often considered permissible on these areas if there is enough reason to believe that these areas are widespread in the region and future planned developments are unlikely to result in the widespread loss (>50 %) of similar habitat at a regional scale.
- *Medium* – These are slightly modified systems which occur along gradients of disturbances of low-medium intensity with some degree of connectivity with other ecological systems OR ecosystems with intermediate levels of species diversity but may include potential ephemeral habitat for threatened species; and
- *Low* – Degraded and highly disturbed/transformed systems with little ecological function and are generally very poor in bird species diversity (most species are usually exotic or weeds).

2.4 Limitations

- It is assumed that third party information (obtained from government, academic/research institution, non-governmental organisations) is accurate and true.
- Some of the datasets are out of date and therefore extant distribution ranges may have shifted although these datasets provide insight into historical distribution ranges of relevant species.
- The datasets are mainly small-scale and could not always consider azonal habitat types that may be present on the study area (e.g. artificial livestock watering points). In addition, these datasets encompass surface areas larger than the study area, which could include habitat types and species that are

not present on the study site. Therefore the potential to overestimate species richness is highly likely while it is also possible that certain cryptic or specialist species could have been be overlooked in the past.
- Some of the datasets (e.g. SABAP2) managed by the Animal Demography Unit of the University of Cape Town were recently initiated and therefore incomplete.
- This company, the consultants and/or specialist investigators do not accept any responsibility for conclusions, suggestions, limitations and recommendations made in good faith, based on the information presented to them, obtained from the surveys or requests made to them at the time of this report.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Locality

The San Solar PV development area is located 16km north west of Kathu in the Northern Cape Province and east of Dibeng. The development area is also located on the Remaining extent of the Farm Wincanton 472 (Figure 1).

3.2 Regional Vegetation Description

The proposed PV facility corresponds to the Savanna Biome and more particularly to the Eastern Kalahari Bushveld Bioregion as defined by Mucina & Rutherford (2006). It comprehends an ecological type known as Kathu Bushveld (Mucina & Rutherford, 2006) (Figure 5).

Kathu Bushveld is entirely confined to the Northern Cape and occurs from Kathu and Dibeng in the south, and northwards to the Botswana border near Van Zylsrus. It consists of a medium tree layer of *Vachellia (=Acacia) erioloba* and a shrub layer dominated by *Senegalia (=Acacia) mellifera, Diospyros lycioides* and *Lycium hirsutum.*

Kathu Bushveld is least threatened with none conserved in statutory conservation areas. More than 1 % is transformed, mainly due to iron ore mining near Sishen.

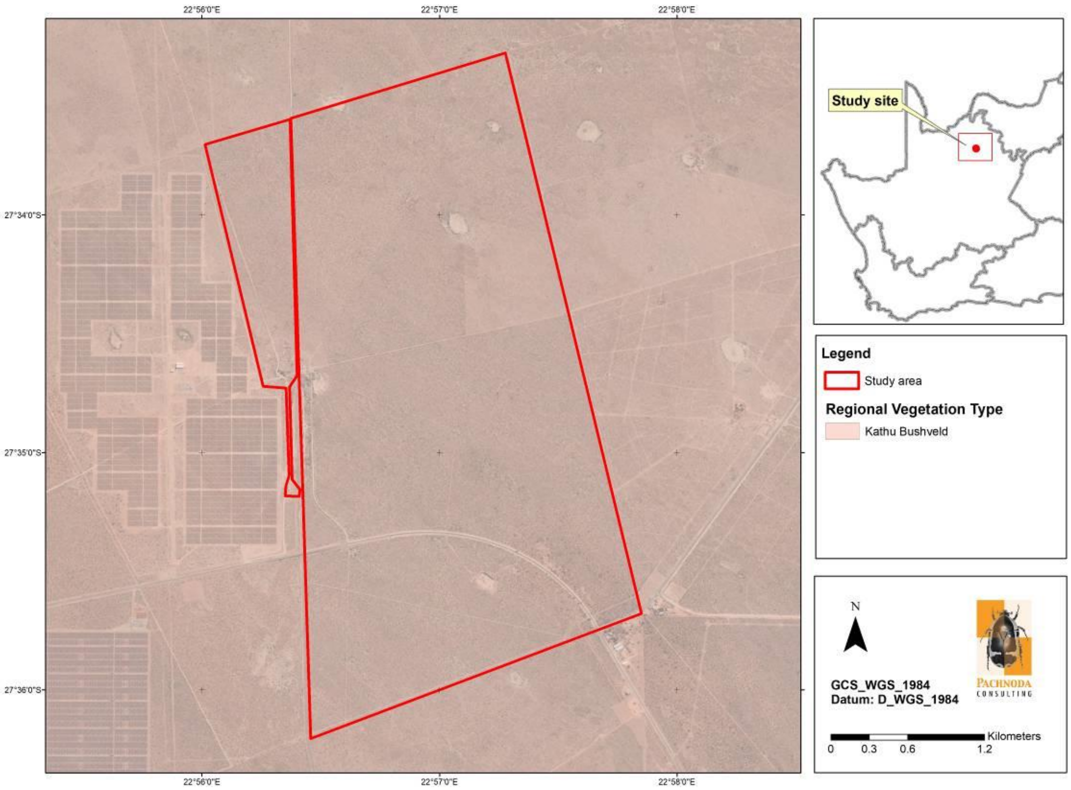


Figure 5: A satellite image illustrating the regional vegetation type corresponding to the study area. Vegetation type categories were defined by Mucina & Rutherford (2006).

3.3 Land cover, land use and existing infrastructure.

According to the South African National dataset of 2013-2014 (Geoterrainimage, 2015) the study area comprehends the following land cover categories (Figure 6):

Natural areas:
- Grassland;
- Low shrubland; and
- Woodland and open bush.

Transformed areas:
- Mines and quarries.

From the land cover dataset it is evident that most of the development area is covered by natural grassland and low shrubland. The development area is primarily vacant. Existing infrastructure includes roads and what appear to be small quarries. The grassland was probably erroneously digitised since this unit should be placed in the low shrubland category, which is part of the Kathu Bushveld.

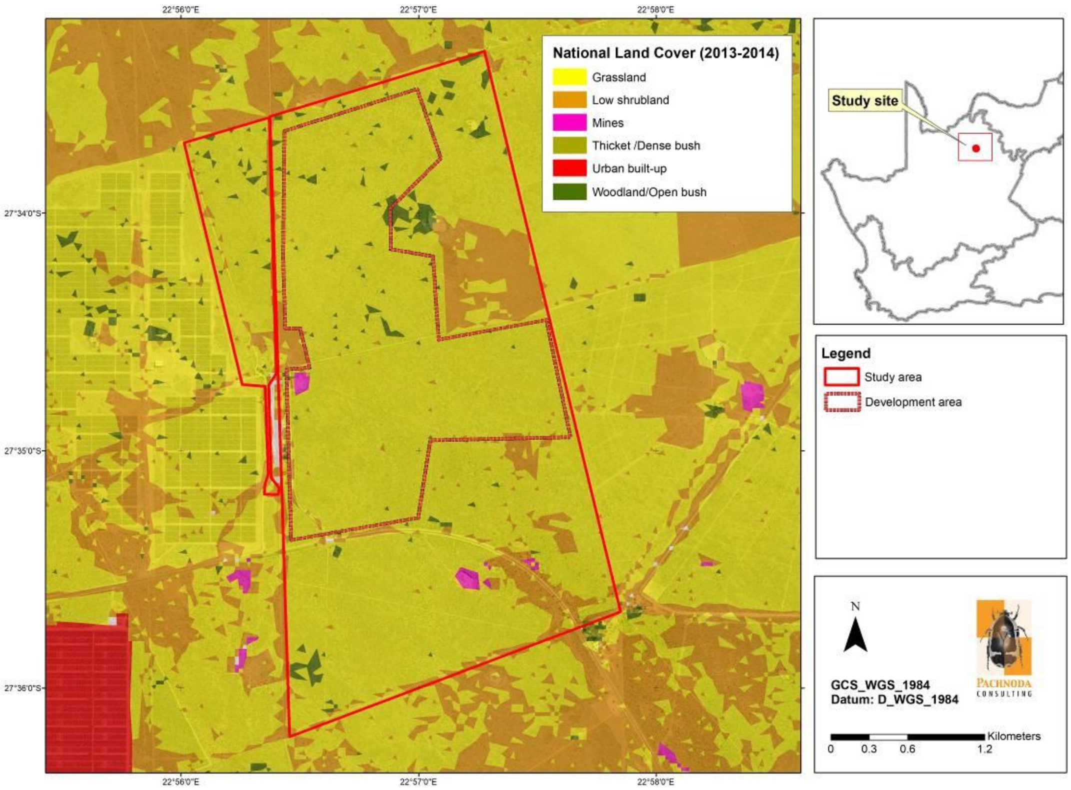


Figure 6: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study and development areas.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

There are no formal protected or conservation areas or any Important Bird and Biodiversity Areas in close proximity to the study area.

3.5 Annotations on the National Web-Based Environmental Screening Tool

Regulation 16(1)(v) of the Environmental Impact Assessment Regulations, 20145 (EIA Regulations) provides that an applicant for Environmental Authorisation is required to submit a report generated by the Screening Tool as part of its application. On 5 July 2019, the Minister of Environmental Affairs, Forestry and Fisheries published a notice in the Government Gazette giving notice that the use of the Screening Tool is compulsory for all applicants to submit a report generated by the Screening Tool from 90 days of the date of publication of that notice.

The Screening Tool is intended to allow for pre-screening of sensitivities in the landscape to be assessed within the EA process. This assists with implementing the mitigation hierarchy by allowing developers to adjust their proposed development footprint to avoid sensitive areas. The Screening Tool report will indicate the (preliminary) environmental sensitivities that intersect with the proposed development footprint as defined by the applicant as well as the relevant Protocols.

As the Screening Tool contains datasets that are mapped at a national scale, there may be areas where the Screening Tool erroneously assigns, or misses, environmental sensitivities because of mapping resolution and a high paucity of available and accurate data. Broad-scale site investigations will provide for an augmented and site-specific evaluation of the accuracy and 'infilling' of obvious and large-scale inaccuracies. Information extracted from the National Web-based Environmental Screening Tool (Department of Environmental Affairs, 2020), indicated that the study site holds a **medium** sensitivity with respect to the relative animal species protocol (Figure 7) (report generated 02/06/2022):

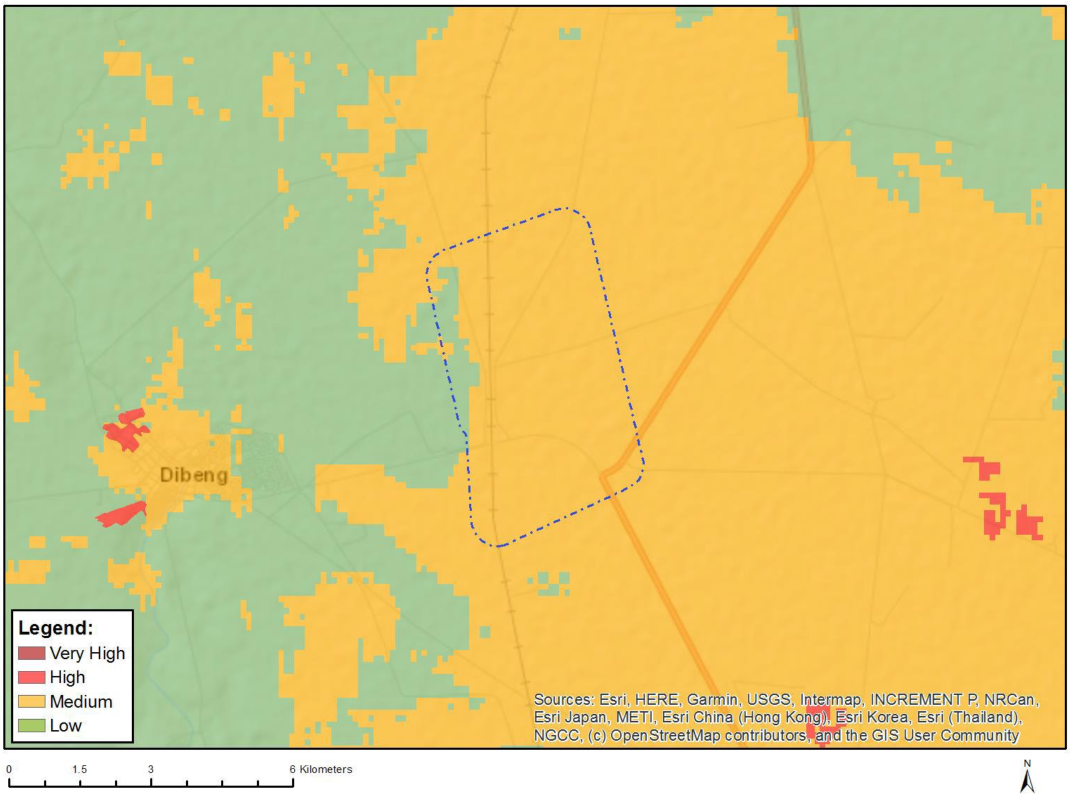


Figure 7: The animal species sensitivity of the study area (including a 500m buffer) according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Subject to confirmation
Medium	Aves - *Sagittarius serpentarius*
Medium	Aves -*Gyps africanus*

It is evident from the results of the Screening Tool report that the study area contains habitat of medium for two threatened bird species, which include the endangered Secretarybird (*Sagittarius serpentarius*) and the critically endangered White-backed Vulture (*Gyps africanus*).

The study site holds a **low** sensitivity with respect to the relative avian theme (Figure 8) (report generated 02/06/2022):

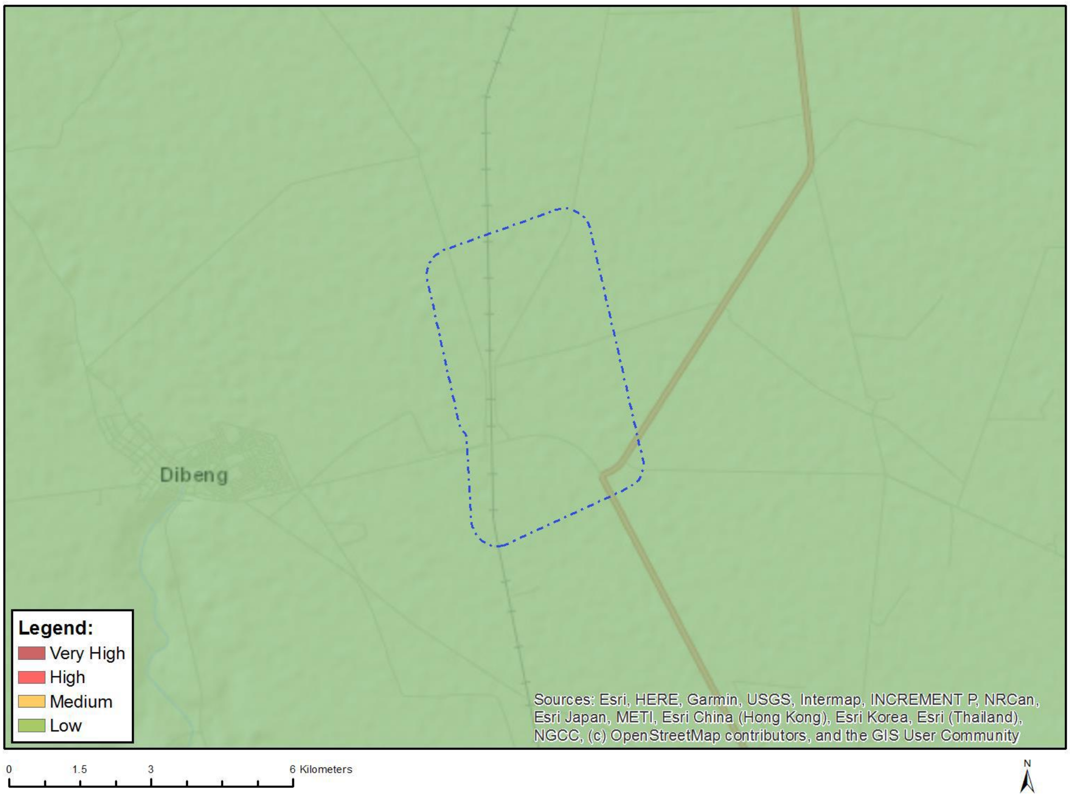


Figure 8: The relative avian sensitivity of the study area (including a 500m buffer) according to the Screening Tool.

It is evident from the results of the Screening Tool report that the study area is potentially not an important area for bird species with a high probability to interact with the solar infrastructure and that the site does not potentially overlap with important avian flyways.

However, the study site holds a **very high** sensitivity with respect to the relative terrestrial biodiversity theme (Figure 9) (report generated 02/06/2022):

Figure 9: The relative terrestrial biodiversity sensitivity of the study area (including a 500m buffer) according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low Sensitivity
Very High	Ecological support area

It is evident from the results of the Screening Tool report that the study area forms part of an ecological support area which should be determined during a terrestrial ecological evaluation as part of the EA process.

4. RESULTS AND DISCUSSION

4.1 Avifaunal habitat types

Apart from the regional vegetation type, the local composition and distribution of the vegetation associations on the development area are a consequence of a combination of factors simulated by soil texture, geology and historical disturbance regimes which have culminated in a number of habitat types that deserve further discussion (Figure 10, Figure 11 and Figure 12):

1. *Kathu Bushveld:* This unit is prominent on the study area and covers a significant extent in surface area of the proposed development area. It is represented by two floristic variations which also provide habitat for two discrete avifaunal associations. The first floristic variation consists of open

short shrubland dominated by open short *Senegalia mellifera - Tarchonanthus camphoratus* shrubland with a fairly well developed graminoid layer. It provides habitat for small passerine granivores and leaf-gleaning insectivores, most notably that of Scaly-feathered Weaver (*Sporopipes squamifrons*), Black-chested Prinia (*Prinia flavicans*) and Chestnut-vented Warbler (*Curruca subcoerulea*). Birds of prey are rare and mainly occurs overhead during hunting bouts. Large-terrestrial species occur at low densities and consist of the Red-crested Korhaan (*Lophotis ruficrista*) and Northern Black Korhaan (*Afrotis afraoides*). The average bird density on this habitat type is expected to approximate 10.51 birds.ha^{-1} with a richness of approximately 20 - 25 species (according to Pachnoda Consulting, 2017). The second variation is compositionally similar to the aforementioned habitat types, but it includes a distinct tree canopy consisting of scattered *Vachellia erioloba* trees. The increase in vertical heterogeneity is positively correlated with species richness. Typical species include Spotted Flycatcher (*Muscicapa striata*), Fork-tailed Drongo (*Dicrurus adsimilis*), Southern Yellow-billed Hornbill (*Tockus leucomelas*), Ashy Tit (*Melaniparus cinerascens*) and Southern Masked Weavers (*Ploceus velatus*) which are normally uncommon from the adjacent shrubland. The *V. erioloba* trees also provide perching and potential nesting sites for small to medium-sized birds of prey. The expected average bird density of this floristic variation approximates 12.53 birds.ha^{-1} and the expected richness is 30 - 40 species (according to Pachnoda Consulting, 2017).

2. *Kathu Bushveld on deep red sands:* This unit is prominent on the eastern part of the study area. It is represented by dense *Senegalia mellifera - Tarchonanthus camphoratus* shrubland on deep red sands. The floristic variation is compositionally similar to the aforementioned habitat type, although the shrub layer is marginally taller and denser. The expected bird density is higher, although richness remained constant when compared to the open Kathu Bushveld. The expected average bird density on this habitat type approximates 13.69 birds.ha^{-1} and the expected richness is 20 - 30 species (according to Pachnoda Consulting, 2017).

