

CHAPTER 2a

Avifauna

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Executive Summary

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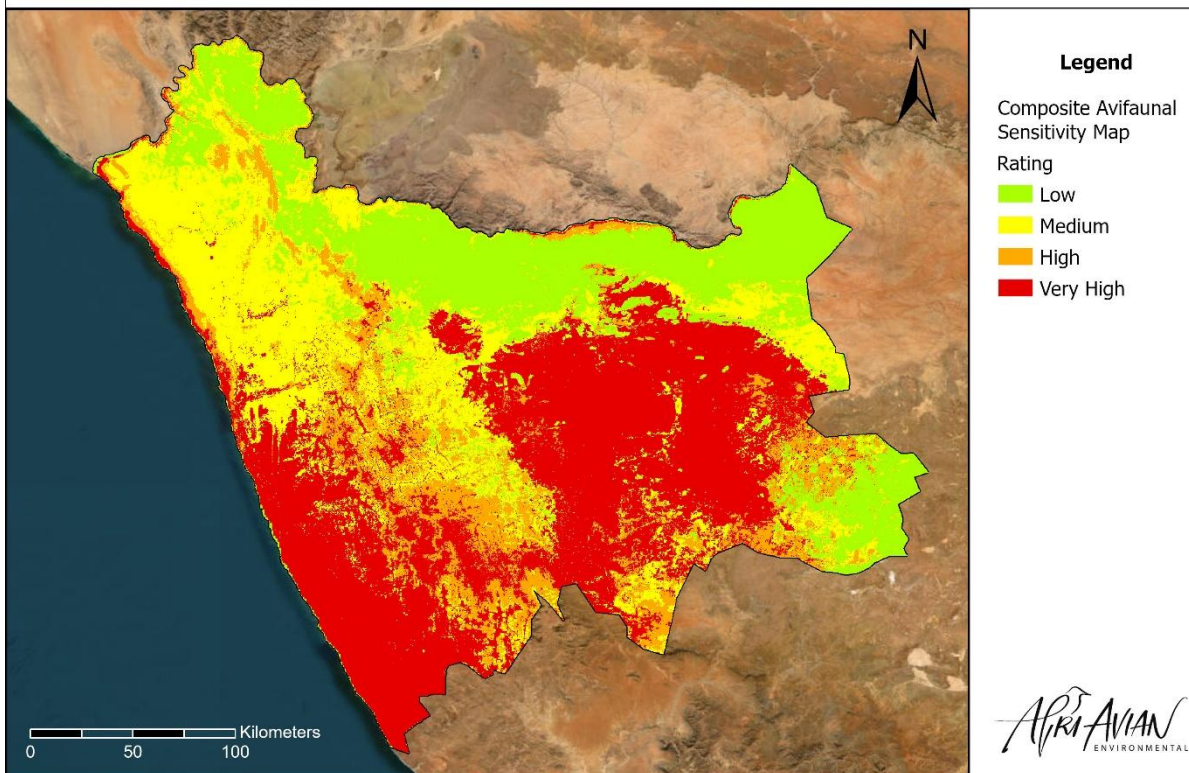
3 This Avifaunal Specialist Assessment forms part of the Strategic Environmental Assessment (SEA) for the
4 proposed Boegoebaai Port, Special Economic Zone (SEZ), and associated Green Hydrogen (GH₂)
5 developments in the Northern Cape Province of South Africa. Work Package 2 (WP2) evaluates potential
6 impacts on avifauna across the Namakwa Region, covering the Richtersveld, Nama Khoi, Kamiesberg, and
7 Khai-Ma local municipalities, under three development scenarios:

- 8
- **Scenario 0:** Dynamic Baseline (no GH₂ development, 2023–2050)
 - 9 • **Scenario 1:** “Small GH₂” (5 GW electrolyser, 0.5 Mtpa GH₂ by 2030)
 - 10 • **Scenario 2:** “Big GH₂” (40 GW electrolyser, 4 Mtpa GH₂ by 2050)

11
12 The study integrates multi-year bird atlas data, species distribution modelling, habitat mapping, and a
13 weighted risk assessment for 44 priority avifaunal species—comprising threatened, endemic, and
14 range-restricted bird species.

15 The Namakwa Region lies largely within the Succulent Karoo Biodiversity Hotspot, hosting 15 Key
16 Biodiversity Areas (KBAs) and several protected areas. Habitats range from coastal duneveld and estuarine
17 wetlands to arid shrublands and mountain scrub, supporting species of global and national conservation
18 concern such as Black Harrier (EN), Ludwig’s Bustard (EN), Martial Eagle (EN), and Red Lark (VU, endemic).
19 The DFFE Screening Tool classifies much of the region as of Very High avian sensitivity, particularly for
20 wind-related impacts. The figure below shows avifaunal sensitivity of the Namakwa Region as it relates to
21 impacts posed by renewable energy-related, including linear infrastructure in support of the various GH₂
22 development scenarios.

Composite Avifaunal Sensitivity Map of the Namakwa Region



23

1 Interpretation of the Avifaunal Sensitivity Maps:

2 Five avifaunal sensitivity maps were produced to reflect the relative ecological sensitivity of the landscape
 3 to these potential impact pathways. Each map is derived from species distribution models weighted by
 4 species-specific vulnerability scores (threat status, range size, endemism, and susceptibility to each impact
 5 type). These maps represent potential risk or relative sensitivity to renewable energy-related infrastructure
 6 rather than fixed exclusion or “no-go” zones. They are intended as a strategic-level planning tool to guide
 7 early screening, highlight areas warranting increased caution and preconstruction monitoring, and inform
 8 project-level environmental impact assessments (EIAs). Final delineation of any formal avoidance or
 9 exclusion areas must occur during site-specific EIAs, informed by local surveys and observer effort.

10 Key impact pathways relating to priority avifauna include:

- 11 • **Displacement due to Disturbance** – Noise, lighting, and human activity during construction and
 12 operation.
- 13 • **Habitat Loss / Fragmentation / Transformation** – Port, SEZ, renewable energy and linear infrastructure
 14 footprints.
- 15 • **Collisions** – Wind turbines, powerlines, masts, and other tall structures.
- 16 • **Electrocutions** – Transmission and distribution infrastructure, particularly affecting large raptors and
 17 vultures.

18 Key findings concluded from this avifaunal risk assessment are:

- 19 • **Without mitigation**, both GH₂ development scenarios present **High to Very High** risks to priority
 20 avifaunal species, especially in areas of **Very High Sensitivity**.
- 21 • **Scenario 2 (“Big GH₂”)** carries the greatest cumulative risk, with potentially severe to extreme
 22 consequences for Endangered and Critically Endangered bird species.
- 23 • **With implementation of best-practice mitigation**, risks can be reduced to **Moderate-High**, but residual
 24 impacts remain considerable in sensitive habitats.

25 Even the baseline scenario reflects ongoing pressures as a result of climate change, mining, agriculture,
 26 and existing renewable energy expansion.

27 In conclusion, the Namakwa Region’s exceptional avifaunal diversity faces substantial risk from large scale
 28 GH₂ and associated infrastructure development given the scale of the proposed infrastructure required.
 29 Strategic avoidance of high and very high sensitivity areas, rigorous application of the mitigation hierarchy,
 30 and the implementation of robust monitoring frameworks are essential to balance renewable energy
 31 ambitions, associated with the GH₂ development proposal for the Boegoebaai Port and SEZ, with
 32 biodiversity conservation in the broader Namakwa Region. The SEA and this avifaunal risk assessment
 33 therefore provide a defensible, spatially explicit framework to guide sustainable regional planning for
 34 development and safeguarding irreplaceable bird populations.

35 Key recommended strategic management actions resulting from this avifaunal risk assessment include:

36 *1. Spatial Planning & Sensitivity Controls*

37 Embed avifaunal sensitivity mapping into planning tools (such as EMFs, SDFs, IDPs), designate no-go
 38 zones for critical habitats, apply science-based buffers, align infrastructure to avoid very high and high-risk
 39 areas, and cap cumulative development in sensitive landscapes.

1 2. *Technology-Specific Standards*

2 Adopt bird-safe design and operational mitigation measures for wind and solar infrastructure, powerlines,
3 masts, and port/desalination facilities to ensure minimising collision, electrocution, and disturbance risks
4 through appropriate siting, engineering, and seasonal restrictions.

5 3. *Monitoring & Adaptive Management*

6 Use standardised pre- and post-construction monitoring protocols with GenEst¹, set Thresholds of
7 Potential Concern (TPCs), link results to Potential Biological Removal (PBR) rates and Population Viability
8 Analysis (PVA), and trigger adaptive measures when thresholds are exceeded.

9 4. *Governance & Data Management*

10 Mandate avifaunal standards and independent oversight in approvals, require cumulative impact reviews,
11 ensure open data sharing, and establish a regional technical forum for coordinated decision-making.

12 5. *Incentives & Financing*

13 Fast-track low-risk, high-standard projects and fund biodiversity actions such as retrofitting hazardous
14 infrastructure and securing key buffer habitats through a dedicated conservation fund.

15

16

¹ A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (<https://www.usgs.gov/software/genest-a-generalized-estimator-mortality>).

Contents

1		
2		
3	Executive Summary _____	2
4	Contents _____	5
5	Tables _____	7
6	Figures _____	7
7		
8	1. INTRODUCTION _____	10
9	2. SCOPE OF THIS STRATEGIC ASSESSMENT -WORK PACKAGE 2 (WP2) _____	10
10	2.1 Study Area i.e., Namakwa Region _____	10
11	2.2 GH ₂ Development Scenarios for Assessment _____	11
12	2.2.1 SCENARIO 0 – DYNAMIC BASELINE (2023 – 2050) _____	11
13	2.2.2 SCENARIO 1 – “SMALL GH ₂ ” (by 2030) _____	11
14	2.2.3 SCENARIO 2 – “BIG GH ₂ ” (by 2050) _____	11
15	2.3 Infrastructure Types impacting Avifauna within the Namakwa Region _____	12
16	2.3.1 Renewable energy and electrical grid infrastructure _____	12
17	2.3.2 Green hydrogen plants _____	12
18	2.3.3 Desalination plants _____	13
19	2.3.4 Roads, rail and pipelines _____	13
20	2.3.5 Masts and towers _____	13
21	3. KEY POTENTIAL IMPACTS ON AVIFAUNA _____	15
22	3.1 Displacement due to Disturbance _____	15
23	3.2 Displacement due to Habitat Loss / Fragmentation / Transformation _____	15
24	3.3 Injury or Mortality due to Collisions _____	16
25	3.4 Injury or Mortality due to Electrocution _____	16
26	4. APPROACH AND METHODOLOGY _____	17
27	5. ASSUMPTIONS AND LIMITATIONS _____	19
28	6. KEY ENVIRONMENTAL ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREA _____	20
29	6.1 Habitat Features _____	20
30	6.2 Priority Bird Species of the Namakwa Region _____	21
31	6.3 DFFE Screening Tool _____	23
32	6.4 Sensitivity Analysis and Mapping _____	25
33	6.4.1 Study Area Definition _____	25
34	6.4.2 Species Data and Distribution Modelling _____	25
35	6.4.3 Impact Scoring Framework _____	26
36	6.4.4 Conservation Weighting System _____	26
37	6.4.5 Composite Weighting _____	27
38	6.5 Spatial Risk Mapping _____	27
39	6.5.1 Raster Processing _____	27
40	6.5.2 Risk Classification _____	27
41	6.6 Quality Assurance _____	28
42	6.6.1 Data Validation _____	28
43	6.6.2 Process Validation _____	28
44	6.7 Synthesis of Avian Sensitivity Mapping for Renewable Energy Technologies _____	28

1	6.7.1	Sensitivity to Wind Energy Development _____	28
2	6.7.2	Sensitivity to Solar PV Development _____	29
3	6.7.3	Interpretation and Application _____	29
4	7.	RISK ASSESSMENT _____	36
5	7.1	How Risk is Determined _____	36
6	7.2	How Consequence is Determined _____	37
7	7.3	How Risk Categories are Defined _____	37
8	7.4	Risk Assessment with and without Mitigation _____	38
9	7.5	Recommended Management Responses for Risk Categories _____	41
10	8.	RECOMMENDED STRATEGIC MANAGEMENT ACTIONS TO MINIMISE	
11		AVIFAUNAL IMPACTS IN REGIONAL PLANNING _____	41
12	8.1	Sensitivity Mapping and Spatial Controls _____	41
13	8.2	Mitigation Hierarchy and Policy Standards _____	42
14	8.3	Technology-Specific Design Requirements _____	42
15	8.3.1	Wind Energy: _____	42
16	8.3.2	Solar PV Energy: _____	42
17	8.3.3	Powerlines and Substations: _____	42
18	8.3.4	Masts and Towers: _____	43
19	8.3.5	Roads, Rail and Pipelines: _____	43
20	8.3.6	Desalination and Ports (where relevant): _____	43
21	8.4	Monitoring, Thresholds and Adaptive Management _____	43
22	8.5	Governance, Permitting, and Data Management _____	43
23	8.6	Incentives and Financing _____	44
24	9.	CONCLUSIONS AND RECOMMENDATIONS _____	44
25	10.	BIBLIOGRAPHY AND REFERENCES _____	46
26	11.	ANNEXURE A _____	50

<p>ANNEXURE A: Table detailing the species-impact scoring framework that defines the sensitivity categories underpinning the multiplicative weighting system used to enable the spatial risk mapping for this avifaunal specialist assessment</p>

28
29
30

Tables

1		
2		
3	Table 1:	Brief description of the main renewable energy-related infrastructure aspects (Source: CSIR, 2025) _____ 12
4	Table 2:	GH2 development scenario quantifications (Scenario 1 and Scenario 2) for the Namakwa regional
5		assessment (Source: CSIR, 2025) _____ 14
6	Table 3:	Priority avifaunal species including Species of Conservation Concern and/or endemic species that have
7		been recorded in the Namakwa Region as it relates to the SEA. CR = Critically Endangered, EN =
8		Endangered, VU = Vulnerable, NT = Near Threatened, E = Endemic, NE = Near Endemic, SLE = Endemic
9		to South Africa, Lesotho and Eswatini _____ 22
10	Table 4:	Consequence thresholds defined for determining potential risk of impact to avifauna within the
11		Namakwa Region _____ 37
12	Table 5:	Predefined risk categories applicable to the Avifaunal Risk Assessment for this SEA (Source: CSIR, 2025) _ 38
13	Table 6:	Risk Assessment determined for negative impacts to Avifauna within the Namakwa Region for each
14		proposed GH ₂ development scenario _____ 39
15		

