DEVELOPMENT OF THE DICOMA PV FACILITY AND ASSOCIATED INFRASTRUCTURE ON A SITE NEAR LICHTENBURG, NORTH WEST PROVINCE

Avifauna Baseline and Impact Assessment Report

November 2021

Compiled by:
Pachnoda Consulting CC
Lukas Niemand Pr.Sci.Nat

PO Box 72847
Lynwood Ridge
Pretoria
0040

Prepared for:
Savannah Environmental (Pty) Ltd

PO Box 148
Sunninghill
Gauteng
2157
0040

EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Dicoma PV facility and associated infrastructure on Portion 1, 9 and 10 of the Farm Houthaalboomen 31, near Lichtenburg, North West Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the project 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 (August 2021 and November 2021).

Four prominent avifaunal habitat types was identified on the site, and consisted of open mixed dolomite grassland with bush clump mosaics, open mixed woodland, artificial livestock watering holes and a *Eucalyptus* plantation. However, power line servitudes occur on the southern boundary of the study site of which the pylons were used for roosting by vultures. Approximately 176 bird species are expected to occur in the wider study area, of which 97 species were observed in the study area. The expected richness included 11 threatened or near threatened species, 15 southern African endemics and 21 are near-endemic species. The critically endangered White-backed Vulture (*Gyps africanus*) was confirmed during the surveys, mainly as roosting individuals or birds soaring overhead. Eleven southern African endemics and 15 near-endemic species were confirmed on the study site.

The main impacts associated with the proposed PV solar facility includes 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), with the exception of the potential for birds to collide with the associated power lines, which was high without mitigation (and moderate after mitigation). The study site is not located near any prominent wetland system or impoundment, and therefore the risk of waterbird collisions with the proposed infrastructure was considered to be low.

The endangered Cape Vulture (*Gyps coprotheres*) and critically endangered White-backed Vulture (*Gyps africanus*) (and to a lesser degree also Lappet-faced Vulture *Torgos tracheliotos*) were identified as regular foraging visitors to the study site (according to SABAP2 reporting rates and on-site observations). These species are highly prone to power line collisions, whereby the proposed energy facility (especially the proposed overhead power lines) could pose a collision and electrocution risk to vultures. The risk of collision/electrocution was considered likely when vultures feed on a carcass in close proximity to a power line or when attempting to roost on the pylon structures.

In addition, a total of 39 collision-prone bird species have been recorded from the wider study area (*sensu* atlas data), of which 21 species were birds of prey.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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 Dicoma PV (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)
21 November 2021

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 15 years of experience in ecological-related assessments and more than 10 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 Background

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd on behalf of Dicoma PV (Pty) Ltd to compile an avifauna impact assessment report for the proposed Dicoma PV facility (herewith referred to as the "study site") and associated infrastructure with a contracted capacity of up to 75MW located on a site approximately 5km north west of the town of Lichtenburg in the North West Province (Figure 1). The development area is situated within the Ditsobotla Local Municipality within the Ngaka Modiri Molema District Municipality. The site is accessible via an existing gravel road which provides access to the development area off the R505, located east of the development area.

The infrastructure of the facility will consist of the following components (Figure 2 and Figure 3):

- PV modules and mounting structures
- Inverters and transformers
- Battery Energy Storage System (BESS)
- Site and internal access roads (up to 8m wide)
- Site offices and maintenance buildings, including workshop areas for maintenance and storage.
- Temporary and permanent laydown area
- Grid connection solution (with two alternative locations assessed) within a 100m wide corridor, including:
    - 33kV cabling between the project components and the facility substation
    - A 132kV facility substation
    - A 132kV Eskom switching station
    - A Loop-in-Loop out (LILO) overhead 132kV power line between the Eskom switching station and the existing Delareyville Munic–Watershed 1 88kV power line.[1]

1.1.1 Dicoma PV Facility

The development area for the Dicoma PV facility and associated infrastructure will be located on the following properties:

- Portion 1 of the Farm Houthaalboomen 31

[1] The LILO corridor intersects with several existing parallel Eskom power lines (Watershed-Sephaku 1 132kV, Dudfield–Watershed 2 88kV, Dudfield-Watershed 1 88kV, and Watershed-Klerksdorp North 1 132kV). Therefore, should the connection to the Delareyville Munic–Watershed 1 88kV not be technically feasible, connection to the above mentioned power lines would still be within the assessed LILO corridor and considered feasible through the construction of a shorter LILO connection.

- Portion 9 of the Farm Houthaalboomen 31
- Portion 10 of the Farm Houthaalboomen 31
- Portion 0 of Farm Talene 25
- Portion 7 of Farm Elandsfontein 34

The development area of the Dicoma PV facility is approximately 180 ha, and will include two alternative grid connection solutions (within a 100m wide corridor).

1.1.2 Grid Connection Alternatives

Two gird connection alternatives are proposed (Figure 2 and Figure 3):

Grid Connection Alternative 1: 33kV MV cabling will connect the Dicoma PV solar array to the 132kV facility substation. The 132kV Eskom switching station is located directly adjacent to the development footprint of the facility substation. The facility substation and Eskom switching station are located approximately 1.3 km east of the Dicoma PV facility on Portion 1 of the Farm Houthaalboomen 31. A 132kV Loop-in-Loop Out power line from the Eskom switching station will connect into the Delareyville Munic–Watershed 1 88kV[2]. The grid connection infrastructure is located within an assessment corridor of 100m wide.

Grid Connection Alternative 2: 33kV MV cabling will connect the PV solar arrays of each facility to a 132kV facility substation. The 132kV Eskom switching station is located directly adjacent to the development footprint of the facility substation. The facility substation and Eskom switching station are located within the development footprint of the Dicoma PV facility on Portion 1 of the Farm Houthaalboomen 31. A 132kV Loop-in-Loop Out power line from the Eskom switching station will connect into the Delareyville Munic–Watershed 1 88kV. The grid connection infrastructure is located within an assessment corridor of 100m wide.

[2] The LILO corridor intersects with several existing parallel Eskom power lines (Watershed-Sephaku 1 132kV, Dudfield–Watershed 2 88kV, Dudfield-Watershed 1 88kV, and Watershed-Klerksdorp North 1 132kV). Therefore, should the connection to the Delareyville Munic–Watershed 1 88kV not be technically feasible, connection to the above mentioned power lines would still be within the assessed LILO corridor and considered feasible through the construction of a shorter LILO connection.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the project area[3] 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; sensu IUCN, 2021; 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 site;
    - 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).

[3] The "project area" has a larger footprint than the proposed Dicoma PV facility and its associated infrastructure (the "study site"), which includes Portions 1, 9 and 10 of the Farm Houthaalboomen 31. It also includes the proposed grid connection alternatives.

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.

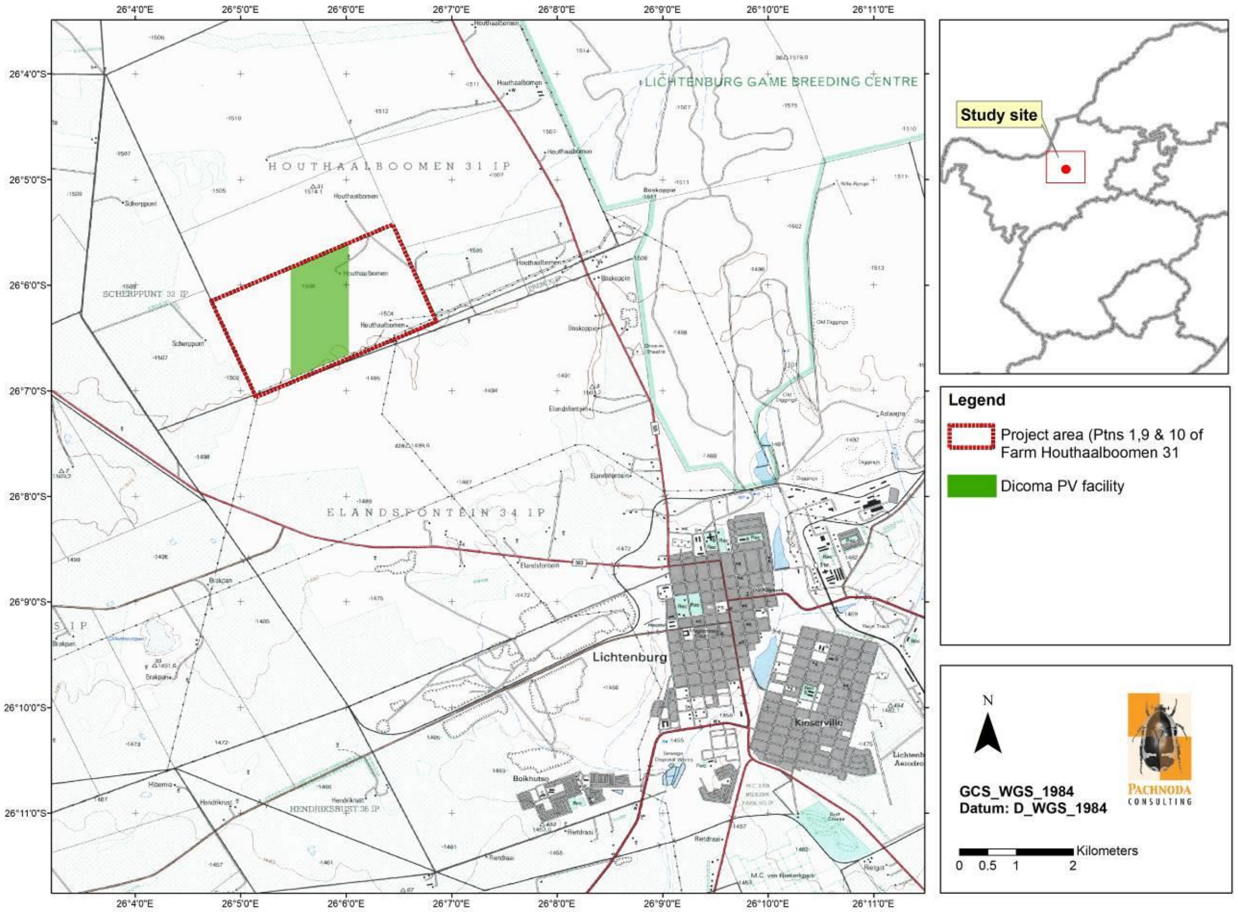


Figure 1: A topo-cadastral image illustrating the geographic position of the Dicoma PV facility.

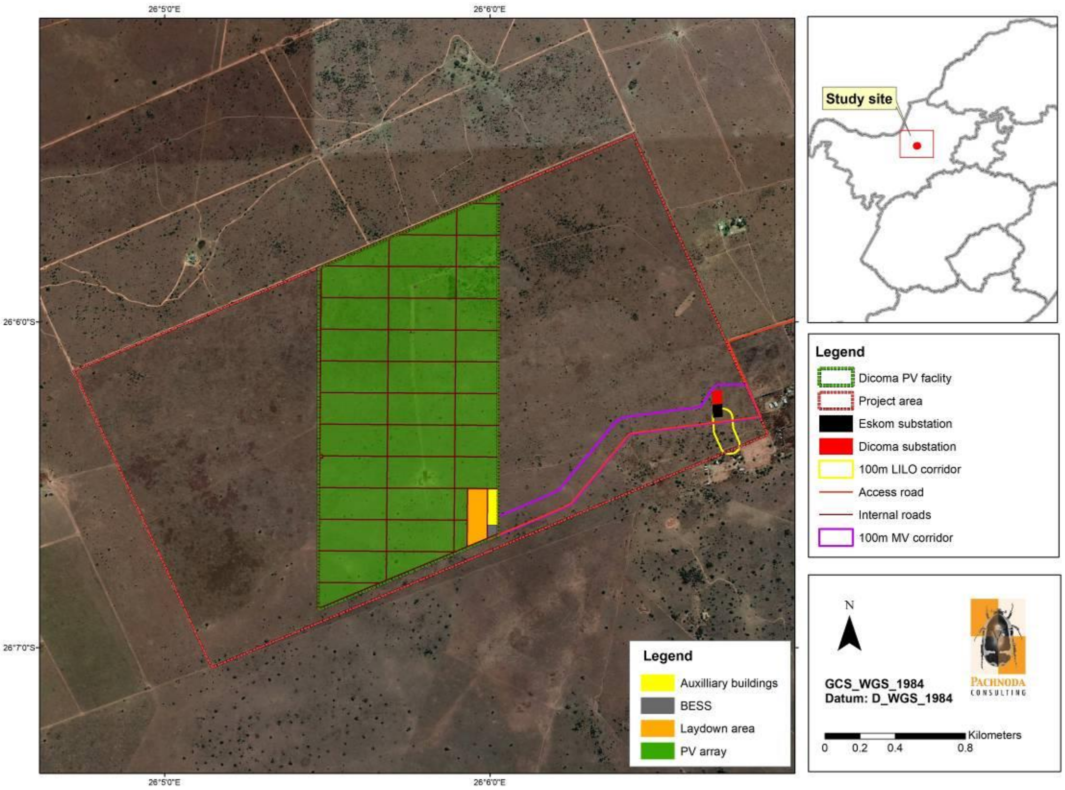


Figure 2: A satellite image illustrating the geographic position of the proposed Dicoma PV facility and associated infrastructure with grid connections for Alternative 1.

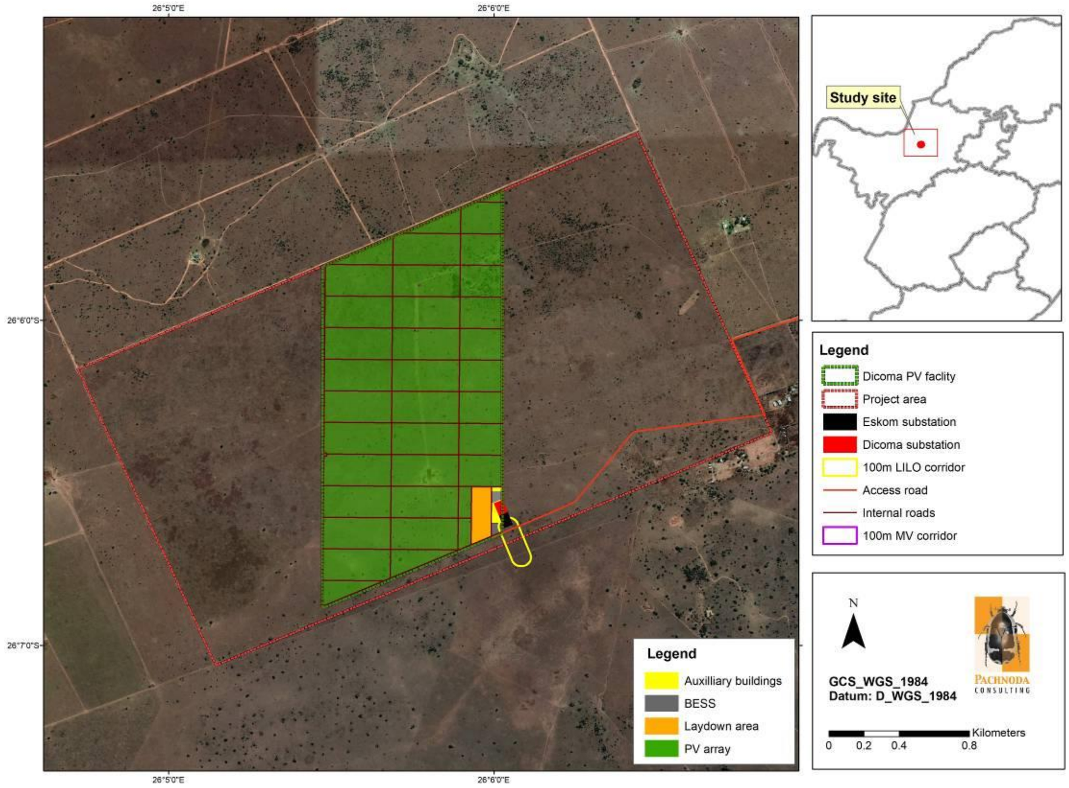


Figure 3: A satellite image illustrating the geographic position of the proposed Dicoma PV facility and associated infrastructure with grid connections for Alternative 2.

2. METHODS & APPROACH

The current report places emphasis on the avifaunal community as a key indicator group on the proposed study site, 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 (04 - 06 August 2021 and 15 - 17 November 2021); and
- personal observations from similar habitat types in proximity to the study area, with emphasis on assessments conducted by Pachnoda Consulting (2018) where the avifauna study was conducted by the author.

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), Harrison *et al.* (1997) and Del Hoyo *et al.* (1992-2011) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities (e.g. biome-restricted bird species) of selected bird species that could be present on the study site.
- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2021) 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) 2626AA (Lichtenburg). The information was then modified according to the prevalent habitat types present on the study site. 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 site. 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 2605_2605 (although information from all eight pentad grid surrounding grid 2605_2605 was also scrutinised; Figure 4).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World Bird List v. 11.2), unless otherwise specified (see www.worldbirdnames.org

as specified by Gill et al, 2021). Colloquial (common) names were used according to Hockey *et. al.* (2005) to avoid confusion.

- All observations obtained during the site visits (04 - 06 August 2021 and 15 - 17 November 2021) were submitted to the South African Bird Atlas Project (SABAP2).
- Incidental occurrence records for large birds of prey and vulture tracking data were included (up to 2018 only).
- Data on power line derived bird mortalities were requested from the electrical infrastructure mortality incident register (the dataset was provided by EWT).
- The best practice guidelines for solar facilities by BirdLife South Africa (Jenkins et al., 2017).
- Additional information regarding bird-power line interactions was provided by the author's own personal observations.

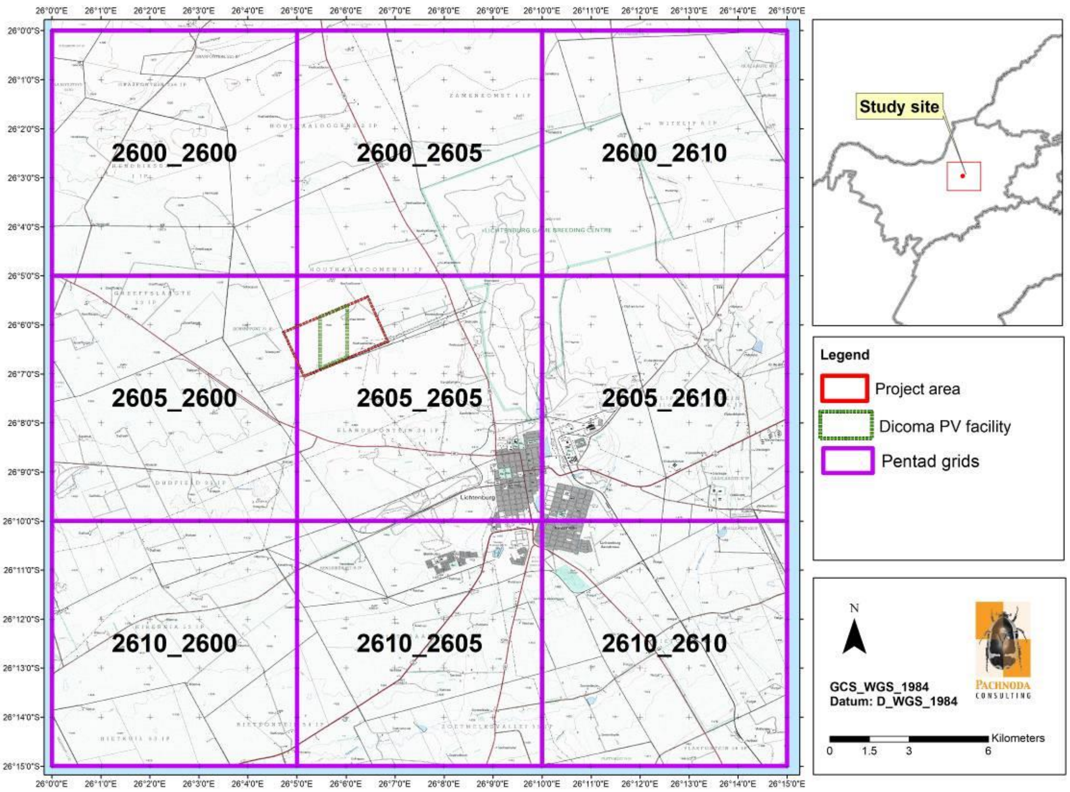


Figure 4: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study site was surveyed during two independent site visits representing an austral dry (winter) season survey (04 - 06 August 2021) and an austral wet (summer) season survey (15 - 17 November 2021).