3. *Ephemeral pans*: These include a number of small basins which tend to hold surface water for a short duration after precipitation events. Surface water is a scarce commodity in arid environments and expected to attract many bird species, both passerines and non-passerines. Therefore, when inundated, the pans provide ephemeral foraging habitat for a number of nomadic waterbirds and shorebirds which under normal environmental conditions, are absent from the study area (e.g. South African Shelduck *Tadorna cana* and Hadeda Ibis *Bostrychia hagedash*). In most instances the pans are bordered by dense woody vegetation dominated by *Ziziphus mucronata* and *Vachellia karroo*, thereby providing refuge and perching opportunities for a variety of bird species. The expected average bird density on this habitat type approximates 8.67 birds.ha^{-1} and the expected richness is 25-35 species.

4. *Open Kathu Bushveld*: These are represented by areas that were historically cleared or were intensively grazed with a low basal graminoid cover. The open woody cover provides foraging opportunities for large terrestrial bird species, many being threatened of near threatened such as the Secretarybird (*Sagittarius serpentarius*) and Kori Bustard (*Ardeotis kori*).

5. *Artificial livestock watering points*: These are represented by artificial water troughs and reservoirs with the purpose to provide drinking water to livestock. However, they act as focal congregation areas for many granivore passerine species including daily visits by sandgrouse. This habitat feature sustains high bird richness values and also provides foraging habitat for bird of prey.

6. *Transformed areas (including quarries)*: These areas are represented by roads, old homesteads and quarries. These often provide habitat for generalist/unspecialised bird species. However, the exposed rocky habitat and vertical banks left by past quarrying activities often attract rupicolous (rock-loving) bird species to the area that were invariably absent or rare in the area, such as Short-toed Rock Thrush (*Monticola brevipes*). The latter species is a winter visitor to the region.

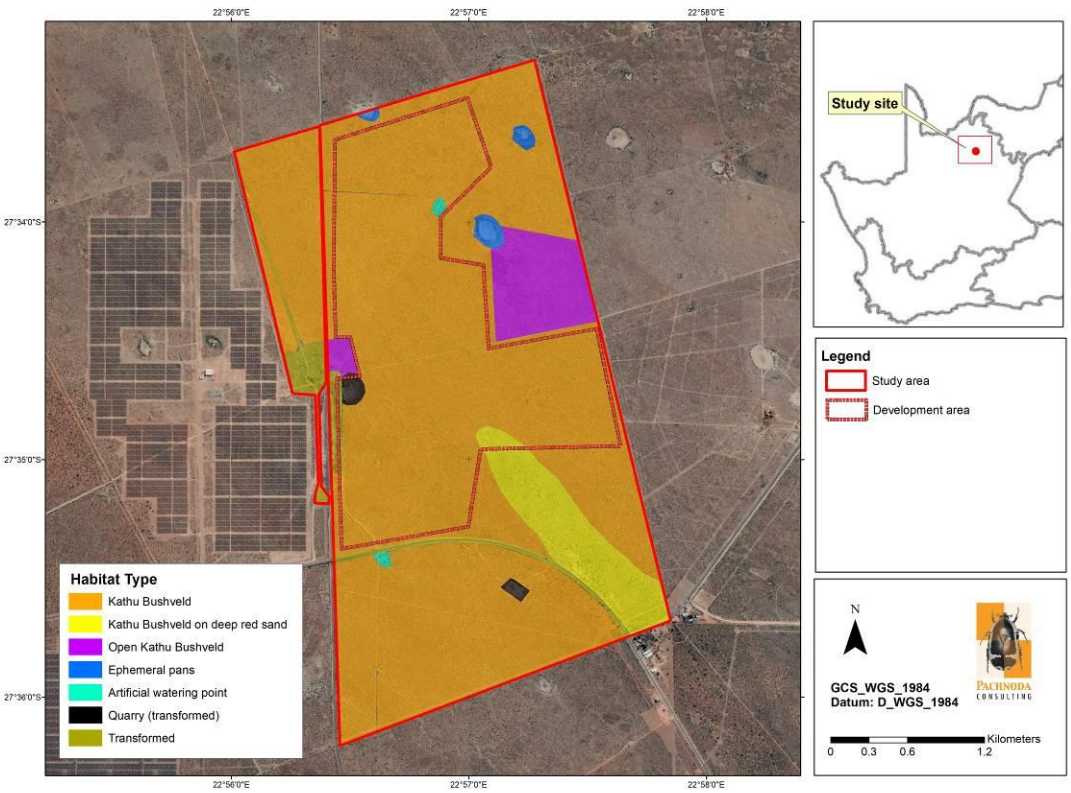


Figure 10: A map illustrating the avifaunal habitat types on the study and development areas.

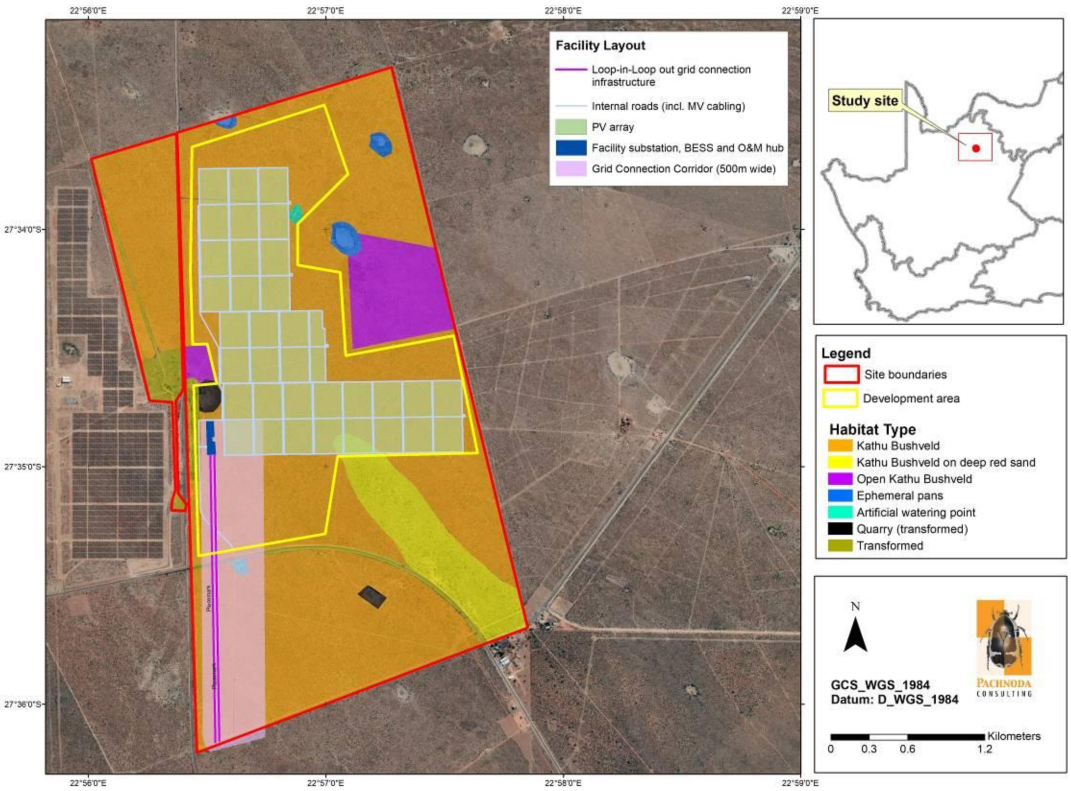
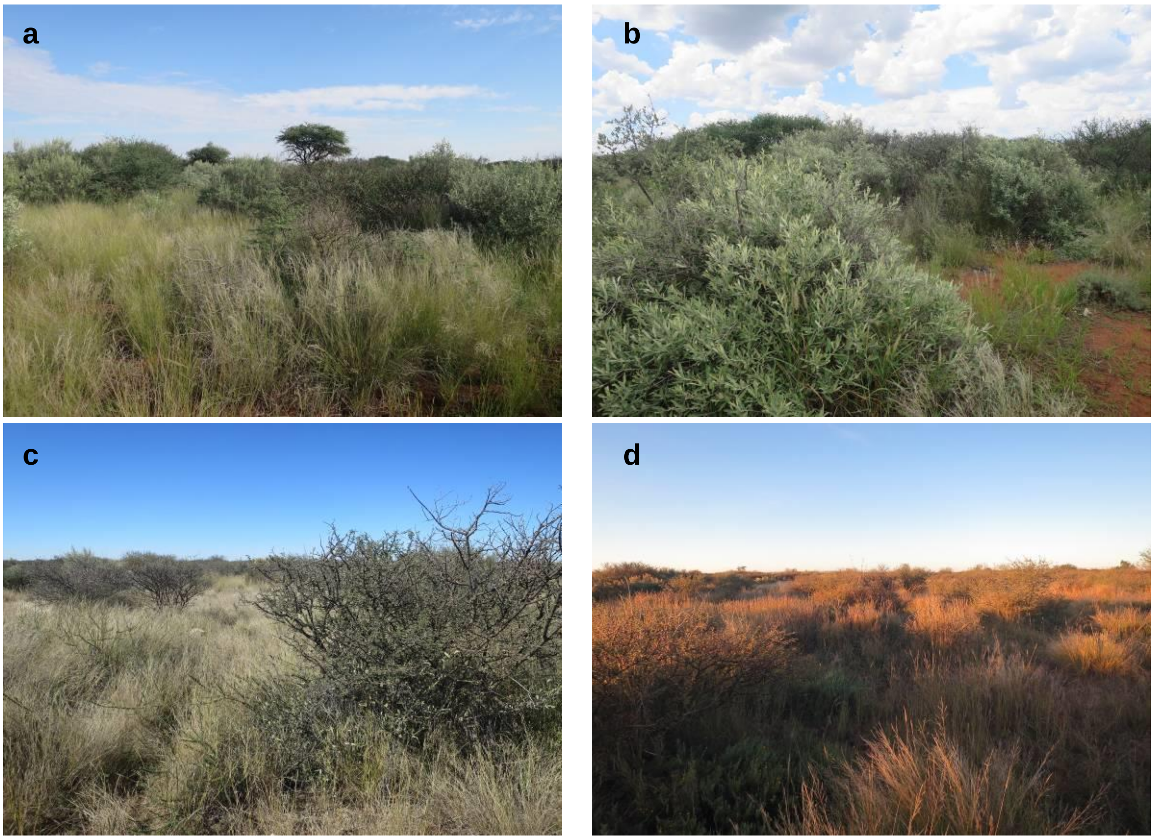
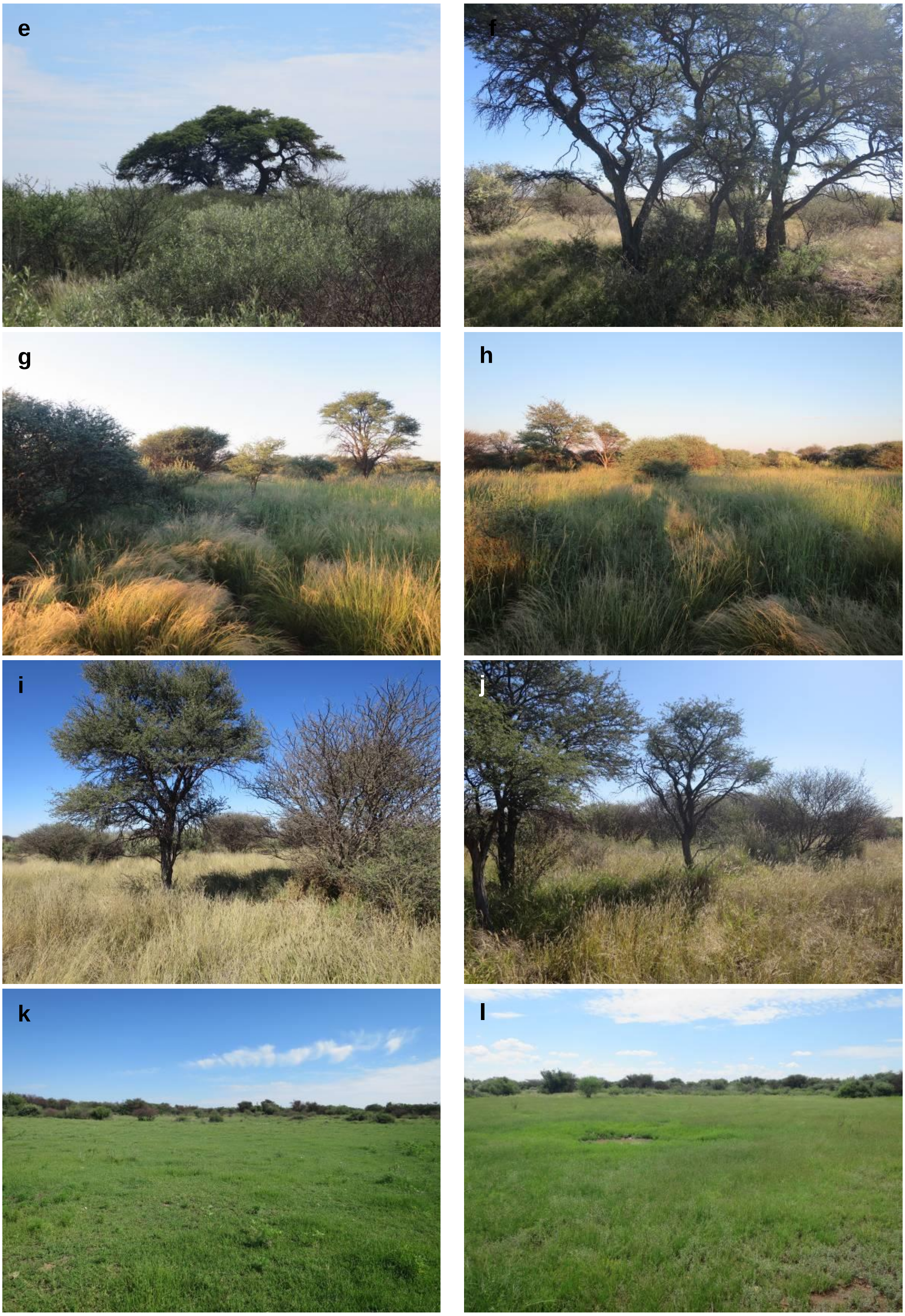


Figure 11: A map illustrating the avifaunal habitat types relative to the proposed facility infrastructure.

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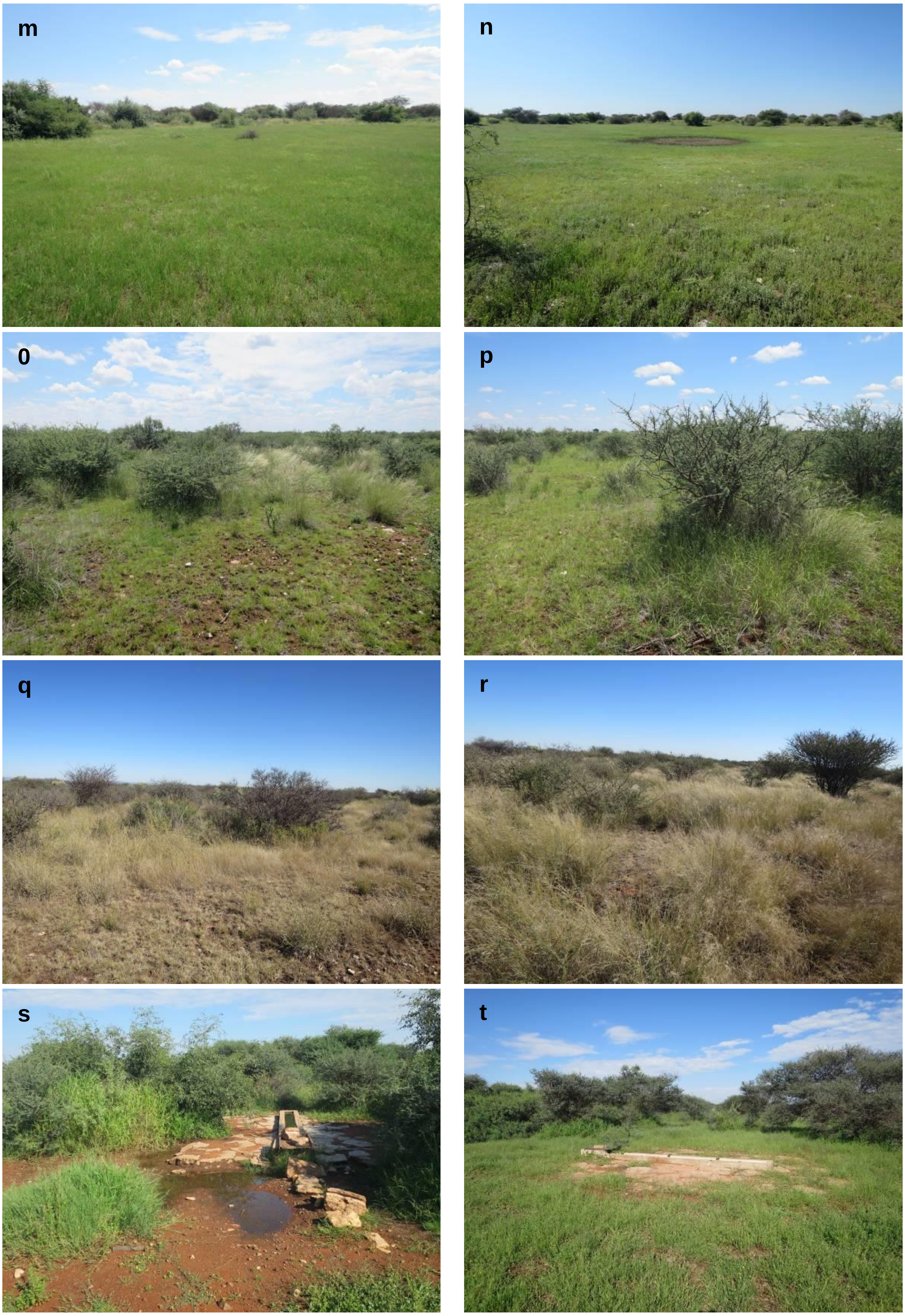
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Figure 12: A collage of images illustrating examples of avifaunal habitat types observed on the study area: (a - d) Kathu Bushveld with open short shrubveld (e - f) Kathu Bushveld with *Vachellia erioloba* emergents, (g - j) Kathu Bushveld on deep red sands, (k - n) ephemeral pans, (o - r) open Kathu Bushveld, (s - w) artificial livestock watering points and (x - z) examples of quarries and transformed anthropogenic habitat.

4.2 Species Richness and Summary statistics

Approximately 152 bird species are expected to occur in the study area (refer to Appendix 1 and Table 1). The expected richness was inferred from the South African Bird Atlas Project (SABAP1 & SABAP2)[4] (Harrison et al., 1997; www.sabap2.birdmap.africa) and the presence of suitable habitat in the study area. The expected richness is also strongly correlated with favourable environmental conditions (e.g. during good rains) and seasonality (e.g. when migratory species are present). This equates to 15 % of the approximate 987[5] species listed for the southern African subregion[6] (and approximately 17 % of the 871 species recorded within South Africa[7]). However, the species richness obtained from the pentad grids 2730_2255 and 2735_2255 corresponding to the study area[8] is lower than the expected number of species with an average of 82.5 species recorded. The average number of species for each full protocol card submitted (for observation of two hours or more) is 38.2 species (range = 20 - 58 species).