Figures

16		
17		
18	Figure 1:	The spatial extent of the two SEA Work Packages with this report focusing on the Work Package 2 study
19		area i.e., the Broader Namakwa Region (Source: CSIR, 2025). _____ 11
20	Figure 2:	Bird distribution data for the WP2 study area i.e., Namakwa region (indicated in green) has been
21		obtained from 874 SABAP2 pentads. The 20 pentads comprising the WP1 study area i.e., Boegoebaai
22		Port and SEZ are indicated in pink. _____ 19
23	Figure 3:	The Namakwa Region of South Africa (outlined in black) contains 15 Key Biodiversity Areas (Source:
24		https://www.keybiodiversityareas.org/map). _____ 21
25	Figure 4:	The sensitivity of the Namakwa Region as it relates to the Animal Species Theme (Source: DFFE
26		Screening Tool, 2025). _____ 24
27	Figure 5:	The sensitivity of the Namakwa Region as it relates to the Avian (Wind) Theme (Source: DFFE Screening
28		Tool, 2025). _____ 25
29	Figure 6:	The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating mainly
30		nest/roost location data and GPS tracking data of 10 key priority SCC. _____ 30
31	Figure 7:	The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44
32		priority avian species selected for this risk assessment as it relates to the potential impact of
33		displacement due to disturbance. _____ 31
34	Figure 8:	The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44
35		priority avian species selected for this risk assessment as it relates to the potential impact of
36		displacement due to habitat loss / fragmentation / transformation. _____ 32
37	Figure 9:	The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44
38		priority avian species selected for this risk assessment as it relates to the potential impact of injuries or
39		direct mortalities due to collisions. _____ 33
40	Figure 10:	The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44
41		priority avian species selected for this risk assessment as it relates to the potential impact of injuries or
42		direct mortalities due to electrocutions. _____ 34
43	Figure 11:	The composite avian sensitivity of the Namakwa Region generated from the weighted analysis
44		incorporating the 44 priority avian species selected for this risk assessment considering all four primary
45		sensitivity layers applying the maximum rule. _____ 35
46	Figure 12:	Risk and opportunity is qualitatively measured by multiplying the likelihood of an impact (negative or
47		positive) by the severity of the consequence or benefit (Source: CSIR, 2025). _____ 36
48		

Abbreviations

1		
2		
3	BGIS	Biodiversity Geographic Information System
4	BLSA	BirdLife South Africa
5	CR	Critically Endangered
6	CSIR	Council for Scientific and Industrial Research
7	DFFE	Department of Forestry, Fisheries and the Environment
8	E	Endemic
9	ECO	Environmental Control Officer
10	EIA	Environmental Impact Assessment
11	EMF	Environmental Management Framework
12	EMPr	Environmental Management Programme
13	EN	Endangered
14	EWT	Endangered Wildlife Trust
15	GenEst	Generalized Estimator of Mortality
16	GH ₂	Green Hydrogen
17	GPS	Global Positioning System
18	GW	Gigawatt
19	IBA	Important Bird Area
20	IDP	Integrated Development Plan
21	IUCN	International Union for the Conservation of Nature
22	KBA	Key Biodiversity Area
23	kV	Kilovolt
24	LC	Least Concern
25	Mtpa	Million Tonnes Per Annum
26	MW	Megawatt
27	NA	Not Endemic
28	NCEDA	Northern Cape Economic Development Trade and Investment Promotion Agency
29	NE	Near Endemic
30	NGO	Non-Governmental Organization
31	NPAES	National Protected Area Expansion Strategy
32	NT	Near Threatened
33	OHL	Overhead Powerline
34	PAOI	Proposed Area of Impact
35	PBR	Potential Biological Removal
36	PSC	Project Steering Committee
37	PVA	Population Viability Analysis

1	PV	Photovoltaic
2	SABAP1	First Southern African Bird Atlas Project
3	SABAP2	Second Southern African Bird Atlas Project
4	SANBI	South African Biodiversity Institute
5	SANEDI	South African National Energy Development Institute
6	SANParks	South African National Parks
7	SCC	Species of Conservation Concern
8	SDF	Spatial Development Framework
9	SDM	Species Distribution Model
10	SEA	Strategic Environment Assessment
11	SEZ	Special Economic Zone
12	SLE	Endemic to South Africa, Lesotho and Eswatini
13	TNPA	Transnet National Ports Authority
14	TPC	Thresholds of Potential Concern
15	VU	Vulnerable
16	WEF	Wind Energy Facility
17	WP2	Work Package 2
18		

1. INTRODUCTION

The Transnet National Ports Authority (TNPA) has embarked on determining the feasibility for the development, construction, and operation of a deep-water port with associated landside port facilities at Boegoebaai, Northern Cape. The proposed new port development is primarily to enable the Northern Cape's Provincial Economic Development strategy including the Green Hydrogen (GH₂) Strategy and expanding the mining and industrial base in the Northern Cape.

Green hydrogen is hydrogen gas (H₂) that is produced using renewable energy sources, typically solar or wind power, through a process called electrolysis. In this process, water (H₂O) is split into hydrogen (H₂) and oxygen (O) using an electric current, and when that electricity comes from renewable sources, the resulting hydrogen is considered "green."

Green hydrogen production, at the scale envisaged, is a diverse and multifaceted process with many direct and indirect impacts, both positive and negative. All programme components (including their interconnected transport corridors) would require vast areas of land surface, as well as other resource intensive inputs, all proposed in a sparsely populated but ecologically sensitive, arid region. Existing land uses in the study area include conservation, agriculture, fisheries, tourism, and mining.

A Strategic Environmental Assessment (SEA) has been initiated through a collaboration between the South African National Energy Development Institute (SANEDI), Northern Cape Economic Development Trade and Investment Promotion Agency (NCEDA), and the Transnet National Ports Authority (TNPA) (the Project Steering Committee (PSC)). The Council for Scientific and Industrial Research (CSIR) has been appointed to undertake this independent SEA. The overarching purpose of the SEA is to develop an integrated decision-making framework to guide the planning of the proposed Boegoebaai Port, Special Economic Zone, and wider Namakwa region in a sustainable manner.

AfriAvian Environmental has been appointed by the CSIR to conduct the SEA's avifaunal component for the proposed Boegoebaai Port and Special Economic Zone (WP1 report dated April 2025²) and the wider Namakwa Region (**WP2 i.e., this report**).

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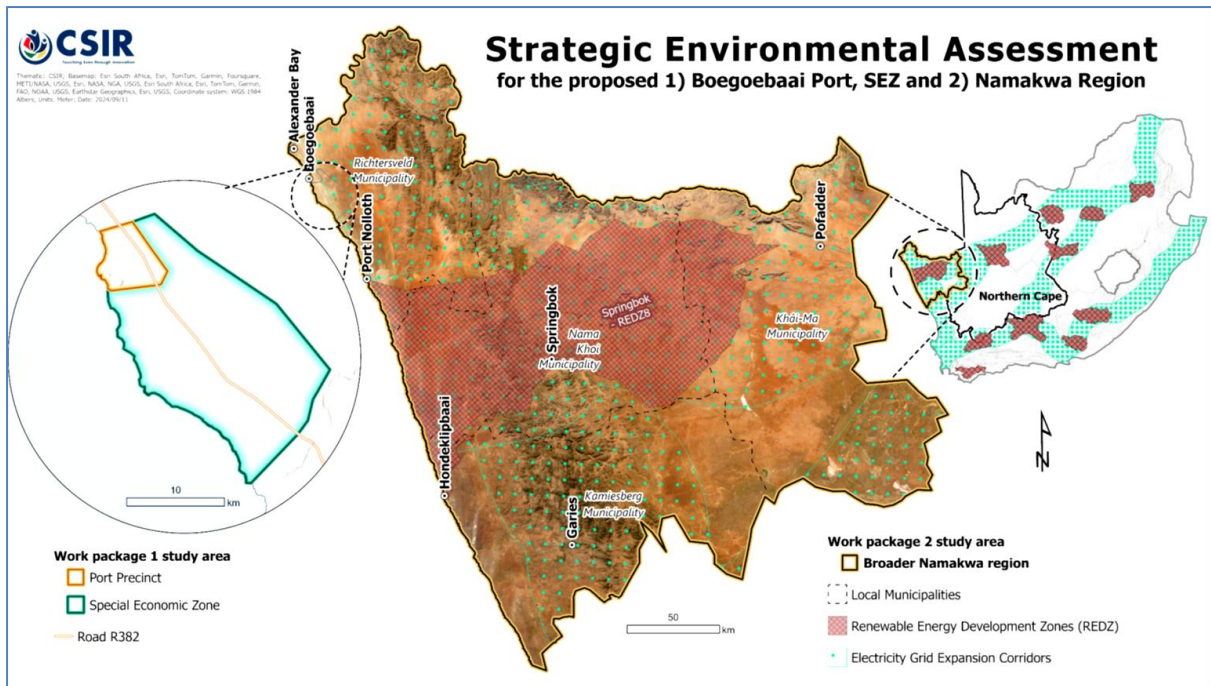
2. SCOPE OF THIS STRATEGIC ASSESSMENT -WORK PACKAGE 2 (WP2)

2.1 Study Area i.e., Namakwa Region

The spatial scope for the WP2 Avifaunal Assessment is delimited by four local municipalities: the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities (**Figure 1**).

30

² Froneman et al. 2025. Strategic Environmental Assessment for the proposed Boegoebaai Port and Special Economic Zone: Work Package 1 – Avifaunal Specialist Assessment. AfriAvian Environmental (Pty) Ltd.



1
2 **Figure 1:** The spatial extent of the two SEA Work Packages with this report focusing on the Work Package 2 study
3 area i.e., the Broader Namakwa Region (Source: CSIR, 2025).

4 **2.2 GH₂ Development Scenarios for Assessment**

5 Two GH₂ development scenarios will be assessed, each compared to an existing dynamic baseline, where
6 no GH₂ development occurs but other anthropogenic and climate changes continue, and are described
7 below:

8 **2.2.1 SCENARIO 0 – DYNAMIC BASELINE (2023 – 2050)**

9 The Boegoebaai Port and SEZ remains undeveloped and no GH₂ is produced in this area of the Northern
10 Cape. The Namakwa Region’s economy proceeds to be shaped by mining (i.e., diamonds, zinc, lead,
11 copper and sand), agriculture (mainly livestock), fishing, and a growing renewable energy sector, alongside
12 seasonal tourism linked to the Namaqualand wildflower displays. Also persisting are the current social (e.g.
13 migration, unemployment), ecological and climatic (e.g. desertification, storm surges, coastal flooding, etc.)
14 trends impacting on the Namakwa Region.

15 Contrary, conservation is being promoted as the preferred land use for the Namakwa Region, rather than
16 mining or industrial activities that carry environmental costs. This approach is supported by landscape
17 conservation initiatives (for example, SANParks’ Mega Living Landscapes, conservation stewardships and
18 park management), provincial strategic planning under NPAES, and Nature Reserve expansion plans.

19 **2.2.2 SCENARIO 1 – “SMALL GH₂” (by 2030)**

20 The Boegoebaai Port and SEZ are developed and a five (5) GW electrolyser producing 0.5 million tonnes
21 GH₂ per annum (Mtpa) and its derivatives are supported by 10 GW of renewable energy (the scenario
22 assumes 60% solar; 40% wind).

23 **2.2.3 SCENARIO 2 – “BIG GH₂” (by 2050)**

24 The Boegoebaai Port and SEZ are expanded and GH₂ development is upscaled to a 40 GW electrolyser
25 producing a total of 4 Mtpa GH₂ and its derivatives supported by 80 GW of renewable energy (the scenario
26 assumes 60% solar; 40% wind).

1 **2.3 Infrastructure Types impacting Avifauna within the Namakwa Region**

2 **2.3.1 Renewable energy and electrical grid infrastructure**

3 While some wind and solar PV generation will be located near the SEZ, the sensitivity of the local
 4 environment and potential coastal impacts (e.g., corrosion) mean that most power will come from
 5 dispersed renewable projects, often several hundreds of kilometres distant, each requiring its own site-
 6 specific environmental impact assessment (EIA) (Error! Reference source not found.). Electricity will be
 7 supplied to the GH₂ production plant via new transmission and distribution infrastructure (**Table 2**).

8 **Table 1:** Brief description of the main renewable energy-related infrastructure aspects (Source: CSIR, 2025)

Renewable energy	Aspect	Description
Wind	Turbines	Rotor with blades, nacelle, tower, generating capacity of 4-8 MW per turbine, hub height 150-180 m, blade length ~100 m
	Associated infrastructure	Foundations (~32 m ²), access roads, battery energy storage system (BESS), on-site electrical system, substations, transmission lines, construction camp, operations and maintenance facilities, meteorological masts, communication towers.
Solar PV	Solar panels	Monocrystalline/polycrystalline silicon cells, panel height ~6 m, fixed or dual-axis tracking, single or bifacial modules.
	Associated infrastructure	Inverters, mounting structures, BESS, foundations, access roads, electrical system, substations, transmission lines, electrical components, construction camp, operations and maintenance facilities.

9
 10 Note that the typical parameters for wind and solar PV infrastructure provided in Table 1 above, such as
 11 the individual generating capacity of turbines, hub height, blade length and PV panel height, are based on
 12 current industry practice. These parameters are used as the assumption in this SEA and are likely to
 13 change due to technological advancements in the period to 2050.