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 35 point counts (as per Buckland et al. 1993) from the project area (wider study area with 15 points corresponding to the Dicoma PV facility), where all birds seen and heard from a specific point over a set period of time was recorded. 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 5. 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).

Strong winds occurred during both the austral dry and wet season, meaning that most of the birds took cover and perched inside shrubs and the graminoid layer, thereby obscuring detection by means of conventional static point count sampling. Therefore, the sampling approach was adapted so that all the bird species seen within approximately 100m from the centre of the point were recorded (resulting in an area of 3.14 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 100m 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.

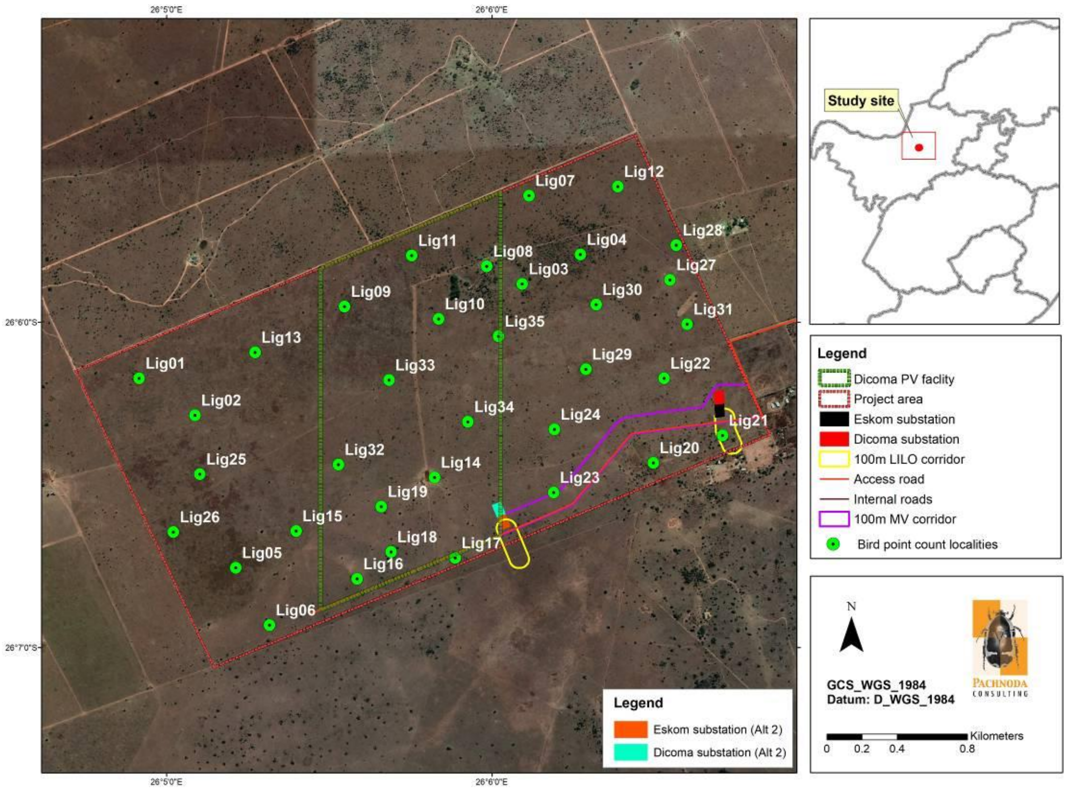


Figure 5: A map illustrating the spatial position of 35 bird point counts located within the project area.

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.

- The study area was previously poorly surveyed prior to the baseline survey. Therefore, bird richness information for the area is 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 proposed Dicoma PV facility is located on part of Portion 1, 9 and 10 of the Farm Houthaalboomen 31 as well as Portion 0 of Farm Talene 25 and Portion 7 of Farm Elandsfontein 34. It is located approximately 5km north west of the town of Lichtenburg in the North West Province (Figure 1).

3.2 Regional Vegetation Description

The study site corresponds to the Grassland Biome and more particularly to the Dry Highveld Grassland Bioregion as defined by Mucina & Rutherford (2006). It consists of an ecological type known as Carletonville Dolomite Grassland (Mucina & Rutherford, 2006) (Figure 6).

From an avifaunal perspective it is evident that bird diversity is positively correlated with vegetation structure, and floristic richness is not often regarded to be a significant contributor of patterns in bird abundance and their spatial distributions. Although grasslands are generally poor in woody plant species, and subsequently support lower bird richness values, it is often considered as an important habitat for many terrestrial bird species such as larks, pipits, korhaans, cisticolas, widowbirds including large terrestrial birds such as Secretarybirds, cranes and storks. Many of these species are also endemic to South Africa and display particularly narrow distribution ranges. Due to the restricted spatial occurrence of the Grassland Biome and severe habitat transformation, many of the bird species that are restricted to the grasslands are also threatened or experiencing declining population sizes.

Carletonville Dolomite Grassland is confined to the dolomite plains that stretch from Lichtenburg in the North West Province to sections of rocky grassland in Gauteng, especially between altitudes of 1 350m and 1 450m. It occurs on slightly undulating plains dissected by prominent chert ridges, thereby containing a grassland composition rich in floristic species forming a complex mosaic dominated by many plant species.

Currently, only 2% of the remaining 76% of untransformed Carletonville Dolomite Grassland is formally protected within the Cradle of Humankind World Heritage Site and various nature reserves such as Abe Baily and Krugersdorp Nature Reserves.

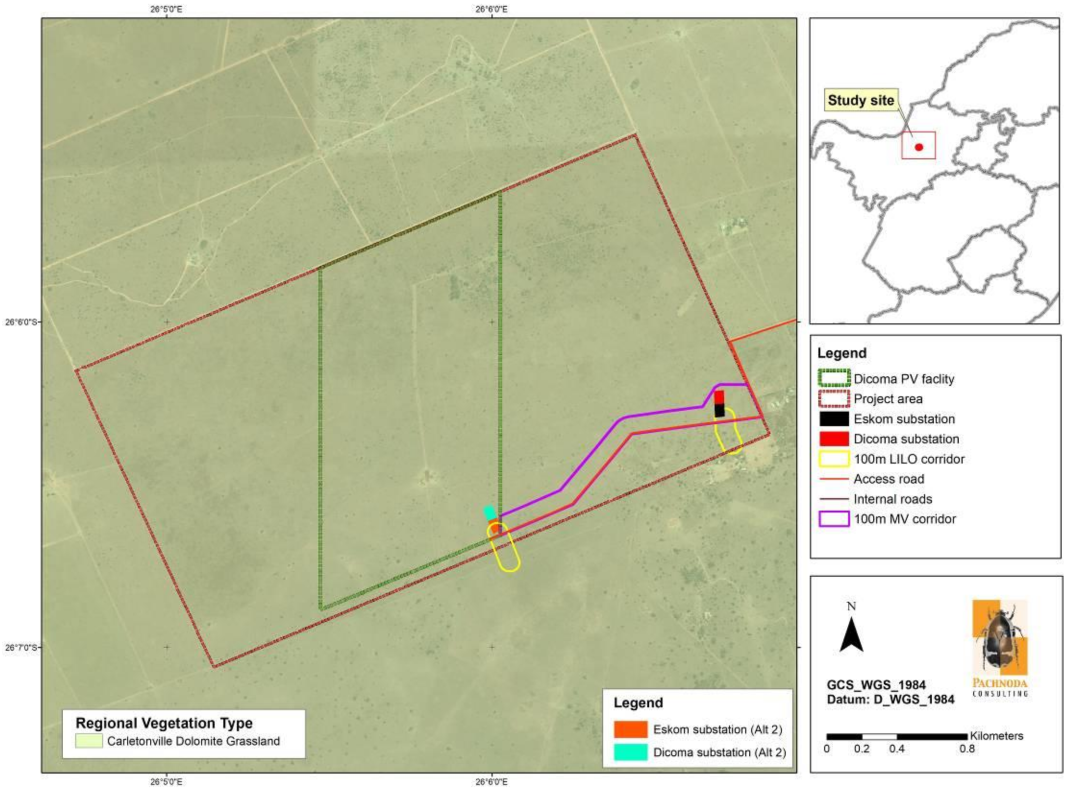


Figure 6: A topographic image illustrating the regional vegetation type corresponding to the study site. Vegetation type categories were identified according to Mucina & Rutherford (2006).

3.3 Land cover, land use and existing infrastructure.

According to the South African National dataset of 2013-2014 (Geoterrainimage, 2015) the project area comprehends the following land cover categories (Figure 3):

Natural areas:

- Grassland;
- Low shrubland; and
- Woodland and open bush.

Transformed areas:

- Cultivation.

From the land cover dataset it is evident that most of the study site is covered by natural grassland, low shrubland and patches of woodland. The study site is primarily used for livestock production and livestock grazing. Existing infrastructure includes a number of powerline servitudes located on the southern boundary of the site.

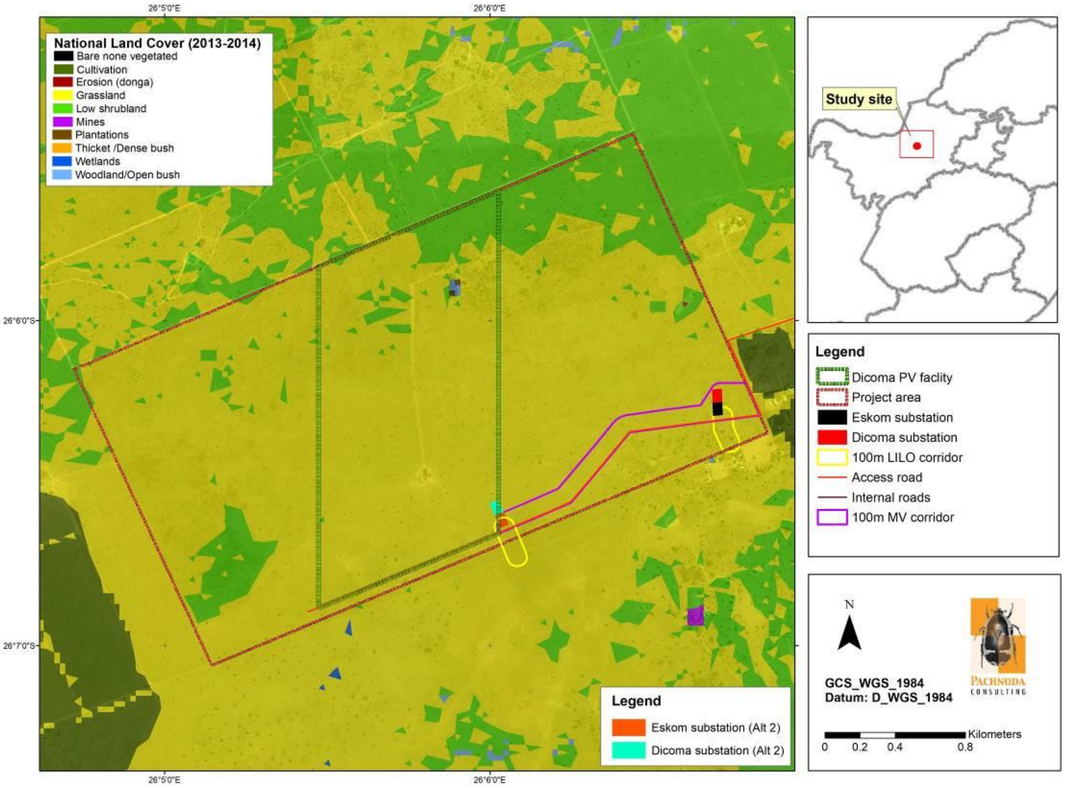


Figure 7: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed study area.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study site is located approximately 4km west of the Lichtenburg Game Breeding Centre (Figure 6). This conservation area contains a variety of game species, and the facility used to operate a vulture restaurant which attracts foraging vultures (c. three species) to the region. This area is currently under new management (by lease agreement with the municipality).

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

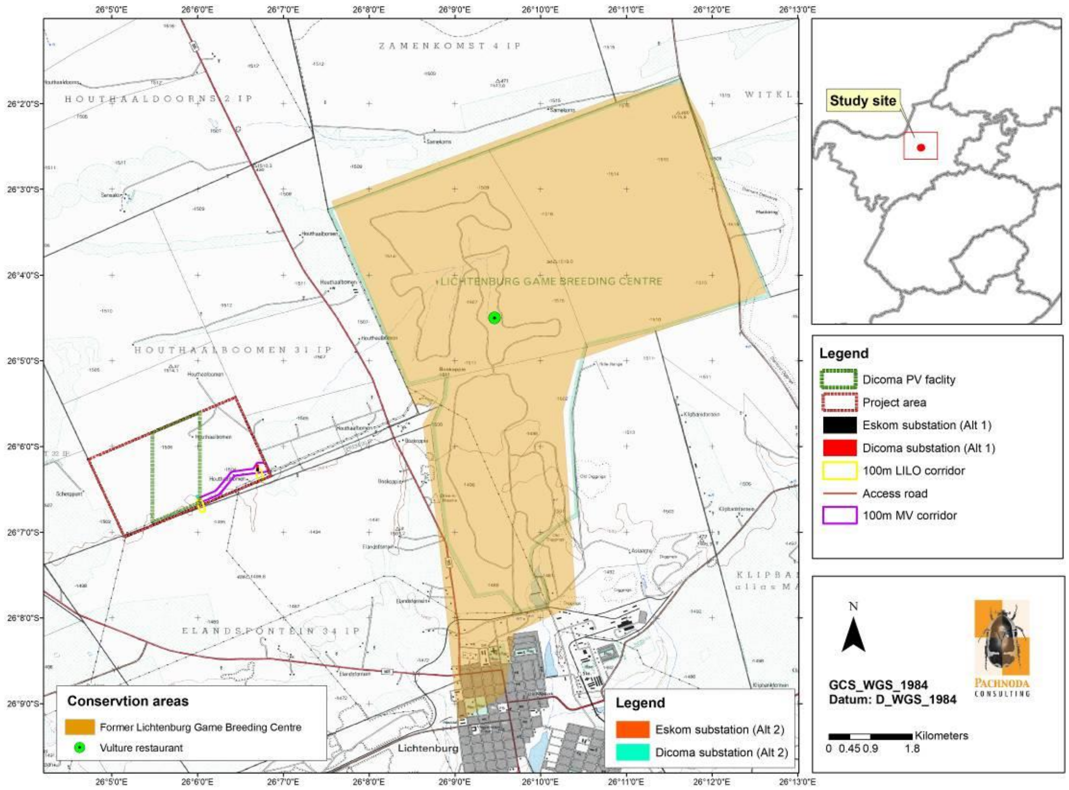


Figure 8: A map illustrating the locality of a game facility and a vulture restaurant adjacent to the proposed study site. Note the locality of an active vulture restaurant in the study region.

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 study site are a consequence of a combination of factors simulated by soil type, geology and grazing intensity (presence of livestock) which have culminated in a number of habitat types that deserve further discussion (Figure 9 and Figure 10):

1. *Open mixed dolomite grassland with bush clump mosaics:* This unit is dominant on the study site and covers nearly the entire surface area of the proposed PV facility. It is represented by two discrete floristic variations which also provide habitat for two discrete avifaunal associations. The first floristic variation consists of open untransformed to semi-transformed mixed dolomite grassland and bush clumps with an eminent woody layer. The grassland variation is represented by untransformed and grazed Carletonville Dolomite Grassland, depending on grazing intensity, and dominated by "late-successional" graminoids such a *Themeda triandra, Cymbopogon caesius, C.*

pospischilii, Trachypogon spicatus, Elionurus muticus and *Andropogon schirensis*. It is occupied by a typical grassland bird composition dominated by insectivorous and granivore passerine bird species such as Desert Cisticola, (*Cisticola aridulus*), Eastern Clapper Lark (*Mirafra fasciolata*) (Melodious Lark (*Mirafra cheniana*), Spike-heeled Lark (*Chersomanes albofasciata*), Cape Longclaw (*Macronyx capense*), Ant-eating Chat (*Myrmecocichla formicivora*) and African Pipit (*Anthus cinnamomeus*). Prominent non-passerine species include Orange River Francolin (*Scleroptila gutturalis*), Swainson's Spurfowl (*Pternistis swainsonii*), Northern Black Korhaan (*Afrotis afraoides*), Crowned Lapwing (*Vanellus coronatus*) and Black-winged Kite (*Elanus caeruleus*).

The bush clumps form a prominent mosaic characterised by the dominance of a woody layer of *Searsia lancea, S. pyroides, Ziziphus mucronata, Gymnosporia buxifolia* and *Asparagus laricinus*. *Celtis africana* and *Olea europaea subsp. africana* forms canopy constituents in some areas. The eminent increase in vertical heterogeneity provided by the woody layer is colonised by a "Bushveld" bird association consisting of insectivorous passerines such as Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Sylvia subcoerulea*), Kalahari Scrub Robin (*Cercotrichas paena*), Fiscal Flycatcher (*Melaenornis silens*), Dark-capped Bulbul (*Pycnonotus tricolor*) as well as granivores such as Yellow Canary (*Crithagra flaviventris*) and Southern Masked Weaver (*Ploceus velatus*). Non-passerine bird taxa are represented by Laughing Dove (*Spilopelia senegalensis*), Ring-necked Dove (*Streptopelia capicola*), Acacia Pied Barbet (*Tricholaema leucomelas*) and White-backed Mousebird (*Colius colius*).

2. *Mixed open woodland:* This unit is prominent on the north eastern parts of the proposed Dicoma PV facility. It is represented by tall microphyllous woodland dominated by *Senegalia cf. hereroensis* as well as other plant species that are similar in floristic composition to the bush clump mosaics. The tall vertical heterogeneity assists with the colonisation of a "Bushveld" bird association consisting of mainly insectivorous passerines. The latter composition is similar to the bird composition predicted for the bush clump mosaic habitat unit. Other noteworthy species include Crested Barbet (*Trachyphonus vaillantii*), Crimson-breasted Shrike (*Laniarius atrococcineus*) and Common Scimitarbill (*Rhinopomastus cyanomelas*).

3. *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 and non-passerine species, including Cape Sparrow (*Passer melanurus*), Laughing Dove (*Spilopelia senegalensis*), Namaqua dove (*Oena capensis*), Scaly-feathered Weaver (*Sporopipes squamifrons*) and Wattled Starling (*Creatophora cinerea*).

4. *Transformed areas*: This area is represented by an *Eucalyptus* sp. grove. It is an unimportant habitat for bird species, although it could provide roosting habitat for certain non-passerine birds such as the Hadeda Ibis (*Bostrychia hagedash*).

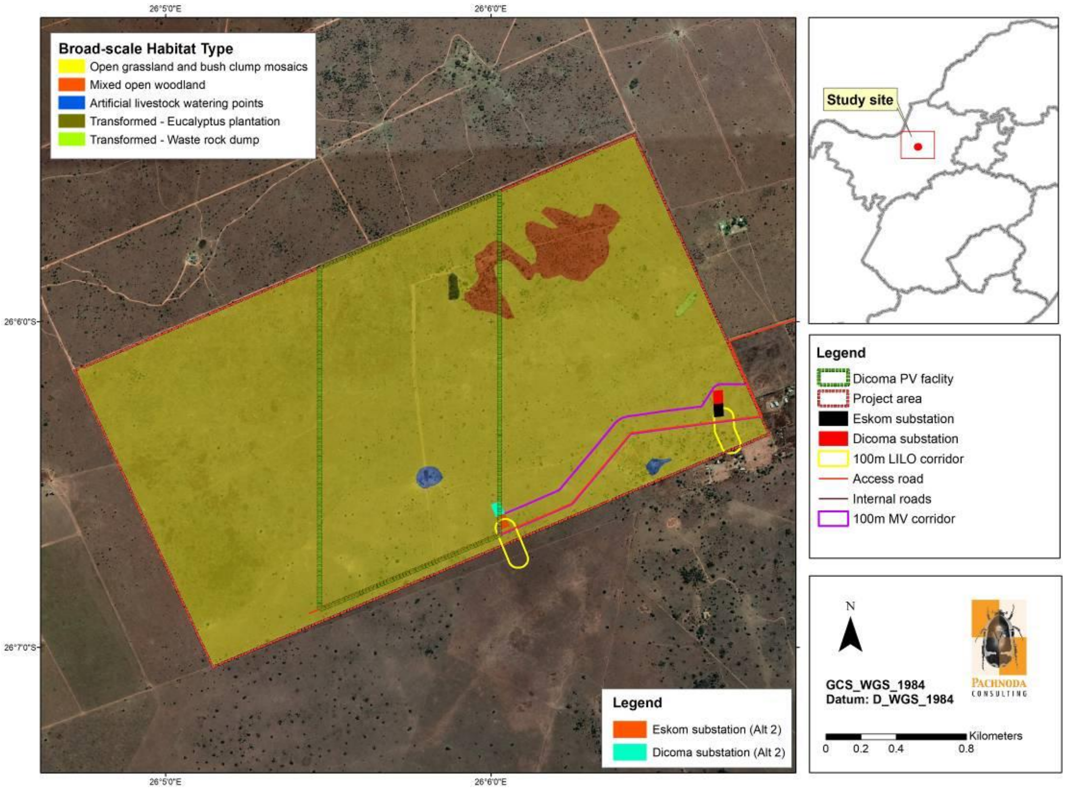


Figure 9: A habitat map illustrating the important avifaunal habitat types on the study site.