According to field observations, the total number of species observed on the study area is *ca*. 91 species (see Appendix 1). It shows that the surveys on the study area produced a higher tally when compared to the average richness recorded for the corresponding pentad grids and were regarded as sufficient. On a national scale, the species richness per pentad on the study area is considered to be moderate to high (refer to Figure 13).

According to Table 1, the study area is poorly represented by biome-restricted[9] (see Table 2) and local endemic bird species. However, the expected number of regional near-endemic species is high with *ca*. 50 % of the regional near-endemic species being present on the study area. Of the 152 bird species expected to occur in the study area, only four are threatened or near threatened species, four are local near-endemic species, while it was evident that local endemic species is absent from the area. In addition, one threatened species (White-backed Vulture *Gyps africanus*) was observed on habitat adjacent to the study area (Table 3). Furthermore, eight southern African endemics and 24 near-endemic species were confirmed on the study site and the immediate surroundings (Table 3). Waterbird species were highly irregular with only three species observed (all of them fly-overs) during the surveys (e.g. South African Shelduck *Tadorna cana*, African Sacred Ibis *Threskiornis aethiopicus* and White-faced Whistling Duck (*Dendrocygna viduata*).

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4 The expected richness statistic was derived from the pentad grid 2730_2255 (including adjacent 8 grids) totalling 150 bird species (based on 57 submitted cards, 42 being full protocol cards and 15 being ad hoc cards).

5 *sensu* www.zestforbirds.co.za (Hardaker, 2020) including four recently confirmed bird species (vagrants).

6 A geographical area south of the Cunene and Zambezi Rivers (includes Namibia, Botswana, Zimbabwe, southern Mozambique, South Africa, eSwatini and Lesotho).

7 With reference to South Africa (including Lesotho and eSwatini (BirdLife South Africa, 2022).

8 Including observations made during the February 2022 and May 2022 surveys.

9 A species with a breeding distribution confined to one biome. Many biome-restricted species are also endemic to southern Africa.

Table 1: A summary table of the total number of species, Red listed species (according to Taylor *et al*., 2015 and the IUCN, 2022), endemics and biome-restricted species (Marnewick *et al*., 2015) expected (*sensu* SABAP1 and SABAP2) to occur in the study site and immediate surroundings.

Description	Expected Richness Value (study area and surroundings)***	Observed Richness Value (study area)****
Total number of species*	152 (17 %)	91 (60 %)
Number of Red Listed species*	4 (3 %)	1 (25 %)
Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	5 (15 %)	3 (60 %)
Number of local endemics (BirdLife SA, 2022)*	0 (0 %)	0 (100 %)
Number of local near-endemics (BirdLife SA, 2022)*	4 (13 %)	3 (75 %)
Number of regional endemics (Hockey *et al*., 2005)**	12 (11 %)	8 (67 %)
Number of regional near-endemics (Hockey *et al*., 2005)**	31 (51 %)	24 (77 %)

* only species in the geographic boundaries of South Africa (including Lesotho and eSwatini) were considered.

** only species in the geographic boundaries of southern Africa (including Namibia, Botswana, Zimbabwe and Mozambique south of the Zambezi River) were considered

*** Percentage values in brackets refer to totals compared against the South African avifauna (*sensu* BirdLife SA, 2022).

**** Percentage values in brackets refer to totals compared against the expected number of species in the project area.

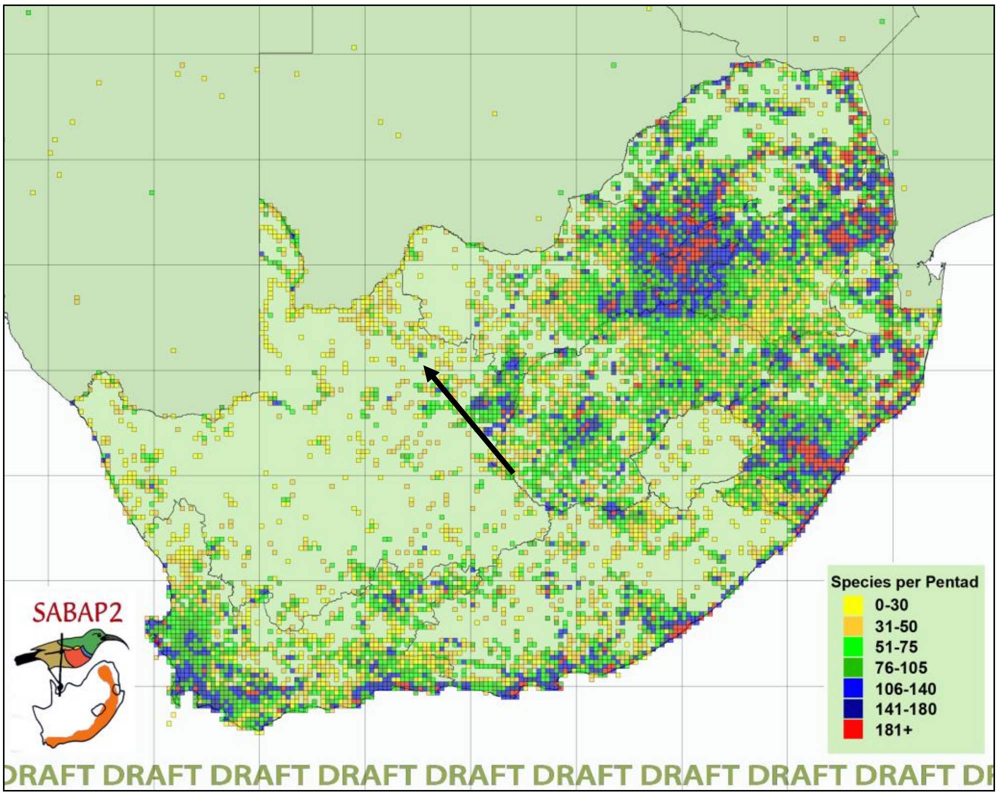


Figure 13: The bird species richness per pentad grid in comparison to the broader study area (see arrow) (map courtesy of SABAP2 and the Animal Demography Unit). According to the SABAP2 database, the study area hosts between 141 and 180 bird species.

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) likely to occur on the study area.

Species	Kalahari-Highveld	Namib-Karoo	Zambezian	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena*)	X			Common
Barred Wren-Warbler (*Calamonastes fasciolatus*)	X			Uncommon to rare
Burchell's Sandgrouse (*Pterocles burchelli*)	X			Common
Layard's Warbler (*Curruca layardi*)		X		Uncommon to Rare
White-bellied Sunbird (*Cinnyris talatala*)			X	Rare

Table 3: Important bird species occurring in the broader study area which could collide and/ or become displaced by the proposed PV infrastructure.

Common Name	Scientific name	Regional Status	Global Status	Observed (Feb. & May 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
White-backed Vulture	*Gyps africanus*	CR	CR	1	1		
Martial Eagle	*Polemaetus bellicosus*	EN	EN		1		
Kori Bustard	*Ardeotis kori*	NT			1		1
South African Shelduck	*Tadorna cana*	End		1	1	1	
Jackal Buzzard	*Buteo rufofuscus*	End			1		
Northern Black Korhaan	*Afrotis afraoides*	End		1	1		1
White-backed Mousebird	*Colius colius*	End		1			1
Southern Pied Babbler	*Turdoides bicolor*	End		1			1
Karoo Thrush	*Turdus smithi*	End					1
Ant-eating Chat	*Myrmecocichla formicivora*	End					1
Karoo Scrub Robin	*Cercotrichas coryphoeus*	End					1
Layard's Tit-Babbler	*Curruca layardi*	End		1			1
Rufous-eared Warbler	*Malcorus pectoralis*	End		1			1
Fiscal Flycatcher	*Sigelus silens*	End		1			1
Orange River White-eye	*Zosterops pallidus*	End		1			1
Red-billed Spurfowl	*Pternistis adspersus*	N-end			1		1
Red-crested Korhaan	*Lophotis ruficrista*	N-end		1	1		1
Pale Chanting Goshawk	*Melierax canorus*	N-end		1	1		

Common Name	Scientific name	Regional Status	Global Status	Observed (Feb. & May 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
Orange River Francolin	*Scleroptila gutturalis*	N-end		1	1		1
Namaqua Sandgrouse	*Pterocles namaqua*	N-end		1	1	1	1
Burchell's Sandgrouse	*Pterocles burchelli*	N-end		1	1	1	1
Acacia Pied Barbet	*Tricholaema leucomelas*	N-end		1			1
Eastern Clapper Lark	*Mirafra fasciolata*	N-end		1			1
Fawn-coloured Lark	*Calendulauda africanoides*	N-end		1			1
Grey-backed Sparrow-lark	*Eremopterix verticalis*	N-end					1
Ashy Tit	*Parus cinerascens*	N-end		1			1
Cape Penduline-tit	*Anthoscopus minutus*	N-end		1			1
African Red-eyed Bulbul	*Pycnonotus nigricans*	N-end		1			1
Kalahari Scrub Robin	*Cercotrichas paena*	N-end		1			1
Short-toed Rock Thrush	*Monticola brevipes*	N-end		1			1
Chestnut-vented Warbler	*Curruca subcoerulea*	N-end		1			1
Barred Wren-Warbler	*Calamonastes fasciolatus*	N-end					1
Marico flycatcher	*Bradornis mariquensis*	N-end		1			1
Chat Flycatcher	*Bradornis infuscatus*	N-end					1
Pririt Batis	*Batis pririt*	N-end		1			1
Dusky Sunbird	*Cinnyris fuscus*	N-end		1			1
Crimson-breasted Shrike	*Laniarius atrococcineus*	N-end		1			1
Bokmakierie	*Telophorus zeylonus*	N-end					1
Cape Sparrow	*Passer melanurus*	N-end		1			1
Scaly-feathered Weaver	*Sporopipes squamifrons*	N-end		1			1
Red-headed Finch	*Amadina erythrocephala*	N-end		1			1
Shaft-tailed Whydah	*Vidua regia*	N-end		1			1
Yellow Canary	*Crithagra flaviventris*	N-end		1			1
White-throated Canary	*Crithagra albogularis*	N-end					1
Lark-like Bunting	*Emberiza impetuani*	N-end					1
Falcon, Lanner	*Falco biarmicus*	VU			1		
	Totals:	**46**	**2**	**32**	**13**	**3**	**40**

Threatened and near threatened species are indicated in red
CR - Critically endangered, EN - endangered, VU - vulnerable, NT - near threatened
End - southern African endemic
N-end - southern African near-endemic

Prior to further analyses where species richness values are considered, it is imperative to determine if all bird species present were sufficiently sampled. Species accumulation curves (SAC) provide a means to examine data and sampling efficacy. For this project the species accumulation curves (SAC) for the point count data were generated using the software program Estimates S (version 9) with 100 randomizations (as recommended in Colwell, 2013). Curves were generated for the full data set (all point counts). Sampling sufficiency was determined by establishing whether a point had been reached where a line representing one new sample adding one new species was tangent to the curve (Brewer & McCann, 1982). The Michaelis-Menten equation (Soberôn & Llorente 1993) was fitted to the predicted number of species using Estimates S (Raaijmakers, 1987). A satisfactory level of sampling was achieved if 90 % of the bird species were detected, and hence predicted by the model (Moreno & Halffter, 2000).

The species accumulation curve (SAC) reached an asymptote at approximately 21 point counts (Figure 14). The sampling captured approximately 82% of the number of species predicted by the Michaelis-Menten model at 16 point counts. Approximately 95% of the species was captured by 50 counts. Therefore, sampling effort was considered sufficient and recorded most of the species present on the study area area during the respective survey sessions.

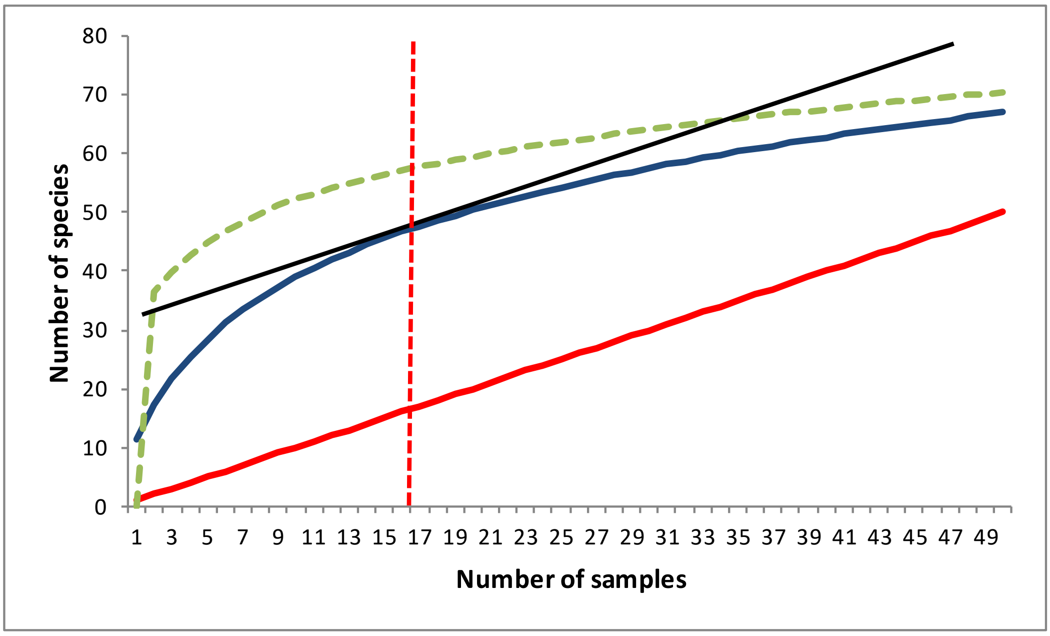
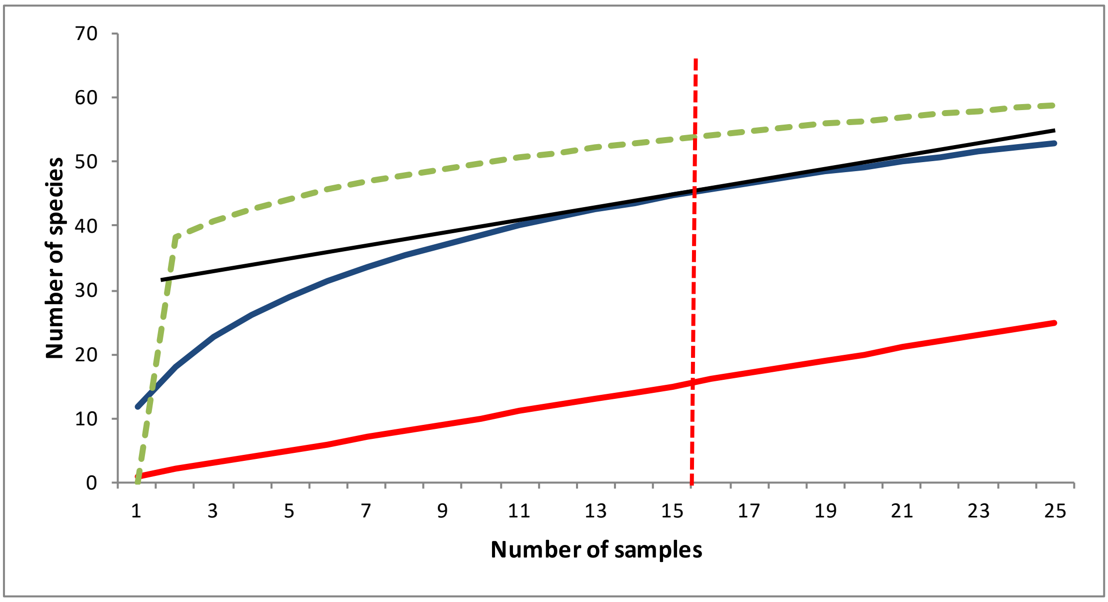


Figure 14: The species accumulation curve (SAC) (red line) for bird points sampled during the February 2022 and May 2022 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 16 counts (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

The species accumulation curve (SAC) for each survey also reached an asymptote at approximately 16 point counts (Figure 15). The sampling captured approximately 84% of the number of species predicted by the Michaelis-Menten model at 16 point counts during both surveys. Between 89.5% and 90% of the species was captured by 25 counts repectively. Therefore, sampling effort was considered sufficient and recorded most of the species present on the study area during the respective survey sessions.



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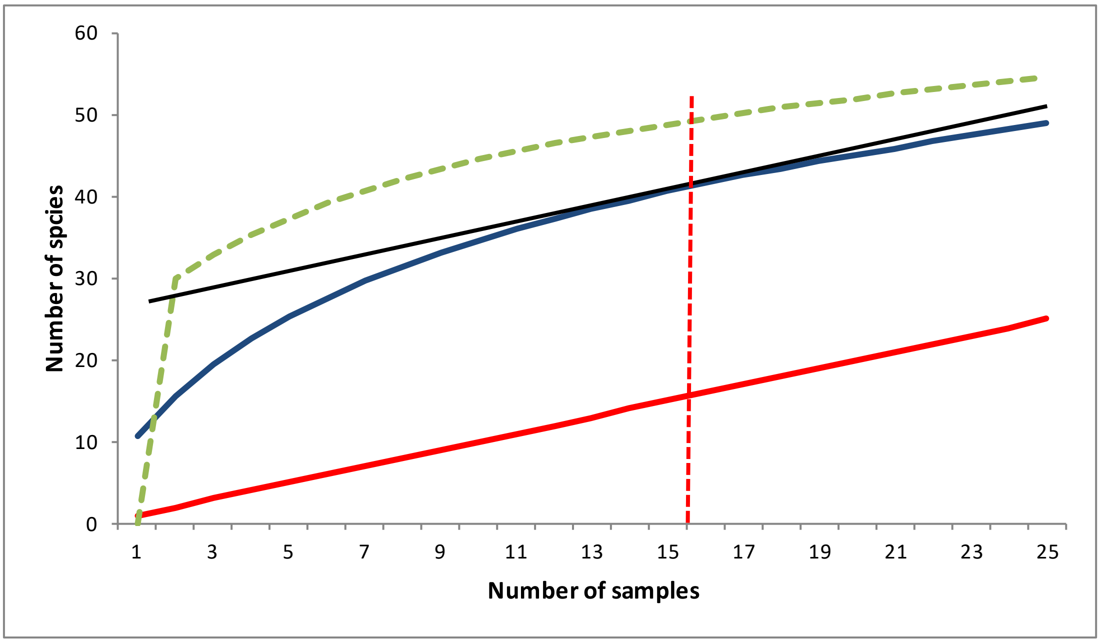

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Figure 15: The species accumulation curve (SAC) (red line) for bird points sampled during (a) February 2022 and the (b) May 2022 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 16

counts for both surveys (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

4.3 Bird species of conservation concern

Table 4 provides an overview of bird species of conservation concern that could occur on the development area based on their historical distribution ranges and the presence of suitable habitat. According to Table 4, a total of four species have been recorded in the wider study area (sensu SABAP2) which include two globally threatened species, one globally near threatened species and one regionally threatened species.

It is evident from Table 4 that these species occur at low reporting rates (< 3% for full protocol cards and <10 % for *ad hoc* cards submitted), which suggests that these species are highly irregular visitors to the development area. However, the Kori Bustard (*Ardeotis kori*) may be under-recorded in the area (due to the low number of citizen scientists) that have visited the area for which suitable habitat is provided by the open Kathu Bushveld units. However, even during the surveys it remained absent form the study area, of which the most plausible explanation is the high cover abundance of the shrub layer consisting of *Senegalia mellifera* and *Tarchonanthus camphoratus* which may impede the movement of this species (including other large terrestrial bird species) during foraging bouts and hence deter this species from utilising the area. the same assumption is also relevant to the apparent absence of Secretarybirds (*Sagittarius serpentarius*) in the area.