14 Renewable energy (wind and solar) facilities and associated powerline infrastructure can impact avifauna
 15 through collision and electrocution risks, particularly for large, slow-flying or migratory species; habitat loss
 16 or alteration from facility footprints; and disturbance from noise, lighting, and human activity. Poorly sited
 17 wind or solar installations can displace sensitive species or increase mortality due to collisions in areas of
 18 suitable habitat and high-use bird corridors. Powerlines may also create barrier effects, disrupting flight
 19 paths and access to key foraging or breeding areas. Careful siting, bird-friendly pylon design, and proper
 20 marking of powerlines can reduce these risks.

21 **2.3.2 Green hydrogen plants**

22 Green hydrogen plants are the core production hubs that turn water and renewable electricity into a
 23 storable, transportable, and versatile clean fuel. This makes them central to both the green hydrogen value
 24 chain and the broader renewable energy transition (**Table 2**). Green hydrogen plants are the conversion
 25 engines that link renewable energy generation to a wide range of low-carbon applications, while also
 26 accelerating renewable energy deployment, enabling deep decarbonisation, and creating new economic
 27 opportunities.

28 Green hydrogen plants themselves do not usually pose the same direct collision or displacement risks to
 29 birds as wind turbines or tall transmission structures. However, they can still have considerable, often
 30 indirect avifaunal impacts because they are rarely stand-alone facilities. They are typically part of a much
 31 larger infrastructure footprint that includes renewable energy generation, electricity transmission, water
 32 supply and export logistics. The green hydrogen plant is often the anchor for a web of associated
 33 infrastructure. While the plant's core process is relatively benign to birds, its enabling components i.e., the

1 renewable energy generation, electricity transmission, water supply and export facilities can create
2 substantial avifaunal risks if not carefully sited, designed and managed.

3 **2.3.3 Desalination plants**

4 Desalination plants are critical enabling links in many large-scale green hydrogen projects, especially in
5 coastal or arid regions where freshwater is scarce, but renewable energy potential is high (**Table 2**).
6 Desalination plants make it possible to turn abundant seawater into the ultra-pure feedstock electrolyzers
7 need, unlocking green hydrogen production in water-scarce but renewable-rich regions, while also offering
8 opportunities for community water supply and integrated, low-carbon infrastructure.

9 Desalination plants can affect avifauna primarily through habitat disturbance during construction and
10 operation, noise and lighting impacts that may disrupt breeding or foraging behaviour, and indirect effects
11 from associated marine infrastructure. Coastal intakes and brine discharge can alter nearshore
12 ecosystems, potentially reducing prey availability for birds favouring the littoral active zone, while increased
13 human activity and vessel traffic may disturb roosting and nesting sites.

14 **2.3.4 Roads, rail and pipelines**

15 Transport infrastructure such as roads, railways and pipelines (**Table 2**) can impact avifauna through
16 habitat loss and fragmentation, disturbance by noise, vibration and lighting, as well as increased collision
17 risk with vehicles, trains or overhead powerlines. Linear corridors may also create barrier effects, altering
18 flight paths and access to feeding or breeding areas, while construction and maintenance activities can
19 disrupt nesting and foraging. In sensitive habitats, these impacts can be significant, especially for large,
20 low-maneuvrability or ground-nesting bird species.

21 The following transport infrastructure is planned in the broader Namakwa Region:

- 22 • New pipelines for the bulk transport of GH₂ to and from Namibia, Saldanha Bay (Scenario 1) and
23 Prieska (Scenario 2).
- 24 • New rail between the Boegoebaai Port and Kenhardt connecting to the existing Saldanha-Sishen
25 railway route.
- 26 • Upgrade and expansion of roads to and from Alexander Bay.
- 27 • Roads associated with the construction, operation and maintenance of new renewable energy
28 facilities, railways and pipelines.

29 **2.3.5 Masts and towers**

30 Masts and turbines are the vertical backbone of green hydrogen infrastructure, from capturing the wind
31 that powers electrolyzers, to gathering the climate data that underpins investment decisions, to enabling
32 communications and control systems that keep complex, distributed renewable-hydrogen networks
33 running smoothly.

34 Masts and towers can impact avifauna mainly through collision risk, particularly for large, fast-flying or
35 nocturnal species attracted to or disoriented by lights. Guy wires on tall masts increase this risk. They may
36 also cause habitat displacement if placed in sensitive areas and serve as perching or nesting sites for
37 some species, which can lead to increased predation pressure or exposure to operational hazards. Careful
38 siting, design, and proper marking can reduce these risks.

1 **Table 2:** GH2 development scenario quantifications (Scenario 1 and Scenario 2) for the Namakwa regional assessment (Source: CSIR, 2025)

2

3

	Aspect	Unit	Sc1: Small GH ₂	Sc2: Big GH ₂	Assumptions
SEZ	Electrolyser capacity	GW	5	40	Northern Cape Green Hydrogen Master Plan ambition
	Electrolyser footprint	ha	75	600	15 ha per 1 GW
	GH2 volume	mtpa	0,5	4,0	10 GW electrolyser = 1 mtpa GH2
	GH2 storage footprint	ha	250	2 000	10 ha per 20 000 tpa (500 ha for 1 mtpa)
	Ammonia volume	mtpa	2,8	22,7	1 mt H2 for 5,67 mt NH3 (1Mt of ammonia contains 176.5 kg (just 17.65%))
	Ammonia footprint	ha	57	454	1 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (20 ha for 1 mtpa)
	Ammonia storage footprint	ha	28	227	0,5 ha per 50 000 tpa NH3 (e.g. Enertrag Hendrina) (10 ha for 1 mtpa)
	Desalination output volume	ML/day	36	286	25 kg water per 1 kg GH2 (considering electrolysis and cooling). 1Mtpa GH2 output required 25 Mtpa (=25000 MLpa) water / 350 operational.
	Desalination footprint	ha	7	57	5 ML/day output needs 1 ha
	Desalination discharge	ML/day	48	387	Ratio of desalinated water to brine discharge water to be 42.5:57.5. (i.e 42.5% of intake sea water is converted to desalinated water and 57.5% is discharged as brine).
	Pipeline intake volume	ML/day	84	672	Output + discharge
REGION	RE capacity total	GW	10	80	1 Mt/yr of H2 needs 10 GW electrolyser, that is powered by 20 GW
	RE capacity - solar	GW	6	48	60 % solar : 40 % wind
	RE footprint - solar	ha	12 000	96 000	0,5MW/ha
	RE extent - solar		12 000	96 000	Footprint = extent
	RE facilities - solar	no of facilities	6	48	Clusters of 1 GW facilities
	RE capacity - wind	GW	4	32	60 % solar : 40 % wind
	RE footprint - wind	ha	4 000	32 000	1 MW/ha
	RE extent - wind	ha	40 000	320 000	0,1 MW/ha
	RE facilities - wind	no of facilities	3	21	Clusters of 1,5 GW facilities
	Road length	km	300	600	New roads and upgrades same distances / routes as pipelines
	Road footprint	ha	1 200	2 400	40 m (Rural class 2 road 40-70 m. TRH26 Road Classification and Access Management)
	Rail length	km	550	550	Boegoebaai – Kenhardt. New rail direction south-east to connect to the existing Saldanha-Sishen route.
	Rail footprint	ha	1 600	1 650	30 m for rail and service track
	Pipeline length	km	300	600	Sc1: NAM<BB>SB (300km); Sc2: BB>Prieska (300km)
	Pipeline footprint	ha	600	1 200	20 m servitude
Powerline length	km	260	1 387	Assume grid strengthening / shared infrastructure 30 km TX associated with each RE cluster.	
Powerline footprint	ha	1 300	6 933	50 m servitude (TRH 27 South African Manual for Permitting Services in Road Reserves)	
Main infrastructure components footprint		ha	21 082	142 240	

Units: GW = gigawatt; mtpa = million tonne per annum; ha = hectare; ML/day = million litres per day; km = kilometre

3. KEY POTENTIAL IMPACTS ON AVIFAUNA

3.1 Displacement due to Disturbance

The construction phase of any proposed development associated with the Boegoebaai Port and SEZ (see Section 2.2 and 2.3 above) can disturb bird populations and their habitats, particularly if construction activities occur in or near areas that birds rely on for nesting, feeding, or roosting. Birds are highly sensitive to changes in their environment, and the disruption caused by the construction and operation of the proposed project can have several adverse effects.

The noise and activity associated with vehicles, machinery and construction operations can disturb birds, especially those sensitive to human presence or loud sounds. Species that require quietness and undisturbed environments for nesting or breeding may abandon their nests if they perceive the area as unsafe or stressful. This disturbance can disrupt breeding cycles, leading to reduced reproductive success and therefore population decline.

Additionally, the presence of machinery and vehicles can pose direct threats to birds through collisions or accidental disturbances. Birds, particularly ground-nesting species, or those flying low over the area, may be at risk of injury or mortality from these activities.

The construction and operation of the proposed development may involve several activities aimed at excavating, processing, and utilising materials for construction purposes. Some of the activities which could be associated with the proposed development, which could cause species displacement due to disturbance, include:

- **Site Selection and Preparation:** This involves identifying suitable locations for the proposed development based on proximity to construction sites needing materials and the quality of materials available. Site preparation may include clearing vegetation and levelling the area.
- **Excavation:** The primary construction activity could be excavation, where soil, gravel, sand, or other materials are extracted from the ground using heavy machinery such as excavators, bulldozers, or loaders. This activity will be a significant source of noise and movement disturbance.
- **Material Processing:** Excavated materials often need processing to meet specific size and quality requirements for construction. This can involve crushing, screening, or washing the materials to remove impurities to ensure consistency.
- **Material Stockpiling:** Processed materials are stockpiled onsite for storage and subsequent transportation to construction sites. Proper stockpiling techniques are important to prevent erosion, maintain material quality, and ensure safety.
- **Transportation:** Transporting materials for the proposed project to construction sites is a significant part of operations. This may involve using trucks, conveyor belts, or other equipment to move materials efficiently and safely.

3.2 Displacement due to Habitat Loss / Fragmentation / Transformation

Construction activities and infrastructure, such as pipelines, powerlines and roads, can fragment habitats and restrict species movement / dispersal. Renewable energy developments in addition to the port related and green hydrogen developments can have significant impacts on avifauna, primarily through habitat loss and degradation. The construction and expansion of ports often involve land reclamation, dredging, and the destruction of wetlands and intertidal zones, which are critical habitats for many bird species (Dugan, 1990; BirdLife International, 2021). These areas serve as feeding, nesting, and roosting sites, particularly for migratory shorebirds that rely on undisturbed coastal habitats during their journeys (Goss-Custard & Verboven, 1993). In addition, the construction of renewable energy (wind and solar) facilities, their

1 associated electricity grid infrastructure and their extensive road network require the clearance of large
2 areas of vegetation, earthworks and often trenching for foundations and component installations.

3 The loss of vegetation and natural landscapes disrupts ecological balance, leading to reduced food
4 availability and increased competition among avian species (Ma et al. 2014). Pollution from port
5 operations, including possible oil spills and chemical runoff, can degrade water quality and affect the
6 health of aquatic ecosystems, further impacting bird populations dependent on these areas (Boersma et
7 al. 2001). Such habitat loss and fragmentation can result in declining bird populations, threatening the
8 biodiversity of avian communities in and around the proposed Port Expansion Area, as well as within the
9 Namakwa Region.

10 3.3 Injury or Mortality due to Collisions

11 Wind energy generation has experienced rapid worldwide development over recent decades as its
12 environmental impacts are considered to be relatively lower than those caused by traditional energy
13 sources, with reduced environmental pollution and water consumption (Saidur et al. 2011). However, bird
14 fatalities due to collisions with wind turbines and associated infrastructure such as powerlines,
15 substations, communications towers and/or meteorological masts have been consistently identified as a
16 main ecological drawback to wind energy (Drewitt & Langston, 2006).

17 Collisions with wind turbines appear to kill fewer birds than collisions with other man-made infrastructures,
18 such as powerlines, buildings or even traffic (Erickson et al. 2005). Nevertheless, estimates of bird deaths
19 from collisions with wind turbines worldwide range from 0 to almost 40 deaths per turbine per year
20 (Sovacool, 2009). The number of birds killed varies greatly between sites, with some sites posing a higher
21 collision risk than others, and with some species being more vulnerable than others. These numbers may
22 not reflect the true magnitude of the problem, as some studies do not account for detectability biases such
23 as those caused by scavenging, searching efficiency and search radius (Bernardino et al. 2013; Erickson et
24 al. 2005; Huso & Dalthorp, 2014). Additionally, even for low fatality rates, collisions with wind turbines may
25 have a disproportionate effect on some species. For long-lived species with low productivity and slow
26 maturation rates (e.g. raptors), even low mortality rates can have a significant impact at the population
27 level (Carrete et al. 2009; Drewitt & Langston, 2006).

28 High bird fatality rates at several wind farms have raised concerns among the industry and scientific
29 community in South Africa and abroad. According to the latest BirdLife South Africa (BLSA) report on bird
30 fatalities at operational wind farms, a total of 2444 unique bird fatality incidents were recorded at wind
31 farms, with losses attributed to turbine collisions, powerlines and other anthropogenic impacts. These
32 incidents involved 202 bird species. Of these, 198 were recorded as turbine collisions (BLSA, 2025). The
33 situation is even more critical for Species of Conservation Concern (SCC) which sometimes are most at
34 risk.

35 High profile examples include the Altamont Pass Wind Resource Area (APWRA) in California because of
36 high fatality of Golden eagles (*Aquila chrysaetos*), Tarifa in Southern Spain for Griffon vultures (*Gyps*
37 *fulvus*), Smøla in Norway for White-tailed eagles (*Haliaeetus albicilla*), and the port of Zeebrugge in Belgium
38 for gulls (*Larus* sp.) and terns (*Sterna* sp.) (Barrios & Rodríguez, 2004; Drewitt & Langston, 2006; Everaert
39 & Stienen, 2008; Thelander et al. 2003). Due to their specific features and location, and characteristics of
40 their bird communities, these wind farms have been responsible for a large number of fatalities that
41 culminated in the deployment of additional measures to minimize or compensate for bird collisions.
42 However, currently, no simple formula can be applied to all sites; in fact, mitigation measures must
43 inevitably be defined according to the characteristics of each wind farm and the diversity of species
44 occurring there (Marques et al. 2014). An understanding of the factors that explain bird collision risk and
45 how they interact with one another is therefore crucial to proposing and implementing valid mitigation
46 measures (BLSA, 2025).