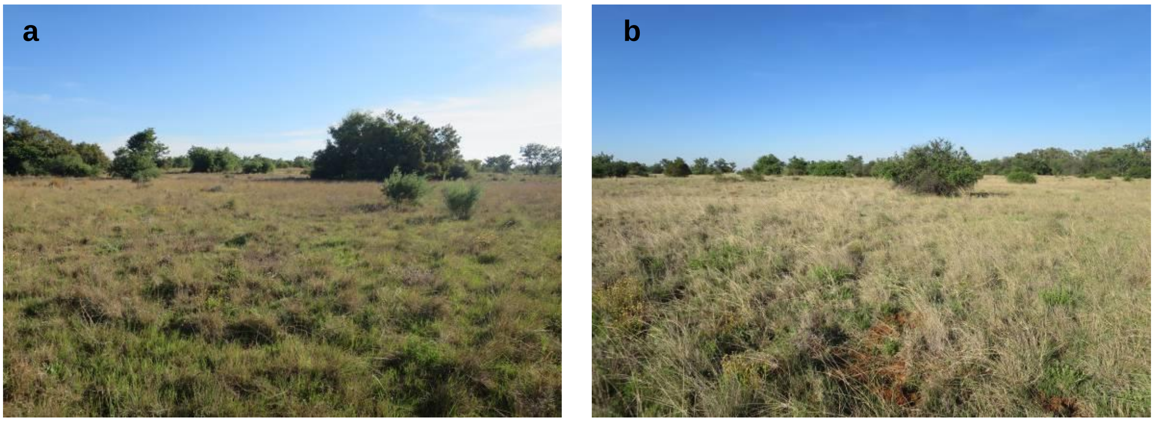


Figure 10: A collage of images illustrating examples of avifaunal habitat types on the study site observed on the study site (a - d) open mixed dolomite grassland and bush clump mosaics, (e - f) mixed open woodland and (g - h) artificial livestock watering points and (i) an *Eucalyptus* sp. grove.

4.2 Species Richness and Summary statistics

Approximately 176 bird species are expected to occur in the wider 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 17 % of the approximate 985[5] species listed for the southern African subregion[6] (and approximately 21 % of the 857 species recorded within South Africa[7]). However, the species richness obtained[8] from the pentad grid 2605_2605 corresponding to the project area was slightly higher than the expected number of species, with 186 species recorded. The latter mainly includes waterbird and shorebird taxa which were absent from the study site due to the absence of suitable wetland habitat. According to field observations, the total number of species observed on the project area is *ca*. 97 species (61 species during the austral dry season and 78 during the austral summer; see Appendix 1). The total species richness obtained from the pentad grid 2605_2605 corresponding to the project area contained 176 species, with an average number of 50 species for each full protocol card submitted (for observation of two hours or more). On a national scale, the species richness per pentad on the study area is considered moderate (refer to Figure 11).

According to Table 1, the study site is poorly represented by biome-restricted[9] (see Table 2) and local endemic bird species. It does support *ca*. 34 % of the near - endemic species present in the subregion. Of the 176 bird species expected to occur in the project area, 11 are threatened or near threatened species, 15 are southern African endemics and 21 are near-endemic species. In addition, one threatened species (White-backed Vulture *Gyps africanus*) was observed on the study site (Table 3). Furthermore, 11 southern African endemics and 15 near-endemic species were confirmed on the study site and the immediate surroundings (Table 3).

Prominent wetland features and waterbodies are absent from the study site and surroundings, thereby explaining the absence of waterfowl, wading birds and shorebird taxa on the study site.

---

[4] The expected richness statistic was derived from the QDS 2626AA (Lichtenburg) with a total of 271 bird species recorded (according to 142 cards submitted) and pentad grid 2605_2605 (including adjacent grids) totalling 241 bird species (based on 76 full protocol cards).

5 *sensu* www.zestforbirds.co.za (Hardaker, 2020)

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

7 With reference to South Africa (including Lesotho and Swaziland (BirdLife South Africa, 2018).

8 Including observations made during the August 2021 and November 2021 surveys.

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

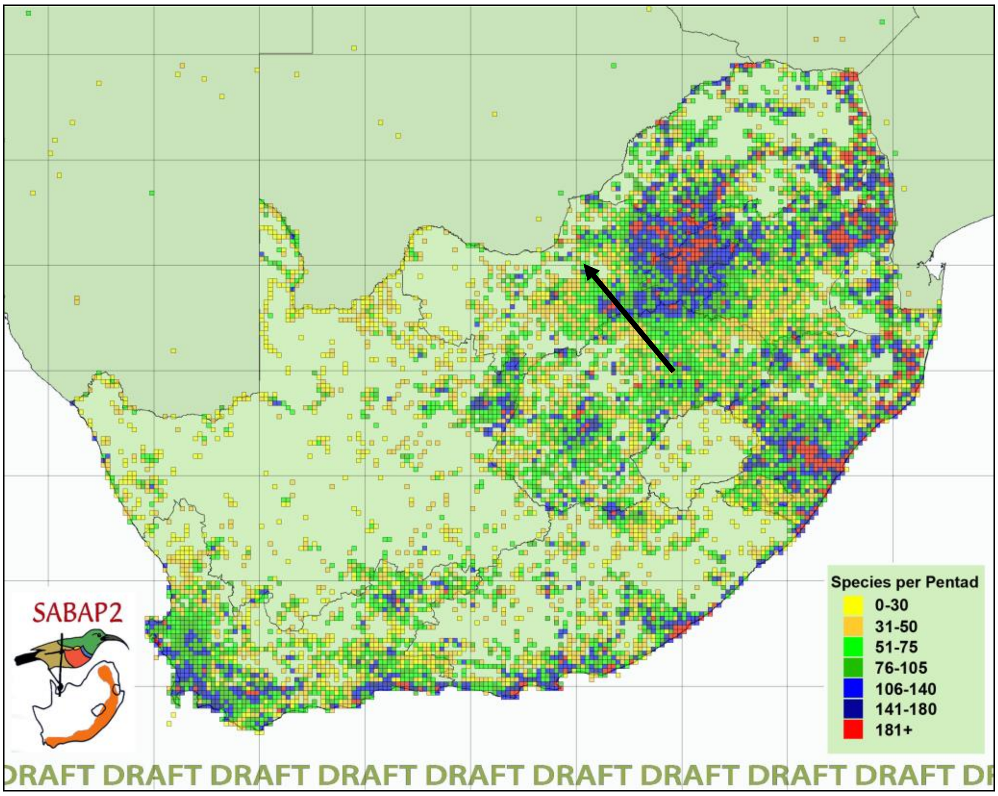


Figure 11: The bird species richness per pentad grid in comparison to the broader study area (see arrow) (map courtesy of SABAP2 and the Animal Demography Unit). According to the SABAP2 database, the study area hosts between 76 - 105 species.

Table 1: A summary table of the total number of species, Red listed species (according to Taylor *et al*., 2015 and the IUCN, 2021), 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 (project area and surroundings)***	Observed Richness Value (project area)****
Total number of species*	176 (17 %)	97 (55 %)
Number of Red Listed species*	11 (9 %)	1 (9 %)
Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	4 (29 %)	4 (100 %)
Number of local endemics (BirdLife SA, 2018)*	2 (5 %)	1 (50 %)
Number of local near-endemics (BirdLife SA, 2018)*	7 (23 %)	6 (86 %)
Number of regional endemics (Hockey *et al.*, 2005)**	15 (14 %)	11 (73 %)
Number of regional near-endemics (Hockey *et al.*, 2005)**	21 (34 %)	15 (71 %)

* only species in the geographic boundaries of South Africa (including Lesotho and Swaziland) 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, 2018).
**** Percentage values in brackets refer to totals compared against the expected number of species in the project area.

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) observed on the study site and immediate surroundings.

Species	Kalahari-Highveld	Zambezian	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena*)	X		Common
Kurichani Thrush (*Turdus libonyana*)		X	Uncommon
White-throated Robin-chat (*Cossypha humeralis*)		X	Common
White-bellied Sunbird (*Cinnyris talatala*)		X	Common

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

Common Name	Scientific name	Regional Status	Global Status	Observed (Aug. & Nov. 2021)	Collision with power lines	Displacement (disturbance & loss of habitat)
Vulture, White-backed	*Gyps africanus*	CR	CR	1	1	1
Vulture, Cape	*Gyps coprotheres*	EN	EN		1	1
Vulture, Lappet-faced	*Torgos tracheliotos*	EN	EN		1	1
Eagle, Martial	*Polemaetus bellicosus*	EN	VU		1	1
Eagle, Tawny	*Aquila rapax*	EN	VU		1	1
Barbet, Acacia Pied	*Tricholaema leucomelas*	End		1		1
Boubou, Southern	*Laniarius ferrugineus*	End				1
Chat, Anteating	*Myrmecocichla formicivora*	End		1		1
Cliff-swallow, South African	*Hirundo spilodera*	End		1		1
Flycatcher, Fairy	*Stenostira scita*	End		1		1
Flycatcher, Fiscal	*Melaenornis silens*	End		1		1
Korhaan, Northern Black	*Afrotis afraoides*	End		1	1	1
Lark, Melodious	*Mirafra cheniana*	End		1		1
Longclaw, Cape	*Macronyx capensis*	End		1		1
Mousebird, White-backed	*Colius colius*	End		1		1
Robin-chat, White-throated	*Cossypha humeralis*	End		1		1
Starling, Pied	*Lamprotornis bicolor*	End				1
Thrush, Karoo	*Turdus smithi*	End		1		1
Weaver, Cape	*Ploceus capensis*	End				1
White-eye, Cape	*Zosterops virens*	End		1		1
Bokmakierie	*Telophorus zeylonus*	N-end		1		1
Bulbul, African Red-eyed	*Pycnonotus nigricans*	N-end		1		1
Bunting, Lark-like	*Emberiza impetuani*	N-end				1
Canary, Yellow	*Crithagra flaviventris*	N-end		1		1
Cisticola, Cloud	*Cisticola textrix*	N-end		1		1
Finch, Red-headed	*Amadina erythrocephala*	N-end				1
Weaver, Scaly-feathered	*Sporopipes squamifrons*	N-end		1		1

Common Name	Scientific name	Regional	Global	Observed	Collision	Displacement
Flycatcher, Marico	*Bradornis mariquensis*	N-end				1
Francolin, Orange River	*Scleroptila levaillantoides*	N-end		1	1	1
Goshawk, Pale Chanting	*Melierax canorus*	N-end		1	1	1
Lark, Eastern Clapper	*Mirafra fasciolata*	N-end		1		1
Penduline-tit, Cape	*Anthoscopus minutus*	N-end				1
Scrub-robin, Kalahari	*Cercotrichas paena*	N-end		1		1
Shrike, Crimson-breasted	*Laniarius atrococcineus*	N-end		1		1
Sparrow, Cape	*Passer melanurus*	N-end		1		1
Sparrow, Great	*Passer motitensis*	N-end		1		1
Tit, Ashy	*Melaniparus cinerascens*	N-end		1		1
Warbler, Chestnut-vented	*Sylvia subcaerulea*	N-end		1		1
Wheatear, Mountain	*Oenanthe monticola*	N-end				1
Whydah, Shaft-tailed	*Vidua regia*	N-end				1
Falcon, Red-footed	*Falco vespertinus*	NT	NT		1	
Crane, Blue	*Anthropoides paradiseus*	NT	VU		1	1
Stork, Abdim's	*Ciconia abdimii*	NT			1	
Stork, Marabou	*Leptoptilos crumeniferus*	NT			1	1
Secretarybird	*Sagittarius serpentarius*	VU	EN		1	1
Falcon, Lanner	*Falco biarmicus*	VU			1	
	Totals:	**46**	**9**	**27**	**14**	**43**

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 12). The sampling captured approximately 80% of the number of species predicted by the Michaelis-Menten model at 21 point counts. Approximately 87% of the species was captured by 35 counts, sampling effort was considered sufficient and recorded most of the species present on the project area during the respective survey sessions.

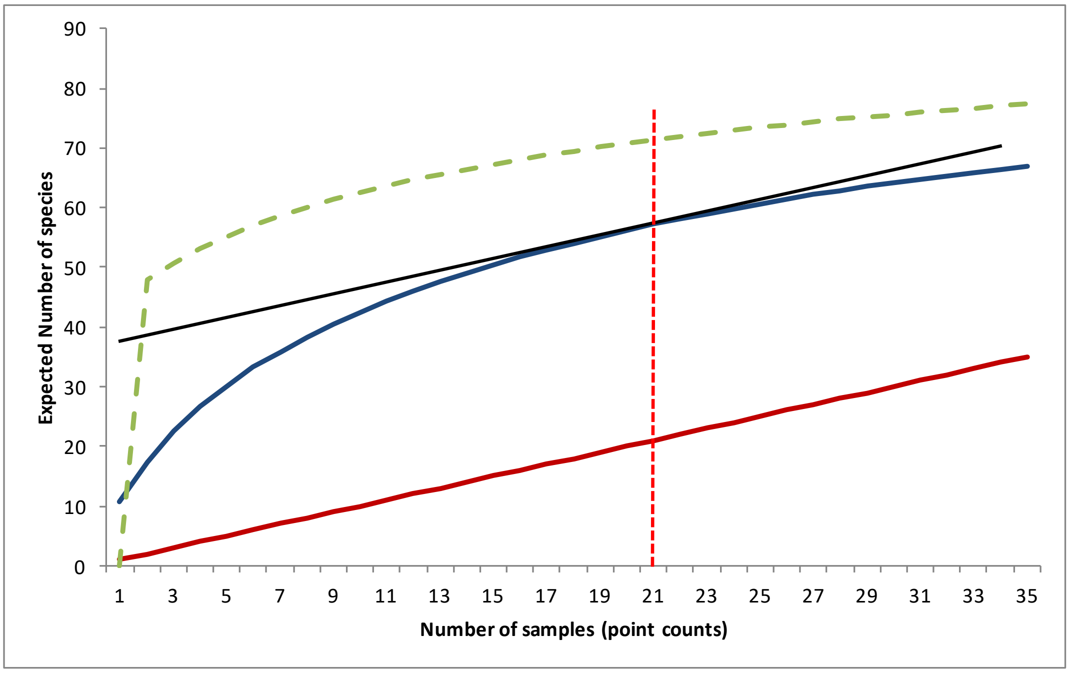


Figure 12: The species accumulation curve (SAC) (red line) for bird points sampled during the August 2021 and November 2021 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 21 counts (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 study site based on their historical distribution ranges and the presence of suitable habitat. According to Table 4, a total of 11 species have been recorded in the wider study area (sensu SABAP1 & SABAP2) which include six globally threatened species, one globally near threatened species, two regionally threatened species and two regionally near-threatened species.

It is evident from Table 4 that the highest reporting rates (>5%) were observed for the globally endangered Cape Vulture (*Gyps coprotheres*), the globally critically endangered White-backed Vulture (*Gyps africanus*), the globally endangered Lappet-faced Vulture (*Torgos tracheliotos*). These species have a high likelihood of occurrence pending the presence of suitable food (livestock carcasses). Six independent observations were made of White-backed Vulture (*Gyps africanus*) on the project area during the August 2021 winter survey, consisting of five individual birds soaring over the Dicoma site.

The regionally vulnerable Lanner Falcon (*Falco biarmicus*) and regionally near threatened Abdim's Stork (*Ciconia abdimii*) show reporting rates between 3 % and

4 %. These species have a moderate probability of occurrence and are regarded as occasional foraging visitors to the area.

The remaining species have low reporting rates (<2%) and are regarded as irregular foraging visitors with low probabilities of occurrence. However, during the site visits it was noticed that extensive areas of suitable foraging habitat persists for some of these species (e.g. Secretarybird *Sagittarius serpentarius*) despite being ominously absent from the area. It is possible that the low reporting rates reflect the poor coverage of the study area by citizen scientists (e.g. birdwatchers), and some of these species could occur in higher numbers due to being overlooked. As an example, Red-footed Falcons (*F. vespertinus*) often occur in flocks of the similar-looking Amur Falcon (*F. amurensis*), which, based on reporting rates, appear to be a common summer visitor to the area. Therefore, it is highly possible that Red-footed Falcons were previously overlooked or misidentified.

Table 4: Bird species of conservation concern that could utilise the study site based on their historical distribution range and the presence of suitable habitat. Red list categories according to the IUCN (2021)* and Taylor et al. (2015)**.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=64)	Preferred Habitat	Potential Likelihood of Occurrence
Anthropoides paradiseus (Blue Crane)	Vulnerable	Near threatened	47.18	-	Prefers open grasslands. Also forages in wetlands, pastures and agricultural land.	Potential vagrant or highly irregular foraging visitor. It has not been observed on the study area since 2007.
Aquila rapax (Tawny Eagle)	Endangered-	Endangered	2.11	-	Lowveld and Kalahari savannas, especially game farming areas and reserves	An irregular visitor or vagrant to the study site. It has not been observed on the study area since 2007.
Ciconia abdimii (Abdim's Stork)	-	Near threatened	7.75	3.70	Open stunted grassland, fallow land and agricultural fields.	An uncommon or occasional summer foraging visitor to areas consisting of secondary grassland or arable land.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=64)	Preferred Habitat	Potential Likelihood of Occurrence
Falco vespertinus (Red-footed Falcon)	Near threatened	Near threatened	2.11	2.67	Varied, prefers to hunt open arid grassland and savannoid woodland, often in company with Amur Falcons (*F. amurensis*).	An occasional summer foraging visitor to the area.
Falco biarmicus (Lanner Falcon)	-	Vulnerable	2.82	4.00	Varied, but prefers to breed in mountainous areas.	An occasional foraging visitor to the study area.
Gyps coprotheres (Cape Vulture)	Endangered	Endangered	17.16	10.67	Mainly confined to mountain ranges, especially near breeding site. Ventures far afield in search of food.	A regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses).
Gyps africanus (White-backed Vulture)	Critically Endangered	Critically Endangered	16.18	13.33	Breed on tall, flat-topped trees. Mainly restricted to large rural or game farming areas.	A regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses).
Leptoptilos crumeniferus (Marabou Stork	-	Near threatened	0.70	1.56	Varied, from savanna to wetlands, pans and floodplains – dependant of game farming areas	An irregular scavenging visitor to the area. It has not been observed on the study area since 2007.
Polemaetus bellicosus	Endangered	Endangered	-	1.33	Varied, from open karroid	An irregular foraging visitor.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP1 (n=142)	Mean Reporting rate: SABAP2 (n=64)	Preferred Habitat	Potential Likelihood of Occurrence
(Martial Eagle)					shrub to lowland savanna.	
Sagittarius serpentarius (Secretarybird)	Endangered	Vulnerable	2.45	2.67	Prefers open grassland or lightly wooded habitat.	Regarded as an irregular foraging visitor to the study site despite the widespread presence of suitable foraging habitat.
Torgos tracheliotos (Lapped-faced Vulture)	Endangered	Endangered	5.63	5.33	Lowveld and Kalahari savanna; mainly on game farms and reserves	A fairly regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses).