Table 4: Bird species of conservation concern that could utilise the study area based on their historical distribution range and the presence of suitable habitat. Red list categories according to the IUCN (2022)* and Taylor et al. (2015)**.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2 (n=50)	Preferred Habitat	Potential Likelihood of Occurrence
Falco biarmicus (Lanner Falcon)	-	Vulnerable	2.22 (singe observation)	Varied, but prefers to breed in mountainous areas.	An irregular foraging visitor to the study area. Most recent record obtained during June 2009 (sensu SABAP2).
Polemaetus bellicosus (Martial Eagle)	Endangered	Endangered	2.22	Varied, from open karroid shrub to lowland savanna.	An irregular foraging visitor to the study area although a pair is known to occur south of the study area on the Farm

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2 (n=50)	Preferred Habitat	Potential Likelihood of Occurrence
					Limebank 471 (pers. obs. @ 20 May 2021 - see Figure 16). This pair may occasionally forages over the study area.
Ardeotis kori (Kori Bustard)	Near threatened	Near threatened	2.22	Open savannoid grassland and open secondary shrubland	An uncommon foraging and breeding resident. It was last recorded during October 2021from the study area.
Gyps africanus (White-backed Vulture)	Critically Endangered	Critically Endangered	New record for the area	Breed on tall, flat-topped trees. Mainly restricted to large rural or game farming areas.	An irregular foraging/scavenging visitor to the study area pending the presence of food. Four individuals were observed soaring high at approximately 600m northwest of the study area on the Farm Flatlands 429 (08/02/2022).

4.3.1 Notes on the occurrence of White-backed Vulture (Gyps africanus)

The White-backed Vulture (*Gyps africanus*) is a large-bodied scavenging raptors are that was formerly listed as vulnerable in South Africa (Barnes 1998), although recent evidence based on severe declining trends in the global population in recent years has upgraded its status to critically endangered (BirdLife International, 2021). It remains an uncommon to highly irregular foraging visitor in the study area, and was only recently observed during the February 2022 survey where four individuals were observed soaring high over Farm Flatlands 426 (approximately 600m northwest of the study area). This observation was also the first record of this species for the pentad grids surrounding the study area (Figure 16). It is however present further west and south of the study area (Figure 17). It appears that the scarcity of large trees (especially *V. erioloba*) may be a limiting factor in the area, since this species prefers to roost and breed in tall trees (pers. obs.). However, the high occurrence of this species to the southeast of the study area (approximately 90km southwest of the study area) is attributed to the presence of high voltage powerlines, where the birds tend to roost on the tall pylon structures (pers. obs.) owing to the absence of suitable tall roosting trees.

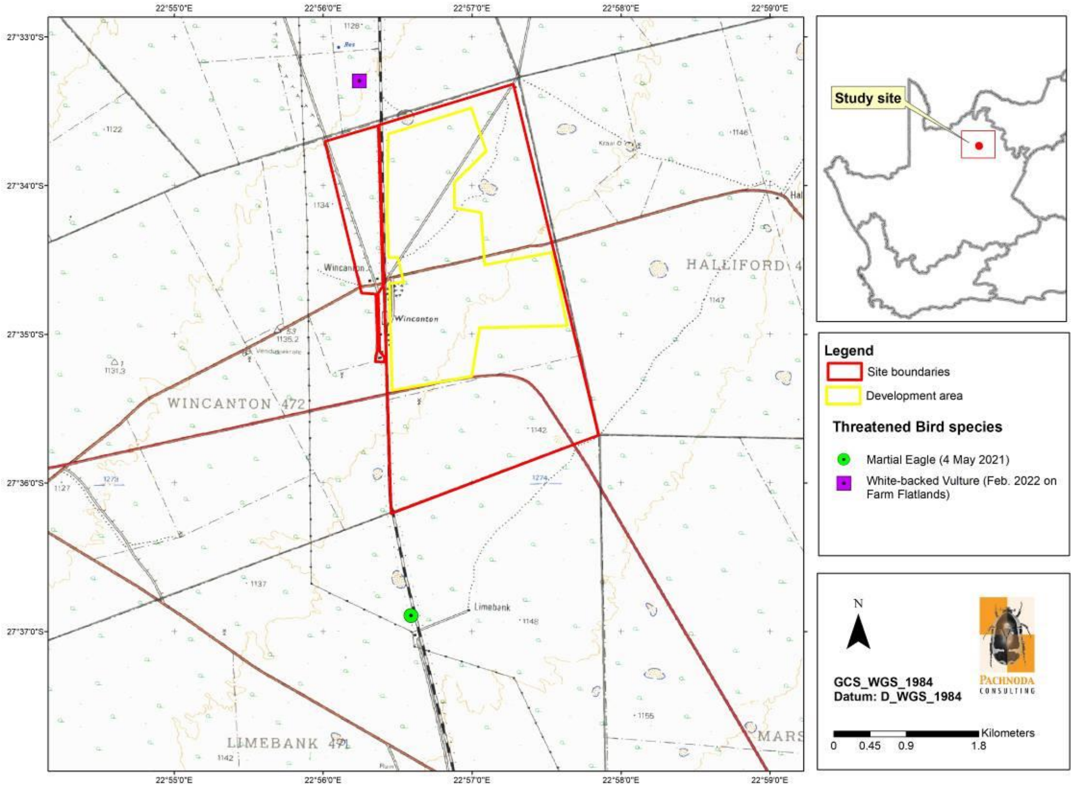

Figure 16: A map illustrating the occurrence of the endangered Martial Eagle (*Polemaetus bellicosus*) and critically endangered White-backed Vulture (*Gyps africanus*) in close proximity to the study area.

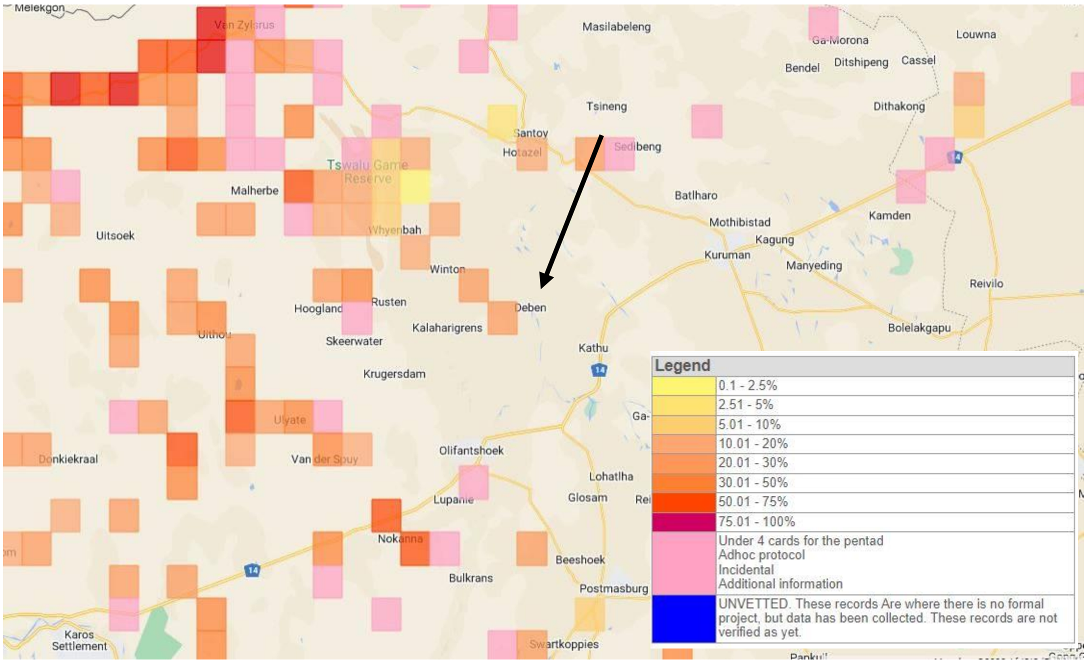

Figure 17: The occurrence of White-backed Vulture (*Gyps africanus*) on the study area according to SABAP2 reporting rates (the arrow indicates the position of the study area). Note the presence of vultures to the west and southwest of the study area (map courtesy and copyright of SABAP2 and Animal Demography Unit).

4.3.2 Notes on the occurrence of Secretarybird (Sagittarius serpentarius)

The conservation status of this species was upgraded from Vulnerable to Endangered since recent evidence suggested that it has experienced rapid declines across its entire range due to habitat loss, anthropogenic disturbances, and intensive grazing (Birdlife International, 2020). Secretarybirds are widespread in Africa south of the Sahara, but have declined over most of their geographic distribution range due to the loss of suitable habitat caused by inappropriate grazing regimes (resulting in the expansion of woody vegetation), cultivation and urbinazation. The expansion of woody vegetation often result in a reduction of suitable foraging habitat and foraging efficacy (Birdlife International, 2020). In addition, it is also highly susceptible to collision with electrical cables of powerlines, with over 94 powerline fatalities recorded over the past 20 years in South Africa. Based on reporting rates, this species appear to be more largely absent from the study area, with high reporting rates further to the west and north of the study area (Figure 18), especially in the Tswalu and Witsand areas, and areas west of Postmasburg. The low reporting rates (or absence) of Secretarybirds on the study is probably correlated to the absence of large open areas, in particular open savanna and grassland on the study area since they tend to avoid areas of dense bush or very rocky areas. The high cover abundance of microphyllous shrub (e.g. Senegalia mellifera) on the study area probably displaced this species from utilising the area.

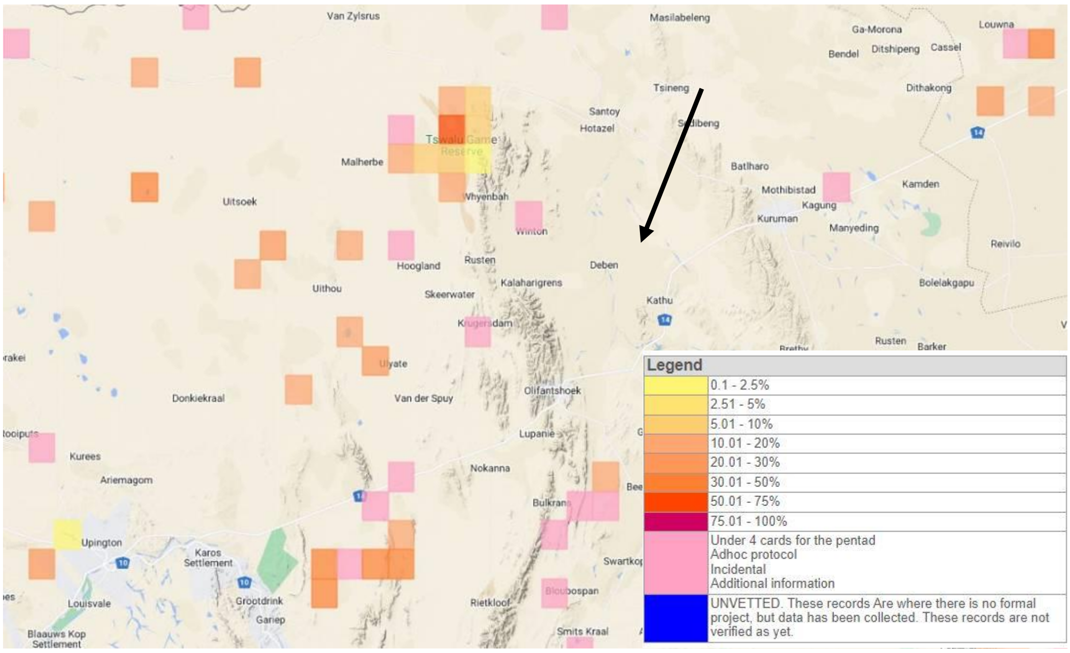

Figure 18: The occurrence of Secretarybirds (*Sagittarius serpentarius*) on the study area according to SABAP2 reporting rates (the arrow indicates the position of the study area). Note the presence of Secretarybirds to the west and southwest of the study area (map courtesy and copyright of SABAP2 and Animal Demography Unit).

4.4 Bird Assemblage Structure and Composition

4.4.1 Summary of point counts

A total of 67 bird species and an average abundance of 631 individuals were recorded from 25 bird points (representing two replicative counts) located on the study area. The data provides an estimate of the bird richness and their numbers on the study site and immediate surroundings obtained during two independent survey sessions. A mean of 17.24 species and 25.24 individuals were recorded per point count. The highest number of species and individuals recorded from a point count was between 28 - 33 species (manly from artificial livestock watering holes and certain pans/depressions) and 66.5 individuals (from artificial watering points). The lowest number of species and individuals was respectively seven species and eight individuals (from dense Kathu Bushveld). The mean frequency of occurrence of a bird species in the study area was 25.73 % and the median was 16.00%, while the most common value (mode) was 4.00%. The latter represents those species that were encountered in only one point count. Three species occurred in all the point counts (c. Black-chested Prinia *Prinia flavicans*, Chestnut-vented Warbler *Curruca subcaerulea* and Kalahari Scrub-robin *Cercotrichas paena*), while 11 species occurred in 50% or more of the counts (Table 5),

Table 5: Bird species with a frequency of occurrence greater than 50% observed on the study area (according to 25 counts).

Species	Frequency (%)	Species	Frequency (%)
Black-chested Prinia (*Prinia flavicans*)	100.00	Chestnut-vented Warbler (*Curruca subcarulea*)	100.00
Kalahari Scrub-robin (*Cercotrichas paena*)	100.00	Violet-eared Waxbill (*Granatina granatina*)	92.00
Yellow-Canary (*Crithagra flaviventris*)	92.00	Scaly-feathered Weaver (*Sporopipes squamifrons*)	88.00
Brown-crowned Tchagra (*Tchagra australis*)	64.00	Desert Cisticola (*Cisticola arudulus*)	60.00
Dusky Sunbird (*Cinnyris fuscus*)	60.00	Sabota Lark (*Calendulauda sabota*)	60.00
Yellow-bellied Eremomela (*Eremomela icteropygialis*	56.00		

4.4.2 Summary of richness and average abundance (per point count)

Displacement of birds by the proposed infrastructure is one of the impacts that is anticipated to occur. By mapping the spatial distribution of the number of species and average abundance values obtained from each point count, it is possible to predict where displacement of birds will be more intensive. According to Figure 19 and Figure 20 it is evident that moderate to high bird numbers (as well as a moderate - high number of bird species) occur at artificial watering points and at some of the pans. In addition, the presence of tall canopy tree was also responsible for an elevated number of bird species (as evidenced on the Kathu Bushveld on deep red sands). Therefore, the potential displacement of birds due to the loss of habitat during construction is likely to occur at habitat which features the availability of surface water and a tall tree canopy.

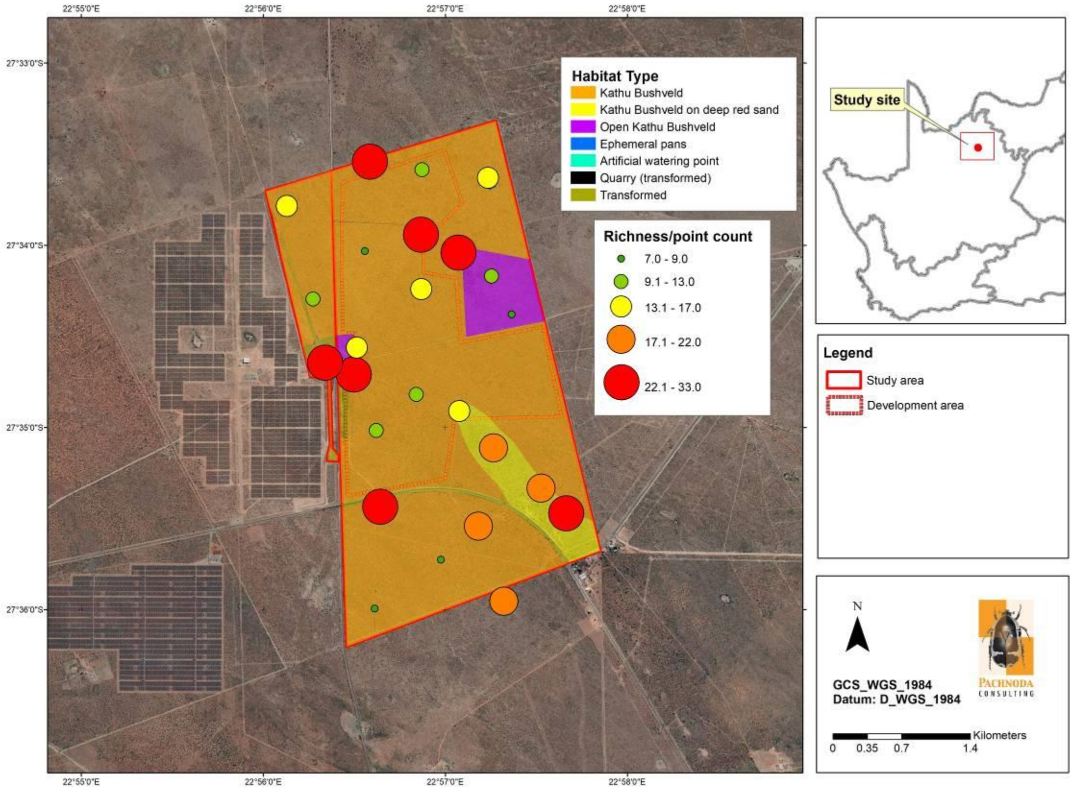

Figure 19: A map of the study area illustrating the spatial distribution of bird richness values (number of species) obtained for each point count.

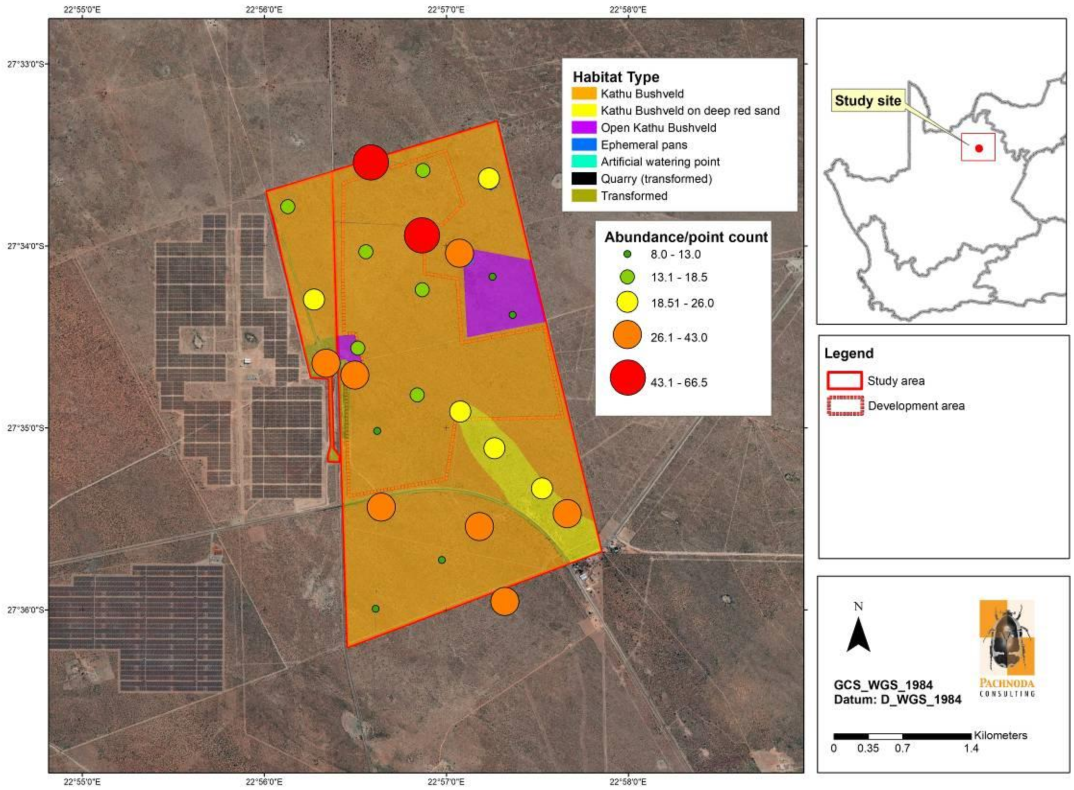

Figure 20: A map of the study area illustrating the distribution of bird abundance values (average number of individuals) obtained for each point count.