47 3.4 Injury or Mortality due to Electrocutation

48 Electrocutation refers to the scenario where a bird is perched, or attempts to perch, on the electrical
49 structure and causes an electrical short circuit by physically bridging the air gap between live components

1 and/or live and earthed components (Van Rooyen, 2004). The electrocution risk is largely determined by
 2 the voltage of the proposed overhead powerline (OHL) and the pole/tower (pylon) design. Should the
 3 proposed OHL be constructed using a 132 kV tower specification, the electrocution impact for the majority
 4 of priority species will be negligible. The Cape Vulture is one of the priority species, due to its size and
 5 gregarious nature, capable of bridging the clearance distances of an OHL constructed using this
 6 specification.

7 Ordinarily, the construction of a single circuit powerline using the approved bird-friendly pylon/tower design
 8 D-DT-7649 in accordance with the Distribution Technical Bulletin titled *Refurbishment of 66/88 kV line*
 9 *kite type frames with D-DT-7649 type top configuration - Reference Number 240-170000467* will
 10 eliminate the electrocution risk. The configuration of the insulators and the clearance distances between
 11 the live and earthed components on this structure can comfortably accommodate a perching vulture.
 12 However, if the OHL is built on lattice structures, it is imperative that there is a minimum clearance of 1.8
 13 m between the jumper cables and/or insulators and the horizontal earthed component on the lattice
 14 structure (pers. comm. Lourens Leeuwner - Eskom-EWT Strategic Partnership Manager). Additional
 15 mitigation in the form of insulating sleeves on jumper cables present on strain poles and terminal poles
 16 must be implemented (if suitable insulation material is readily available); alternatively, all jumper cables
 17 must be suspended below the crossarms.

18 Electrocutions within proposed on-site substations at both the Port Precinct, the SEZ and the renewable
 19 energy facilities are possible, however, the likelihood of this impact on the more sensitive SCC is remote,
 20 as these species are unlikely to regularly utilise the infrastructure within the on-site substation for perching
 21 or roosting. Species that are more vulnerable to this impact are medium-sized raptors, corvids, owls, and
 22 certain species of waterbirds.

23

24 4. APPROACH AND METHODOLOGY

25 To assess the avifaunal sensitivity of the Namakwa Region, various datasets were used to compile
 26 sensitivity layers for each priority species including SCC. The layers were ranked according to endemism
 27 and conservation status, and fine scale habitat suitability to develop a four-tier sensitivity map. See Section
 28 6.4 for more detail.

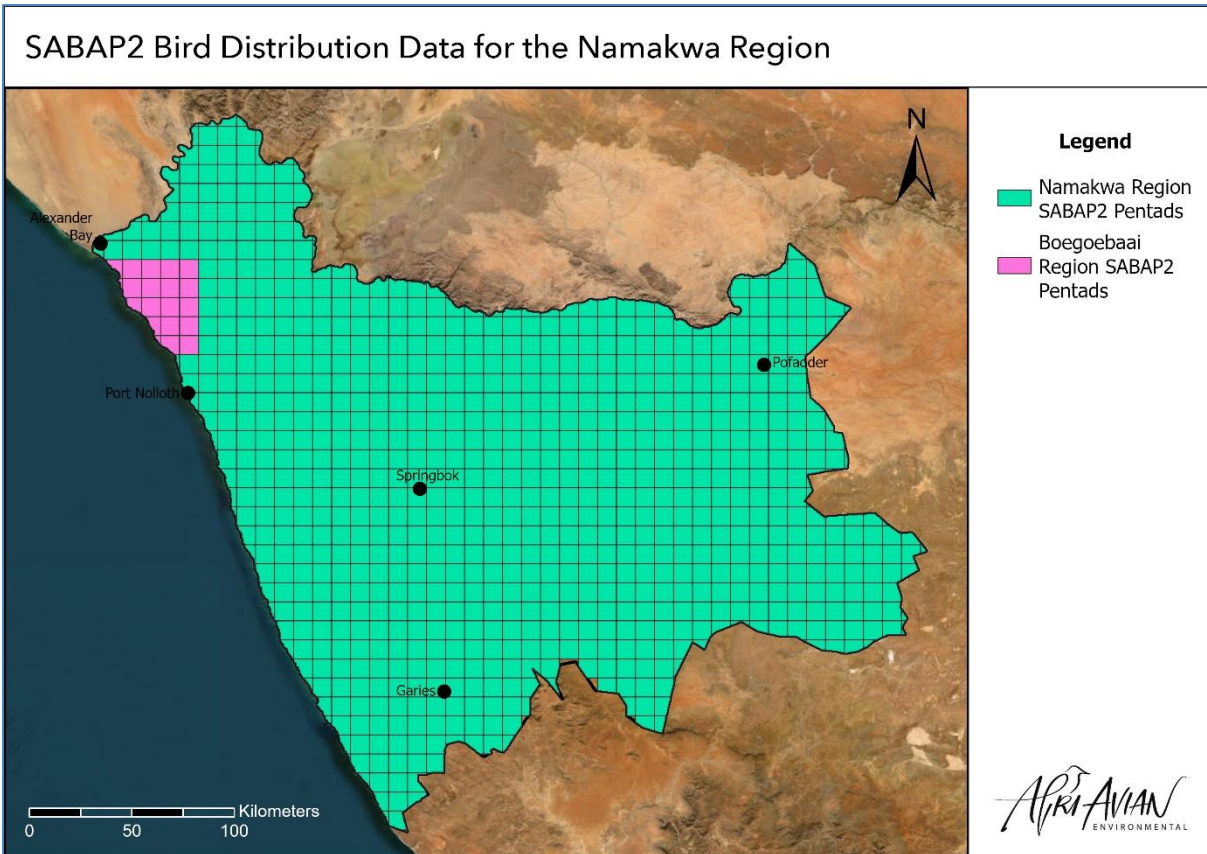
29 A weighted sensitivity modelling approach was applied to generate these layers. For each priority species,
 30 spatial predictions from species distribution and habitat suitability models were combined with
 31 conservation-weighting factors that accounted for (i) threat status, (ii) range size, and (iii) degree of
 32 endemism. These parameters were used to express each species' relative vulnerability to key impact
 33 pathways, namely disturbance/displacement, habitat loss, collision, and electrocution. The weighted
 34 species layers were then normalised and aggregated to produce cumulative, continuous sensitivity
 35 surfaces per impact type. This approach provides a precautionary yet comparable spatial framework across
 36 species and impact types, allowing for differentiation of relative ecological risk at a regional scale.

37 The following information sources and methods were used to conduct this study:

38 • Bird distribution data from the Second Southern African Bird Atlas Project (SABAP2) was obtained
 39 (<https://sabap2.birdmap.africa/>), to ascertain which species occur in the pentads relevant to the
 40 Namakwa Region. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5' × 5').
 41 Each pentad is approximately 8 × 9 km. To get a more representative impression of the birdlife in the
 42 area, a consolidated dataset was obtained for a total of 874 pentads some of which intersect the
 43 proposed Port Precinct and SEZ development sites, with the Namakwa Region also referred to as the
 44 "study area" (Figure). This SABAP2 dataset is therefore based on avifaunal species presence recorded
 45 within the study area since 2007 (i.e., 18 years).

46 • The SABAP2 data in this region is usually not as comprehensive as in the rest of South Africa due to
 47 decreased observer effort (fewer people living in the area and access difficulty), therefore the data was
 48 supplemented by species distribution models and habitat suitability models as well as general
 49 knowledge of the area.

- 1 • A target species list was generated by assessing SABAP2 data, BirdLasser citizen science data and
2 intersecting species distribution models for the Namakwa Region that includes the originally assessed
3 5 km Proposed Area of Impact (PAOI) buffer around the Boegoebaai Port Precinct and SEZ (AfriAvian
4 WP1 Avifaunal Assessment, April 2025). This assessment of all available data yielded a priority list of
5 44 threatened and/or endemic avian species that were included in the analysis. Species distribution
6 models have been developed for more than >100 SCCs as part of a national assessment of avian
7 sensitivity. Species distribution models were developed using a standardised methodology that is
8 aligned with what was used to develop avian models for the DFFE National Screening Tool.
- 9 • For the habitat suitability models, a classification of the vegetation types of the Namakwa region was
10 obtained from the First Atlas of Southern African Birds (SABAP1) and the 2018 National Vegetation
11 Map compiled by the South African National Biodiversity Institute (Mucina & Rutherford, 2006, as
12 revised by SANBI, 2018).
- 13 • The national threatened status of all priority species was determined with the use of the most recent
14 edition of the Red List Book of Birds of South Africa, Lesotho, and Swaziland (Lee et al. 2025), and the
15 latest authoritative summary of southern African bird biology (Hockey et al. 2005).
- 16 • The global threatened status of all priority species was determined by consulting the latest (2024)
17 IUCN Red List of Threatened Species (<http://www.iucnredlist.org/>).
- 18 • The database on the Key Biodiversity Areas (KBAs) of South Africa ([Key Biodiversity Areas in South
19 Africa - SANBI](#)) was consulted for information on potentially relevant KBAs within the study area.
- 20 • An intensive internet search was conducted to source information on the impacts of the proposed
21 development on avifauna.
- 22 • Satellite imagery (Google Earth © 2025) was used to view the study area on a landscape level and to
23 help identify bird habitat on the ground.
- 24 • The South African National Biodiversity BGIS map viewer was used to determine the locality of the
25 study area relative to National Protected Areas.
- 26 • The DFFE National Screening Tool (<https://screening.environment.gov.za/screeningtool/>) was used to
27 determine the assigned sensitivity of the study area as it relates to the Animal Species and Avian
28 (Wind) Environmental Themes.



1

2 **Figure 1:** Bird distribution data for the WP2 study area i.e., Namakwa region (indicated in green) has been obtained
 3 from 874 SABAP2 pentads. The 20 pentads comprising the WP1 study area i.e., Boegoebaai Port and SEZ are
 4 indicated in pink.

5

6 **5. ASSUMPTIONS AND LIMITATIONS**

7 This study assumed that the sources of information used in this report are reliable. In this respect, the
 8 following must be noted:

- 9 • The focus of the study is primarily on the potential impacts of the planned development scenarios on
 10 priority avifaunal species which were defined as follows:
- 11 – South African Red List species (Species of Conservation Concern)
 - 12 – South African endemics and near endemics
 - 13 – Waterbirds
 - 14 – Raptors; and
 - 15 – Species vulnerable to disturbance and/or habitat loss.
- 16 • The assessment of impacts is based on the baseline environment as it currently exists within the
 17 Namakwa Region and nearby surrounding environment.
- 18 • Conclusions in this study are based on experience of these and similar species in different parts of
 19 South Africa. Bird behaviour can never be entirely reduced to formulas that will be valid under all
 20 circumstances.

- 1 • The study area refers to the Namakwa Region that is 5 819 784.13 hectares in extent and covered by
 2 the 874 SABAP2 pentads, and that includes the proposed Boegoebaai Port and SEZ development area
 3 (Figure).

4

5 **6. KEY ENVIRONMENTAL ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREA**

6 **6.1 Habitat Features**

7 The Namakwa Region of the Northern Cape falls largely within the Succulent Karoo Biome, one of the
 8 world's biodiversity hotspots, and encompasses a rich mosaic of vegetation types that are classified based
 9 on climate, geology, soils, and plant communities (Mucina & Rutherford, 2006).

10 These vegetation types within the Succulent Karoo and the adjacent Desert, Fynbos and Nama Karoo
 11 biomes, range from arid winter-rainfall shrublands of the Lowland Succulent Karoo to the endemic-rich
 12 rocky slopes of the Upland Succulent Karoo/Kamiesberg Mountain Scrubland. Coastal habitats include
 13 Namaqualand Strandveld on calcareous sands, Coastal Duneveld with stabilised and mobile dunes, and
 14 Seashore Vegetation on rocky and sandy shores. Seasonal floral displays occur in the Namaqualand
 15 Blomveld, while inland sandy plains are represented by Inland Duneveld and Oograbies Plains Sandy
 16 Grassland. Unique features include Heuweltjiesveld on nutrient-rich termite mounds, Klipkoppe Scrubland
 17 with localised succulent endemics, and Riethuis-Wallekraal Quartz Vygieveld with specialised quartz-patch
 18 flora. Additional habitats comprise Namaqualand Sand Fynbos on sandstone soils, Arid Grassland in the
 19 eastern interior, ephemeral Namaqualand Rivers with riparian woodland, and saline wetlands such as Salt
 20 Pans and Arid Estuarine Salt Marshes, which are vital for waterbirds (Mucina & Rutherford, 2006; as
 21 revised by SANBI, 2018).