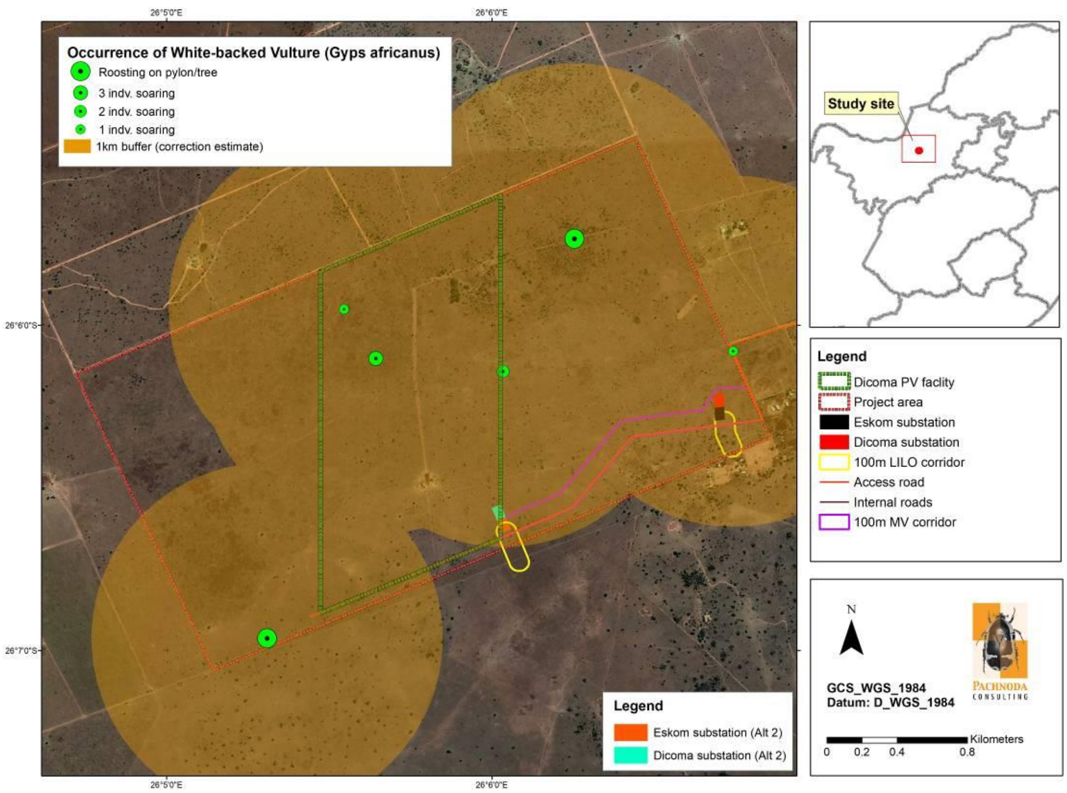


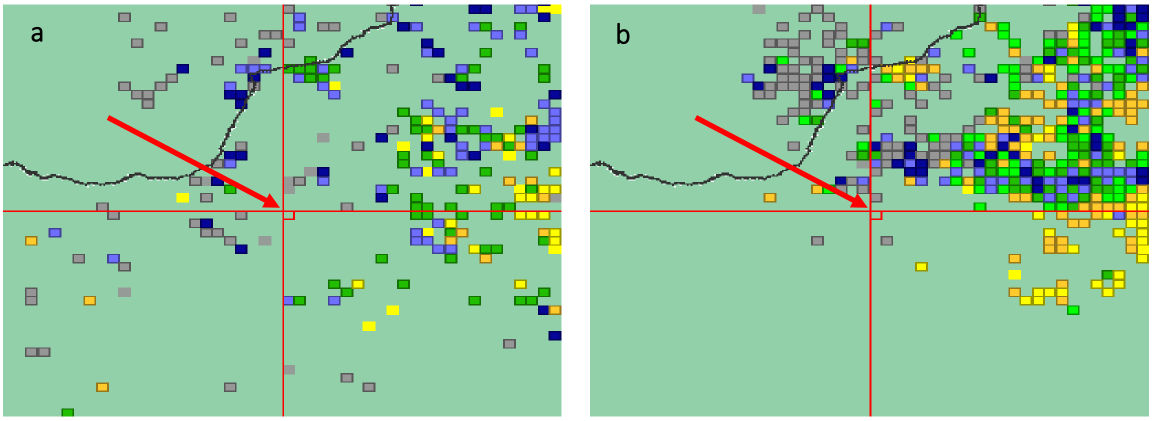
Figure 13: A map illustrating the occurrence of threatened and near threatened bird species observed on the study site and immediate surrounding during surveys conducted in August 2021 and November 2021[10].

4.4 Novelties and "Out of range" species

Three of the bird species observed on the study site represent new records for the wider study area or at least part of the project area. They are regarded as "full out of range" species according to their respective known distribution ranges (Figure 14).

Most of these species have simply not been observed in the region owing to the paucity of dedicated citizen scientists (e.g. the birding fraternity) visiting the area.

- Temminck's Courser (*Cursorius temminkii*) - One observation of an individual flying overhead (August 2021).
- Kurrichane Thrush (*turdus libonyana*) - A single observation (November 2021) of a bird flushed from open mixed woodland.
- White-throated Robin-chat (*Cossypha humeralis*) - A number of observations from open mixed woodland habitat.



[10] The 1 km buffer area is added to provide information regarding the anticipated foraging area of the birds since the observations were projected and not from birds seen directly overhead. The foraging areas of the vultures may be larger than suggested by the observations made in the field.

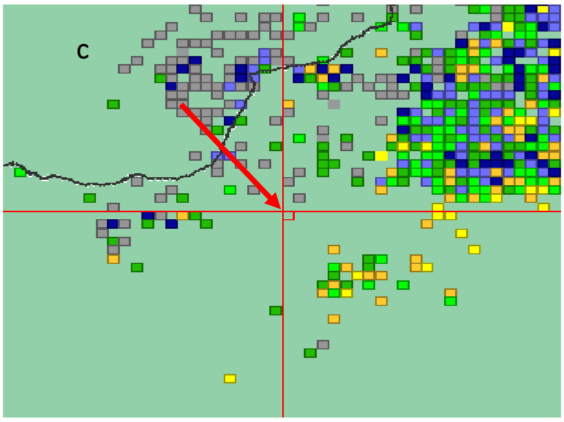


Figure 14: An example of distribution maps representing "full out of range" bird species observed during the respective surveys. Large squares represent quarter degree grids (SABAP1) and small squares are pentad grids (SABAP2): (a) Temminck's Courser (*Cursorius temminkii*), (b) Kurrichane Thrush (*Turdus libonyana*) and (c) White-throated Robin-chat (*Cossypha humeralis*).

4.5 Bird Assemblage Structure and Composition

4.5.1 Summary of point counts

A total of 67 bird species and an average abundance of 502.5 individuals were recorded from 35 bird points (according to two replicative counts) located on the project area. In addition, a total of 58 bird species and an average abundance of 235.0 individuals were recorded from 15 bird points (according to two replicative counts) located on the Dicoma site itself. The data provides an estimate of the bird richness and their numbers on the study site and immediate surroundings obtained during an austral dry and wet season survey. A mean of 25.6 species and 15.77 individuals were recorded per point count. The highest number of species and individuals recorded from a point count was respectively 40 species and 72 individuals (from open mixed woodland). The lowest number of species and individuals was respectively four species and three individuals (from open moribund grassland). The mean frequency of occurrence of a bird species at the Dicoma site was 20.11% and the median was 10.00%, while the most common value (mode) was 6.67%. The latter represents those species that were encountered in only one point count. Five species occurred in 50 % or more of the counts (Table 5), while two species (c. Chestnut-vented Warbler *Curruca subcaerulea* and Desert Cisticola *Cisticola aridulus*) occurred in >80% of all the counts (Table 5).

Table 5: Bird species with a frequency of occurrence greater than 50%, observed on the Dicoma study site (according to 15 counts).

Species	Frequency (%)	Species	Frequency (%)
Chestnut-vented Warbler (*Curruca*	86.70	Black-chested Prinia (*Prinia flavicans*)	66.67

subcaerulea)			
Desert Cisticola (*Cisticola arudulus*)	80.00	Ring-necked Dove (*Streptopelia capicola*)	66.67
Laughing Dove (*Spilopelia senegalensis*)	73.33		

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

Displacement of birds by the proposed infrastructure is one of the impacts that will 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 15 and Figure 16 it is evident that the high bird numbers (as well as a high number of bird species) occur in the tall open woodland at the north eastern part of the Dicoma site. In addition, moderately high bird species numbers is also evident from the artificial livestock watering hole on the central part of the Dicoma site. This means that the potential displacement of birds due to the loss of habitat during construction is likely to be higher at open mixed woodland and artificial watering holes.

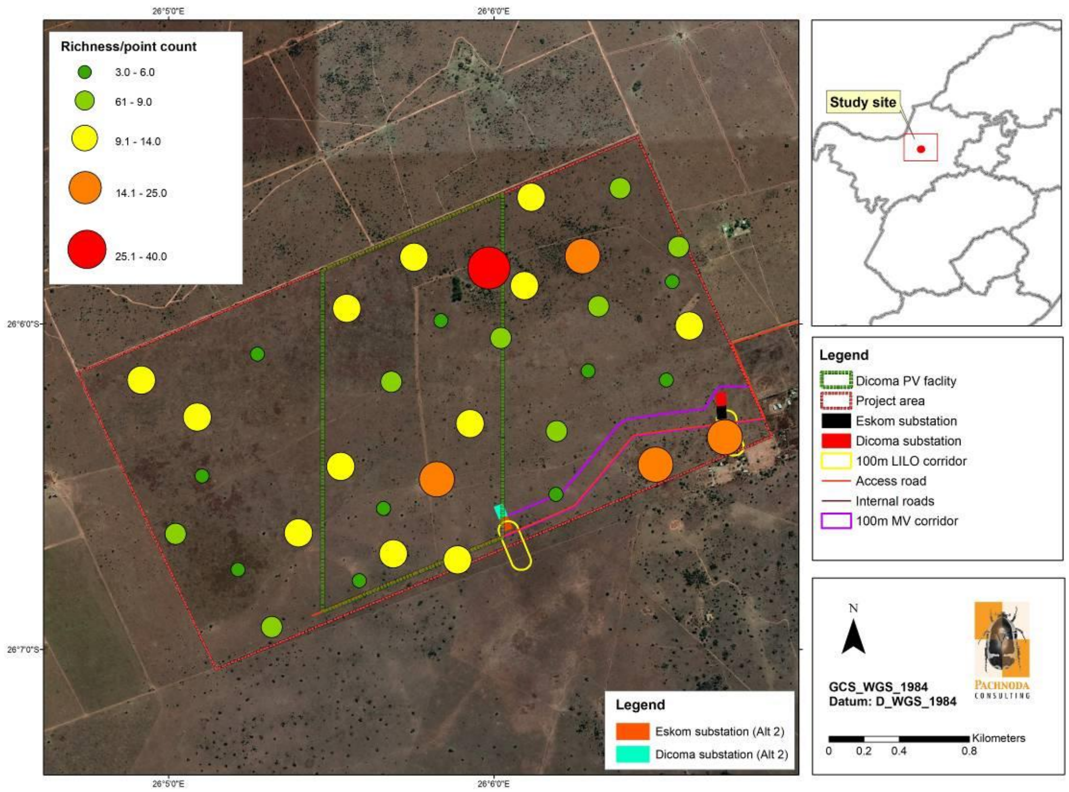


Figure 15: A map of the study site illustrating the spatial distribution of richness values (number of species) obtained for each point count.

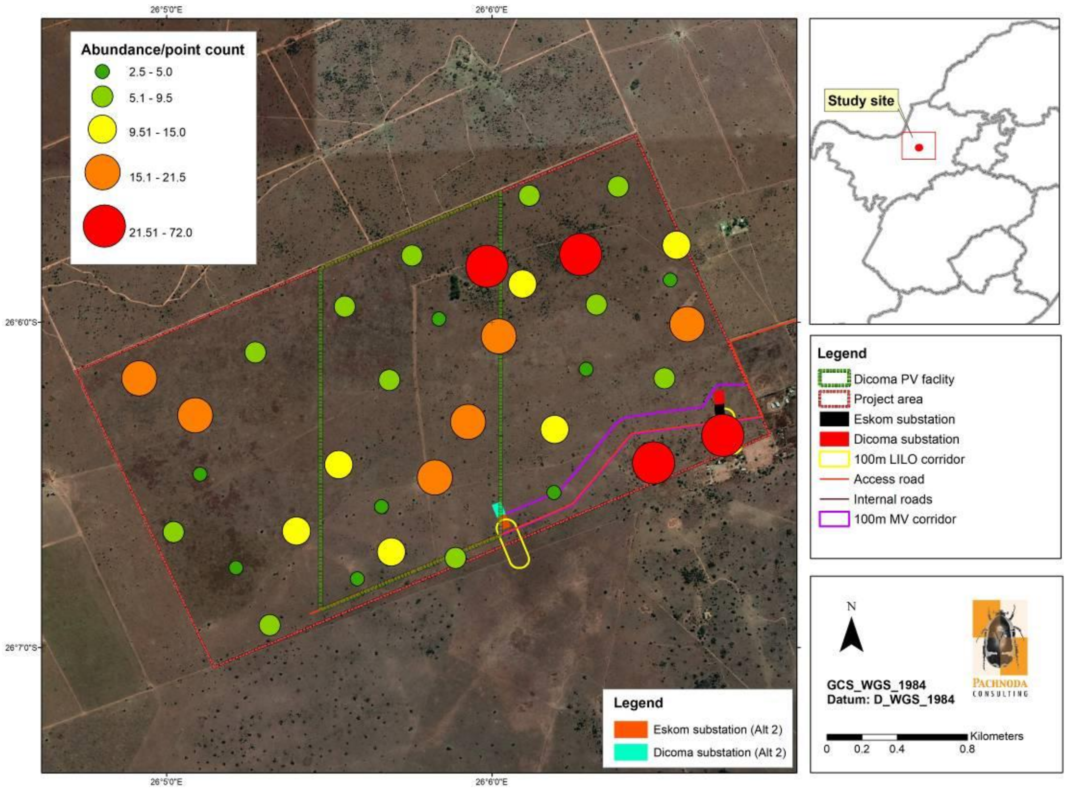


Figure 16: A map of the study site illustrating the distribution of abundance values (average number of individuals) obtained for each point count.

4.5.3 Dominance and typical bird species

The dominant (typical) species on the Dicoma study site 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 Dicoma study site include the Desert Cisticola (*Cisticola aridulus*), Black-chested Prinia (*Prinia flavicans*) and Chestnut-vented Warbler (*Curruca subcoerulea*). These species are considered widespread species in the broader study area and occur in most of the habitat types present. It is also evident from Table 6 that the typical bird assemblage is represented by insectivore (insect-eating) taxa, but also includes other less common but functionally important guilds which include frugivores (fruit-eaters), carnivores and granivores.

Table 6: Typical bird species on the study site.

Species	Av.Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
Desert Cisticola (*Cisticola aridulus*)	0.73	1.17	21.12	Insectivore: upper canopy foliage gleaner
Chestnut-vented Warbler (*Curruca subcaerulea*)	1.30	1.34	19.54	Insectivore: upper canopy foliage gleaner
Black-chested Prinia (*Prinia flavicans*)	1.23	0.77	10.84	Insectivore: upper canopy foliage gleaner
Laughing Dove (*Spilopelia senegalensis*)	1.13	0.94	10.52	Granivore: ground gleaner
Ring-necked Dove (*Streptopelia capicola*)	0.63	0.79	9.62	Granivore: ground gleaner
Rufous-naped Lark (*Mirafra africana*)	0.27	0.48	5.07	Insectivore: ground gleaner
Southern Fiscal (*Lanius collaris*)	0.30	0.46	3.17	Carnivore: ground gleaner
Red-faced Mousebird (*Urocolius indicus*)	0.70	0.37	2.69	Frugivore: upper canopy gleaner
Yellow Canary (*Crithagra flaviventris*)	0.63	0.37	2.40	Granivore: lower to upper canopy gleaner
Wattled Starling (*Creatophora cinerea*)	1.40	0.32	2.33	Insectivore: ground gleaner

4.5.4 Composition and diversity

Multidimensional scaling and hierarchical agglomerative clustering ordination of bird abundance values obtained from 35 point counts on the project area differentiate between three discrete bird associations (Global R= 0.4, p=0.387; Figure 17), although the difference between these associations are statistically insignificant. These include an (1) association on dolomite grassland with bush clump mosaics, an (2) association pertaining to open mixed woodland, and (3) an association at artificial livestock watering points.

The habitat fidelity between species is illustrated in Figure 17 by plotting the relative abundance values of Chestnut-vented Warbler (*Curruca subcaerulea*). It shows that the Chestnut-vented Warbler (a "bushveld" species) is widely distributed within the grassland/bush clump mosaics, thereby implying that "grassland' and "bushveld" compositions integrate with each other and pure compositions thereof are absent/rare. Point Lig28 is considered an outlier and occurs on secondary *Hyparrhenia* grassland. The bird richness and abundance on Lig28 was low.

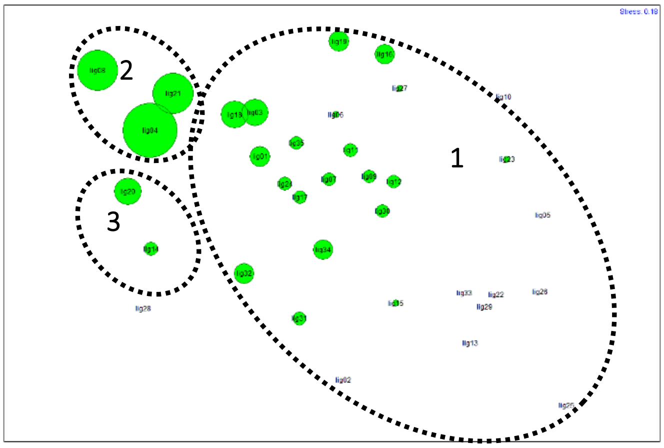


Figure 17: A two-dimensional non-metric multidimensional scaling ordination (stress=0.18) of the relative abundances of bird species based on Bray-Curtis similarities obtained from 35 point counts on the project area. It differentiates between three bird associations on (1) dolomite grassland with scattered bush clumps, (2) open mixed woodland and (3) artificial livestock watering points. The green circles represent the relative abundances of Chestnut-vented Warbler (*Curruca subcaerulea*).

The following bird associations are relevant to the Dicoma site:

1. Association on dolomite grassland with scattered bush clumps

This is the dominant bird composition on the Dicoma study site and is confined to open grassland with scattered bush clumps. The bird composition therefore contains both "grassland" and "bushveld" bird species.

Dominant species: The Desert Cisticola (*Cisticola aridulus*), Black-chested Prinia (*Prinia flavicans*), Laughing Dove (*Spilopelia senegalensis*), Rufous-naped Lark (*Mirafra africana*) and Ring-necked Dove (*Streptopelia capicola*) are ubiquitous, while Eastern Clapper Lark (*M. fasciolata*), Southern Fiscal (*Lanius collaris*), Helmeted Guineafowl (*Numida meleagris*), Ant-eating Chat (*Myrmecocichla formicivora*) are prominent in the grassland matrix. The Chestnut-vented Warbler (*Sylvia subcaerulea*), Southern Masked Weaver (*Ploceus velatus*), African Red-eyed Bulbul (*Pycnonotus nigricans*) and the Kalahari Scrub-robin (*Cercotrichas paena*) are dominant in the bush clumps.

Indicator species[11]: Desert Cisticola (*Cisticola aridulus*), Rufous-naped Lark (*Mirafra africana*), Ant-eating Chat (*Myrmecocichla formicivora*), Cape Longclaw (*Macronyx capense*), Northern Black Korhaan (*Afrotis afraoides*), Spike-heeled Lark

[11] Indicator species refers to a species with high numbers and is restricted to a particular habitat.

(*Chersomanes albofasciata*), Orange River Francolin (*Scleroptila gutturalis*), Melodious Lark (*Mirafra cheniana*) and Cloud Cisticola (*Cisticola textrix*).

2. Association on open mixed woodland

This association is confined to the tall microphyllous woodland on the north eastern parts of the Dicoma site.

Dominant species: The Red-faced Mousebird (*Urocolius indica*), Chestnut-vented Warbler (*Curruca subcaerulea*), Cape White-eye (*Zosterops virens*), Black-chested Prinia (*Prinia flavicans*) and African Red-eyed Bulbul (*Pycnonotus nigricans*) are dominant, while Neddicky (*Cisticola fulvicapilla*), Wattled Starling (*Creatophora cinerea*) and Southern Masked Weaver (*Ploceus velatus*) are also present in high numbers.