4.4.3 Dominance and typical bird species

The dominant (typical) species on the study area are presented in Table 6. Only those species that cumulatively contributed to more than 90% to the overall similarity between the point counts are presented.

The three most typical bird species on the study area include the Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcaerulea*) and Kalahari Scrub-robin (*Cercotrichas paena*). These species are considered widespread species in the broader study area and occur in most of the habitat types that area present. It is also evident from Table 6 that the typical bird assemblage is predominantly represented by insectivores (insect-eating) and by granivores (seed-eating taxa).

Table 6: Typical bird species on the study area.

Species	Av.Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
Black-chested Prinia (*Prinia flavicans*)	3.02	2.77	14.41	Insectivore: upper canopy foliage gleaner
Chestnut-vented Warbler (*Curruca subcaerulea*)	2.44	3.07	13.68	Insectivore: upper canopy foliage gleaner

Kalahari Scrub-robin (*Cercotrichas paena*)	1.70	3.26	12.47	Insectivore: upper canopy foliage gleaner
Violet-eared Waxbill (*Granatina granatina*)	1.54	1.89	9.97	Granivore: upper to lower canopy gleaner
Yellow Canary (*Crithagra flaviventris*)	1.60	1.88	9.56	Granivore: upper to lower canopy gleaner
Scaly-feathered Weaver (*Sporopipes squamifrons*)	2.34	1.54	8.73	Granivore: upper to lower canopy gleaner
Desert Cisticola (*Cisticola aridulus*)	0.38	0.69	3.73	Insectivore: upper canopy foliage gleaner
Brown-crowned Tchagra (*Tchagra australis*)	0.52	0.74	3.60	Insectivore: upper canopy foliage gleaner

4.4.4 Composition and diversity

Multidimensional scaling and hierarchical agglomerative clustering ordination of bird abundance values obtained from 25 point counts on the study area differentiate between three discrete bird associations (Global R= 0.56, p=0.001; Figure 21), with statistically significant differences due to the presence of surface water and canopy height. These include (1) an association on short Kathu Bushveld, (2) an association pertaining to tall Kathu Bushveld on red sands ("parkland") and (3) an association confined pans and the presence of surface water.

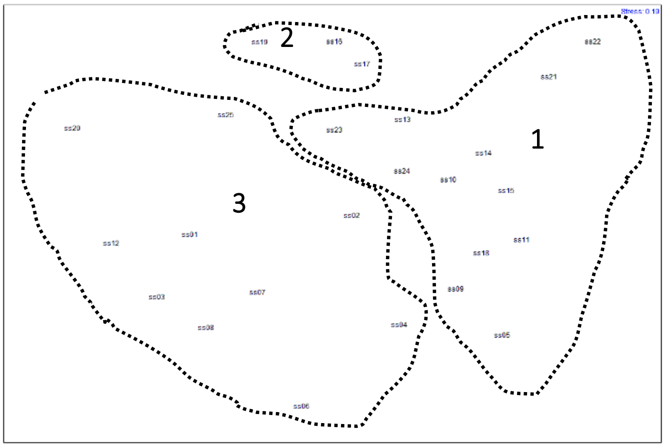

Figure 21: A two-dimensional non-metric multidimensional scaling ordination (stress=0.19) of the relative abundances of bird species based on Bray-Curtis similarities obtained from 25 point counts on the project area. It differentiates between three bird associations: (1) an association on short Kathu Bushveld, an (2) association pertaining to tall Kathu Bushveld on red sand and (3) an association confined to pans and the presence of surface water

The following bird associations are relevant to the study site and immediate surroundings:

1. Association on short Kathu Bushveld

Dominant species: The Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcaerulea*), Kalahari Scrub-robin (*Cercotrichas paena*), Violet-eared Waxbill (*Granatina granatina*), Green-winged Pytilia (*Pytilia melba*), Shaft-tailed Whydah (*Vidua regia*), Dusky Sunbird (*Cynnyris fuscus*) and African Red-eyed Bulbul (*Pycnonotus nigricans*).

Indicator species[10]: Mainly African Red-eyed Bulbul (*P. nigricans*) and Violet-eared Waxbill (*Granatina granatina*), which occur in high numbers.

2. Association on open tall Kathu bushveld on red sand

Dominant species: The Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcaerulea*), Kalahari Scrub-robin (*Cercotrichas paena*), Violet-eared Waxbill (*Granatina granatina*), Pririt Batis (*Batis pririt*), Scaly-feathered Weaver (*Sporopipes squamifrons*), Yellow Canary (*Crithagra flaviventris*) and Dusky Sunbird (*Cynnyris fuscus*).

Indicator species: Ashy Tit (*Melaniparus cinerascens*), Marico Sunbird (*Cinnyris mariquensis*), Orange-river White-eye (*Zosterops pallidus*) and Brubru (*Nilaus afer*).

3. Association on pans and at surface water

Dominant species: The Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcaerulea*), Kalahari Scrub-robin (*Cercotrichas paena*), Violet-eared Waxbill (*Granatina granatina*), Pririt Batis (*Batis pririt*), Scaly-feathered Weaver (*Sporopipes squamifrons*), Yellow Canary (*Crithagra flaviventris*) and Dusky Sunbird (*Cynnyris fuscus*) - similar to tall Kathu Bushveld.

Indicator species: Black-throated Canary (*Crithagra atrogularis*), Red-billed Quelea (*Quelea quelea*), Burchell's Sandgrouse (*Pterocles burchelli*), Namaqua Sandgrouse (*Pterocles namaqua*), Zitting Cisticola (*Cisticola juncidis*) and Cape Sparrow (*Passer melanurus*).

The highest number of bird species on the study area was observed from pans and areas with surface water, followed by the bird association on tall Kathu Bushveld (Table 7). The lowest number of bird species was recorded from dense short Kathus Bushveld.

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[10] Indicator species refers to a species with high numbers that is restricted to a particular habitat.

Table 7: A summary of the observed species richness and number of bird individuals confined to the bird associations on the study area.

Bird Association	Number of species	Number of Individuals	Shannon Wiener Index H'(log_e)
Short Kathu Bushveld	32	11.72	0.96
Tall Kathu Bushveld (on red sand)	34	10.26	0.98
Pans and presence of surface water	52	13.47	0.97

4.5 Passerine bird densities

Forty-nine passerine bird species were recorded from 25 point counts on the study area. The study area comprises of approximately 19.64 species.ha^{-1} (Appendix 2). The average density per hectare is 28.21 birds.ha^{-1} and ranges between 10.26 birds.ha^{-1} to 66.03 birds.ha^{-1}.

4.6 Movements/dispersal of Collision-prone birds

The only deterministic daily flight routes were from two sandgrouse species (c. Burchell's Sandgrouse *Pterocles burchelli* and Namaqua Sandgrouse *Pterocles namaqua*), which arrive in the mornings to drink at one of the artificial livestock watering holes on the study area, especially during the dry season (Figure 22). This particular artificial watering hole is approximately 50m from the proposed PV arrays, whereby it is recommended that bird flight diverters be applied to the panels nearest to the watering hole in order to minimise the potential interaction (collision trauma) of commuting sandgrouse individuals with the panels and associated infrastructure. The only other **regular** waterbird that occur in the area is the South African Shelduck (*Tadorna cana*), which could also potentially collide with the PV infrastructure when visiting inundated pans or artificial watering holes in the area (Figure 22).

In addition, the home ranges of approximately 10 pairs of Red-crested Korhaan (*Lophotis ruficrista*) and two pairs of Northern Black Korhaan (*Afrotis afraoides*) correspond to the study area (Figure 23). The proposed PV arrays coincide with at least three pairs of Red-crested Korhaan and one pair of Northern Black Korhaan, which have a high probability to become displaced due to the loss of habitat (Figure 23).

Other collision-prone species that is resident on the study area include a pair of Pale Chanting Goshawks (*Melierax canorus*) and two pairs of Gabar Goshawk (*Micronisus gabar*) (Figure 22).

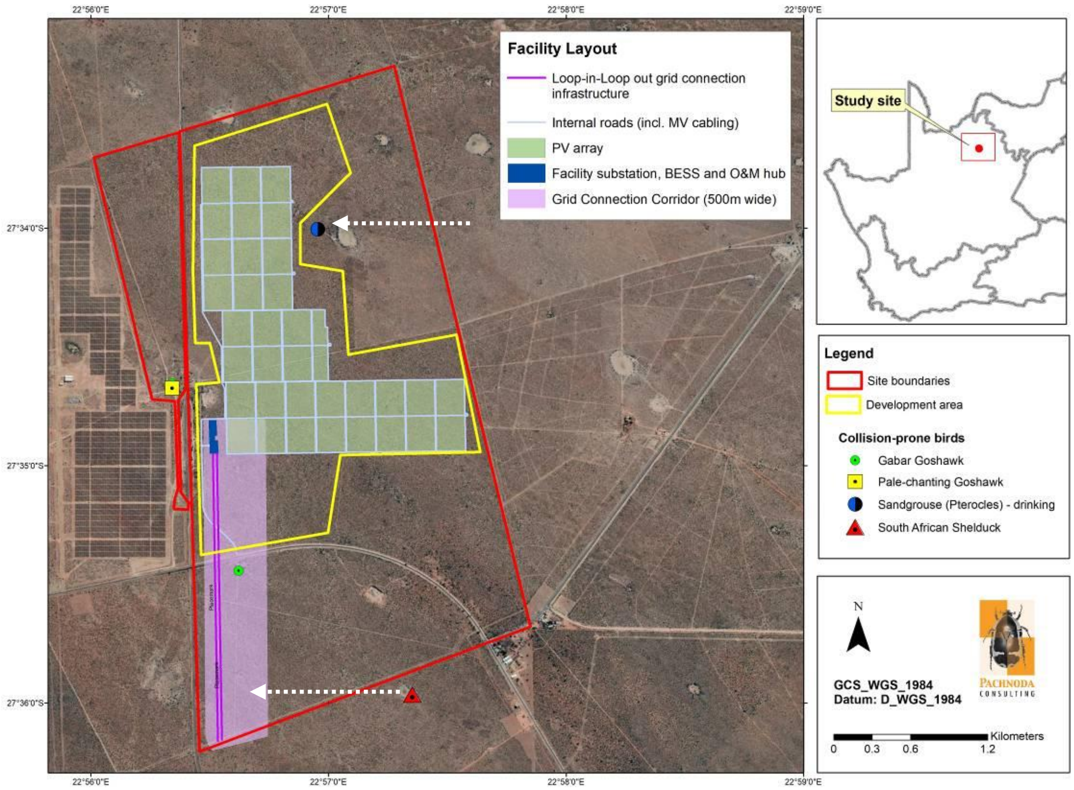

Figure 22: A map of the study site illustrating the occurrence and movements of collision-prone birds.

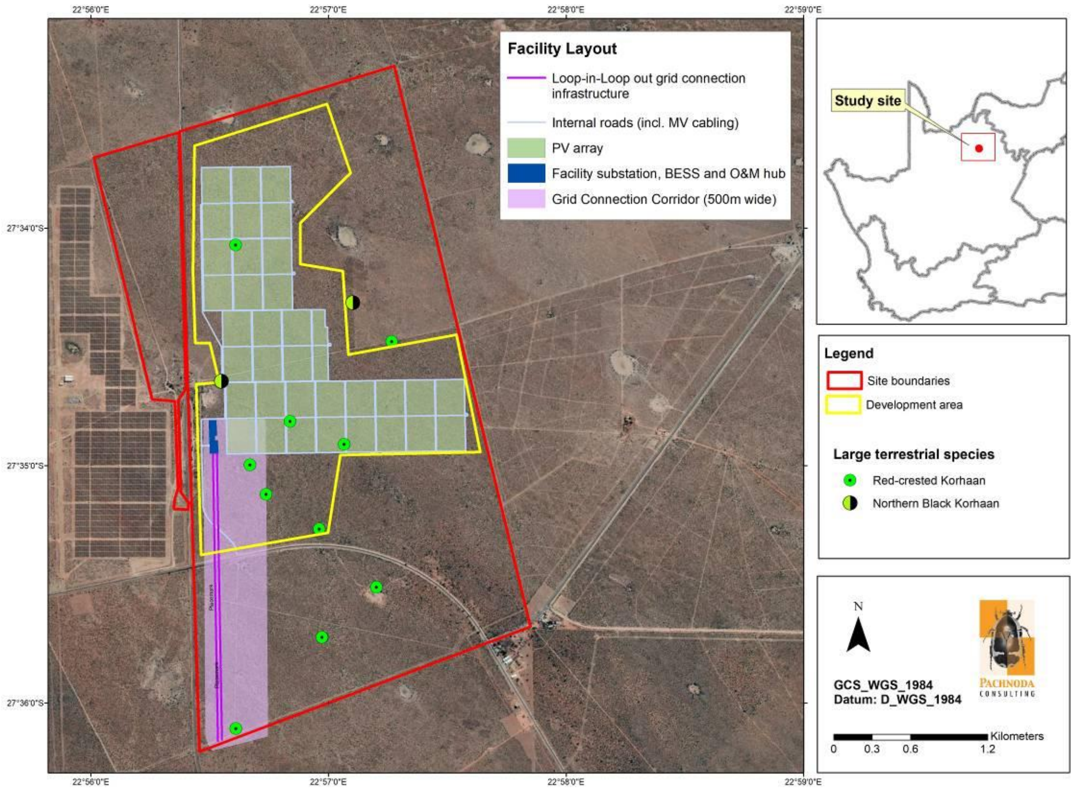

Figure 23: A map of the study area illustrating the occurrence of collision prone terrestrial bird species.

4.7 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising of potential sensitive elements based on the following arguments (Figure 24 and Figure 25):

Areas of high sensitivity

The open Kathu Bushveld, ephemeral pans and artificial watering points are considered to be of high avifaunal sensitivity. The open Kathu Bushveld provides potential foraging habitat for large terrestrial bird species such as the Kori Bustard (*Ardeotis kori*), many which are also prone towards collisions with powerlines, although the frequency of occurrence of these species remains low in the area.

The ephemeral pans provide ephemeral foraging opportunities for waterbirds and shorebird taxa, which are rare or absent in the area when these are dry. Many of these species are highly nomadic in the area and may become disorientated by the "lake effect" caused by the PV panels which may result in bird colliding with the panels (and also powerlines). The pans are also important from a functional and dynamic perspective at the landscape level since these form part of an "inter-connected" system or "stepping stones" of pans within the regional context, meaning that environmental conditions at these pans (e.g. water levels, salinity, food availability) are constantly changing depending on precipitation and evaporation. Therefore, none of the pans are exactly similar to each, thereby providing a continuous supply of resources for waterbirds when inundated.

The artificial livestock watering points attract large numbers of granivore passerine and non-passerine bird species, of which many need to drink water on a daily basis (e.g. sandgrouse). The placement of electrical and PV infrastructure in close proximity to these areas could increase potential avian collisions with the infrastructure. These areas are therefore of artificial origin, but could be relocated to other areas.

Areas of medium sensitivity

It includes the Kathu Bushveld (including Kathu Bushveld on deep red sands) which are prominent in the region and provides potential suitable foraging habitat for some collision-prone bird species, including the Northern Black Korhaan (*Afrotis afraoides*) and Red-crested Korhaan (*Lophotis ruficrista*) with the potential to interact (e.g. collide) with the proposed electrical infrastructure. In addition, reporting rates for threatened and near threatened bird species are anticipated to be relatively low in this unit, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat is natural. In addition, Kathu Bushveld is widespread in the region.

The Kathu Bushveld on deep red sands is expected to sustain a higher number of bird species when compared to the other units.

Areas of low sensitivity

These habitat units are represented by transformed types and roads, homesteads and quarries.

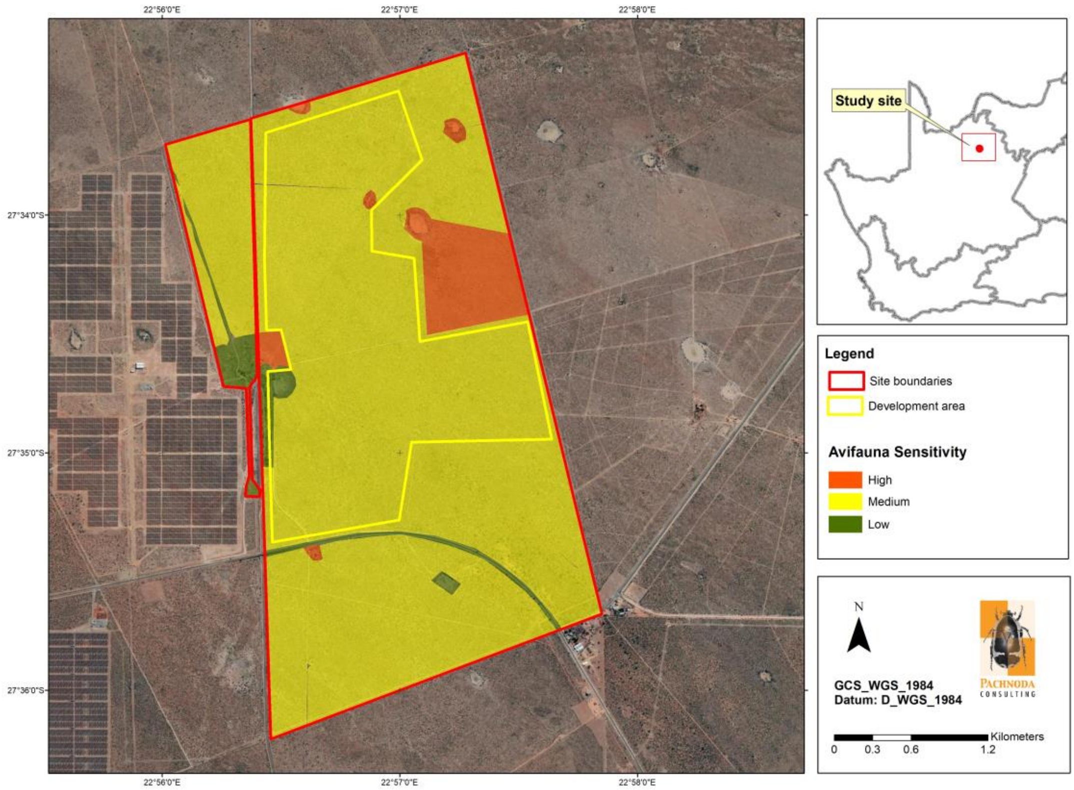

Figure 24: A map illustrating the avifaunal sensitivity of the study and development areas based on habitat types supporting bird taxa of conservation concern and important ecological function.