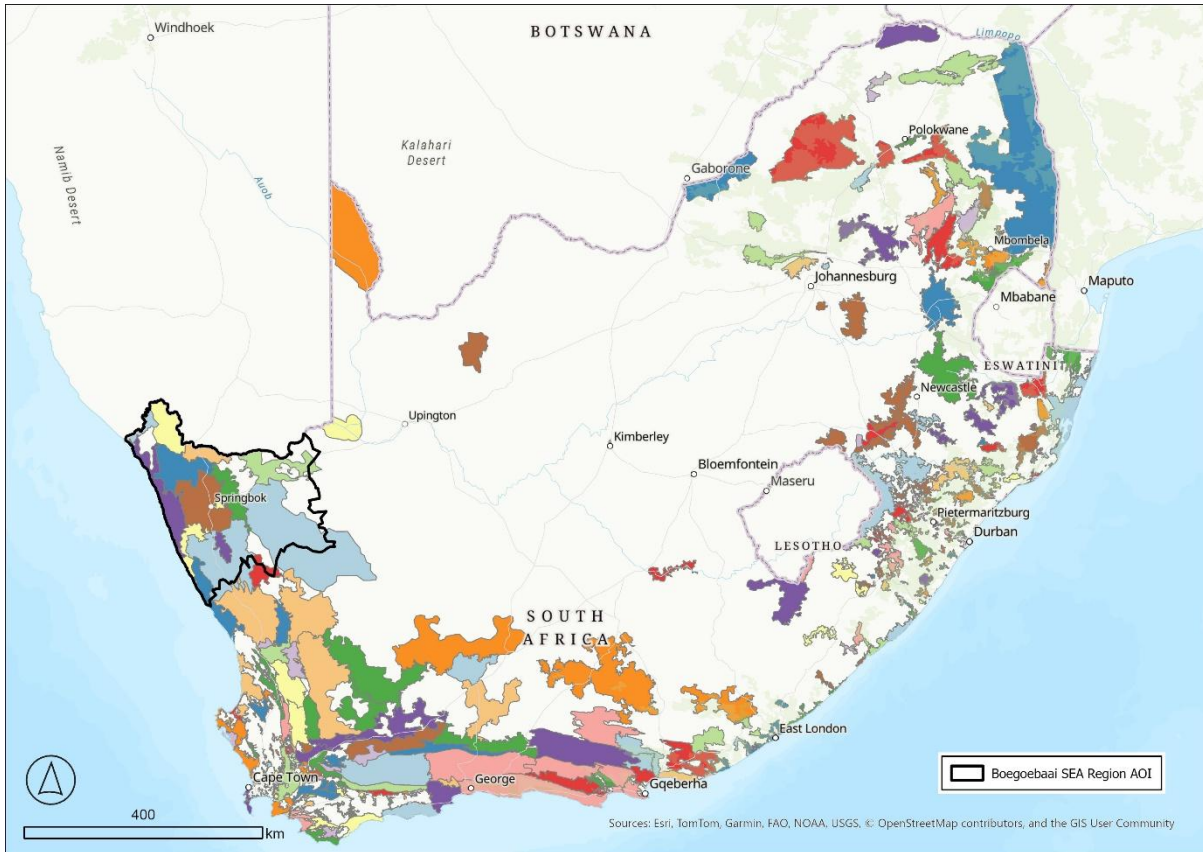
22 The Namakwa Region further includes several formally Protected Areas, declared in terms of the National
 23 Environmental Management: Protected Areas Act (Act No. 57 of 2003, as amended by Act 2 of 2022, such
 24 as the |Ai-|Ais/Richtersveld Transfrontier Park, the Namakwa National Park, Gamsberg Nature Reserve
 25 and the Goegap Nature Reserve (DFFE, 2022).

26 The Namakwa Region also comprises 15 Key Biodiversity Areas (KBAs). KBAs are 'sites that contribute
 27 significantly to the global persistence of biodiversity', which means they are the most important places in
 28 the world for species and their habitats – whether these be in terrestrial, freshwater, estuarine, or marine
 29 ecosystems. Sites qualify as global KBAs if they meet the specific standardised criteria and quantitative
 30 thresholds focused on one or more of five trigger aspects; threatened biodiversity, geographically restricted
 31 biodiversity, ecological integrity, biological processes, and irreplaceability through quantitative analysis.

32 KBAs featured within the Namakwa Region (Figure) include the following:

- 33 a) Aggeneys - Pella - Pofadder
- 34 b) Bushmanland Inselbergs
- 35 c) Bushmanland Interior
- 36 d) Gariiep Desert
- 37 e) Goegap
- 38 f) Kamiesberg
- 39 g) Kliprand
- 40 h) Namaqualand Sandveld North
- 41 i) Namaqua National Park
- 42 j) Namaqualand Hardeveld North
- 43 k) Namaqualand Hardeveld South

- 1 l) Namaqualand Sandveld South
- 2 m) Orange River Estuary - Southern Namib Desert
- 3 n) Richtersveld National Park
- 4 o) Southern Richtersveld
- 5



6
7 **Figure 1:** The Namakwa Region of South Africa (outlined in black) contains 15 Key Biodiversity Areas (Source:
8 <https://www.keybiodiversityareas.org/map>).

9

10 6.2 Priority Bird Species of the Namakwa Region

11 To date, one hundred and thirty-eight (138) bird species have been recorded in the Namakwa Region
12 through the Second Southern African Bird Atlas Project (SABAP2) over a period of 18 years. Of the 138
13 species, 44 are considered priority species. Priority species were defined as species that are particularly
14 sensitive to displacement due to disturbance and/or habitat loss, as well as risk of collisions and
15 electrocutions; endemic and near-endemic species; all SCC; waterbirds; raptors; and range restricted
16 species. The 44 priority bird species recorded in the Namakwa Region that were selected for further
17 assessment include SCC as well as those that are endemic or near-endemic to South Africa (**Table**).

18 It should be noted that observer effort in this area is generally low due to the sparseness of the human
19 population and the remoteness (inaccessibility) of the area. Therefore, the SABAP2 species list is not
20 necessarily fully comprehensive of the Namakwa Region.

21

1 **Table 3:** Priority avifaunal species including Species of Conservation Concern and/or endemic species that have
 2 been recorded in the Namakwa Region as it relates to the SEA. CR = Critically Endangered, EN = Endangered, VU =
 3 Vulnerable, NT = Near Threatened, E = Endemic, NE = Near Endemic, SLE = Endemic to South Africa,
 4 Lesotho and Eswatini

Species Name	Scientific Name	Global Conservation Status	Regional Conservation Status	Endemism
African Fish Eagle	<i>Ichthyophaga vocifer</i>	-	-	-
African Marsh Harrier	<i>Circus ranivorus</i>	-	VU	-
African Rock Pipit	<i>Anthus crenatus</i>	NT	-	SLE
Bank Cormorant ³	<i>Phalacrocorax neglectus</i>	EN	EN	-
Bateleur	<i>Terathopius ecaudatus</i>	EN	EN	-
Black Harrier	<i>Circus maurus</i>	EN	EN	NE
Black Stork	<i>Ciconia nigra</i>	-	EN	-
Black-eared Sparrow-Lark	<i>Eremopterix australis</i>	-	-	NE
Black-headed Canary	<i>Serinus alario</i>	-	-	NE
Blue Crane	<i>Grus paradisea</i>	VU	VU	-
Burchell's Courser	<i>Cursorius rufus</i>	-	VU	-
Cape Cormorant ⁴	<i>Phalacrocorax capensis</i>	EN	EN	-
Cape Clapper Lark	<i>Mirafrapa apiata</i>	-	-	NE
Cape Eagle-Owl	<i>Bubo capensis</i>	-	-	-
Cape Long-billed Lark	<i>Certhilauda curvirostris</i>	-	-	E
Cape Rock Thrush	<i>Monticola rupestris</i>	-	-	SLE
Cape Spurfowl	<i>Pternistis capensis</i>	-	-	NE
Cape Sugarbird	<i>Promerops cafer</i>	-	-	E
Cape Vulture	<i>Gyps coprotheres</i>	VU	VU	-
Caspian Tern	<i>Hydroprogne caspia</i>	-	VU	-
Chestnut-banded Plover	<i>Anarhynchus pallidus</i>	-	VU	-
Cinnamon-breasted Warbler	<i>Euryptila subcinnamomea</i>	-	-	NE
Curlew Sandpiper	<i>Calidris ferruginea</i>	VU	VU	-
Damara Tern	<i>Sterna balaenarum</i>	-	EN	-
Dune Lark (Coastal)	<i>Calendulauda erythrochlamys patae</i>	-	-	NE
Great White Pelican	<i>Pelecanus onocrotalus</i>	-	VU	-
Greater Flamingo	<i>Phoenicopterus roseus</i>	-	NT	-
Grey-winged Francolin	<i>Scleroptila afra</i>	-	-	SLE
Ground Woodpecker	<i>Geocolaptes olivaceus</i>	NT	NT	SLE
Jackal Buzzard	<i>Buteo rufofuscus</i>	-	-	NE

³ Marine species were not included in this Terrestrial Avifaunal Study. Marine species assessments are included in the Marine Specialist Study for the Boegoebaai SEA.

⁴ Marine species were not included in this Terrestrial Avifaunal Study. Marine species assessments are included in the Marine Specialist Study for the Boegoebaai SEA.

Species Name	Scientific Name	Global Conservation Status	Regional Conservation Status	Endemism
Karoo Eremomela	<i>Eremomela gregalis</i>	-	-	NE
Karoo Korhaan	<i>Heterotetrax vigorsii</i>	-	NT	-
Lanner Falcon	<i>Falco biarmicus</i>	-	NT	-
Ludwig's Bustard	<i>Neotis ludwigii</i>	EN	EN	-
Maccoa Duck	<i>Oxyura maccoa</i>	EN	VU	-
Martial Eagle	<i>Polemaetus bellicosus</i>	EN	EN	-
Orange-breasted Sunbird	<i>Anthobaphes violacea</i>	-	-	E
Peregrine Falcon	<i>Falco peregrinus</i>	-	-	-
Red Lark	<i>Calendulauda burra</i>	VU	VU	E
Sclater's Lark	<i>Spizocorys sclateri</i>	NT	NT	NE
Secretarybird	<i>Sagittarius serpentarius</i>	EN	VU	-
Sentinel Rock Thrush	<i>Monticola explorator</i>	NT	-	SLE
Southern Black Korhaan	<i>Afrotis afra</i>	VU	VU	E
Verreaux's Eagle	<i>Aquila verreauxii</i>	-	VU	-

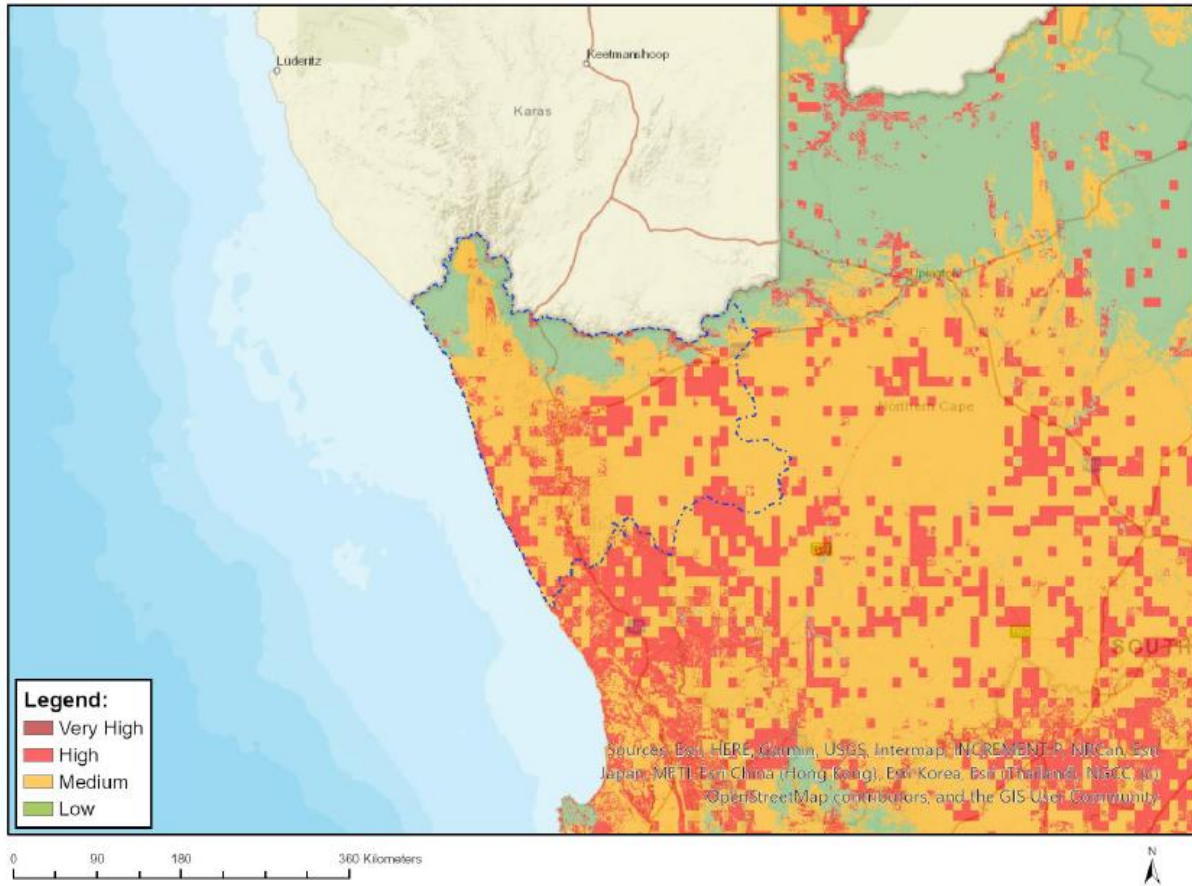
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2 6.3 DFFE Screening Tool

3 The Namakwa Region is classified partially as High, Medium and Low sensitivity for avifauna according to
4 the Animal Species Theme of the DFFE Screening Tool (Error! Reference source not found.). The Namakwa R
5 egion is classified partially as Very High, High, Medium and Low sensitivity for avifauna according to the
6 Avian (Wind) Theme of the DFFE Screening Tool (**Figure**). The Namakwa Region also contains confirmed
7 habitat for SCC as defined in the Protocol for the specialist assessment and minimum report content
8 requirements for environmental impacts on terrestrial animal species (Government Gazette No 43855,
9 Government Notice 1150 of 30 October 2020). SCCs are listed on the IUCN Red List of Threatened
10 Species (2025) or South Africa's National Red List (2025) as Critically Endangered, Endangered,
11 Vulnerable or Near Threatened.

12 The occurrence of SCC in the Namakwa Region is confirmed by the SABAP2 data as indicated in **Table 3**
13 (Section 6.2).

14 Based on the confirmed habitat, the SABAP2 data, and modelling outputs the overall classification of **Very**
15 **High** and **High** sensitivity for avifauna in the Screening Tool is supported.



1
2
3

Figure 2: The sensitivity of the Namakwa Region as it relates to the Animal Species Theme (Source: DFFE Screening Tool, 2025).