Indicator species: Cape White-eye (*Zosterops virens*), White-throated Robin-chat (*Cossypha humeralis*), Long-billed Crombec (*Sylvietta rufescens*), Ashy Tit (*Melaniparus cinerascens*), Chinspot Batis (*Batis molitor*), Crested Barbet (*Trachyphonus vaillantii*), Crimson-breasted Shrike (*Laniarius atrococcineus*), Spotted Flycatcher (*Muscicapa striata*), Violet-eared Waxbill (*Granatina granatina*), Green-winged Pytilia (*Pytilia melba*), Southern Grey-headed Sparrow (*Passer diffusus*) and Common Scimitarbill (*Rhinopomastus cyanomelas*).

3. Association at artificial livestock watering holes

This association is confined to the cattle through and kraal site on the central part of the Dicoma site.

Dominant species: The Wattled Starling (*Creatophora cinerea*), Laughing Dove (*Spilopelia senegalensis*), White-backed Mousebird (*Colius colius*), Cape Sparrow (*Passer melanurus*) and African Red-eyed Bulbul (*Pycnonotus nigricans*) attain high numbers.

Indicator species: Cape Sparrow (*Passer melanurus*), Rattling Cisticola (*Cisticola cheniana*), Red-billed Quelea (*Quelea quelea* - high numbers) and Red-eyed Dove (*Streptopelia semitorquata*).

The highest number of bird species on the project area was observed from open mixed woodland, followed by the bird association on open dolomite grassland with bush clump mosaics (Table 7 and Figure 18). The lowest number of bird species was recorded from the artificial livestock watering holes. High numbers of birds were observed from the open mixed woodland and artificial watering holes.

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

Bird Association	Number of species	Number of Individuals	Shannon Wiener Index H'(log_e)
Open mixed woodland	45.00	50.83	3.38
Open dolomite grassland and mixed bush clump mosaics	42.00	9.21	3.13
Artificial livestock watering hole	31.00	36.75	2.84

4.6 Passerine and non-passerine densities

Sixty-six bird species, representing 18 non-passerine species and 48 passerines were recorded from 35 point counts on Dicoma site and immediate surroundings. The Dicoma site and immediate surroundings comprises of approximately 3.37 species.ha^{-1} (Appendix 2). The average density per hectare is 4.57 birds.ha^{-1} and ranges between 0.80 birds.ha^{-1} to 22.93 birds.ha^{-1}.

4.7 Movements/dispersal of Collision-prone birds

Deterministic daily dispersal of birds (Figure 18, Figure 19 and Figure 20) was not observed apart from a high frequency of foraging Pied Crows (*Corvus albus*) (Figure 20). The occurrence of birds of prey was regarded as occasional, although foraging vultures occurred regularly during the dry season pending the availability of carcasses or food at a nearby vulture restaurant (Figure 18). Furthermore, the home ranges of approximately nine to 10 pairs of Northern Black Korhaans correspond to the project area, with three pairs observed on the Dicoma site (Figure 19).

The flight routes of the birds were random and haphazard and no predicted/deterministic pattern could be established. Therefore, these species utilise searching as a means to find potential food during foraging excursions. It is also evident that the distribution of the crows has shifted to the existing powerline servitudes and to the open mixed woodland which provide nesting opportunities for these birds.

The absence of any nearby water bodies, dams and drainage lines explains the general absence of waterbirds passing in the area.

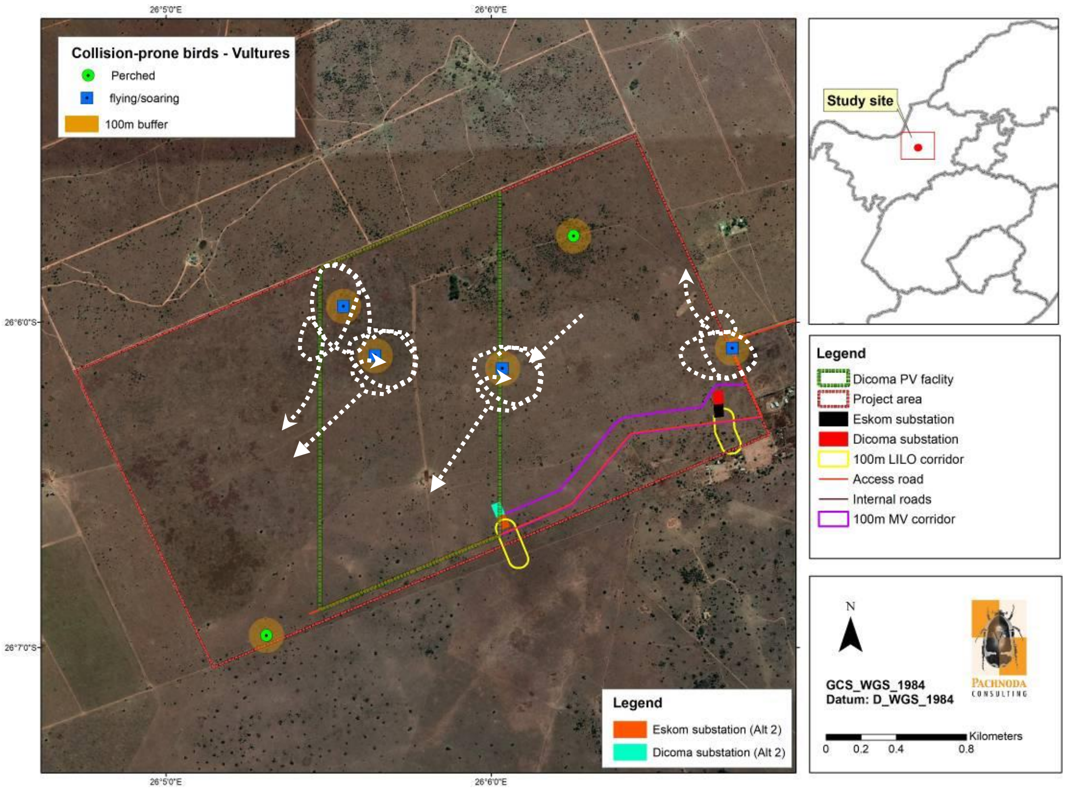


Figure 18: A map of the study site illustrating the occurrence and movements of collision prone birds: Vultures.

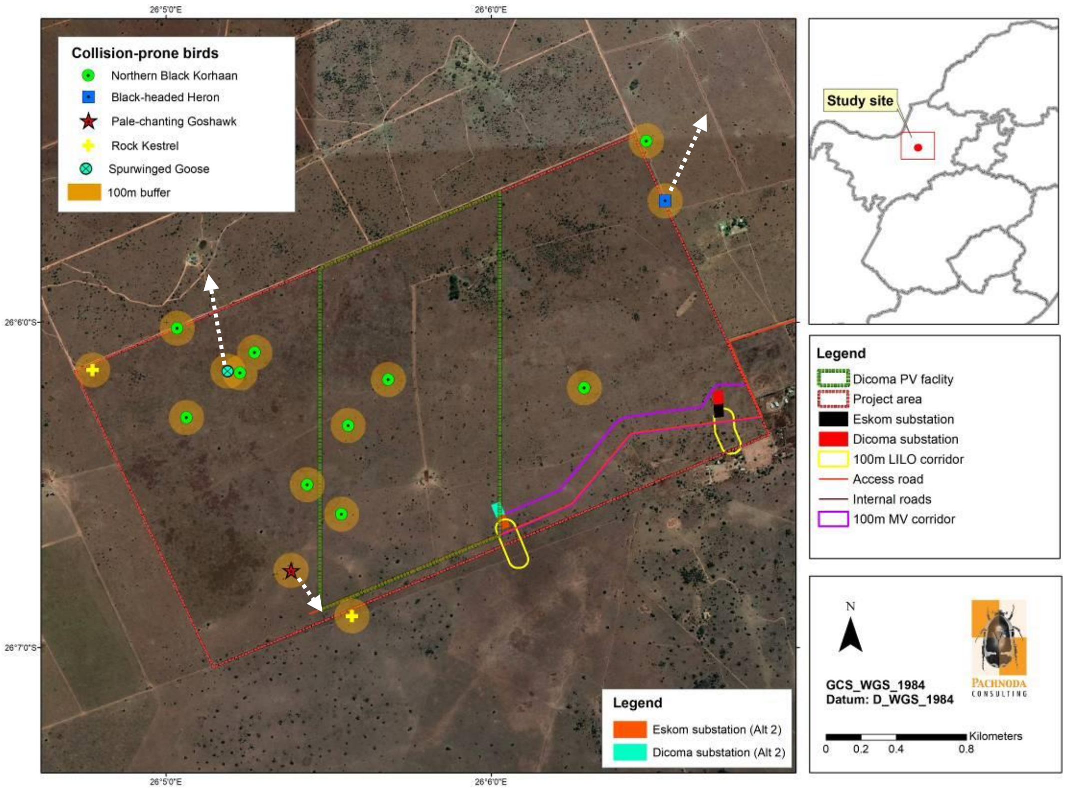


Figure 19: A map of the study site illustrating the occurrence and movements of collision prone birds: Large terrestrial birds and birds of prey.

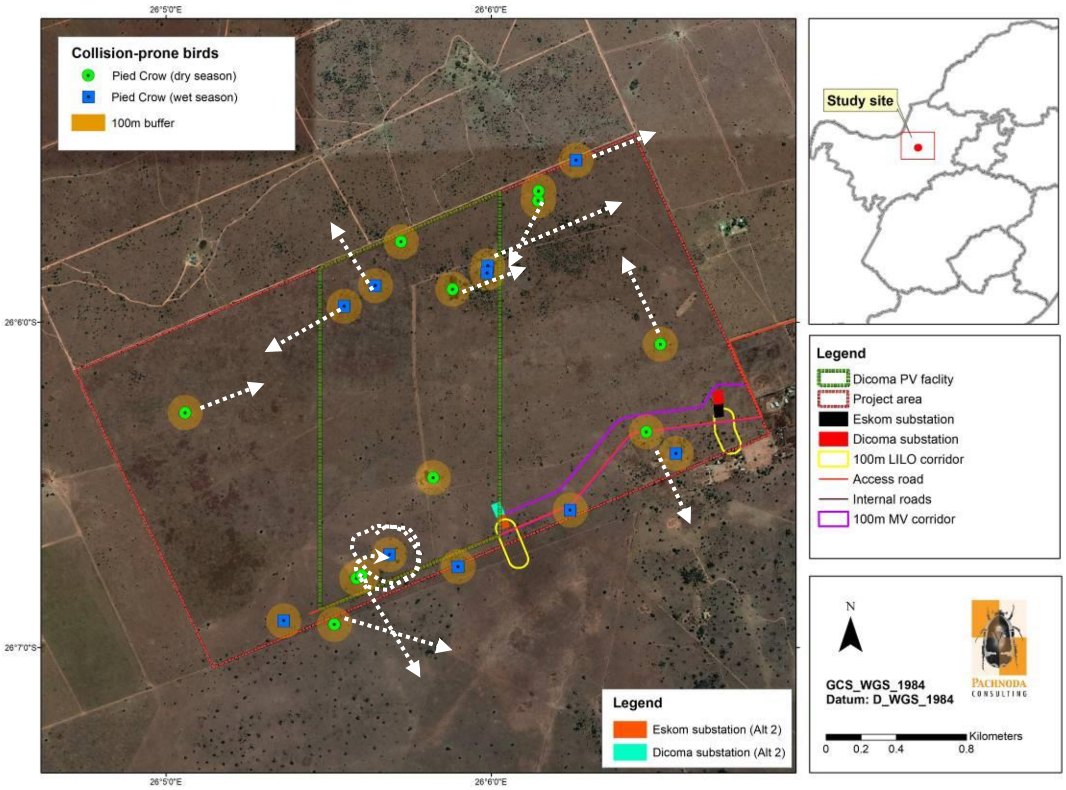


Figure 20: A map of the study site illustrating the occurrence and movements of collision prone birds: Pied Crow.

4.8 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising potential sensitive elements based on the following arguments (Figure 21):

Areas of medium sensitivity

It includes open mixed woodland, artificial livestock watering points and extensive open grassland and bush clump mosaics. The mixed woodland was often used as roosting platforms for vultures (observed during the dry season survey in August 2021) and supported areas where a higher number of bird species are anticipated to occur.

The artificial livestock watering points attracted large numbers of granivore passerine and non-passerine bird species, of which many need to drink water on a daily basis. The placement of electrical 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.

The extensive open grassland and bush clump mosaics provide potential suitable foraging habitat for some collision-prone bird species, including the Northern Black

Korhaan (*Afrotis afraoides*) with the potential to interact (e.g. collide) with the proposed electrical infrastructure. However, reporting rates for threatened and near threatened bird species are relatively low, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat is natural. In addition, the open grassland and bush clump mosaics are widespread in the region.

Areas of low sensitivity

These habitat units are represented by transformed types and include a *Eucalyptus* plantation.

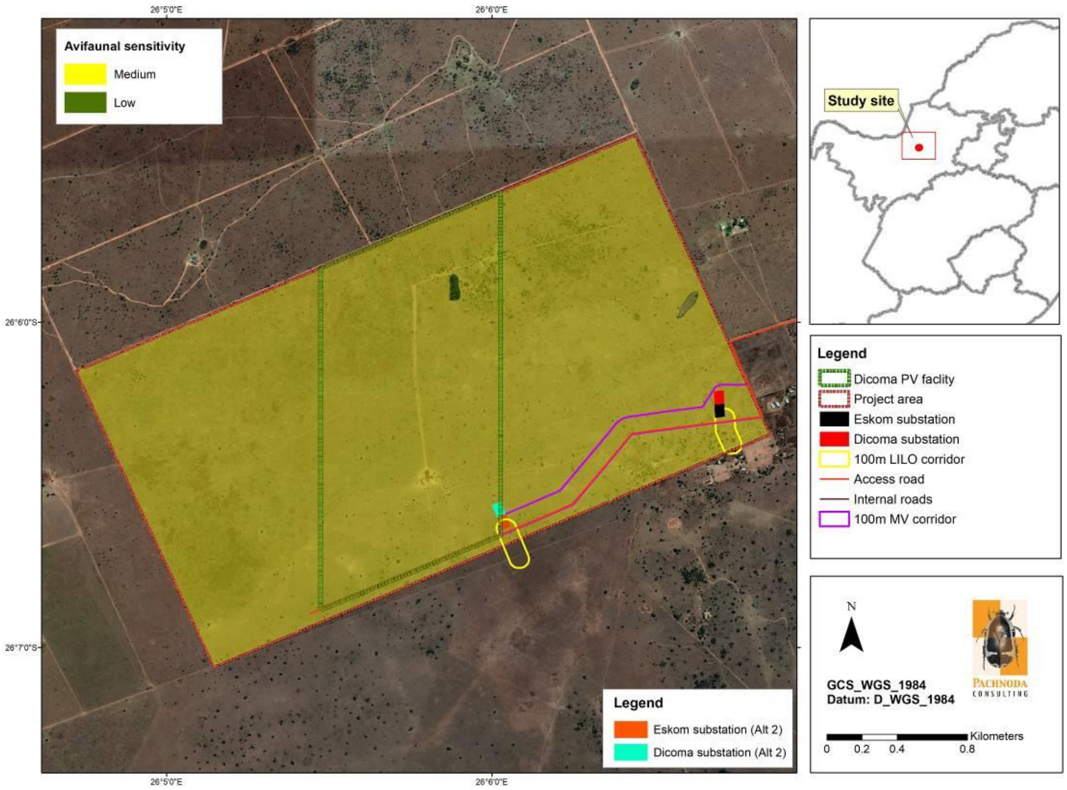


Figure 21: A map illustrating the avifaunal sensitivity of the study site based on the ecological condition of habitat types and the occurrence of collision prone species.

4.9 Overview of Avian Impacts at Solar Facilities

4.9.1 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.

4.9.2 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.

4.10 Impacts associated with the Dicoma PV Facility

Table 8 provides a summary of the impacts anticipated and quantification thereof.

4.10.1 Loss of habitat and displacement of birds

Approximately 180 ha of the site 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 3.37 species.ha^{-1} and 4.57 birds.ha^{-1} will become displaced should the activity occur across all the habitat types on the study site (as per Jenkins et al., 2017). Displacement will mainly affect passerine and smaller non-passerine species inhabiting the untransformed dolomite grasslands and bush clump mosaics.

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:

- Northern Black Korhaan (*Afrotis afraoides*);
- White-browed Scrub-robin (*Cossypha humeralis*);
- Ashy Tit (*Melaniparus cinerascens*);
- Kalahari Scrub Robin (*Cercotrichas paena*);
- Orange River Francolin (*Scleroptila gutturalis*) and potentially also small to medium birds of prey such as:
- Black-winged Kite (*Elanus caeruleus*)
- Rock Kestrel (*Falco rupicolus*) and
- Black-chested Snake-eagle (*Circaetus pectoralis*).

When considering the number of displaced bird species and their widespread occurrence in the region, the predicted impact due to the overall displacement and habitat loss is moderate without mitigation measures.

Two internal substation and LILO corridor options are proposed (alternative 1 and alternative 2). It is unlikely that the significance of the impact will differ should the proposed substations and corridors be constructed at any of the alternative layout options. Both alternative options contain the same habitat types. In addition, the proposed substation covers a small surface area, which will result in a reduced impact significance rating (when compared to the PV layout).

4.10.2 Creation of "new" avian habitat and bird pollution

It is possible that the 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*);
- Common Myna (*Acridotheres tristis*);
- 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.

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

The study site is not located in close proximity to any major wetland system or water body. The nearest wetland system is approximately 4km east of the site, and the nearest large wetland system that is inundated is approximately 6 km from the study site, which explain the low occurrence of waterbird taxa at the study site. These wetland habitat types are often utilised by waterbirds which could accidentally mistake the reflective panels for waterbodies, thereby resulting in bird collisions with the panel surfaces. At this stage the impact is considered to be low although it is uncertain what the significance of it will be during the peak summer season depending on subsequent site visits (e.g. pre-construction monitoring) during the peak wet season when most of the wetland features in the region are inundated. This makes predictions regarding the occurrence of waterbird species and their numbers (e.g. density) in the area inconceivable.

However, desktop results and site observations show that the following species could interact with the panel infrastructure:

- Yellow-billed Duck (*Anas undulata*);
- Red-billed Teal (*Anas erythrorhynchus*);
- South African Shelduck (*Tadorna cana*);
- Spur-winged Goose (*Plectropterus gambiensis*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- Black-headed Heron (*Ardea melanocephala*); and probably also
- Grey Heron (*Ardea cinerea*) and
- White-faced Duck (*Dendrocygna viduata*).

Of these species, the Spur-winged Goose and Black-headed Heron were confirmed from the immediate surroundings.

In the absence of sufficient information on the occurrence of waterbird taxa in the area, as well as the lack of data on bird mortalities caused by collisions, the precautionary principle was applied which results in an impact of moderate significance (in the absence of any mitigation measures).

4.10.4 Interaction with overhead power lines and reticulation

A short loop-in loop out corridor is proposed consisting of two alternatives at the internal substation (LILO Alternative 1 and LILO Alternative 2) which feeds directly into the existing power line network. Birds are impacted in three ways by means of overhead power lines. 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 power lines. 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. However, electrocution is proportional to the spatial position of carcasses, and will probably only occur when a carcass is located underneath or in close proximity to an overhead distribution power line.

- *Collision*

Collisions with earth wires have probably accounted for most bird-power line 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.

This may be true for most other bird species that are prone towards power line collisions, although the risk of Cape Vultures and White-backed Vultures colliding with the power line will persist due to the foraging behaviour and ecological requirements of this species. Cape Vultures feed communally and congregate in large numbers at a carcass; therefore any power line in close proximity could result in this species colliding with the earth wires, often resulting in more than a single mortality.

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

It is anticipated that access roads need to be constructed, including the clearing of vegetation as part of the power line servitude. 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	Permanent (5)	Permanent (5)
Magnitude	High (8)	Moderate (6)
Probability	Definite (5)	Highly Probable (4)
Significance	**High (75)**	**Medium (52)**
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
Substation (Alternative 1 & 2)	**Without mitigation**	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Permanent (5)	Permanent (5)
Magnitude	Low (4)	Minor (2)
Probability	Definite (5)	Probable (3)
Significance	**Medium (50)**	**Low (24)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes
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. It is unlikely that the significance of the impact will change should the facility be constructed on any of the alternative options. Both the PV facility and substation options contain the same habitat types of medium sensitivity. The best practicable mitigation will be to consolidate infrastructure to areas where existing impacts occur (e.g. placing the proposed power line alongside existing power lines). The proposed substation covers a small surface area, which will result in a reduced impact significance rating.		
Residual: It is anticipated that during rehabilitation (after removal of the panels) that the vegetation will revert to secondary grassland and shrubland resulting in a decreased bird species richness with low evenness values on a local scale. The residual impact of the PV facility will be medium. The residual impact of the substation will be low due to the small surface area of habitat loss.		