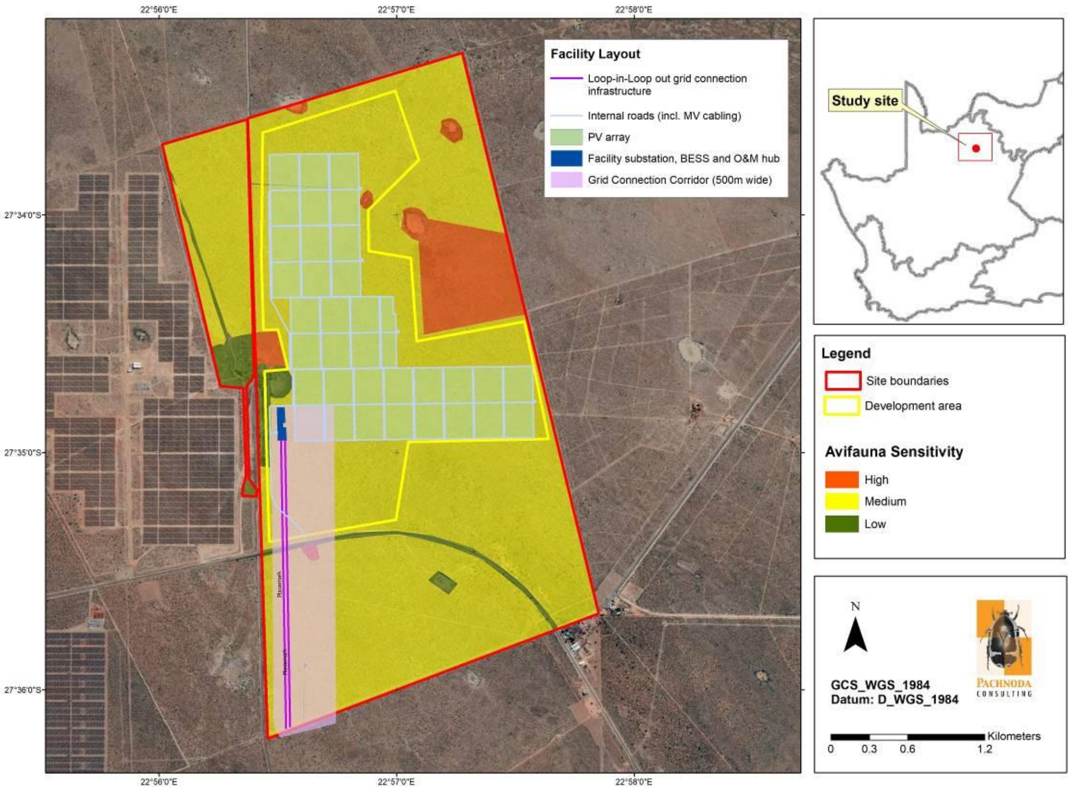

Figure 25: A map illustrating the avifaunal sensitivity of the study and development areas relative to the proposed facility infrastructure.

4.8 Overview of Avian Impacts at Solar Facilities

4.8.1 Background to solar facilities and their impact on birds

Birds are mobile, and are therefore also more readily affected by solar facilities than other taxonomic groups (e.g. mammals). In fact, birds are also vulnerable to impacts caused by other types of energy facilities such as overhead power lines and wind farms. Little information is available on the impacts of solar energy facilities on birds although Gunerhan *et al.* (2009), McCrary *et al.* (1986), Tsoutsos *et al.* (2005) and the recent investigation reports on bird fatalities in the USA by Kagen *et al*. (2014) and Walston *et al*. (2016) provide discussions thereof. These studies have shown that avian fatalities vary greatly between the geographic positions of the solar facilities and also depend on the type of solar facility. In addition, very few of the large solar facilities in operation undertake systematic monitoring of avian fatalities, which explains the lack of detailed information of avian impacts. According to these studies conducted at both Concentrated Solar Power (CSP) and PV facilities, avian incidental fatalities range from 14 to over 180 birds which were summarised over a survey period conducted during one to three years. According to the Walston *et al.* (2016) assessment, the average annual mortality rate for known utility-scale solar facilities (the annual number of estimated bird deaths per megawatt of electrical capacity) is 2.7, and 9.9 for known and unknown fatalities (which include carcasses found on the project site of which the death is not known). McCrary *et al.* (1986) found an average rate of mortality of 1.9-2.2 birds per week affecting 0.6-0.7% of the local bird population. However, most of the avian fatalities at these solar facilities are also probably underestimated since 10-30% of dead birds are removed by scavengers before being noted. From these analyses and assessments it was evident that:

- Medium levels of bird fatalities occur at PV sites when compared to CSP sites (due to solar flux-based mortalities associated with CSP sites).
- Approximately 81 % of all avian mortalities were caused by collisions, including collisions with electrical distribution lines.
- Most of the mortalities were small passerines (especially swallows).
- Fatalities at these solar facilities also include waterbirds (e.g. grebes, herons and gulls) which were probably attracted by the apparent "lake effect" caused by the reflective surface of the PV panels.
- Approximately 10-11 % of the fatalities consists of waterbirds, but could be as high as 49 % at certain facilities.
- It is unclear if the "lake effect" caused by the panels (at PV facilities) or mirrors (at CSP facilities) are the main cause of birds colliding or interacting with the infrastructure (since both waterbirds and other passerines are colliding with the infrastructure).
- Most of the fatalities are of resident birds as opposed to migratory species.

In a review report by Harrison *et al.* (2016), an attempt was made to provide evidence of the impacts caused by solar PV facilities alone (not combined with CSP facilities) on birds in the UK. These authors reviewed approximately 420 scientific documents, including 37 so-called "grey" literature from non-government and government organisations for any evidence relating to the ecological impacts of solar PV facilities. Their main findings were as follows:

- The majority of the documents were not relevant and peer-reviewed documents of experimental scientific evidence on avian fatalities were non-existent.
- Results based on carcass searches suggest that the bird collision risk at PV developments are low, although these studies did not take collision by overhead power lines into account.
- Many of the documents recommended that PV developments in close proximity to protected areas should be avoided.
- The PV panels reflect polarised light, which can attract polarotactic insects with potential impact to their reproductive biology. In addition, the polarising effect of the PV panels may also induce drinking behaviour in some birds, which may mistake the panels for water.
- They conclude that impact assessment reports should consider taxon-specific requirements of birds and their guilds.

4.8.2 Impacts of PV solar facilities on birds

The magnitude and significance of impacts to birds caused by solar facilities will depend on the following factors:

- The geographic locality of the planned solar facility;
- The size or surface extent of the solar facility;
- The type of solar facility (according to the technologies applied, e.g. PV or CSP); and
- The occurrence of collision-prone bird species (which are often closely related to the locality of the solar facility).

Any planned solar facility corresponding to an area with many threatened, range-restricted or collision-prone species will have a higher impact on these birds. In addition, any planned solar facility located in close proximity to important flyways, wetland systems or roosting/nesting sites used by the aforementioned species will have a higher impact.

The main impacts associated with PV solar facilities include (Jenkins *et al*., 2017):

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction;
- Disturbances caused to birds during construction and operation;
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or waterbirds colliding with the panels (as they are mistaken for waterbodies);
- Collision with associated infrastructure (mainly overhead power lines and reticulation); and
- Attracting novel species to the area (owing to the artificial provision of new habitat such as perches and shade) which could compete with the residing bird population.

4.9 Impacts associated with the San Solar PV Solar Energy Facilities

Table 8 provides a summary of the impacts anticipated and quantification thereof (see Appendix 3 for methods used during the assessment of impacts).

4.9.1 Loss of habitat and displacement of birds

Approximately 197.61 ha will be cleared of vegetation and habitat to accommodate the panel arrays and associated infrastructure. Clearing of vegetation will inevitably result in the loss of habitat and displacement of bird species. From the results, approximately 19.64 species.ha^{-1} and 28.21 birds.ha^{-1} will become displaced should the activity occur (as per Jenkins et al., 2017). Displacement will mainly affect regional endemic passerine and smaller non-passerine species inhabiting the Kathu Bushveld habitat of medium avifaunal sensitivity, although at least three pairs of Red-crested Korhaan and one pair of Northern Black Korhaan will become displaced.

The following bird species are most likely to be impacted by the loss of habitat due to their habitat requirements, endemism and conservation status (although not limited to) due to the proposed development:

- Burchell's Sandgrouse (*Pterocles burchelli*);
- Namaqua Sandgrouse (*Pterocles namaquus*)
- Fawn-colored Lark (*Calendulauda africanoides*);
- Kori Bustard (*Ardeotis kori*) - low potential;
- Layard's Warbler (*Curruca layardi*) - rare on study area;
- Pale Chanting Goshawk (*Melierax canorus*);
- Red-crested Korhaan (*Lophotis ruficrista*);
- Northern Black Korhaan (*Afrotis afraoides*);
- Kalahari Scrub Robin (*Cercotrichas paena*);
- White-backed Mousebird (*Colius colius*);
- Southern Pied Babbler (*Turdoides bicolor*) - uncommon on study area;
- Rufous-eared Warber (*Malcorus pectoralis*);
- Orange River Francolin (*Scleroptila gutturalis*).

4.9.2 Creation of "new" avian habitat and bird pollution

It is possible that the PV infrastructure (during operation) could attract bird species which may occupy the site or interact with the local bird assemblages in the wider region. These include alien and cosmopolitan species, as well as aggressive omnivorous passerines which could displace other bird species from the area:

- House Sparrow (*Passer domesticus*);
- Pied Crow (*Corvus albus*); and
- Speckled Pigeon (*Columba guinea*).

The infrastructure may attract large numbers of roosting columbid taxa, especially Speckled Pigeons (*Columba guinea*), which may result in avian "pollution" through excreta, thereby fouling the panel surfaces. The impact is manageable and will result in a low significance.

4.9.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The presence of surface water in close proximity to the study area consisted of a few small ephemeral pans and artificial livestock watering holes, with an absence of any large impoundments or perennial rivers. This explains the low occurrence of waterbird and shorebird taxa on the study area. The only waterbirds with a high frequency of occurrence which could interact with the PV panels are the Egyptian Goose (*Alopochen aegyptiaca*), South African Shelduck (*Tadorna cana*), African Sacred Ibis (*Threskiornis aethiopicus*) and potentially also White-faced Whistling Duck (*Dendrocygna viduata*). The high ephemeral nature of the pans and irregular rainfall patterns makes predictions regarding the occurrence of waterbird species and their numbers (e.g. density) in the area inconceivable. In addition, two sandgrouse species (c. Burchell's Sandgrouse *Pterocles burchelli* and Namaqua Sandgrouse *Pterocles namaqua*) could also interact with the PV panels when attempting to drink at these artificial watering holes. Some of the PV panel arrays will be located within 50m from such a watering hole which was regularly visited by sandgrouse (mainly arriving from the east).

Desktop results and site observations show that the following species could interact with the panel infrastructure:

- Burchell's Sandgrouse (*Pterocles burchelli*)
- Namaqua Sandgrouse (*Pterocles namaqua*)
- South African Shelduck (*Tadorna cana*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- White-faced Duck (*Dendrocygna viduata*);
- African Sacred Ibis (*Threskiornis aethiopicus*) and potentially also
- Little Grebe (*Tachybaptus ruficollis*);
- Black-headed Heron (*Ardea melanocephala*);
- Red-billed Teal (*Anas erythrorhynchus*);
- Cape Teal (*Anas capensis*); and
- Black-winged Stilt (*Himantopus himantopus*).

4.9.4 Interaction with overhead powerlines and reticulation

The grid connection will consists of an overhead Loop-in-Loop out (LILO) connection to the existing Umtu 132kV powerline. The length of the LILO connection is approximately 2.3km and will be positioned parallel to existing Eskom powerlines. Birds are impacted in three ways by means of overhead powerlines (described below). It is however a common rule that large and heavy-bodied terrestrial bird species are more at risk of being affected in a negative way when interacting with powerlines in general. These include the following:

- *Electrocution*

Electrocution happens when a bird bridges the gap between the live components or a combination of a live and earth component of a power line, thereby creating a short circuit. This happens when a bird, mainly a species with a fairly large wingspan attempts to perch on a tower or attempts to fly-off a tower. Many of these species include vultures (of the genera *Gyps* and *Torgos*) as well as other large birds of prey such as the Martial Eagle (*Polemaetus bellicosus*) (Ledger & Annegarn, 1981; Kruger, 1999; Van Rooyen, 2000). These species will attempt to roost and even breed on the tower structures if available nesting platforms are a scarce commodity in the area. Other types of electrocutions happen by means of so-called “bird-streamers”. This happens when a bird, especially when taking off, excretes and thereby causes a short-circuit through the fluidity excreta (Van Rooyen & Taylor, 1999).

Large transmission lines (from 220 kV to 765 kV) are seldom a risk of electrocution, although smaller distribution lines (88 – 132kV) pose a higher risk. However, for this project, the design of the pylon is an important consideration in preventing bird electrocutions.

Collision

Collisions with earth wires have probably accounted for most bird-powerline interactions in South Africa. In general, the earth wires are much thinner in diameter when compared to the live components, and therefore less visible to approaching birds. Many of the species likely to be affected include heavy, large-bodied terrestrial species such as bustards, korhaans and a variety of waterbirds that are not very agile or manoeuvrable once airborne. These species, especially those with the habit of flying with outstretched necks (e.g. most species of storks) find it difficult to make a sudden change in direction while flying – resulting in the bird flying into the earth wires.

Areas where bird collisions are likely to be high could be ameliorated by marking the lines with appropriate bird deterrent devices such as “bird diverters” and “flappers” to increase the visibility of the lines.

- *Physical disturbances and habitat destruction caused during construction and maintenance*

It is anticipated that part of the LILO servitude will be cleared of vegetation. In addition, construction activities go hand in hand with high ambient noise levels. Although construction is considered temporary, many species will vacate the area during the construction phase and will become temporarily displaced.

Table 8: The quantification of impacts associated with the proposed PV facility and its infrastructure.

1. Nature: Losses of natural habitat and displacement of birds through physical transformation, modifications, removals and land clearance. This impact is mainly restricted to the construction phase and is permanent.		
PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Moderate (6)
Probability	Definite (5)	Highly Probable (4)
Significance	**Medium (60)**	**Medium (48)**

Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: It is difficult to mitigate against the loss of habitat since clearing of vegetation (or habitat) will be required for the infrastructure associated with the project. The PV facility and associated infrastructure occur predominantly on habitat types of medium sensitivity. The best practicable mitigation will be to consolidate infrastructure (e.g. proposed powerline) to areas where existing impacts occur (e.g. placing the proposed powerline alongside existing powerlines).		
Residual: Decreased bird species richness, low evenness values and subsequent loss of avian diversity on a local scale. The impact will also result in sterilisation of local landscapes and increased fragmentation of habitat.		

2. Nature: The creation of novel or new avian habitat for commensal bird species or superior competitive species. This is expected to occur during the operation phase of the facility.		
PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Footprint (1)	Footprint (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Low (18)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, with experimentation	Yes
Mitigation: Apply bird deterrent devices and remove nest structures constructed on infrastructure associated with the PV facility under the guidance of the ECO.		
Residual: Secondary displacement by completive bird species such as crows and increased fecundity rate for commensal bird species that are adapted to anthropogenic activities. The impact is regarded as low.		

3. Nature: Avian collision impacts related to the PV facility during the operation phase (collision with the PV panels).		
PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Moderate (6)
Probability	Highly Probable (4)	Probable (3)
Significance	**Medium (56)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, potential loss of endemic/near-endemic waterfowl and sandgrouse	Yes, potential loss of endemic/near-endemic waterfowl and sandgrouse

	species.	species.
Can impacts be mitigated?	Yes, with experimentation	Yes, with experimentation

Mitigation:
Apply bird deterrent devices such as rotating flashers/reflectors to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels - these should especially be placed at panels nearest to pans and watering points. Security/CCTV cameras may be installed to quantify mortalities (cameras are also installed along the perimeter fence for security measures and may also proved effective to quantify mortalities). Buffer pans by at least 200-300m (arrays should be positioned at least 200-300m away from pans). If post-construction monitoring predicts and/or confirms any bird mortalities, an option is to employ video cameras at selected areas to document bird mortalities and to conduct direct observations and carcass searches on a regular and systematic basis. If bird mortalities occur at watering points, it is recommended that the watering hole be relocated (at least 300m from the PV arrays - preferred recommendations) or the watering point should be removed.

Residual:
Direct mortality is possible and may still occur irrespective of applied mitigation measures. Regular and systematic monitoring is proposed to assess the efficacy of applied mitigation and further research and testing is suggested to improve mitigation measures (e.g. bird deterrent devices). The residual impact is regarded as moderate.

4. Nature:
Avian collision impacts related to overhead power lines during operation.

LILO Corridor	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Minor (2)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.	Yes
Can impacts be mitigated?	Yes	Yes

Mitigation:
Apply bird deterrent devices to the power lines and make use of "bird-friendly" pylon structures. Avoid the placement of any watering points in close proximity to any overhead electrical infrastructure in order to avoid attracting birds of prey or scavenger species to the study site. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to conduct direct observations and carcass searches on a regular and systematic basis. Collisions will be reduced if the LILO corridor is placed alongside existing powerlines.

Residual:
Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be low.

5. Nature:
Avian electrocution related to the new distribution lines during operation.

LILO Corridor	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)

Probability	Probable (3)	Probable (3)
Significance	**Low (30)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: Avoid the placement of watering points in close proximity to any overhead electrical infrastructure in order to avoid attracting birds of prey or scavenger species such as vultures to the study area. Make use of bird-friendly pylons and bird guards as recommended by EWT.		
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be low.		

4.9.5 Collision-prone bird species

A total of 34 collision-prone bird species have been recorded in the wider study area, of which 13 species are birds of prey and eight are waterbirds/shorebird taxa (Table 9). Collision-prone species with the highest probability to occur along the power-line servitude includes the Helmeted Guineafowl (*Numida meleagris*), Pale-chanting Goshawk (*Melierax canorus*), Speckled Pigeon (*Columba guinea*), Pied Crow (*Corvus albus*), Namagua Sandgrouse (*Pterocles namaqua*), Burchell's Sandgrouse (*P. burchellii*), Red-crested Korhaan (*Lophotis ruficrista*), Gabar Goshawk (*Micronisus gabar*) and Northern Black Korhaan (*Afrotis afraoides*). Four of the 34 species are regionally threatened and include the endangered Martial Eagle (*Polemaetus bellicosus*), vulnerable Lanner Falcon (*Falco biarmicus*), critically endangered White-backed Vulture (*Gyps africanus*) and near threatened Kori Bustard (*Ardeotis kori*) (sensu Taylor et al., 2015).

Table 9: Collision-prone bird species expected to be present on the study area and inferred from the South African Atlas Project (SABAP2).