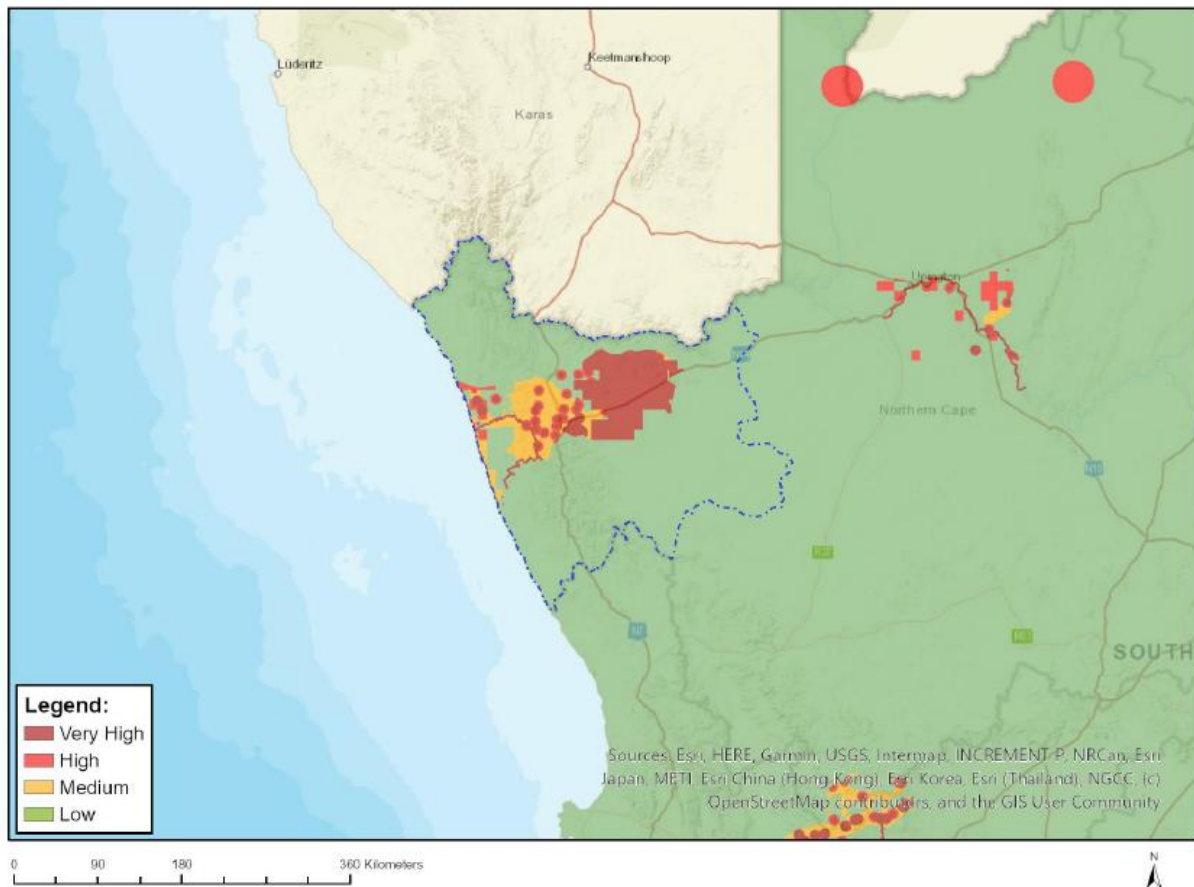


Figure 3: The sensitivity of the Namakwa Region as it relates to the Avian (Wind) Theme (Source: DFFE Screening Tool, 2025).

6.4 Sensitivity Analysis and Mapping

6.4.1 Study Area Definition

The sensitivity analysis for this risk assessment was conducted within the study area defined as the Namakwa Region, encompassing the Richtersveld, Nama Khoi, Kamiesberg, and Khâi-Ma Local Municipalities (including the Boegoebaai Port Precinct and SEZ) in the Northern Cape Province. The analysis area was defined using the established Area of Interest (AOI) polygon to ensure consistent spatial boundaries and exclude background areas that could bias statistical analyses.

6.4.2 Species Data and Distribution Modelling

➤ Species Distribution Model Processing

Species occurrence data and corresponding habitat suitability models were obtained from existing Species Distribution Model (SDM) datasets for the Namakwa Region. The SDM processing workflow involved several filtering stages to identify SCCs:

1. **Initial Dataset:** All available SDMs for the study area were compiled, representing the complete range of species with modelled habitat distributions.
2. **Habitat Threshold Filtering:** Species were filtered based on a minimum habitat area threshold of 5000 hectares within the study area (i.e. the species was distributed across $\geq 0.1\%$ of the study

1 area). This threshold was applied to focus the analysis on species with sufficient habitat
2 representation to warrant detailed impact assessment.

3 3. **Final Species Set:** Species meeting the habitat threshold criteria were retained for detailed impact
4 scoring, while those below the threshold were excluded from quantitative risk assessment but
5 documented for completeness. See **Annexure A** for details.

6 ➤ *Species Attribute Integration*

7 Species-specific conservation attributes were integrated from authoritative databases for the 44 priority
8 avian species that were selected for this risk assessment, including:

- 9 • South African Red Data Book (Lee et. al. 2025) conservation status classifications (CR, EN, VU and
10 NT)
- 11 • Range size categories (Small, Medium, Large)
- 12 • Endemism classifications (Endemic, Sub-regional endemic, Near endemic)

13 **6.4.3 Impact Scoring Framework**

14 ➤ *Impact Type Classification*

15 Four primary impact categories were assessed based on GH₂ and renewable energy related infrastructure
16 effects on terrestrial avifauna:

- 17 1. **Displacement - Disturbance:** Behavioural avoidance and habitat abandonment due to human
18 activities and infrastructure presence.
- 19 2. **Displacement - Habitat Loss/ Fragmentation/ Transformation:** Direct habitat loss through
20 infrastructure footprint and associated developments.
- 21 3. **Collisions:** Direct mortality from collisions with infrastructure such as wind turbines, powerlines
22 and masts/towers.
- 23 4. **Electrocutions:** Mortality from electrocution on transmission and distribution infrastructure.

24 ➤ *Base Impact Scoring per Impact Category*

25 Species-specific susceptibility scores (0-5 scale) were assigned for each impact type based on:

- 26 • Literature review of species-specific vulnerability assessments;
- 27 • Expert knowledge of species ecology and behaviour; and
- 28 • Documented impacts from comparable developments typical of the GH₂ and renewable energy
29 sectors.

30 **6.4.4 Conservation Weighting System**

31 A multiplicative weighting system was applied to base impact scores to prioritise species of higher
32 conservation concern. See **Annexure A** for details:

33 ➤ *Red Data Status Multipliers*

- 34 • Critically Endangered (CR): 16×
- 35 • Endangered (EN): 8×

- 1 • Vulnerable (VU): 4×
- 2 • Near Threatened (NT): 2×
- 3 • Least Concern (LC): 1×

4 ➤ *Range Size Multipliers*

- 5 • Small range: 10×
- 6 • Medium range: 5×
- 7 • Large range: 1×

8 ➤ *Endemism Multipliers*

- 9 • Endemic (E): 5×
- 10 • Sub-regional/local endemic (SLE): 5×
- 11 • Near-endemic (NE): 3×
- 12 • Not endemic (NA): 1×

13 **6.4.5 Composite Weighting**

14 The final conservation multiplier was calculated as:

15 Conservation Multiplier = Red Data Multiplier × Range Multiplier × Endemism Multiplier

16 Final Weighted Score per Impact = Base Impact Score × Conservation Multiplier (**Figure 7-10**)

17 **6.5 Spatial Risk Mapping**

18 **6.5.1 Raster Processing**

19 Individual species SDMs were processed to create weighted impact surfaces:

- 20 1. *NoData Handling*: NoData values in source rasters were converted to zero to enable mathematical
21 operations while preserving spatial extent.
- 22 2. *Weight Application*: Each species' SDM was multiplied by its corresponding weighted impact score
23 for each impact type.
- 24 3. *Cumulative Impact Calculation*: Species-specific weighted rasters were summed within each
25 impact category to create cumulative impact surfaces.

26 **6.5.2 Risk Classification**

27 Cumulative impact rasters were classified into four risk categories using custom quantile breaks:

- 28 • **Low Risk**: 0-30th percentile (%)
- 29 • **Medium Risk**: >30th-60th percentile (%)
- 30 • **High Risk**: >60th-80th percentile (%)

- 1 • **Very High Risk:** >80th-100th percentile (%)

2 Quantile breaks were calculated from pixels with values >0 within the AOI (i.e., Namakwa Region) to ensure
3 classification reflected actual impact gradients rather than background areas.

4 6.6 Quality Assurance

5 6.6.1 Data Validation

- 6 • SDM file integrity was verified through spatial extent and value range checks.
- 7 • Species name matching between SDM datasets and scoring databases was validated using
8 automated and manual fuzzy matching procedures.
- 9 • Statistical outliers in scoring and weighting calculations were identified and verified.

10 6.6.2 Process Validation

- 11 • Incremental processing approaches were implemented to enable resumable workflows and
12 individual species verification.
- 13 • Classification results were cross validated against alternative statistical methods (natural breaks,
14 equal intervals) to ensure robustness.
- 15 • Final risk maps were visually inspected for spatial coherence and ecological plausibility.

16 6.7 Synthesis of Avian Sensitivity Mapping for Renewable Energy Technologies

17 The weighted species-impact modelling for 44 priority avifaunal species produced four primary sensitivity
18 layers corresponding to key renewable energy impact pathways: disturbance/displacement, habitat
19 transformation, collision, and electrocution (**Figures 7–10**). Together, these depict the relative ecological
20 sensitivity of the Namakwa Region to large-scale renewable energy development (**Figure 11**).

21 While these maps share a common baseline of species-level ecological vulnerability, their dominant drivers
22 differ between wind and solar PV infrastructure. Accordingly, two broad synthesis layers can be interpreted:

23 6.7.1 Sensitivity to Wind Energy Development

24 Wind energy infrastructure poses elevated risks of collision (with turbine blades, towers, and associated
25 powerlines) and electrocution (on transmission infrastructure), as well as localised disturbance during
26 construction and operation. The combined collision plus electrocution sensitivity surface therefore provides
27 the most representative indicator of wind-related avian sensitivity.

28 At the regional scale, areas of Very High sensitivity correspond largely to:

- 29 • the Kamiesberg uplands and escarpment zones,
- 30 • the Springbok–Garies corridor, and
- 31 • parts of the coastal plain south of Port Nolloth, where raptor and large terrestrial species densities
32 are elevated and flight activity intersects likely turbine-suitable topography.
- 33 • These zones align closely with previously mapped Key Biodiversity Areas (KBAs) and regions
34 already classified as Very High sensitivity under the DFFE National Screening Tool.

1 6.7.2 Sensitivity to Solar PV Development

2 Solar PV installations have comparatively lower direct collision or electrocution risk but can result in habitat
3 loss, fragmentation, and displacement of ground-nesting and/or habitat specialist bird species over large
4 footprints. The combined habitat-loss and disturbance sensitivity surface therefore best represents solar-
5 related avian sensitivity.

6 High and Very High sensitivity areas for solar PV broadly coincide with:

- 7 • the central Namaqualand shrublands and mountain foothills east of Springbok,
- 8 • the Garies–Kamiesberg–Springbok belt, and
- 9 • the southern and inland coastal plains where species richness and breeding habitat overlap with
10 flat, developable terrain.
- 11 • Here, the potential for displacement of endemic and/or threatened larks, bustards, and ground-
12 nesting species is greatest.

13 6.7.3 Interpretation and Application

14 These technology-specific syntheses highlight complementary but distinct spatial patterns of risk. They are
15 intended to guide strategic-level screening and spatial planning, rather than prescribe exclusion zones.
16 Local sensitivity can vary substantially depending on site characteristics such as habitat type, micro-
17 topography, and proximity to breeding or foraging areas. Therefore, final technology-specific risk
18 assessment and weighting should be refined through site-level EIA processes, informed by detailed
19 avifaunal surveys.

20 At the SEA scale, these combined sensitivity layers offer an integrated, precautionary basis for identifying
21 areas where:

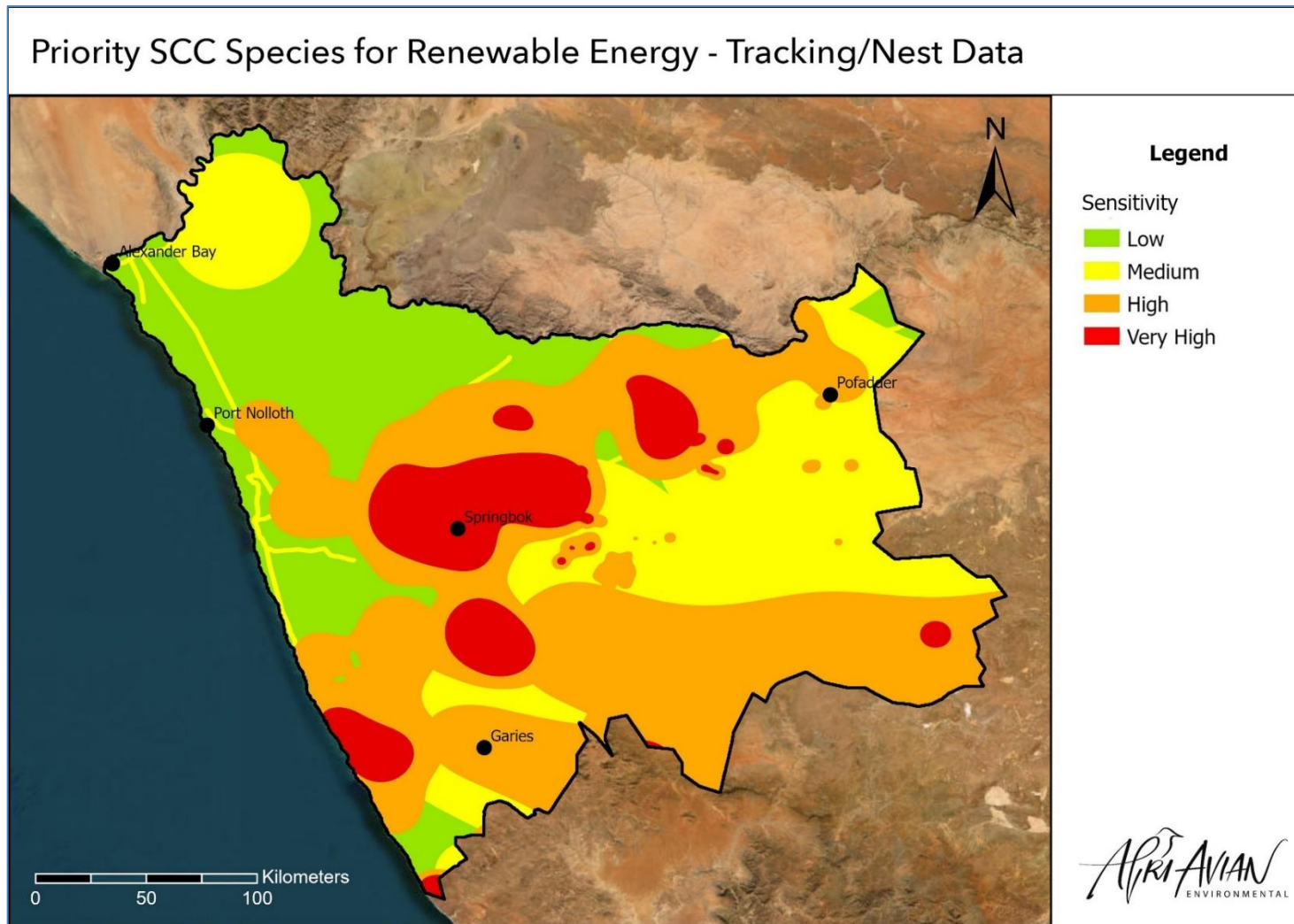
- 22 • wind and solar development should be prioritised toward lower sensitivity zones, and
- 23 • pre-construction monitoring and mitigation planning should be emphasised in high-sensitivity
24 zones.