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	Low (4)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (30)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
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. If pre-construction and 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.		
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 low.		

4. Nature: Avian collision impacts related to overhead power lines during operation.		
LILO Corridor - Alternative 1 and 2)	**Without mitigation**	**With mitigation**
Extent	Local (1)	Local (1)
Duration	Long-term (4)	Long-term (4)

Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Probable (3)
Significance	**Medium (33)**	**Low (27)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird 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 (if pylons are used). Avoid the placement of cattle feedlots, kraals and watering points in close proximity to any overhead electrical infrastructure. 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. In addition, the impact significance (after mitigation) will be reduced if the proposed corridor is placed alongside existing power line servitudes.		
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be medium.		

5. Nature: Avian electrocution related to the new distribution lines during operation.		
All proposed overhead corridors	**Without mitigation**	**With mitigation**
Extent	Regional (4)	Immediate area (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Probable (3)	Probable (3)
Significance	**Medium (48)**	**Medium (45)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, owing to the potential loss of critically endangered or endangered bird species	Yes, impact could still occur irrespective of mitigation.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: Electrocution is proportional to the spatial position of carcasses (with reference to scavenging birds of prey), and will probably only occur when a carcass is located underneath or in close proximity to an overhead distribution power line. Apply bird deterrent devices to the power line. Avoid the placement of cattle feedlots and watering points near electrical infrastructure. All cattle feedlots within close proximity of powerlines (~100m) should preferably be relocated (>100m from powerlines). Grazing of cattle at or in close proximity to distribution lines should be monitored at all times and preferably be avoided (to minimise potential livestock carcasses near distribution lines). Make use of bird-friendly pylons and bird guards as recommended by EWT. Position electrical infrastructure in close proximity to existing infrastructure.		
Residual: Direct mortality is possible and may still happen irrespective of applied mitigation measures. The residual impact will be medium.		

4.10.5 Collision-prone bird species

A total of 39 collision-prone bird species have been recorded in the wider study area, of which 21 species are birds of prey (Table 9). Three of these species are vulture taxa (Cape Vulture *Gyps coprotheres*, White-backed Vulture *Gyps africanus* and Lappet-faced Vulture *Torgos tracheliotos*). Those species with SABAP2 reporting rates higher than 10% are regarded to be regular in the area and include the highly collision-prone and threatened White-backed Vulture and Cape Vulture.

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

Common Name	Scientific Name	National conservation status (sensu Taylor et al., 2015)	SABAP2 Reporting Rate (Full Protocol)
Pale Chanting Goshawk	*Melierax canorus*		n/a
Rock Kestrel	*Falco rupicolus*		n/a
Speckled Pigeon	*Columba guinea*		69.33
Hadada Ibis	*Bostrychia hagedash*		62.67
Western Cattle Egret	*Bubulcus ibis*		49.33
Ant-eating Chat	*Myrmecocichla formicivora*		46.67
Pied Crow	*Corvus albus*		45.33
Helmeted Guineafowl	*Numida meleagris*		44.00
Swainson's Spurfowl	*Pternistis swainsonii*		40.00
Northern Black Korhaan	*Afrotis afraoides*		34.67
Yellow-billed Duck	*Anas undulata*		34.67
Black-winged Kite	*Elanus caeruleus*		32.00
Black-headed Heron	*Ardea melanocephala*		26.67
Amur Falcon	*Falco amurensis*		21.33
Egyptian Goose	*Alopochen aegyptiaca*		20.00
Orange River Francolin	*Scleroptila gutturalis*		20.00
Rock Dove	*Columba livia*		18.67
Lesser Kestrel	*Falco naumanni*		16.00
White-backed Vulture	*Gyps africanus*	CR	13.33
Yellow-billed Kite	*Milvus aegyptius*		12.00
African Sacred Ibis	*Threskiornis aethiopicus*		10.67
Cape Vulture	*Gyps coprotheres*	EN	10.67
Spur-winged Goose	*Plectropterus gambensis*		10.67
Coqui Francolin	*Peliperdix coqui*		6.67
Lappet-faced Vulture	*Torgos tracheliotos*	EN	5.33
Black-chested Snake Eagle	*Circaetus pectoralis*		4.00
Common (Steppe) Buzzard	*Buteo buteo vulpinus*		4.00
Greater Kestrel	*Falco rupicoloides*		4.00
Lanner Falcon	*Falco biarmicus*	VU	4.00
African Harrier-Hawk	*Polyboroides typus*		2.67
Arrow-marked Babbler	*Turdoides jardineii*		2.67
Red-footed Falcon	*Falco vespertinus*	NT	2.67
Secretarybird	*Sagittarius serpentarius*	VU	2.67
Spotted Eagle-Owl	*Bubo africanus*		2.67

Common Name	Scientific Name	National conservation status (sensu Taylor et al., 2015)	SABAP2 Reporting Rate (Full Protocol)
Western Barn Owl	*Tyto alba*		2.67
Black Kite	*Milvus migrans*		1.33
Brown Snake Eagle	*Circaetus cinereus*		1.33
Martial Eagle	*Polemaetus bellicosus*	EN	1.33
Abdim's Stork	*Ciconia abdimii*	NT	0.00

The study site does not coincide with any prominent wetland system or impoundment which will lower the risk of waterbird collisions with the proposed electrical infrastructure.

4.10.6 Vultures

Three species of vulture occur in the project area, which are prone towards electrocution and collision with power lines. These include the globally critically endangered White-backed Vulture (*Gyps africanus*), the globally endangered Cape Vulture (*G. coprotheres*) and the globally endangered Lappet-faced Vulture (*Torgos tracheliotos*). These species are of international significance and any mortality of adult individuals could have a negative effect on its species' population recruitment. Most of these suffer from a shortage of food supplies which is responsible for low reproductive rates, especially for Cape Vultures (Taylor *et al*., 2015). In addition, most of these species also tend to congregate at mammalian carcasses, where they feed in large groups, especially Cape Vultures. In addition, Cape Vultures also typically search for food in groups. It is such congregations which increase the risk of mortalities whenever these individuals forage or roost in close proximity to power lines. In addition, the proposed study site is also in close proximity to the foraging rangeland of Cape Vultures as evidenced by dispersal data obtained from vulture individuals fitted with satellite tracking devices (Figure 22).

The highest number of mortalities due to electrocution and collision recorded in the study region pertains to Cape Vultures (*Gyps coprotheres*) and White-backed Vultures (*Gyps africanus*) (according to the electrical infrastructure mortality incident register) (Figure 23). Most of the mortalities were caused by electrocution from smaller distribution lines in the area, although a significant number of Cape Vulture mortalities (*c*. 30 %) were also the result of collisions with transmission lines (Figure 23). There is a definite correlation between the size (in terms of voltage) of the power line and the type of mortality, whereby electrocution incidents were prominent at distribution lines while collisions occur at transmission lines. Therefore, it is postulated that the proposed power line network could contribute towards the rate of collision mortalities in vulture species in the area. Most of the power line interactions also occurred in the Ventersdorp and Lichtenburg area (Figure 24), with a single mass mortality involving 10 Cape Vultures and eight White-backed Vultures on 09 March 2009. **It clearly shows that when these species congregate (for example when feeding from a carcass in close proximity to a power line or when roosting on pylons or nearby structures in close proximity to power lines), the risk of mortality due to both electrocution and collision is greatly increased**. It was also evident from the mortality data that incidents are continuous with a recent mortality recorded during 06 February 2018 and 13 incidents recorded during the last two years. Most of the recent incidents pertain to collisions, which are an indication that mitigation measures such as the application of bird diverters tend to be ineffective.

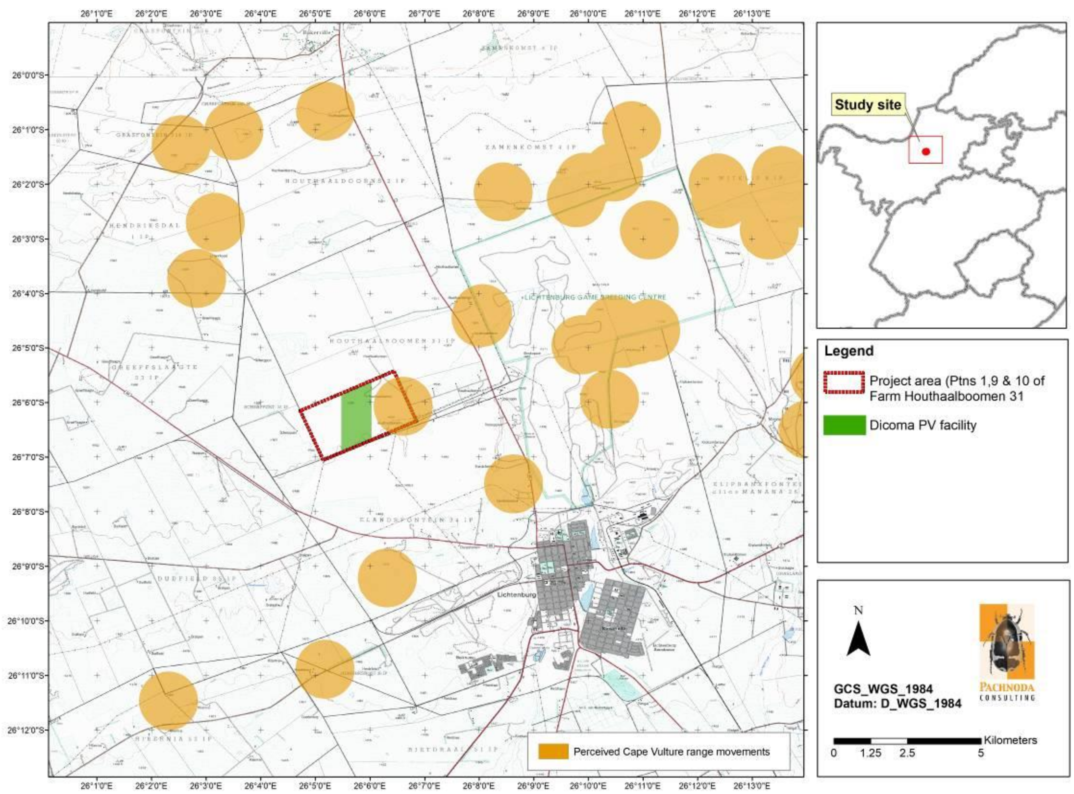


Figure 22: The occurrence of Cape Vultures (*Gyps coprotheres*) within the study region fitted with satellite trackers.

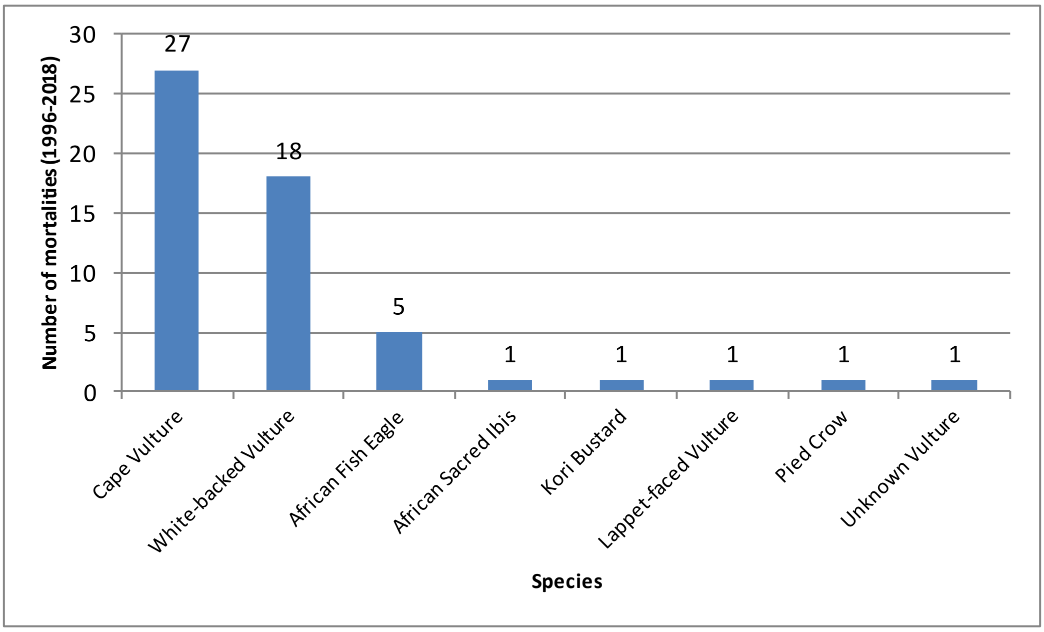


Figure 23: The number of mortalities (electrocutions and collisions) per bird species due to transmission and distribution lines in the study region (1996-2018).

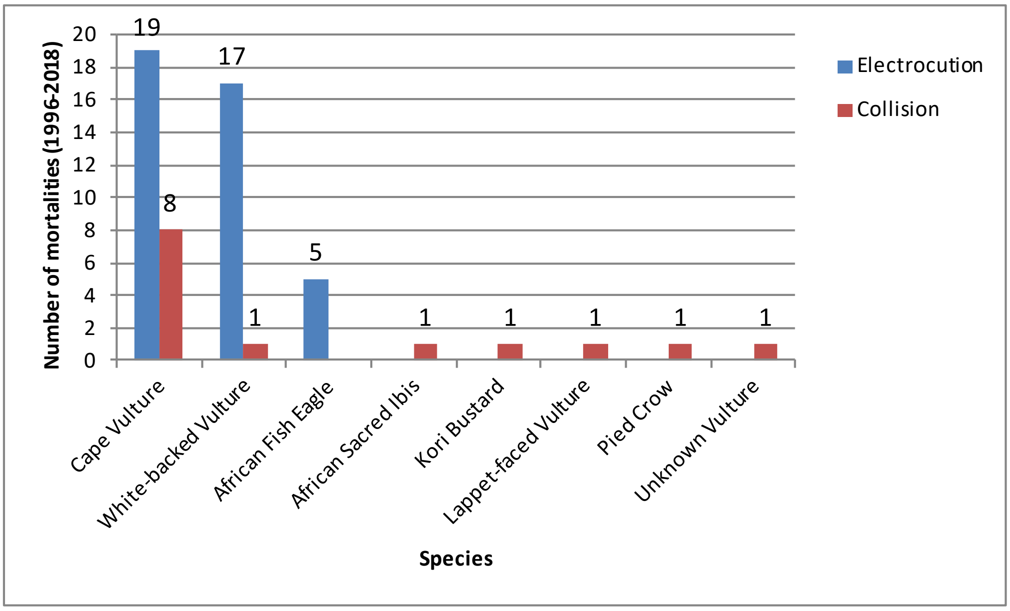


Figure 24: The number of mortalities per bird species caused by electrocutions (distribution lines) and collisions (transmission lines) in the study region (1996-2018).

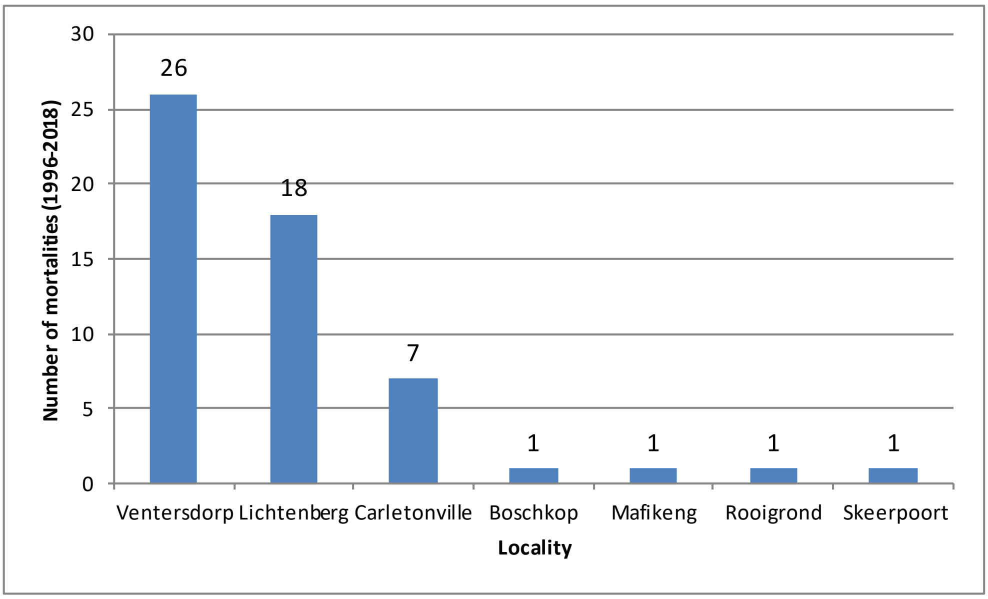


Figure 25: The number of bird mortalities caused by power lines per geographic locality (1996-2018), including the Lichtenburg area.

4.11 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 in the study area due to other planned solar farm projects and electrical infrastructure in the region.

The Dicoma PV facility is one of three similar facilities located in the project area. The other two facilities include the Setaria and Barleria PV facilities which are also located on Portions 1, 9 and 10 of the Farm Houthaalboomen 31. These three solar facilities will cumulatively occupy an area of approximately 542 ha.

In addition, three other PV facilities (Lichtenburg 1 - 3 PV facilities) are planned on the Remaining Extent of Portion 02 of the Farm Zamenkomst No 04, Portion 06 of the Farm Zamenkomst No 04 and Portion 23 of Farm Houthaalboomen No 31 respectively. These facilities are located approximately 5km north of the Dicoma PV facility. These three solar facilities will cumulatively occupy an area of approximately 784 ha.

Other solar projects are also proposed in the region which include the 75MW Tlisitseng PV Facilities (covering a maximum of 600 ha in total on Portion 25 of the Farm Houthaalboomen No. 31), the Watershed Solar Energy Facility and the Lichtenburg Solar Park.

The cumulative impacts are likely to exacerbate the displacement and loss of habitat. In addition, the grid connection (via overhead power lines) of these facilities with high voltage lines will increase the probability of bird strikes with power lines and avian mortalities due to collision and electrocution. *It is especially vulture species that are at risk of colliding or electrocution by the proposed additional electrical infrastructure*.

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 (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Moderate (6)	High (8)
Probability	Highly Probable (4)	Definite (5)
Significance	**Medium (48)**	**High (70)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes
Confidence in findings: High.		
Mitigation: The best practicable mitigation will be to consolidate infrastructure (e.g. proposed power line) to areas where existing impacts occur (e.g. placing the proposed power lines alongside existing power lines). The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.		

2. Nature: Avian collision impacts related to the PV facility during the operation 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	Minor (2)	Moderate (6)
Probability	Improbable (2)	Probable (2)
Significance	**Low (16)**	**Low (26)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area
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.		

3. Nature: Avian collision impacts related to the overhead power lines during operation.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Regional (4)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Probable (3)	Highly Probable (4)
Significance	**Medium (48)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, impact could still occur irrespective of mitigation.	Yes, owing to the potential loss of critically endangered or endangered bird 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 power lines 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 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	Immediate area (3)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	High (8)
Probability	Probable (3)	Highly Probable (4)
Significance	**Medium (45)**	**High (64)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes, impact could still occur irrespective of mitigation.	Yes, owing to the potential loss of critically endangered or endangered bird species.
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Moderate.		
Mitigation: Make use of bird-friendly pylons and bird guards. As far as possible, position electrical infrastructure in close proximity to existing similar infrastructure.		

4.12 Recommended avifaunal mitigation

4.12.1 Loss of habitat and displacement bird taxa (including threatened and near threatened birds)

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, artificial livestock watering points should be relocated and should be located at least 100m away from powerline servitudes.
- Where possible, part of the open mixed woodland should be retained as open space due to its high avifaunal richness when compared to the other habitat types.
- 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 site 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 lines.

4.12.2 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.
- 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.

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

The following mitigation measures are proposed:

- Implement at least an additional bird survey (pre-construction surveys - see section dealing with monitoring and EMP) during the peak wet season to obtain quantified data on the occurrence or flyways of waterbird taxa. The data will enable informed decisions regarding the use of deterrent devices.
- 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. 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.
- 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.