Common Name	Scientific Name	SABAP2 Reporting Rate
African Sacred Ibis	*Threskiornis aethiopicus*	2.22
Black-chested Snake Eagle	*Circaetus pectoralis*	11.11
Black-winged Kite	*Elanus caeruleus*	2.22
Black-winged Stilt	*Himantopus himantopus*	4.44
Burchell's Sandgrouse	*Pterocles burchelli*	8.89
Cape Teal	*Anas capensis*	6.67
Common (=Steppe) Buzzard	*Buteo buteo vulpinus*	2.22
Egyptian Goose	*Alopochen aegyptiaca*	4.44
Gabar Goshawk	*Micronisus gabar*	15.56
Greater Kestrel	*Falco rupicoloides*	4.44

Common Name	Scientific Name	SABAP2 Reporting Rate
Hadada Ibis	*Bostrychia hagedash*	24.44
Helmeted Guineafowl	*Numida meleagris*	68.89
Jackal Buzzard	*Buteo rufofuscus*	2.22
Kori Bustard	*Ardeotis kori*	2.22
Lanner Falcon	*Falco biarmicus*	2.22
Little Grebe	*Tachybaptus ruficollis*	4.44
Martial Eagle	*Polemaetus bellicosus*	2.22
Namaqua Sandgrouse	*Pterocles namaqua*	17.78
Northern Black Korhaan	*Afrotis afraoides*	22.22
Orange River Francolin	*Scleroptila gutturalis*	4.44
Pale Chanting Goshawk	*Melierax canorus*	35.56
Pied Crow	*Corvus albus*	26.67
Red-billed Spurfowl	*Pternistis adspersus*	13.33
Red-billed Teal	*Anas erythrorhyncha*	2.22
Red-crested Korhaan	*Lophotis ruficrista*	24.44
Rock Dove	*Columba livia*	2.22
Rock Kestrel	*Falco rupicolus*	4.44
South African Shelduck	*Tadorna cana*	8.89
Speckled Pigeon	*Columba guinea*	33.33
Spotted Eagle-Owl	*Bubo africanus*	2.22
Western Barn Owl	*Tyto alba*	17.78
Western Cattle Egret	*Bubulcus ibis*	8.89
White-backed Vulture	*Gyps africanus*	n/a
White-faced Whistling Duck	*Dendrocygna viduata*	2.22

4.10 Cumulative Impacts

Cumulative impacts are defined as impacts that result from additional or incremental activities caused by past or present actions together with the current project. Therefore, cumulative impacts are those that will affect the general avifaunal community on the study area due to other planned solar farm projects and electrical infrastructure in the region.

Three (3) solar facilities have been constructed in the broader area. These include the Sishen Solar PV and Kathu Solar PV facilities located immediately west of the farm Remaining extent of the Farm Wincanton 472. The Kathu Solar facility is a CSP facility located to the east of the study area.

The cumulative impacts are likely to increase the displacement and loss of habitat. In addition while the grid connection (via overhead powerlines) of these facilities could potentially contribute towards bird strikes with powerlines and avian mortalities due to collision in the region.

A summary of the cumulative impacts is provided in Table 10.

Table 10: A summary of the cumulative impacts.

1. Nature: Regional losses of natural habitat and subsequent displacement of birds.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Moderate (6)
Probability	Definite (5)	Definite (5)
Significance	**Medium (60)**	**High (65)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	No	
Confidence in findings: High.		
Mitigation: It is difficult to mitigate against the loss of habitat without considering alternative sites. The best practicable mitigation will be to consolidate infrastructure (e.g. proposed powerline) to areas where existing impacts occur (e.g. placing the proposed powerline alongside existing powerlines).		
2. Nature: Avian collision impacts related to the PV facility during the operational phase (collision with the PV panels).		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Highly Probable (4)	Highly Probable (4)
Significance	**Medium (56)**	**Medium (60)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, potential loss of endemic/near-endemic waterfowl and sandgrouse species.	Yes, potential loss of endemic/near-endemic waterfowl and sandgrouse species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Low.		
Mitigation: Apply bird deterrent devices to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to employ video cameras to document any bird mortalities and to conduct direct observations and carcass searches on a regular and systematic basis.		
3. Nature: Avian collision impacts related to the powerline reticulation and new distribution lines during operation.		

	Overall impact of the proposed project considered in isolation	Cumulative impact of the project and other projects in the area
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	Moderate (6)
Probability	Probable (3)	Probable (3)
Significance	**Medium (36)**	**Medium (36)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: High.		
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. **Allow for construction of new powerlines parallel to existing lines**. To aid post-construction monitoring and/or monitoring of bird mortality rates, it is advised to conduct direct observations and carcass searches on a regular and systematic basis. As a priority, all new power lines should be marked with bird diverters.		
4. Nature: Avian electrocution related to the powerline reticulation and new distribution lines during operation.		

	Without mitigation	With mitigation
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Low (30)**	**Low (30)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.	Yes (to some extent), owing to the potential loss of terrestrial bird and certain bird of prey species.
Can impacts be mitigated?	Yes, to some extent	
Confidence in findings: Moderate.		
Mitigation: Apply bird deterrent devices to the power line and make use of "bird-friendly" pylon structures. As a priority, all new power lines should be marked with bird diverters. Make use of bird-friendly pylons and bird guards. **Position electrical infrastructure in close proximity to existing infrastructure**.		

4.11 Recommended avifaunal mitigation

4.11.1 Loss of habitat and displacement bird taxa

It is difficult to mitigate against the loss of habitat when fixed infrastructure is applied. However, proper site selection of the facility is key to reducing the predicted impacts.

The following mitigation measures are proposed:

- Concentrate all surface infrastructure on habitat of medium to low avifaunal sensitivity. The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.
- Where possible, existing access roads should be used and the construction of new roads should be kept to a minimum.
- Prevent an overspill of construction activities into areas that are not part of the proposed construction site.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.
- All internal electrical reticulation should be placed underground, while the alignment of the power line and substation should be placed parallel to existing powerlines lines.

4.11.2 Creation of "new" avian habitat and bird pollution

The following mitigation measures are proposed:

- Apply bird deterrent devices at selective areas (for example at the corners and middle part of the facility) to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed under the guidance of the ECO.
- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.

4.11.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The following mitigation measures are proposed:

- Apply bird deterrent devices to the panels at selective areas (for example at the corners and middle part of the facility) to discourage birds from colonising/colliding with the infrastructure. Bird deterrent devices should especially be placed at panels nearest to ("facing") pans and watering points These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, flashers, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. An option is to employ video cameras at selected areas to document bird mortalities.

- Buffer pans by at least 200-300m (arrays should be positioned at least 200-300m away from pans).
- Apply systematic reflective/dynamic markers to the boundary fence to increase the visibility of the fence for approaching birds (e.g. korhaan taxa) and to avoid potential bird collisions with the fence structure.
- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.
- If bird mortalities occur at watering points (e.g. one of the watering points is within 50m of the proposed PV arrays), it is recommended that the watering hole be relocated (at least 300m from the PV arrays - preferred recommendations) or the watering point should be removed.

4.11.4 Power line interaction: collision and electrocution with power lines

The following mitigation measures are proposed:

- All internal electrical infrastructure and cabling should be placed underground.
- Avoid the placement any livestock watering points in close proximity to overhead electrical infrastructure. A safe distance of at least 100 m from any overhead powerline is recommended.
- EWT should be consulted on an appropriate pylon design to be used for the project (if pylons are to be used). In general, the proposed pylon design must incorporate the following design parameters:
  - The clearances between the live components should be as wide as possible within the design limitations/capabilities of the power line.
  - The height of the tower should allow for unrestricted movement of terrestrial birds between successive pylons.
  - The live components should be “bundled” to increase the visibility for approaching birds.
  - “Bird streamers” should be eliminated by discouraging birds from perching above the conductors. In addition, conductors should be strung below the pole to avoid bridging the air gap by perching birds of prey.

It is therefore recommended that the pylon design incorporates "features as illustrated in Figure 26[11].

From Figure 26 it is clear that perching by birds is discouraged by the addition of diagonal crossbars or by doing away with the crossbars that holds the conductors in place. Bird “streamers” are also eliminated by fitting the poles with bird guards/spikes above the conductors. However, safe perching is facilitated by the fitment of a horizontal bar on top of the pole structure without the risk of electrocution (due to the perpendicular orientation of the bar relative to the conductors).

[11] Please note that these are examples of recommended pylon designs. These are taken from steel monopole pylons.

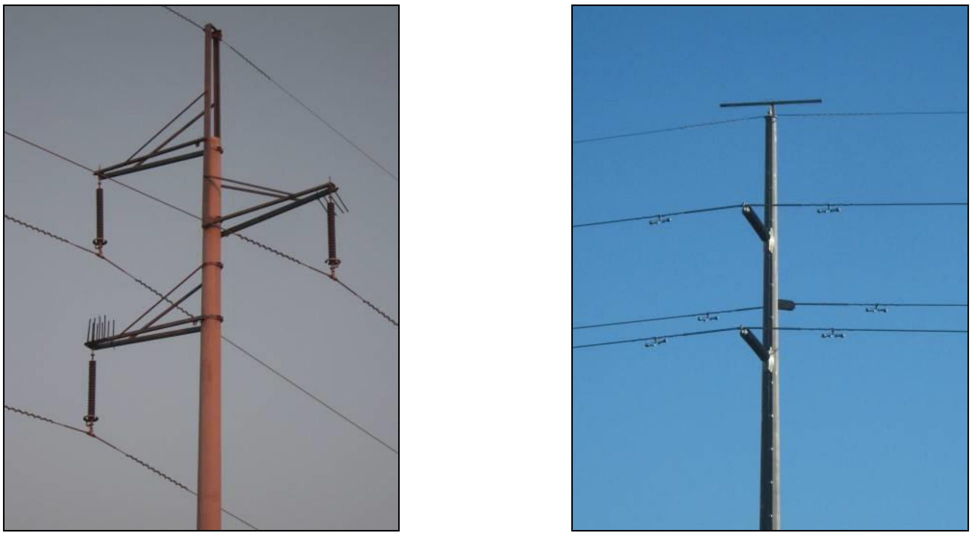

Figure 26: Two bird-friendly tower designs to be considered for the current project.

- All new and planned power lines should be fitted with bird flight diverters (see Figure 27).

Figure 27: Examples of bird flight diverters to be used on the power lines: Double loop bird flight diverter (left) and Viper live bird flapper (right).

4.11.5 General mitigation measures

- All construction sites/areas must be demarcated on site layout plans (preferably), and no construction personnel or vehicles may leave the demarcated area except those authorised to do so. Those areas surrounding the construction sites that are not part of the demarcated development area should be considered as “no-go” areas for employees, machinery or even visitors.
- All road networks must be planned with care to minimise dissection or fragmentation of important avifaunal habitat type. Where possible, the use of existing roads is encouraged.
- Open fires is strictly prohibited and only allowed at designated areas.

- Killing or poaching of any bird species should be avoided by means of awareness programs presented to the labour force. The labour force should be made aware of the conservation issues pertaining to the bird taxa occurring on the study site. Any person found deliberately harassing any bird species in any way should face disciplinary measures, following the possible dismissal from the site.
- Checks must be carried out at regular intervals to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of eroded areas should be undertaken.

4.12 Suggested monitoring and Environmental Management Plan

Information on collision trauma (bird mortalities) and the displacement of birds caused by PV solar facilities is insufficient. Therefore, as per the guidelines of Jenkins *et al.* (2017) it is highly recommended that post construction monitoring be implemented to augment existing data:

- A post-construction survey during operation with a minimum of 3 x 3-5 day surveys over a six month period (including the peak wet season). The surveys aim to obtain mortality data from birds colliding with the panels to advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. The surveys should be conducted in a regular and systematic manner by means of direct observations (and the use of installed video cameras) and carcass searches. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey, sandgrouse and species of conservation concern.
- It is possible that mortalities due to collision will occur at the powerlines even after mitigation. The post-construction monitoring (during operation) should also quantify mortalities caused by the powerline network. Monitoring should be implemented once a month for at least one year. All searches should be done on foot. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

OBJECTIVE 1: Minimize potential collision trauma with infrastructure and augmenting existing information on bird interactions with solar infrastructure

Project Component/s	» PV panel arrays
Potential Impact	» Collision trauma caused by photovoltaic panels (the "lake-effect")
Activity/Risk Source	» Construction and operation of PV infrastructure
Mitigation: Target/Objective	» Zero bird mortalities due to collision trauma caused by PV panels

Mitigation: Action/Control	**Responsibility**	**Timeframe**
• Apply bird deterrent devices to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, flashers, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed.	ECO & OM	Operation (on-going)
• Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.	ECO & OM	Operation (on-going)
• Use indigenous plant species native to the study area during landscaping and rehabilitation.	CER & ECO	Construction phase
• Implement post-construction monitoring and carcass surveys	OM & CER	Directly after construction and during operation - At least 3 surveys, each 3-5 days for a 6 month period
• Compile management programme to assess efficacy of mitigation and on-going research/trials	EM & OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement post-construction surveys during operation with a minimum of 3 x 3-5 day surveys over a six month period (including the peak wet season). • Surveys should coincide with the peak wet season when most of the wetland features in the wider study region are inundated. • Obtain quantified data on waterbird richness and potential flyways, which

	will contribute towards our understanding of impacts related to collision trauma with the panels. • Obtain mortality data from birds colliding with the panels and advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. • Conduct post-construction monitoring in a systematic manner by means of direct observations and the use of installed video cameras and carcass searches. • Implement management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

OBJECTIVE 2: Minimize collisions and electrocution associated with powerlines

Project Component/s	» Overhead powerlines
Potential Impact	» Collision and electrocution caused by powerlines
Activity/Risk Source	» Overhead powerlines
Mitigation: Target/Objective	» Reduced bird mortalities due to collision/electrocution

Mitigation: Action/Control	**Responsibility**	**Timeframe**
• Apply bird deterrent devices to all new powerlines	ECO & CER	Construction
• Implement post-construction monitoring and carcass surveys	OM & CER	Operation - once a month for at least one year
• Compile management programme to assess efficacy of mitigation and on-going research/trials	OM	Operation (on-going)
• Report mortalities (number, locality and species) to Electrical Energy Mortality Register at EWT	OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	• Implement post-construction monitoring to quantify bird mortalities caused by the powerline network. All searches should be done on foot. • Compile a management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

4.13 Analysis of proposed alternatives & an opinion regarding the feasibility of the project

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of San Solar Energy Facility (Pty) Ltd to compile an avifauna impact assessment report for the proposed San Solar PV facility to be located on the Remaining extent of the Farm Wincanton 472, approximately 3km south of Kathu, Northern Cape Province.

Six prominent avifaunal habitat types were identified on the study area, and consisted of three structural variations of Kathu Bushveld, ephemeral pans, artificial livestock watering points and transformed areas consisting of build-up land and quarries. The highest number of bird species and bird individuals were observed from the artificial livestock watering holes and pans, as well as from Kathu Bushveld with a taller tree canopy. Approximately 152 bird species were expected to occur in the wider study area, of which 91 species were observed in the study area during two independent surveys. The expected richness included four threatened or near threatened species, 12 southern African endemics and 31 near-endemic species. These species occurred at low reporting rates (< 3% reporting rates), which suggests that these species are irregular visitors to the area, of which the critically endangered White-backed Vulture (*Gyps africanus*) was observed overhead on a farm adjacent to the study area, while a pair of endangered Martial Eagles (Polemaetus bellicosus) is known from a farm south of the study area. Eight southern African endemics and 24 near-endemic species were confirmed on the study area.

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). However, the risk for certain waterbirds (e.g. shelducks) and sandgrouse species colliding with the PV infrastructure remained eminent due to the presence of surface water (e.g. inundated pans and artificial watering points) on the study area. Post-construction monitoring was recommended along with the installation of appropriate bird diverters and the relocation of artificial watering points to minimise the potential risk of collision trauma in birds.

No fatal-flaws were identified during the assessment, although it was strongly recommended that the proposed mitigation measures and monitoring protocols (e.g. post construction monitoring) be implemented during the construction and operational phase of the project.

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Appendix 1: A shortlist of bird species expected to be present on the study area. The list provides an indication of the species occurrence according to SABAP2 reporting rates. The list was derived (and modified) from species observed in pentad grid 2730_2255 and the eight surrounding grids. The reporting rates include submissions made during the February and May 2022 surveys.

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
432	Acacia Pied Barbet	*Tricholaema leucomelas*	1	82.22	37	16.67	2
341	African Cuckoo	*Cuculus gularis*		2.22	1	0.00	0
424	African Grey Hornbill	*Lophoceros nasutus*	1	46.67	21	16.67	2
418	African Hoopoe	*Upupa africana*		33.33	15	0.00	0
387	African Palm Swift	*Cypsiurus parvus*		22.22	10	0.00	0
692	African Pipit	*Anthus cinnamomeus*		4.44	2	0.00	0
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	91.11	41	16.67	2
81	African Sacred Ibis	*Threskiornis aethiopicus*	1	2.22	1	0.00	0
386	Alpine Swift	*Tachymarptis melba*		4.44	2	0.00	0
575	Ant-eating Chat	*Myrmecocichla formicivora*		15.56	7	0.00	0
514	Ashy Tit	*Melaniparus cinerascens*	1	42.22	19	0.00	0
493	Barn Swallow	*Hirundo rustica*	1	28.89	13	0.00	0
614	Barred Wren-Warbler	*Calamonastes fasciolatus*		4.44	2	0.00	0
344	Black Cuckoo	*Cuculus clamosus*		8.89	4	0.00	0
650	Black-chested Prinia	*Prinia flavicans*	1	88.89	40	25.00	3
146	Black-chested Snake Eagle	*Circaetus pectoralis*		11.11	5	8.33	1
841	Black-faced Waxbill	*Brunhilda erythronotos*	1	37.78	17	0.00	0
245	Blacksmith Lapwing	*Vanellus armatus*		22.22	10	8.33	1
860	Black-throated Canary	*Crithagra atrogularis*	1	15.56	7	0.00	0

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
130	Black-winged Kite	*Elanus caeruleus*		2.22	1	0.00	0
270	Black-winged Stilt	*Himantopus himantopus*		4.44	2	0.00	0
722	Bokmakierie	*Telophorus zeylonus*		2.22	1	0.00	0
381	Bradfield's Swift	*Apus bradfieldi*	1	8.89	4	0.00	0
280	Bronze-winged Courser	*Rhinoptilus chalcopterus*	1	n/a	1	0.00	0
714	Brown-crowned Tchagra	*Tchagra australis*	1	31.11	14	8.33	1
731	Brubru	*Nilaus afer*	1	33.33	15	0.00	0
695	Buffy Pipit	*Anthus vaalensis*		4.44	2	0.00	0
308	Burchell's Sandgrouse	*Pterocles burchelli*	1	8.89	4	0.00	0
531	Cape Penduline Tit	*Anthoscopus minutus*	1	15.56	7	0.00	0
581	Cape Robin-Chat	*Cossypha caffra*		15.56	7	8.33	1
786	Cape Sparrow	*Passer melanurus*	1	77.78	35	0.00	0
737	Cape Starling	*Lamprotornis nitens*	1	80.00	36	16.67	2
98	Cape Teal	*Anas capensis*		6.67	3	0.00	0
316	Ring-necked Dove	*Streptopelia capicola*	1	88.89	40	25.00	3
686	Cape Wagtail	*Motacilla capensis*		51.11	23	8.33	1
450	Cardinal Woodpecker	*Dendropicos fuscescens*		8.89	4	8.33	1
663	Chat Flycatcher	*Melaenornis infuscatus*		2.22	1	0.00	0
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	91.11	41	16.67	2
196	Common Buttonquail	*Turnix sylvaticus*	1	n/a	1	0.00	0
154	Common (=Steppe) Buzzard	*Buteo buteo vulpinus*		2.22	1	0.00	0
734	Common Myna	*Acridotheres tristis*		11.11	5	0.00	0
421	Common Scimitarbill	*Rhinopomastus cyanomelas*	1	31.11	14	0.00	0
378	Common Swift	*Apus apus*		2.22	1	0.00	0