25 This methodology provides a systematic, transparent, and scientifically defensible approach to quantifying
26 cumulative species impact risks from renewable energy development and related infrastructure expansion
27 across the Namakwa Region.

28 Following from the spatial risk mapping, the avian sensitivity of the Namakwa Region, generated from the
29 weighted analysis incorporating the 44 priority avian species selected for further assessment per impact, is
30 illustrated below in **Figure 7 – 10**. **Figure 11** depicts the composite avifaunal sensitivity of the Namakwa
31 Region considering all four impact layers at maximum rule.

32 **Figure 6** illustrates the avian sensitivity of the Namakwa Region generated from the weighted analysis
33 incorporating mainly nest/roost location data and GPS tracking data of 10 key priority SCC i.e., Black
34 Harrier, Blue Crane, Cape Vulture, Ludwig’s Bustard, Martial Eagle, Red Lark, Sclater’s Lark, Secretarybird,
35 Verreaux’s Eagle and White-backed Vulture.

36 The species-impact scoring sheet detailing the information that generated the weighted analysis and
37 subsequent sensitivity ratings for this avifaunal risk assessment, as outlined and discussed above, is
38 included in **Annexure A**.

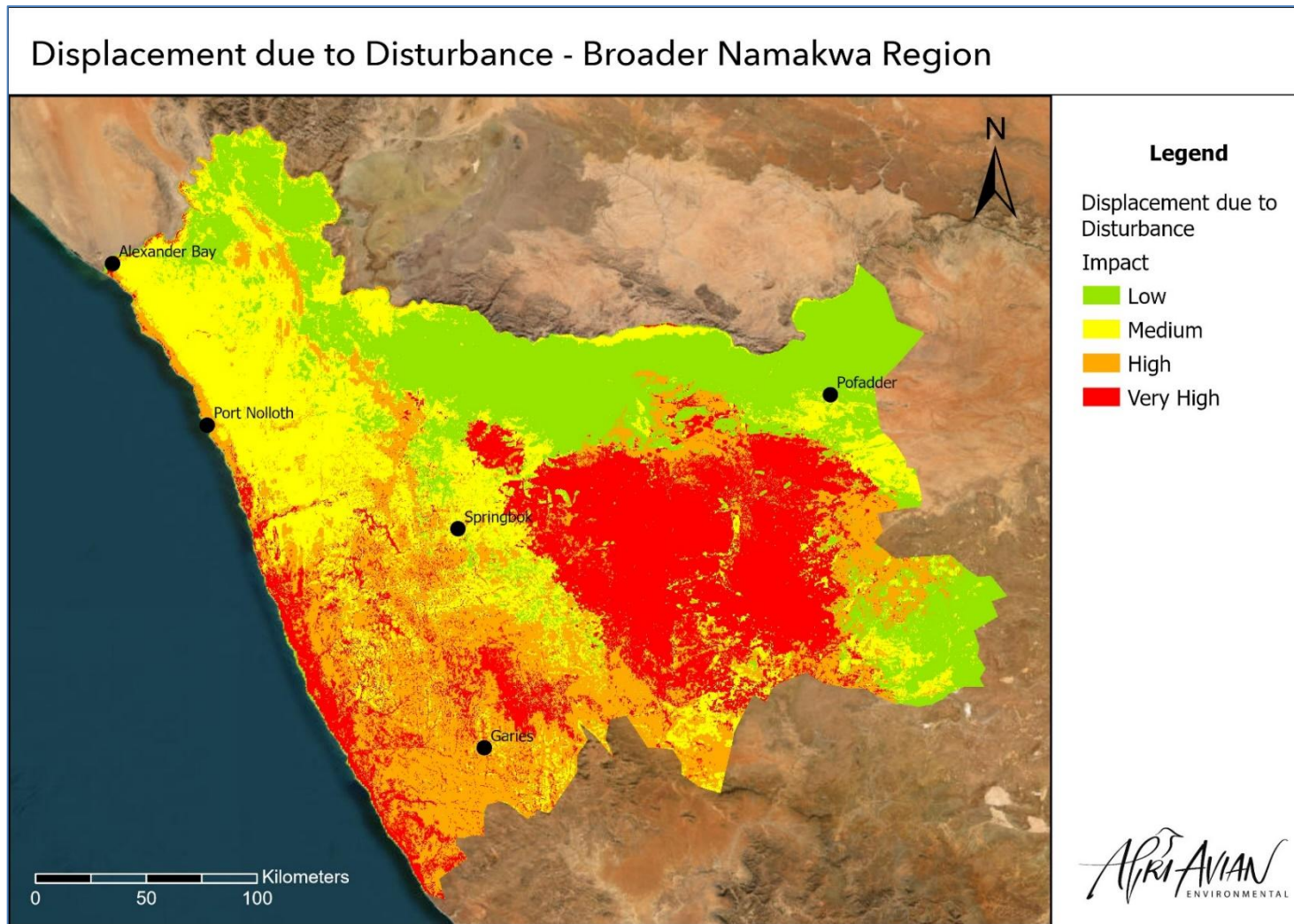


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Figure 4: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating mainly nest/roost location data and GPS tracking data of 10 key priority SCC.

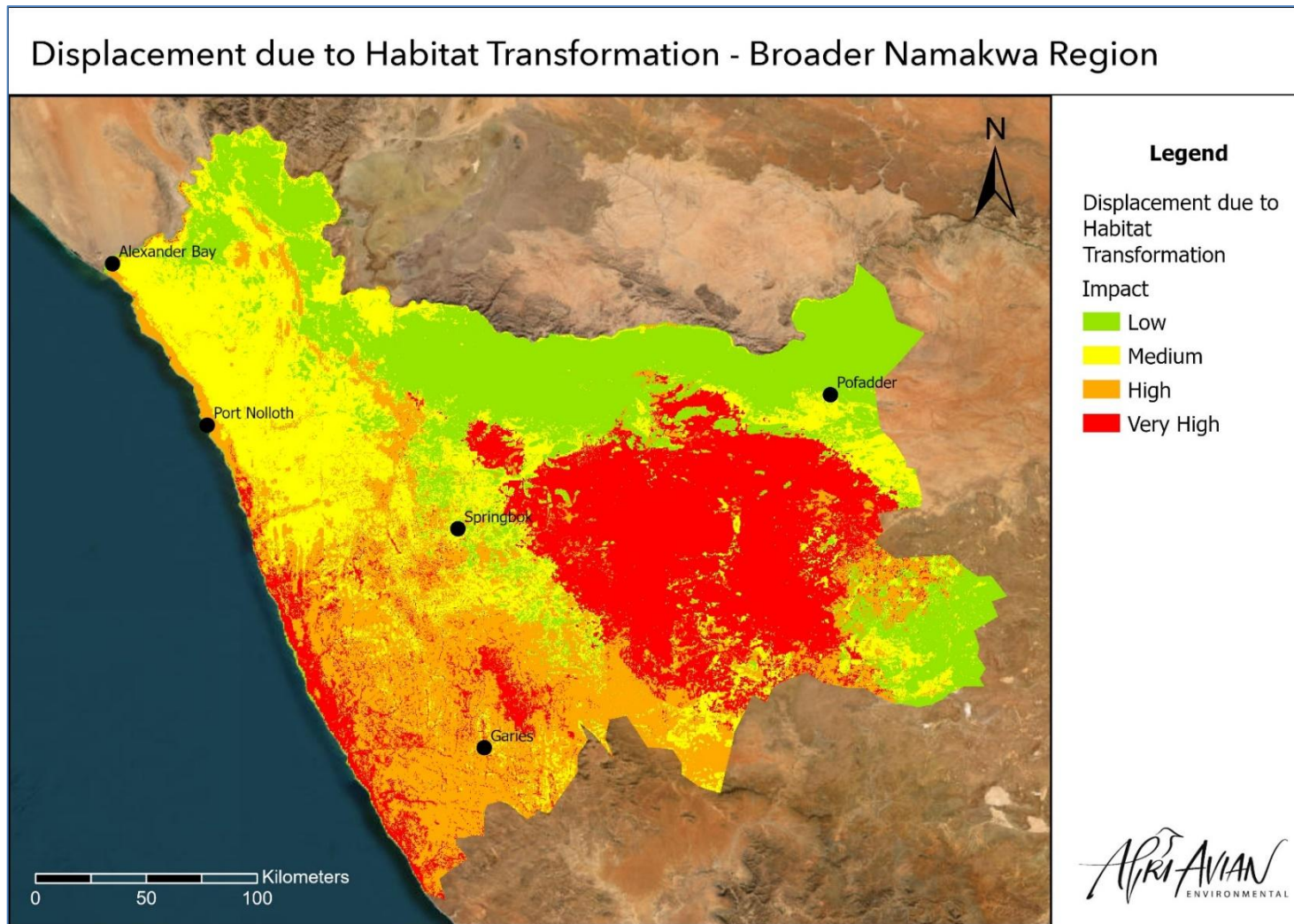


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Figure 5: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of displacement due to disturbance.

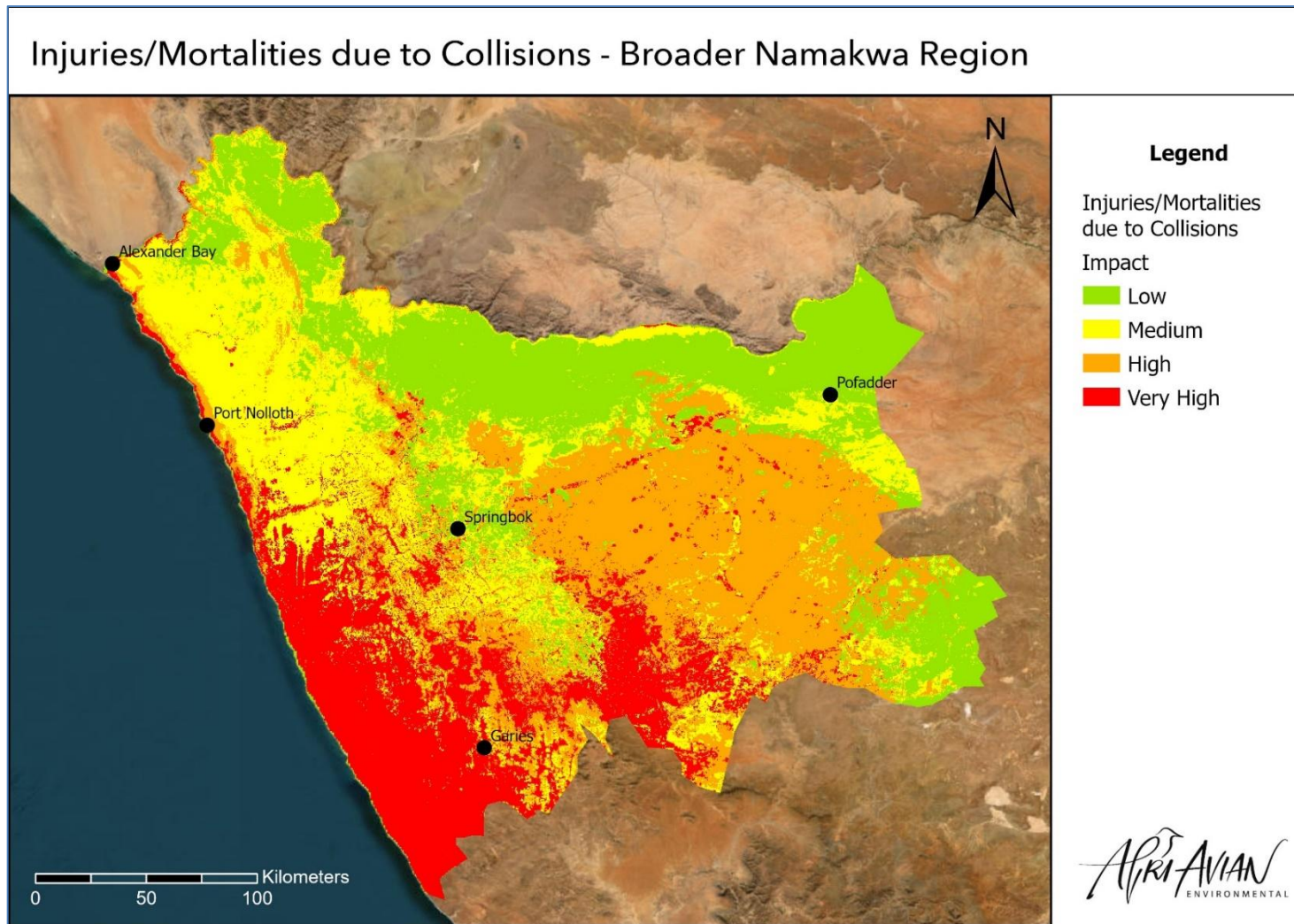


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Figure 6: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of displacement due to habitat loss / fragmentation / transformation.