4.12.4 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.
- Proposed overhead power line servitudes should be placed adjacent to existing power lines. This will increase the visibility of the lines and concentrate impacts rather than segregating impacts onto areas consisting of untransformed habitat.
- It is advised to make use of LILO alternative 2. The footprint of MV corridor alternative 2 is smaller and disturbances caused during construction of the MV corridor (to be placed underground) will encompass a smaller surface area.
- It is advised that all infrastructure be fenced to prevent cattle from accessing into the facility. Avoid the placement of cattle feedlots, kraals and watering points in close proximity to overhead electrical infrastructure. A safe distance of at least 100 m from any overhead powerline is recommended. It is advised that grazing cattle at or in close proximity to distribution lines *(c*. 100 m) be monitored (to avoid the risk of livestock carcasses near distribution lines, which may attract vultures and the increased the risk of collision or electrocution by overhead lines). In the event that a carcass is located, it should immediately be removed from the area. If livestock carcasses are considered safe for consumption by vultures, it may be donated to the nearby vulture restaurant.

- EWT should be consulted on an appropriate pylon design to be used for the project. 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[12].

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).

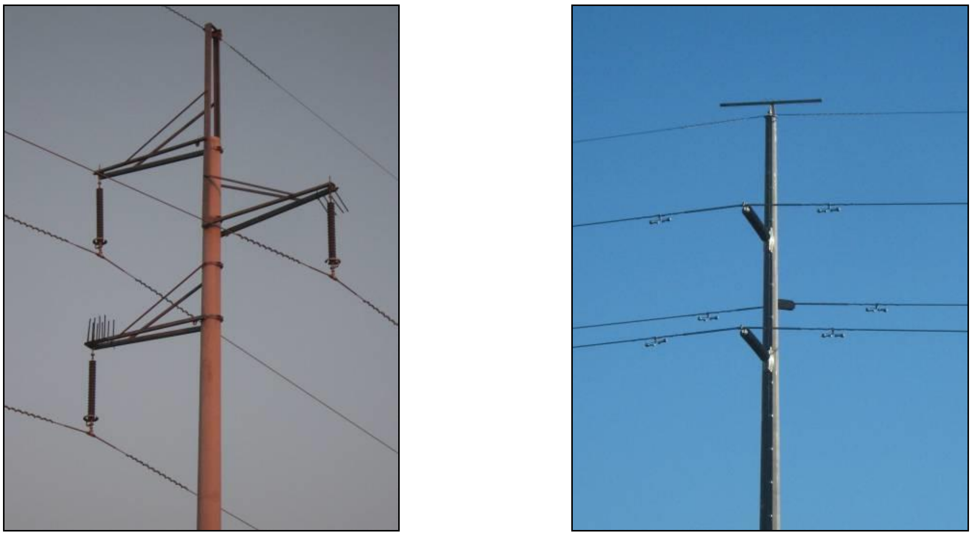


Figure 26: Two bird-friendly tower designs to be considered for the current project.

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

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

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).

4.12.5 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.

4.13 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 additional pre- and post construction monitoring be implemented to augment existing data:

- At least one additional pre-construction survey is recommended, consisting of a minimum of 1-2 days which is necessary to inform the final EMPr during operation. The survey should coincide with the peak wet season when most of the drainage lines and wetland features in the wider study region are inundated. This will enable the observer to obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels.
- A post-construction survey during operation (with a minimum of 2 x 3 day surveys during 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 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 and species of conservation concern.
- It is possible that bird mortalities due to collision will occur at the power lines even after mitigation. The post-construction monitoring (during operation) should also quantify mortalities (especially vulture mortalities) caused by the power line network. The information could then be used to inform the electrical infrastructure mortality incident register. It is suggested that monitoring should be implemented once a month for at least one year when in operation. 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: *Minimise 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	» Operation of PV infrastructure
Mitigation: Target/Objective	» Zero bird mortalities due to collision trauma caused by PV panels

Mitigation: Action/Control	Responsibility	Timeframe
1. 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, 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)
2. 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)
3. Use indigenous plant species native to the study area during landscaping and rehabilitation.	CER & ECO	Construction phase
4. Implement pre-construction monitoring protocols (as per Jenkins et al., 2017).	ECO & EM	Prior to construction - At least 1 survey of 1-2 days (during wet season)
5. Implement post-construction monitoring and carcass surveys (as per Jenkins et al., 2017)	OM & CER	Post- construction - At least 2 surveys, each 3 days during a 6 month period
6. 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	1. Implement at least one pre-construction survey consisting of a minimum of 1-2 days. 2. Surveys should coincide with the peak wet season when most of the

	drainage lines and wetland features in the wider study region are inundated. 3. Obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels. 4. Monitor terrestrial birds at the fixed point counts by using the exact protocol applied during this report. 5. Implement post-construction survey during operation with a minimum of 2 x 3 day surveys during a six month period (including the peak wet season). 6. Obtain mortality data from birds colliding with the panels and advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. 7. Conduct post-construction monitoring in a systematic manner by means of direct observations (an option is the use of installed video cameras at selected areas) and carcass searches. 8. 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: Minimise collisions and electrocution associated with power lines

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

Mitigation: Action/Control	**Responsibility**	**Timeframe**
1. Apply bird deterrent devices to all new power lines power line	ECO & CER	Construction
2. Implement post-construction monitoring and carcass surveys	OM	Operation - daily
3. Compile management programme to assess efficacy of mitigation and on-going research/trials	OM & CER	Operation - monthly for at least one year
4. 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	1. Implement surveys for livestock carcasses. 2. Implement post-construction monitoring to quantify bird mortalities caused by the power line network. All searches should be done on foot. 3. 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.

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

Pachnoda Consulting cc was requested by Savannah Environmental (Pty) Ltd to compile an avifauna baseline and impact assessment report for the proposed Dicoma PV facility and associated infrastructure on Portion 1, 9 and 10 of the Farm Houthaalboomen 31, near Lichtenburg, North West Province.

Four prominent avifaunal habitat types was identified on the site, and consisted of open mixed dolomite grassland with bush clump mosaics, open mixed woodland, artificial livestock watering holes and a *Eucalyptus* plantation. However, power line servitudes occur on the southern boundary of the study site of which the pylons were used for roosting by vultures. Approximately 176 bird species are expected to occur in the wider study area, of which 97 species were observed in the study area. The expected richness included 11 threatened or near threatened species, 15 southern African endemics and 21 are near-endemic species. The critically endangered White-backed Vulture (*Gyps africanus*) was confirmed during the surveys, mainly as roosting individuals or birds soaring overhead. Eleven southern African endemics and 15 near-endemic species were confirmed on the study site.

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), with the exception of the potential for birds to collide with the associated power lines, which was high without mitigation (and moderate after mitigation). The study site is not located near any prominent wetland system or impoundment, and therefore the risk of waterbird collisions with the proposed infrastructure was considered to be low. However, in the absence of sufficient information on the occurrence and rate of passing waterbirds, it was recommended that supporting evidence be acquired by means of peak wet season before construction (pre-construction surveys).

The endangered Cape Vulture (*Gyps coprotheres*) and critically endangered White-backed Vulture (*Gyps africanus*) (and to a lesser degree also Lappet-faced Vulture *Torgos tracheliotos*) were identified as regular foraging visitors to the study site (according to SABAP2 reporting rates and on-site observations). These species are highly prone to power line collisions, whereby the proposed energy facility (especially the proposed overhead power lines) could pose a collision and electrocution risk to vultures. The risk of collision/electrocution was considered likely when vultures feed on a carcass in close proximity to a power line or when attempting to roost on the pylon structures.

No fatal-flaws were identified during the assessment, and irrespective of the layout options proposed for the PV facility and the internal substation alternatives (alternative 1 vs. alternative 2), the significance of the avifaunal impacts were regarded as identical. Impacts related to avian collision and electrocution with overhead power lines between LILO alternative 1 and 2 were also considered to be the same. Nevertheless, it is strongly recommended that the proposed mitigation measures and monitoring protocols (additional with pre- and post construction monitoring) be implemented during the construction and operational phase of the project.

5. REFERENCES

Birdlife South Africa. 2018. *BirdLife South Africa Checklist of Birds in South Africa*, 2018.

Brewer, R. & Mccann, M.T. 1982. *Laboratory and field manual of ecology*. Saunders Publishing, Philadelphia.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L. 1993. *Distance Sampling: Estimating abundance of biological populations*. Chapman and Hall, London.

Clarke, K.R. & Warwick, R.M. 1994. *Changes in marine communities: An approach to statistical analysis and interpretation*. Natural Environmental Research Council, United Kingdom.

Colwell, R.K. 2013. *EstimateS: Statistical estimation of species richness and shared species from samples. Version 9*. User's Guide and application published at: http://purl.oclc.org/estimates.

Del Hoyo, J., Elliott, A. & Christie, D.A. eds. 1992-2011. *Handbook of the Birds of the World.* Vol 1-16. Lynx Edicions, Barcelona.

Geoterrainimage. 2015. *The South African National Land cover Dataset*. Version 05.

Gill, F, D Donsker, & P Rasmussen (Eds). 2021. IOC World Bird List (v 11.2). Doi 10.14344/IOC.ML.10.2. http://www.worldbirdnames.org/.

Gunerhan, H., Hepbasli, A. & Giresunlu, U. 2009. Environmental impacts from the solar energy systems. Energy Sources, Part A: *Recovery, Utilization and Environmental Effects* 31: 131-138.

Hardaker, T. 2020. Southern African Bird List - Version 10 - 22 December 2020.

Harrison, C., Lloyd, H. & Field, C. 2016. *Evidence review of the impact of solar farms on birds, bats and general ecology*. NEER012 report, Manchester Metropolitan University, UK.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V. & Brown, C.J. (eds.). 1997. *The Atlas of Southern African Birds. Vol. 1 & 2*. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J. & Ryan, P.G. (eds.) 2005. *Roberts – Birds of Southern Africa*, VII^th ed. The Trustees of the John Voelker Bird Book Fund, Cape Town.

IUCN Red List of Threatened Species. Version 2021. http://www.iucnredlist.org/.

Jenkins, A.R, Ralston-Paton, S & Smit-Robinson, H.A. 2017. Best practice guidelines: Birds and Solar Energy. Guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa. BirdLife South Africa.

Kagen, R.A., Verner, T.C., Trail, PW & Espinoza, E.O. 2014. Avian mortality at solar energy facilities in southern California: A preliminary analysis. Unpublished report by the National Fish and Wildlife Forensics Laboratory, USA.

Kruger, R. 1999. *Towards solving raptor electrocutions on Eskom Distribution Structures in South Africa.* M. Phil. Mini-thesis. University of the Orange Free State. Bloemfontein. South Africa.

Ledger, J. & Annegarn, H.J. 1981. Electrocution Hazards to the Cape Vulture (*Gyps coprotheres*) in South Africa. *Biological Conservation* 20: 15-24.

Marnewick, M.D., Retief, E.F., Theron, N.T., Wright, D.R. And Anderson, T.A. 2015. *Important Bird and Biodiversity Areas of South Africa*. Johannesburg: BirdLife South Africa.

McCrary, M.D., McKernan, R.L., Schreiber, R.W., Wagner, W.D. & Sciarotta, T.C. 1986. Avian mortality at a solar energy power plant. *Journal of Field Ornithology* 57: 135-141.

Moreno, C. E. & Halffter, G. 2000. Assessing the completeness of bat biodiversity inventories using species accumulation curves. *Journal of Applied Ecology* 37, 149–158.

Mucina, L. & Rutherford, M.C. (eds.). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia 19*. South African National Biodiversity Institute, Pretoria.

Pachnoda Consulting. 2018. Proposed Mahikeng main transmission substation and 1x400kv Pluto-Mahikeng power line within the Merafong City Local Municipality of the Gauteng Province and the Ditsobotla, Ramotshere Moiloa, JB Marks and Mafikeng Local Municipalities of the North West Province. A report compiled for Baagi Environmental Consultants.

Raaijmakers, J.G.W. 1987. Statistical analysis of the Michaelis-Menten equation. *Biometrics* 43: 793-803.

Soberón, J., & J. Llorente. 1993. The use of species accumulation functions for the prediction of species richness. *Conservation Biology* 7 , 480-488.

Sutherland, W.J. 2006. *Ecological census techniques. A handbook*. 2nd Edn. Cambridge University Press.

Sutherland, W.J., Newton, I. and Green, R. E. 2004. *Bird Ecology and Conservation. A handbook of techniques*. Oxford University Press.

Taylor, M.R., Peacock, F. & Wanless, R. (eds.). 2015. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland*. BirdLife South Africa, Johannesburg

Tsoutsos, T., Frantzeskaki, N. & Gekas, V. 2005. Environmental impacts from solar energy technologies. *Energy Policy* 33: 289-296.

Van Rooyen, C.S. 2000. An overview of Vulture Electrocutions in South Africa. *Vulture News* 43: 5-22.

Van Rooyen, C.S. & Taylor, P.V. 1999. *Bird streamers as probable cause of electrocutions in South Africa*. EPRI Workshop on Avian Interactions with Utility Structures, Charleston, South Carolina.

Vosloo, H. 2003. Birds and power lines. *ESI Africa* 3: 38.

Walston Jr. L.J., Rollins, K.E., LaGory, K.E., Smith, K.P. & Meyers, S.A. 2016. A preliminary assessment of avian mortality at utility-scale solar energy facilities in the United States. *Renewable Energy* 92 (2016) 405-414.

Watson, D.M. 2003. The ‘standardized search’: An improved way to conduct bird surveys. *Austral Ecology* 28: 515-525

www.sabap2.birdmap.africa

Appendix 1: A shortlist of bird species expected to be present on the study site and immediate surroundings. 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 2605_2605 and the eight surrounding grids. The reporting rates include submissions made during the August and November 2021 surveys.

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad hoc Protocol (%)	Number of cards
78	Abdim's Stork	*Ciconia abdimii*		0.00	0	3.70	1
432	Acacia Pied Barbet	*Tricholaema leucomelas*	1	37.33	28	3.70	1
171	African Harrier-Hawk	*Polyboroides typus*		2.67	2	0.00	0
418	African Hoopoe	*Upupa africana*		44.00	33	0.00	0
387	African Palm Swift	*Cypsiurus parvus*	1	38.67	29	0.00	0
682	African Paradise Flycatcher	*Terpsiphone viridis*		8.00	6	0.00	0
692	African Pipit	*Anthus cinnamomeus*	1	37.33	28	3.70	1
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	42.67	32	0.00	0
606	African Reed Warbler	*Acrocephalus baeticatus*		20.00	15	0.00	0
81	African Sacred Ibis	*Threskiornis aethiopicus*		10.67	8	0.00	0
576	African Stonechat	*Saxicola torquatus*	1	44.00	33	0.00	0
247	African Wattled Lapwing	*Vanellus senegallus*		1.33	1	0.00	0
772	Amethyst Sunbird	*Chalcomitra amethystina*		5.33	4	0.00	0
119	Amur Falcon	*Falco amurensis*		21.33	16	3.70	1
575	Ant-eating Chat	*Myrmecocichla formicivora*	1	46.67	35	7.41	2
533	Arrow-marked Babbler	*Turdoides jardineii*	1	2.67	2	0.00	0
514	Ashy Tit	*Melaniparus cinerascens*	1	4.00	3	0.00	0
510	Banded Martin	*Riparia cincta*	1	13.33	10	3.70	1
493	Barn Swallow	*Hirundo rustica*	1	36.00	27	7.41	2
622	Bar-throated Apalis	*Apalis thoracica*		1.33	1	0.00	0
128	Black Kite	*Milvus migrans*		1.33	1	0.00	0

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
712	Black-backed Puffback	*Dryoscopus cubla*		1.33	1	0.00	0
650	Black-chested Prinia	*Prinia flavicans*	1	68.00	51	7.41	2
146	Black-chested Snake Eagle	*Circaetus pectoralis*		4.00	3	0.00	0
431	Black-collared Barbet	*Lybius torquatus*	1	34.67	26	3.70	1
715	Black-crowned Tchagra	*Tchagra senegalus*	1	2.67	2	0.00	0
55	Black-headed Heron	*Ardea melanocephala*	1	26.67	20	3.70	1
521	Black-headed Oriole	*Oriolus larvatus*		2.67	2	0.00	0
245	Blacksmith Lapwing	*Vanellus armatus*		70.67	53	3.70	1
860	Black-throated Canary	*Crithagra atrogularis*	1	42.67	32	0.00	0
130	Black-winged Kite	*Elanus caeruleus*	1	32.00	24	25.93	7
839	Blue Waxbill	*Uraeginthus angolensis*		25.33	19	3.70	1
722	Bokmakierie	*Telophorus zeylonus*	1	44.00	33	3.70	1
145	Brown Snake Eagle	*Circaetus cinereus*		1.33	1	0.00	0
714	Brown-crowned Tchagra	*Tchagra australis*	1	13.33	10	7.41	2
402	Brown-hooded Kingfisher	*Halcyon albiventris*		1.33	1	0.00	0
731	Brubru	*Nilaus afer*		4.00	3	3.70	1
695	Buffy Pipit	*Anthus vaalensis*		1.33	1	0.00	0
4131	Burchell's Coucal	*Centropus burchellii*		17.33	13	0.00	0
703	Cape Longclaw	*Macronyx capensis*	1	30.67	23	3.70	1
531	Cape Penduline Tit	*Anthoscopus minutus*		2.67	2	0.00	0
581	Cape Robin-Chat	*Cossypha caffra*	1	21.33	16	0.00	0
786	Cape Sparrow	*Passer melanurus*	1	74.67	56	14.81	4
737	Cape Starling	*Lamprotornis nitens*	1	29.33	22	7.41	2
316	Ring-necked Dove	*Streptopelia capicola*	1	24.00	18	14.81	4
106	Cape Vulture	*Gyps coprotheres*		10.67	8	0.00	0
686	Cape Wagtail	*Motacilla capensis*	1	57.33	43	0.00	0

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
799	Cape Weaver	*Ploceus capensis*		5.33	4	0.00	0
1172	Cape White-eye	*Zosterops virens*	1	28.00	21	0.00	0
568	Capped Wheatear	*Oenanthe pileata*		9.33	7	0.00	0
484	Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*	1	10.67	8	11.11	3
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	38.67	29	7.41	2
673	Chinspot Batis	*Batis molitor*	1	6.67	5	0.00	0
872	Cinnamon-breasted Bunting	*Emberiza tahapisi*		9.33	7	3.70	1
631	Cloud Cisticola	*Cisticola textrix*	1	17.33	13	3.70	1
154	Common (Steppe) Buzzard	*Buteo buteo vulpinus*		4.00	3	7.41	2
734	Common Myna	*Acridotheres tristis*	1	69.33	52	7.41	2
189	Common Quail	*Coturnix coturnix*	1	n/a			
421	Common Scimitarbill	*Rhinopomastus cyanomelas*	1	16.00	12	0.00	0
843	Common Waxbill	*Estrilda astrild*		18.67	14	0.00	0
594	Common Whitethroat	*Curruca communis*		1.33	1	0.00	0
173	Coqui Francolin	*Peliperdix coqui*	1	6.67	5	0.00	0
439	Crested Barbet	*Trachyphonus vaillantii*	1	65.33	49	0.00	0
711	Crimson-breasted Shrike	*Laniarius atrococcineus*	1	17.33	13	0.00	0
242	Crowned Lapwing	*Vanellus coronatus*	1	70.67	53	7.41	2
545	Dark-capped Bulbul	*Pycnonotus tricolor*		32.00	24	0.00	0
630	Desert Cisticola	*Cisticola aridulus*	1	20.00	15	7.41	2
352	Diederik Cuckoo	*Chrysococcyx caprius*	1	32.00	24	3.70	1
1183	Eastern Clapper Lark	*Mirafra fasciolata*	1	18.67	14	0.00	0
89	Egyptian Goose	*Alopochen aegyptiaca*		20.00	15	0.00	0
404	European Bee-eater	*Merops apiaster*	1	28.00	21	0.00	0
678	Fairy Flycatcher	*Stenostira scita*	1	n/a			
570	Familiar Chat	*Oenanthe familiaris*		4.00	3	0.00	0