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
594	Common Whitethroat	*Curruca communis*	1	n/a	1	0.00	0
439	Crested Barbet	*Trachyphonus vaillantii*		46.67	21	8.33	1
711	Crimson-breasted Shrike	*Laniarius atrococcineus*	1	77.78	35	16.67	2
242	Crowned Lapwing	*Vanellus coronatus*	1	55.56	25	8.33	1
630	Desert Cisticola	*Cisticola aridulus*	1	13.33	6	0.00	0
352	Diederik Cuckoo	*Chrysococcyx caprius*	1	15.56	7	8.33	1
764	Dusky Sunbird	*Cinnyris fuscus*	1	17.78	8	0.00	0
1183	Eastern Clapper Lark	*Mirafra fasciolata*	1	11.11	5	0.00	0
89	Egyptian Goose	*Alopochen aegyptiaca*		4.44	2	0.00	0
404	European Bee-eater	*Merops apiaster*	1	31.11	14	8.33	1
570	Familiar Chat	*Oenanthe familiaris*	1	20.00	9	0.00	0
459	Fawn-colored Lark	*Calendulauda africanoides*	1	33.33	15	0.00	0
665	Fiscal Flycatcher	*Melaenornis silens*	1	48.89	22	0.00	0
517	Fork-tailed Drongo	*Dicrurus adsimilis*	1	71.11	32	0.00	0
162	Gabar Goshawk	*Micronisus gabar*	1	15.56	7	0.00	0
874	Golden-breasted Bunting	*Emberiza flaviventris*	1	40.00	18	0.00	0
447	Golden-tailed Woodpecker	*Campethera abingoni*		42.22	19	8.33	1
440	Greater Honeyguide	*Indicator indicator*		2.22	1	0.00	0
122	Greater Kestrel	*Falco rupicoloides*		4.44	2	0.00	0
502	Greater Striped Swallow	*Cecropis cucullata*	1	15.56	7	8.33	1
419	Green Wood Hoopoe	*Phoeniculus purpureus*		2.22	1	0.00	0
830	Green-winged Pytilia	*Pytilia melba*	1	31.11	14	0.00	0
339	Grey Go-away-bird	*Crinifer concolor*		0.00	0	8.33	1
485	Grey-backed Sparrow-Lark	*Eremopterix verticalis*		6.67	3	0.00	0

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
557	Groundscraper Thrush	*Turdus litsitsirupa*	1	40.00	18	0.00	0
84	Hadada Ibis	*Bostrychia hagedash*	1	24.44	11	0.00	0
192	Helmeted Guineafowl	*Numida meleagris*	1	68.89	31	8.33	1
784	House Sparrow	*Passer domesticus*		20.00	9	0.00	0
152	Jackal Buzzard	*Buteo rufofuscus*		2.22	1	0.00	0
348	Jacobin Cuckoo	*Clamator jacobinus*	1	11.11	5	0.00	0
586	Kalahari Scrub Robin	*Cercotrichas paena*	1	77.78	35	25.00	3
583	Karoo Scrub Robin	*Cercotrichas coryphoeus*		4.44	2	0.00	0
1104	Karoo Thrush	*Turdus smithi*		31.11	14	0.00	0
217	Kori Bustard	*Ardeotis kori*		2.22	1	8.33	1
114	Lanner Falcon	*Falco biarmicus*		2.22	1	0.00	0
871	Lark-like Bunting	*Emberiza impetuani*		8.89	4	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*	1	71.11	32	25.00	3
659	Layard's Warbler	*Curruca layardi*	1	4.44	2	0.00	0
706	Lesser Grey Shrike	*Lanius minor*	1	26.67	12	0.00	0
442	Lesser Honeyguide	*Indicator minor*		2.22	1	0.00	0
413	Lilac-breasted Roller	*Coracias caudatus*	1	24.44	11	25.00	3
6	Little Grebe	*Tachybaptus ruficollis*		4.44	2	0.00	0
385	Little Swift	*Apus affinis*		35.56	16	8.33	1
621	Long-billed Crombec	*Sylvietta rufescens*	1	37.78	17	0.00	0
852	Long-tailed Paradise Whydah	*Vidua paradisaea*		6.67	3	0.00	0
661	Marico Flycatcher	*Melaenornis mariquensis*	1	44.44	20	8.33	1
755	Marico Sunbird	*Cinnyris mariquensis*	1	44.44	20	8.33	1
142	Martial Eagle	*Polemaetus bellicosus*		2.22	1	8.33	1

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
318	Namaqua Dove	*Oena capensis*	1	51.11	23	16.67	2
307	Namaqua Sandgrouse	*Pterocles namaqua*	1	17.78	8	0.00	0
637	Neddicky	*Cisticola fulvicapilla*	1	8.89	4	0.00	0
1035	Northern Black Korhaan	*Afrotis afraoides*	1	22.22	10	0.00	0
179	Orange River Francolin	*Scleroptila gutturalis*		4.44	2	0.00	0
1171	Orange River White-eye	*Zosterops pallidus*	1	26.67	12	8.33	1
165	Pale Chanting Goshawk	*Melierax canorus*	1	35.56	16	0.00	0
365	Pearl-spotted Owlet	*Glaucidium perlatum*	1	55.56	25	8.33	1
522	Pied Crow	*Corvus albus*	1	26.67	12	33.33	4
674	Pririt Batis	*Batis pririt*	1	48.89	22	0.00	0
415	Purple Roller	*Coracias naevius*		6.67	3	0.00	0
844	Quailfinch	*Ortygospiza atricollis*	1	6.67	3	0.00	0
642	Rattling Cisticola	*Cisticola chiniana*	1	2.22	1	0.00	0
708	Red-backed Shrike	*Lanius collurio*	1	20.00	9	0.00	0
837	Red-billed Firefinch	*Lagonosticta senegala*		4.44	2	0.00	0
805	Red-billed Quelea	*Quelea quelea*	1	24.44	11	0.00	0
182	Red-billed Spurfowl	*Pternistis adspersus*		13.33	6	0.00	0
97	Red-billed Teal	*Anas erythrorhyncha*		2.22	1	0.00	0
224	Red-crested Korhaan	*Lophotis ruficrista*	1	24.44	11	0.00	0
314	Red-eyed Dove	*Streptopelia semitorquata*		53.33	24	8.33	1
392	Red-faced Mousebird	*Urocolius indicus*	1	68.89	31	8.33	1
820	Red-headed Finch	*Amadina erythrocephala*	1	22.22	10	8.33	1
940	Rock Dove	*Columba livia*	1	2.22	1	0.00	0
123	Rock Kestrel	*Falco rupicolus*		4.44	2	0.00	0

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
506	Rock Martin	*Ptyonoprogne fuligula*		64.44	29	8.33	1
372	Rufous-cheeked Nightjar	*Caprimulgus rufigena*	1	4.44	2	0.00	0
619	Rufous-eared Warbler	*Malcorus pectoralis*	1	15.56	7	0.00	0
460	Sabota Lark	*Calendulauda sabota*	1	22.22	10	0.00	0
789	Scaly-feathered Weaver	*Sporopipes squamifrons*	1	71.11	32	16.67	2
847	Shaft-tailed Whydah	*Vidua regia*	1	37.78	17	8.33	1
561	Short-toed Rock Thrush	*Monticola brevipes*	1	8.89	4	0.00	0
90	South African Shelduck	*Tadorna cana*	1	8.89	4	0.00	0
707	Southern Fiscal	*Lanius collaris*	1	26.67	12	0.00	0
4142	Southern Grey-headed Sparrow	*Passer diffusus*	1	22.22	10	0.00	0
803	Southern Masked Weaver	*Ploceus velatus*	1	64.44	29	0.00	0
536	Southern Pied Babbler	*Turdoides bicolor*	1	31.11	14	0.00	0
426	Southern Yellow-billed Hornbill	*Tockus leucomelas*	1	51.11	23	0.00	0
474	Spike-heeled Lark	*Chersomanes albofasciata*	1	n/a	1	0.00	0
311	Speckled Pigeon	*Columba guinea*		33.33	15	0.00	0
368	Spotted Eagle-Owl	*Bubo africanus*		2.22	1	0.00	0
654	Spotted Flycatcher	*Muscicapa striata*	1	15.56	7	0.00	0
275	Spotted Thick-knee	*Burhinus capensis*	1	20.00	9	0.00	0
411	Swallow-tailed Bee-eater	*Merops hirundineus*		17.78	8	0.00	0
238	Three-banded Plover	*Charadrius tricollaris*		4.44	2	0.00	0
641	Tinkling Cisticola	*Cisticola rufilatus*		4.44	2	0.00	0
840	Violet-eared Waxbill	*Granatina granatina*	1	60.00	27	8.33	1
735	Wattled Starling	*Creatophora cinerea*		13.33	6	0.00	0
359	Western Barn Owl	*Tyto alba*		17.78	8	0.00	0

#	Common Name	Scientific Name	Observed (Feb. & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
61	Western Cattle Egret	*Bubulcus ibis*	1	8.89	4	0.00	0
391	White-backed Mousebird	*Colius colius*	1	60.00	27	0.00	0
107	White-backed Vulture	*Gyps africanus*	1	n/a	1	0.00	0
763	White-bellied Sunbird	*Cinnyris talatala*		6.67	3	0.00	0
780	White-browed Sparrow-Weaver	*Plocepasser mahali*	1	64.44	29	8.33	1
100	White-faced Whistling Duck	*Dendrocygna viduata*	1	2.22	1	0.00	0
383	White-rumped Swift	*Apus caffer*		11.11	5	0.00	0
865	White-throated Canary	*Crithagra albogularis*		8.89	4	0.00	0
495	White-throated Swallow	*Hirundo albigularis*		2.22	1	0.00	0
599	Willow Warbler	*Phylloscopus trochilus*	1	6.67	3	0.00	0
866	Yellow Canary	*Crithagra flaviventris*	1	82.22	37	16.67	2
600	Yellow-bellied Eremomela	*Eremomela icteropygialis*	1	35.56	16	0.00	0
629	Zitting Cisticola	*Cisticola juncidis*	1	2.22	1	0.00	0

Appendix 2: Preliminary density estimates of birds recorded from the study area during two independent surveys conducted during February 2022 and May 2022.

Species	ss01	ss02	ss03	ss04	ss05	ss06	ss07	ss08	ss09	ss10
African Red-eyed Bulbul	1	0.5	2	0	0.5	0	1	1	0.5	0
Ashy Tit	0	0	0	0	0	0	0	0	0	0
Black-chested Prinia	2	3	2.5	4	3	3	3	2	4	3
Black-faced Waxbill	0	0	0	1	1	1	1	1	0	0
Black-throated Canary	0.5	0	0.5	0	0	1.5	1.5	5	0	0
Brown-crowned Tchagra	0.5	0	0	0	0	0	1	0.5	0.5	0.5
Brubru	0	0	0	0	0	0	0	0	0	0
Cape Penduline Tit	2	0	0	0	0	0	0	0	0	0
Cape Sparrow	0	0	0	0	0	0	0	0	0	0
Cape Starling	0	0	0	0	0	0	0	0	0	0
Chestnut-vented Warbler	2	3	5	2	2	2	3	3	2	2
Common Whitethroat	0	0	0	0	0	0	0.5	0	0	0
Crimson-breasted Shrike	1	0	0.5	0	0	0	0	1	0	0
Desert Cisticola	0.5	0.5	0	0.5	0.5	0.5	0	1	1	1
Dusky Sunbird	0.5	0.5	1.5	0.5	0	0	0	0.5	0	1
Fawn-colored Lark	0	0.5	0	0	0	0	0	0	0	0
Fiscal Flycatcher	0	0	0	0	0	0	0	0.5	0	0
Fork-tailed Drongo	0	0	0	0	0	0	0	0	0	0
Golden-breasted Bunting	0	0	0	0	0	0	1	1	1	0
Green-winged Pytilia	1	1	1	1	0	0	1	0	0	0
Ground-scraper Thrush	0	0	0	0	0	0	0	0	0	0
Kalahari Scrub-robin	3	2.5	1	1	1	2	2	2	1	1.5

Species	ss01	ss02	ss03	ss04	ss05	ss06	ss07	ss08	ss09	ss10
Long-billed Crombec	0.5	0	1	0	1	1	1	0	1	0
Marico Flycatcher	2	0	2	0	0	0	2	1	0	0
Marico Sunbird	0	0	0	0	0	0	0	0.5	0	0
Neddicky	0	0	0	0	0	0	0	0	0	0
Orange River White-eye	0	0	0	0	0	0	0	0	0	0
Pririt Batis	1	0	2	1	0	0	1	0	0	0
Quailfinch	0	0	1	0	0	0	0	0	0	0
Rattling Cisticola	0	0	0	0	0	1	0	0	0	0
Red-backed Shrike	1	0	2.5	1	0	0.5	0.5	0	0	0
Red-billed Quelea	0.5	2	1.5	0	0	8	0	0	0	0
Red-headed Finch	0	0	0	0	0	0	0	6	0	0
Rufous-eared Warbler	0	0	0	0	0	0	0	0	0.5	0
Sabota Lark	1	0.5	0.5	0	0	0.5	0.5	0.5	0.5	0.5
Scaly-feathered Weaver	9	3.5	3	2.5	0	4	7	1	0.5	2
Shaft-tailed Whydah	1.5	1.5	1.5	0	0	1	0.5	0.5	0	0
Short-toed Rock-thrush	0	0	0	0	0	0	0	0.5	0	0
Southern Fiscal	0.5	0	0.5	0	0	0	0	0.5	0	0
Southern Grey-headed Sparrow	0	0	0	0	0	0	0	0	0	0
Southern Masked Weaver	1	0	1.5	0	0	0	0	0	0	0
Southern Pied Babbler	0	0	0	0	0	0	0	0	0	0
Spotted Flycatcher	0	0	0	0	0	0.5	0	0	0	0
Violet-eared Waxbill	2	2	2	4	1	2	2	1	1.5	0.5
White-browed Sparrow-weaver	0	0	0	0	0	0	0	0	0	0
Willow Warbler	0	0	0	0.5	0	0	0.5	0	0	0
Yellow Canary	2	1.5	2.5	1	0.5	0	6	2.5	0.5	1

Species	ss01	ss02	ss03	ss04	ss05	ss06	ss07	ss08	ss09	ss10
Yellow-bellied Eremomela	0.5	1	0	0	0	1	0.5	0	0	0
Zitting Cisticola	0.5	0.5	0	0	0	0	0	0	0	0
Number of individuals	37	24	35.5	20	10.5	29.5	36.5	32.5	14.5	13
Number of species	25	16	21	13	9	16	21	22	13	10
Number of birds/ha	**47.44**	**30.77**	**45.51**	**25.64**	**13.46**	**37.82**	**46.79**	**41.67**	**18.59**	**16.67**
Number of species/ha	**32.05**	**20.51**	**26.92**	**16.67**	**11.54**	**20.51**	**26.92**	**28.21**	**16.67**	**12.82**
Average number of birds/ha	**28.21**									
Average number of species/ha	**19.64**									

Species	ss11	ss12	ss13	ss14	ss15	ss16	ss17	ss18	ss19	ss20	ss21	ss22	ss23	ss24	ss25	Mean Birds/ha
African Red-eyed Bulbul	0	0.5	0	0	0	0	0	0	0	0.5	0	0	0.5	0	0.5	**0.02**
Ashy Tit	0	0	0	0	0	0.5	0	0	0.5	0.5	0	0	0	0	0	**0.00**
Black-chested Prinia	2	4	4	5	2	3	4	4	2	2	3	3	2	3	3	**0.15**
Black-faced Waxbill	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	**0.02**
Black-throated Canary	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	**0.02**
Brown-crowned Tchagra	0	1	1	1	0	1	0.5	0	2	0.5	0	0.5	0.5	1.5	0.5	**0.03**
Brubru	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**0.00**
Cape Penduline Tit	0	0	0	0	0	0.5	2	0	0	0	0	0	0	0	0	**0.01**
Cape Sparrow	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	**0.00**
Cape Starling	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**0.00**
Chestnut-vented Warbler	4	3	2	2	2	2	4	3	2	2	2	2	1	2	2	**0.13**
Common Whitethroat	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	**0.00**
Crimson-breasted Shrike	0	1	1	0	0	0	0	0	1.5	0.5	0	0	0	0	0	**0.01**
Desert Cisticola	0.5	0	1	0.5	0.5	0	0	0.5	0	0	0	0	0	0.5	0.5	**0.02**
Dusky Sunbird	0	1	1	0	0	0.5	0.5	0	1	0.5	0	0.5	0.5	0	0.5	**0.02**

Species	ss11	ss12	ss13	ss14	ss15	ss16	ss17	ss18	ss19	ss20	ss21	ss22	ss23	ss24	ss25	Mean Birds/ha
Fawn-colored Lark	0	0	1	1	0	0.5	1	0	2	0	0.5	0	0.5	0.5	0.5	**0.02**
Fiscal Flycatcher	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	**0.00**
Fork-tailed Drongo	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	**0.00**
Golden-breasted Bunting	1	1	0	0	0	0	1	1	0.5	0	0	0	1	0	1	**0.02**
Green-winged Pytilia	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	**0.02**
Ground-scraper Thrush	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**0.00**
Kalahari Scrub-robin	0.5	2	2	2	2	1.5	1.5	1.5	2	2	2.5	1	1.5	1.5	2	**0.09**
Long-billed Crombec	0	2	0	0	0	1	0	1	1	0	0	0	0	0	1	**0.02**
Marico Flycatcher	0	1	1	0	0	0	0	0	0	0	0	0	0	0.5	0	**0.02**
Marico Sunbird	0	2	0	0	0	1	0	0	1	0.5	0	0	0	0	0	**0.01**
Neddicky	0	0	0	0	0	1	0.5	0	0	0.5	0	0	0	0	0.5	**0.01**
Orange River White-eye	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	**0.01**
Pririt Batis	0	1	0	0	0	1	2	1	2	0	0	0	0	1	0	**0.03**
Quailfinch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
Rattling Cisticola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
Red-backed Shrike	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	**0.02**
Red-billed Quelea	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.03**
Red-headed Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.01**
Rufous-eared Warbler	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	**0.01**
Sabota Lark	0.5	0	1	0	1	0	0.5	0	0.5	0	0	0	0	0.5	0.5	**0.02**
Scaly-feathered Weaver	1	7.5	2	1	3	2.5	1	0.5	0.5	0.5	0	0	1	4.5	1	**0.12**
Shaft-tailed Whydah	0	1	0	0	0	0	0	0	0	0	0	0	0.5	0	0	**0.02**
Short-toed Rock-thrush	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
Southern Fiscal	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
Southern Grey-headed Sparrow	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	**0.00**
Southern Masked Weaver	0	5.5	0	0	0	0.5	0	0	0	2.5	0	0	1	1	0.5	**0.03**

Species	ss11	ss12	ss13	ss14	ss15	ss16	ss17	ss18	ss19	ss20	ss21	ss22	ss23	ss24	ss25	Mean Birds/ha
Southern Pied Babbler	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
Spotted Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	**0.00**
Violet-eared Waxbill	1.5	2	0	1	1	2	1.5	1	1.5	2	1	0	1	3	2	**0.08**
White-browed Sparrow-weaver	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	**0.00**
Willow Warbler	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	**0.00**
Yellow Canary	0	5.5	0.5	1	1.5	1	2	0.5	0.5	5.5	1	0.5	1	1.5	0.5	**0.08**
Yellow-bellied Eremomela	1	0.5	0.5	0	0.5	0.5	0	0	1	0.5	0.5	0	0.5	0	1	**0.02**
Zitting Cisticola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**
Number of individuals	12	51.5	18	14.5	14	21	23.5	14	28	28	11.5	8	13	21	19	
Number of species	9	26	13	9	10	18	16	10	22	22	8	7	15	13	19	
Number of birds/ha	**15.38**	**66.03**	**23.08**	**18.59**	**17.95**	**26.92**	**30.13**	**17.95**	**35.90**	**35.90**	**14.74**	**10.26**	**16.67**	**26.92**	**24.36**	
Number of species/ha	**11.54**	**33.33**	**16.67**	**11.54**	**12.82**	**23.08**	**20.51**	**12.82**	**28.21**	**28.21**	**10.26**	**8.97**	**19.23**	**16.67**	**24.36**	
Average number of birds/ha	**28.21**															
Average number of species/ha	**19.64**															