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
665	Fiscal Flycatcher	*Melaenornis silens*	1	42.67	32	7.41	2
517	Fork-tailed Drongo	*Dicrurus adsimilis*		1.33	1	3.70	1
874	Golden-breasted Bunting	*Emberiza flaviventris*		2.67	2	3.70	1
447	Golden-tailed Woodpecker	*Campethera abingoni*		2.67	2	0.00	0
785	Great Sparrow	*Passer motitensis*	1	2.67	2	0.00	0
440	Greater Honeyguide	*Indicator indicator*		4.00	3	0.00	0
122	Greater Kestrel	*Falco rupicoloides*		4.00	3	3.70	1
502	Greater Striped Swallow	*Cecropis cucullata*	1	48.00	36	0.00	0
419	Green Wood Hoopoe	*Phoeniculus purpureus*		9.33	7	0.00	0
830	Green-winged Pytilia	*Pytilia melba*	1	10.67	8	3.70	1
339	Grey Go-away-bird	*Crinifer concolor*	1	20.00	15	0.00	0
557	Groundscraper Thrush	*Turdus litsitsirupa*		6.67	5	0.00	0
84	Hadada Ibis	*Bostrychia hagedash*	1	62.67	47	0.00	0
192	Helmeted Guineafowl	*Numida meleagris*	1	44.00	33	11.11	3
784	House Sparrow	*Passer domesticus*	1	54.67	41	11.11	3
835	Jameson's Firefinch	*Lagonosticta rhodopareia*		2.67	2	0.00	0
586	Kalahari Scrub Robin	*Cercotrichas paena*	1	34.67	26	7.41	2
1104	Karoo Thrush	*Turdus smithi*	1	54.67	41	0.00	0
552	Kurrichane Thrush	*Turdus libonyana*	1	n/a			
114	Lanner Falcon	*Falco biarmicus*		4.00	3	0.00	0
108	Lappet-faced Vulture	*Torgos tracheliotos*		5.33	4	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*	1	90.67	68	25.93	7
706	Lesser Grey Shrike	*Lanius minor*		14.67	11	0.00	0
442	Lesser Honeyguide	*Indicator minor*		4.00	3	0.00	0
125	Lesser Kestrel	*Falco naumanni*		16.00	12	3.70	1
413	Lilac-breasted Roller	*Coracias caudatus*		1.33	1	0.00	0

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
410	Little Bee-eater	*Merops pusillus*		8.00	6	3.70	1
385	Little Swift	*Apus affinis*	1	34.67	26	3.70	1
621	Long-billed Crombec	*Sylvietta rufescens*	1	9.33	7	0.00	0
852	Long-tailed Paradise Whydah	*Vidua paradisaea*		5.33	4	0.00	0
818	Long-tailed Widowbird	*Euplectes progne*	1	41.33	31	14.81	4
661	Marico Flycatcher	*Melaenornis mariquensis*		5.33	4	0.00	0
607	Marsh Warbler	*Acrocephalus palustris*		5.33	4	3.70	1
142	Martial Eagle	*Polemaetus bellicosus*		1.33	1	0.00	0
456	Melodious Lark	*Mirafra cheniana*	1	n/a			
564	Mountain Wheatear	*Myrmecocichla monticola*		2.67	2	0.00	0
318	Namaqua Dove	*Oena capensis*	1	16.00	12	0.00	0
637	Neddicky	*Cisticola fulvicapilla*	1	18.67	14	3.70	1
1035	Northern Black Korhaan	*Afrotis afraoides*	1	34.67	26	3.70	1
179	Orange River Francolin	*Scleroptila gutturalis*	1	20.00	15	3.70	1
838	Orange-breasted Waxbill	*Amandava subflava*		4.00	3	0.00	0
165	Pale Chanting Goshawk	*Melierax canorus*	1	n/a			
522	Pied Crow	*Corvus albus*	1	45.33	34	7.41	2
746	Pied Starling	*Lamprotornis bicolor*		6.67	5	7.41	2
846	Pin-tailed Whydah	*Vidua macroura*		26.67	20	0.00	0
694	Plain-backed Pipit	*Anthus leucophrys*		4.00	3	0.00	0
844	Quailfinch	*Ortygospiza atricollis*	1	18.67	14	3.70	1
642	Rattling Cisticola	*Cisticola chiniana*	1	10.67	8	0.00	0
708	Red-backed Shrike	*Lanius collurio*		22.67	17	0.00	0
837	Red-billed Firefinch	*Lagonosticta senegala*		14.67	11	0.00	0
805	Red-billed Quelea	*Quelea quelea*	1	40.00	30	7.41	2
488	Red-capped Lark	*Calandrella cinerea*		9.33	7	3.70	1

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
813	Red-collared Widowbird	*Euplectes ardens*		5.33	4	0.00	0
314	Red-eyed Dove	*Streptopelia semitorquata*	1	78.67	59	11.11	3
392	Red-faced Mousebird	*Urocolius indicus*	1	52.00	39	7.41	2
120	Red-footed Falcon	*Falco vespertinus*		2.67	2	0.00	0
820	Red-headed Finch	*Amadina erythrocephala*		30.67	23	0.00	0
940	Rock Dove	*Columba livia*	1	18.67	14	0.00	0
123	Rock Kestrel	*Falco rupicolus*	1	n/a			
506	Rock Martin	*Ptyonoprogne fuligula*	1	6.67	5	3.70	1
458	Rufous-naped Lark	*Mirafra africana*	1	36.00	27	3.70	1
460	Sabota Lark	*Calendulauda sabota*		8.00	6	3.70	1
789	Scaly-feathered Weaver	*Sporopipes squamifrons*	1	28.00	21	0.00	0
105	Secretarybird	*Sagittarius serpentarius*		2.67	2	0.00	0
847	Shaft-tailed Whydah	*Vidua regia*		1.33	1	3.70	1
504	South African Cliff Swallow	*Petrochelidon spilodera*	1	30.67	23	0.00	0
707	Southern Fiscal	*Lanius collaris*	1	72.00	54	14.81	4
709	Southern Boubou	*Laniarius ferrugineus*		1.33	1	0.00	0
4142	Southern Grey-headed Sparrow	*Passer diffusus*	1	26.67	20	3.70	1
803	Southern Masked Weaver	*Ploceus velatus*	1	78.67	59	3.70	1
808	Southern Red Bishop	*Euplectes orix*	1	64.00	48	3.70	1
390	Speckled Mousebird	*Colius striatus*	1	16.00	12	3.70	1
311	Speckled Pigeon	*Columba guinea*	1	69.33	52	11.11	3
474	Spike-heeled Lark	*Chersomanes albofasciata*	1	28.00	21	0.00	0
368	Spotted Eagle-Owl	*Bubo africanus*		2.67	2	0.00	0
654	Spotted Flycatcher	*Muscicapa striata*	1	17.33	13	0.00	0
275	Spotted Thick-knee	*Burhinus capensis*	1	6.67	5	0.00	0
88	Spur-winged Goose	*Plectropterus gambensis*	1	10.67	8	0.00	0

#	Common Name	Scientific Name	Observed (August 2021 & November 2021)	SABAP2 Reporting Rate			
867	Streaky-headed Seedeater	*Crithagra gularis*	1	4.00	3	0.00	0
185	Swainson's Spurfowl	*Pternistis swainsonii*	1	40.00	30	0.00	0
649	Tawny-flanked Prinia	*Prinia subflava*		6.67	5	0.00	0
277	Temminck's Courser	*Cursorius temminckii*	1	n/a			
736	Violet-backed Starling	*Cinnyricinclus leucogaster*		1.33	1	0.00	0
840	Violet-eared Waxbill	*Granatina granatina*	1	5.33	4	0.00	0
735	Wattled Starling	*Creatophora cinerea*	1	49.33	37	0.00	0
359	Western Barn Owl	*Tyto alba*		2.67	2	0.00	0
61	Western Cattle Egret	*Bubulcus ibis*	1	49.33	37	3.70	1
391	White-backed Mousebird	*Colius colius*	1	46.67	35	3.70	1
107	White-backed Vulture	*Gyps africanus*	1	13.33	10	0.00	0
763	White-bellied Sunbird	*Cinnyris talatala*	1	13.33	10	0.00	0
780	White-browed Sparrow-Weaver	*Plocepasser mahali*	1	69.33	52	18.52	5
588	White-browed Scrub Robin	*Cercotrichas leucophrys*		1.33	1	0.00	0
409	White-fronted Bee-eater	*Merops bullockoides*		10.67	8	0.00	0
383	White-rumped Swift	*Apus caffer*	1	26.67	20	0.00	0
582	White-throated Robin-Chat	*Cossypha humeralis*	1	n/a			
814	White-winged Widowbird	*Euplectes albonotatus*		20.00	15	3.70	1
599	Willow Warbler	*Phylloscopus trochilus*		10.67	8	3.70	1
866	Yellow Canary	*Crithagra flaviventris*	1	66.67	50	7.41	2
96	Yellow-billed Duck	*Anas undulata*		34.67	26	0.00	0
129	Yellow-billed Kite	*Milvus aegyptius*		12.00	9	7.41	2
812	Yellow-crowned Bishop	*Euplectes afer*		9.33	7	0.00	0
859	Yellow-fronted Canary	*Crithagra mozambica*		2.67	2	0.00	0
629	Zitting Cisticola	*Cisticola juncidis*		33.33	25	0.00	0

Appendix 2: Preliminary density estimates of birds recorded from the Dicoma site and immediate surroundings during two independent surveys conducted during August 2021 and November 2021.

Species	lig01	lig02	lig03	lig04	lig05	lig06	lig07	lig08	lig09	lig10	lig11	lig12	lig13	lig14	lig15	lig16	lig17	lig18	lig19	lig20	lig21	lig22	lig23
Acacia Pied Barbet	0	0	0.5	1	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0
African Red-eyed Bulbul	0	0	1.5	2	0	0	0	1.5	0	0	0	0	0	1.5	0	0	1	0.5	0	2	2	0	0
Ant-eating Chat	0	0.5	0	0	0	0	0	0	0	0	0	0	3.5	0	2	0	0	0	0	0	0	1	0
Arrow-marked Babbler	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ashy Tit	0	0	0	1	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-chested Prinia	2	1.5	1	4	0.5	0.5	1	3	1.5	1	2	1	1	1	1	0	1	0	0	3	3	1	0
Black-collared Barbet	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black-crowned Tchagra	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0
Black-throated Canary	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Bokmakierie	0	0	0	0	0	1	0.5	0.5	0	0	0	0.5	0	0.5	0	0	0	0	0	0	1	0	0
Brown-crowned Tchagra	0.5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Cape Longclaw	0	0.5	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0
Cape Sparrow	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
Cape Starling	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape White-eye	0	0	0	4	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0
Chestnut-backed Sparrow-Lark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Chestnut-vented Warbler	1.5	0	2	4	0	0.5	1	3	1	0	1	1	0	1	0.5	1.5	1	2	1.5	2	3	0	0.5
Chinspot Batis	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cloud Cisticola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Scimitarbill	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crested Barbet	0	0	0	1	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crimsonbreasted Shrike	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crowned Lapwing	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Desert Cisticola	1	2	0.5	0	1.5	1	1	0	1	0.5	1	1.5	1	0	1	1	1	0.5	1	0.5	0	2	1.5
Diederik Cuckoo	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Clapper Lark	0	0.5	0	0	0.5	0	0	0	0.5	0	0	0.5	0	0	0.5	0	0	0	0	0	0	0	0

Species	lig01	lig02	lig03	lig04	lig05	lig06	lig07	lig08	lig09	lig10	lig11	lig12	lig13	lig14	lig15	lig16	lig17	lig18	lig19	lig20	lig21	lig22	lig23
Fiscal Flycatcher	0.5	0	0.5	0.5	0	0	0	1.5	0	0	0.5	0	0	0	0	0	0	0	0	0.5	0	0	0
Green-winged Pytilia	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Grey Go-away-bird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Hadeda Ibis	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helmeted Guineafowl	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0.5	0.5	0	8.5	0	0
Kalahari Scrub Robin	1	1	0	1	0	0.5	0.5	1.5	0	0	0	0	0	0	0	0	0	1	0.5	1	0	0	0
Kurrichane Thrush	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laughing Dove	1	0.5	1.5	3	0	0.5	0.5	7.5	0.5	0	0.5	0.5	0	2	0	1	0.5	1	0	3	2	0	0
Long-billed Crombec	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long-tailed Widowbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melodious Lark	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Namaqua Dove	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Neddicky	0	0	1	1	0	0	0	2.5	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0.5	0	0
Northern Black Korhaan	0	0.5	0	0	0	0	0	0	0	0	0	0	1	0	0.5	0	0	0	0	0	0	0	0
Orange River Francolin	0	3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pied Crow	0	0	0	0.5	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	2.5	0	0	0
Quailfinch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Rattling Cisticola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Red-billed Quelea	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Red-eyed Dove	0	0	0	1	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Red-faced Mousebird	1	0	0.5	3	0	0	0	3	0	0	0	0	0	0	4.5	0	0	1.5	0.5	0	4	0	0
Ring-necked Dove	3	0	1.5	0.5	0	0.5	0.5	3	0.5	0	1.5	0.5	0	0	0	0	0.5	0.5	1	0	0	0	0
Rufous-naped Lark	0	0	0	0	0	0	0.5	0	0.5	0	0.5	0.5	0.5	0.5	1.5	0	0.5	0	0	0	0	1	0.5
Scaly-feathered Weaver	0	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	10	0	0	0
Southern Fiscal	2	0	0	1	0	0	0.5	0.5	1	0	0.5	0	0	1	0.5	0	0.5	0	0	0	0.5	0	0
Southern Grey-headed Sparrow	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern Masked Weaver	0	0	2.5	1	0	0	0.5	3	0	0.5	0	0	0	0	0	0	0	1	0	1.5	1.5	0	0
Spike-heeled Lark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Spotted Flycatcher	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spotted Thick-knee	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0

Species	lig01	lig02	lig03	lig04	lig05	lig06	lig07	lig08	lig09	lig10	lig11	lig12	lig13	lig14	lig15	lig16	lig17	lig18	lig19	lig20	lig21	lig22	lig23
Streaky-headed Seed-eater	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swainson's Spurfowl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0	0	0
Violet-eared Waxbill	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wattled Starling	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	1	1.5	0	2.5	6.5	0	0
Western Cattle Egret	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0.5	0	0	0
White-backed Mousebird	0	1	0	2	0	0	0	1	0	0	0	0	0	1.5	0	0	0	0	0	15	0	0	0
White-bellied Sunbird	0	0	0	0.5	0	0.5	0	1.5	0	0.5	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0
White-browed Sparrow-weaver	3	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
White-throated Scrub Robin	0	0	0.5	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Yellow Canary	0.5	0	0.5	2	0	0	0	5.5	0	0	0	0	0	0.5	0	0.5	1	0.5	0	2	1.5	0	0
Number of individuals	18	19	15	40.5	2.5	6	7.5	72	8.5	3	9.5	6.5	7.5	20	13.5	5	8	10.5	5	53.5	40	6	3
Number of species	13	12	14	25	3	9	11	40	10	5	11	9	6	17	11	5	10	11	6	23	17	5	4
Number of birds/ha	**5.73**	**6.05**	**4.78**	**12.90**	**0.80**	**1.91**	**2.39**	**22.93**	**2.71**	**0.96**	**3.03**	**2.07**	**2.39**	**6.37**	**4.30**	**1.59**	**2.55**	**3.34**	**1.59**	**17.04**	**12.74**	**1.91**	**0.96**
Number of species/ha	**4.14**	**3.82**	**4.46**	**7.96**	**0.96**	**2.87**	**3.50**	**12.74**	**3.18**	**1.59**	**3.50**	**2.87**	**1.91**	**5.41**	**3.50**	**1.59**	**3.18**	**3.50**	**1.91**	**7.32**	**5.41**	**1.59**	**1.27**
Average number of birds/ha	**4.57**																						
Average number of species/ha	**3.37**																						

Species	lig24	lig25	lig26	lig27	lig28	lig29	lig30	lig31	lig32	lig33	lig34	lig35	Birds/ha
Acacia Pied Barbet	0	0	0	0	0	0	0	0	0	0	0.5	0	0.03
African Red-eyed Bulbul	0	0	0	0	1.5	0	1	0.5	0.5	0	0	0	0.14
Ant-eating Chat	0	0.5	0	0	0	0.5	0	0.5	2	1	0.5	0	0.11
Arrow-marked Babbler	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Ashy Tit	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Black-chested Prinia	1	0	0.5	0	0	1	1.5	1	0	1.5	3	1.5	0.37
Black-collared Barbet	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Black-crowned Tchagra	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Black-throated Canary	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Bokmakierie	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Brown-crowned Tchagra	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Cape Longclaw	0	0	1	0	0	0	0	0.5	0	0	0	0	0.02
Cape Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0.05
Cape Starling	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Cape White-eye	0	0	0	0	0	0	0	0	0	0	0	0	0.10
Chestnut-backed Sparrow-Lark	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Chestnut-vented Warbler	1	0	0	0.5	0	0	1	1	1.5	0	1.5	1	0.32
Chinspot Batis	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Cloud Cisticola	0	1	0.5	0	0	0	0	0	0	0	0	0	0.01
Common Scimitarbill	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Crested Barbet	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Crimsonbreasted Shrike	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Crowned Lapwing	0	0	0	0	0	0	0	0	0.5	0	0	0	0.01
Desert Cisticola	1	0.5	1.5	1.5	1	1.5	2	1.5	1	1	0.5	1	0.31
Diederik Cuckoo	0	0	0	0	1	0	0	0	0	0	0	0	0.01
Eastern Clapper Lark	0	0	0.5	0	0	0	0	0	0	0	0	0	0.03
Fiscal Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Green-winged Pytilia	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Grey Go-away-bird	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hadeda Ibis	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Helmeted Guineafowl	0	0	0	0	0	0	0	0	0	0	0	0	0.12
Kalahari Scrub Robin	0.5	0	0	0	0	0	0	0	0.5	0	0.5	0	0.09
Kurrichane Thrush	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Laughing Dove	1	0	0	0.5	0.5	0	0.5	0	0.5	0	1	0.5	0.27

Long-billed Crombec	0	0	0	0	0	0	0	0	0	0	0	0	0.03
Long-tailed Widowbird	0	0	0	0	0	0	0.5	0	0	0	0	0	0.00
Melodious Lark	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Namaqua Dove	0	1	0.5	0	0	0	0	0	0	0	0.5	0	0.02
Neddicky	0	0	0	0	0	0	0	0	0	0	0	1	0.06
Northern Black Korhaan	0	0	0	0	0	0.5	0	0	0	0.5	0	0	0.03
Orange River Francolin	0	0	0	0	0	0	0	0	1	0	0	0	0.04
Pied Crow	0	0	0	0	0	0	0	0	0	0	0	0	0.03
Quailfinch	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	0.01
Red-billed Quelea	0	0	0	0	0	0	0	0	0	0	0	0	0.07
Red-eyed Dove	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Red-faced Mousebird	0	0	0	0	0	0	0	0	0	0	0.5	1	0.18
Ring-necked Dove	0	0	0	0	0	0	0	0	0.5	0.5	0.5	1	0.15
Rufous-naped Lark	0	0	1.5	0	0	1.5	1	0.5	0	1	0.5	0	0.11
Scaly-feathered Weaver	0	0	0	0	0	0	0	0	0	0	0	0	0.16
Southern Fiscal	1	0	0	1	0	0	0	0	0.5	0	0	0	0.10
Southern Grey-headed Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Southern Masked Weaver	1	0	0	0	0	0	0	1	0	0	0	0	0.12
Spike-heeled Lark	0	0	0.5	0	0	0	0	0	0	1	0	0	0.02
Spotted Flycatcher	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Spotted Thick-knee	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Streaky-headed Seed-eater	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Swainson's Spurfowl	0	0	0	0	0	0	0	0.5	0	0	0	0	0.02
Violet-eared Waxbill	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Wattled Starling	4	0	0	0	8.5	0	0	5.5	0	0	0	10	0.40

Western Cattle Egret	0	0	0	0	0	0	0	0	0	0	0	0	0.02
White-backed Mousebird	0	0	0	0	0	0	0	9	0.5	0	7	0	0.34
White-bellied Sunbird	0	0	0	0	0	0	0	0	0	0	0	0	0.04
White-browed Sparrow-weaver	0	0	0	0	1	0	0	0	1.5	0	0	0	0.09
White-throated Scrub Robin	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Yellow Canary	0	0	0	0	1	0	0	0	0	0	0	0	0.14
Number of individuals	10.5	3	6.5	3.5	14.5	5	7.5	21.5	10.5	6.5	16.5	17	
Number of species	8	4	8	4	7	5	7	11	12	7	12	8	
Number of birds/ha	**3.34**	**0.96**	**2.07**	**1.11**	**4.62**	**1.59**	**2.39**	**6.85**	**3.34**	**2.07**	**5.25**	**5.41**	
Number of species/ha	**2.55**	**1.27**	**2.55**	**1.27**	**2.23**	**1.59**	**2.23**	**3.50**	**3.82**	**2.23**	**3.82**	**2.55**	