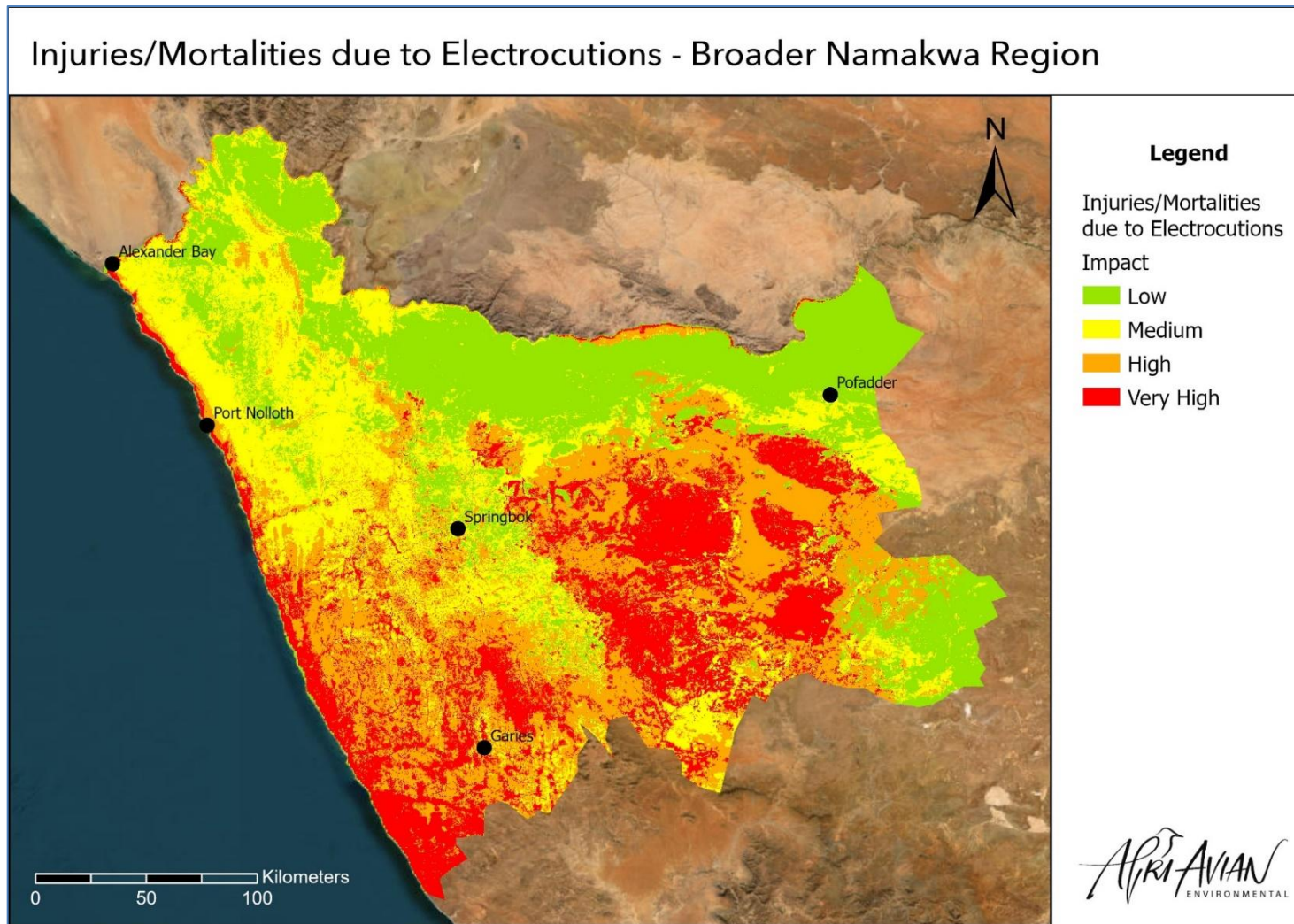


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Figure 7: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of injuries or direct mortalities due to collisions.

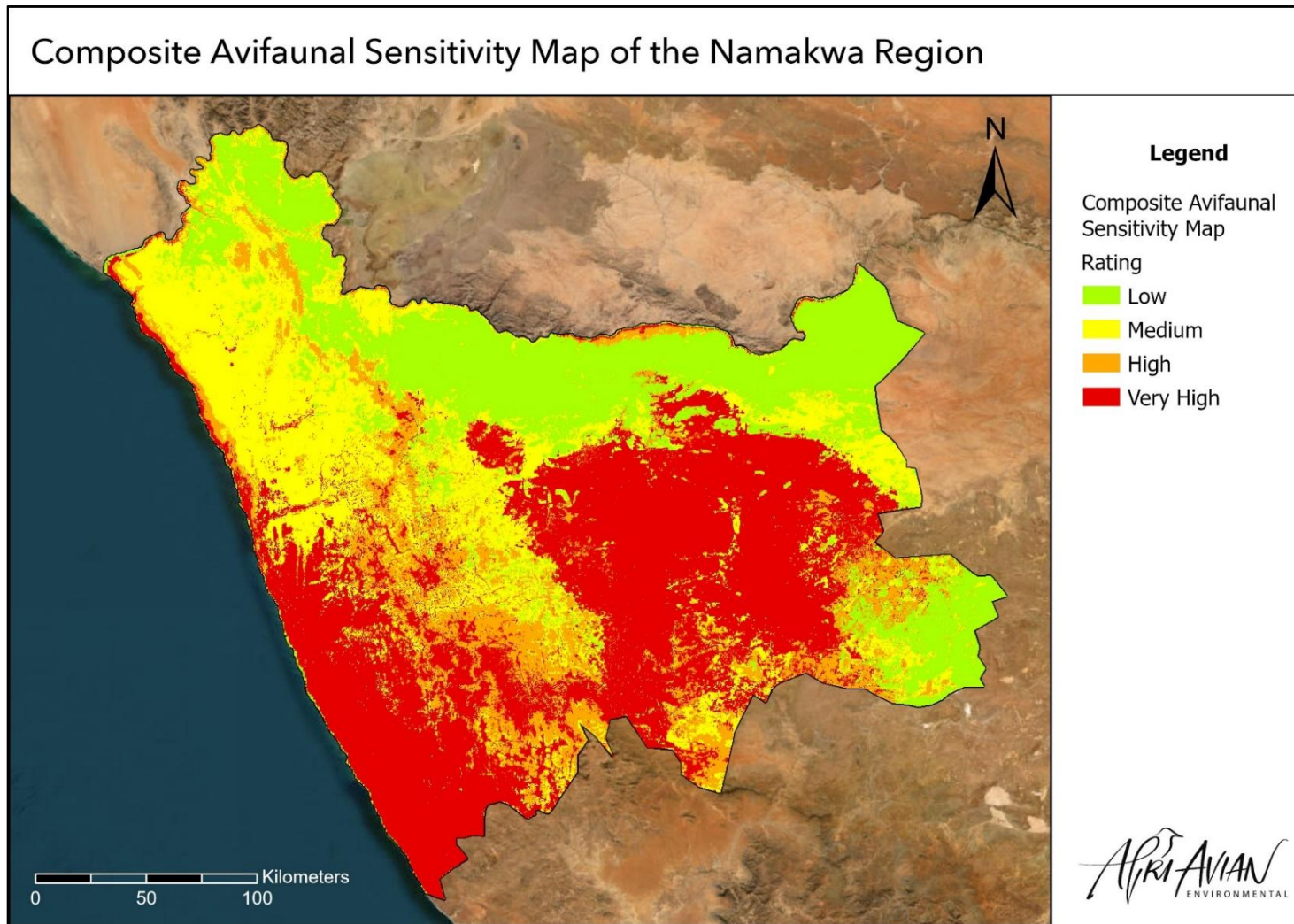


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Figure 8: The avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment as it relates to the potential impact of injuries or direct mortalities due to electrocutions.



1

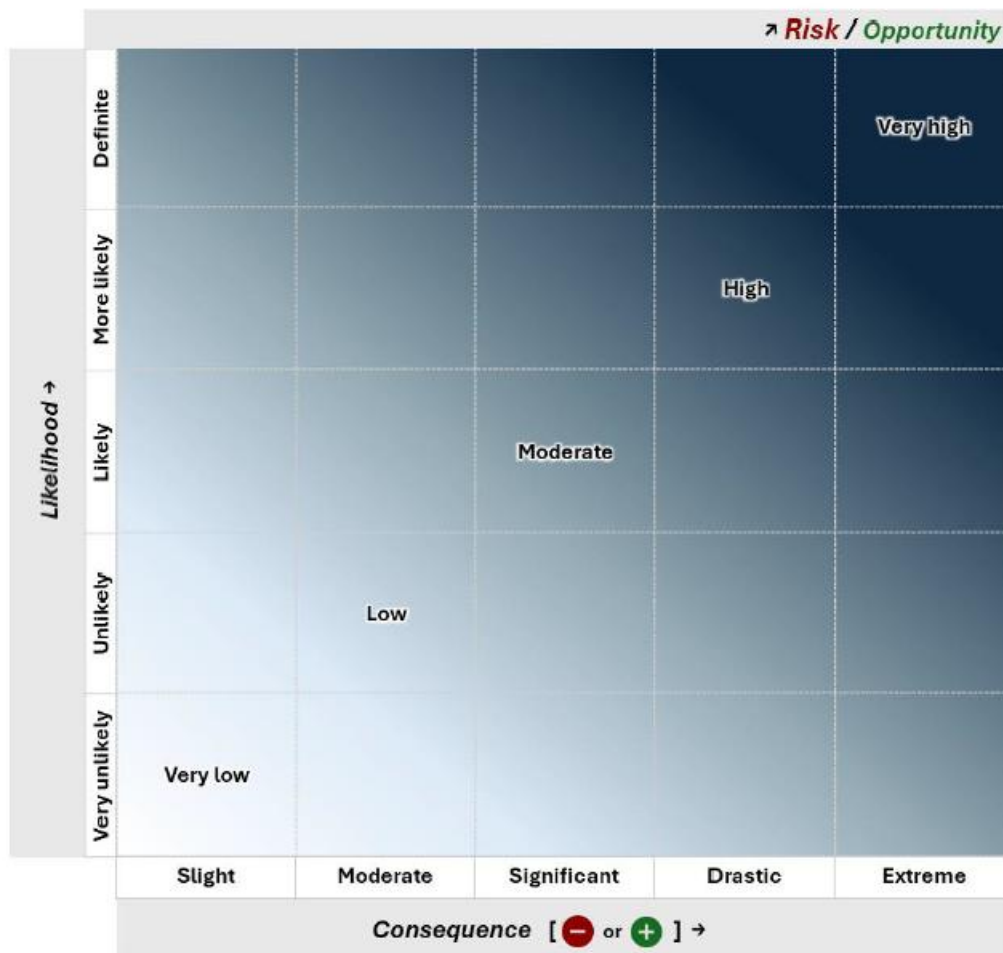
2 **Figure 9:** The composite avian sensitivity of the Namakwa Region generated from the weighted analysis incorporating the 44 priority avian species selected for this risk assessment
 3 considering all four primary sensitivity layers applying the maximum rule.

1 **7. RISK ASSESSMENT**

2 **7.1 How Risk is Determined**

3 In this SEA, risk is determined by evaluating the likelihood of an impact occurring and the potential effect
 4 or consequence of that impact on priority avifaunal species occurring in the Namakwa Region (**Figure**).

5 For this avifaunal specialist assessment, undertaken as part of WP2 of the SEA, the potential impacts to
 6 avifauna (i.e., habitat loss, disturbance, collision and electrocution risk) are considered to be negative (-) in
 7 nature. At present, no direct or indirect opportunities for avifauna have been identified or are predicted
 8 under the current proposed project design and mitigation framework. That said, built-in safeguards such as
 9 biodiversity offsets, conservation servitudes, set-asides, micro-siting and collision deterrents are known to
 10 reduce adverse effects but remain classified as negative unless they deliver measurable net gains (e.g.,
 11 new breeding sites, quantified increases in functional avifaunal habitat, and evidence that gains outweigh
 12 residual losses). As such, potential indirect opportunities for avifauna can be stipulated at a project-by-
 13 project level to potentially achieve an overall no net loss.



14
 15 **Figure 1:** Risk and opportunity is qualitatively measured by multiplying the likelihood of an impact (negative or
 16 positive) by the severity of the consequence or benefit (Source: CSIR, 2025).

1 **7.2 How Consequence is Determined**

2 Consequence, also referred to as severity, refers to the potential outcome or effect if a risk or impact
 3 occurs. It is a key component in determining the overall level of risk and is assessed by evaluating the
 4 degree of harm or damage that could result.

5 In South African avifaunal specialist assessments, particularly those aligned with guidelines stipulated by
 6 BirdLife South Africa and Endangered Wildlife Trust, and in accordance with the Avifaunal Specialist
 7 Protocol (GNR 320 of 2020) in terms of the 2014 NEMA EIA Regulations (as amended) consequence
 8 thresholds are generally distinguished along a gradient of magnitude, extent, duration and reversibility of
 9 an impact occurring, and resultant conservation importance.

10 These consequence thresholds (**Table**) are often applied in impact significance matrices where
 11 consequence is combined with likelihood to determine overall significance ratings. For avifauna, the
 12 population viability context which include species' Red List status, range size, generation length and
 13 sensitivity to the impact mechanism, is central to assigning the correct threshold.

14 **Table 4:** Consequence thresholds defined for determining potential risk of impact to avifauna within the Namakwa
 15 Region

Threshold	Consequence levels defined for impact on Avifauna
Slight	Negligible to very low magnitude; localised; short-term; fully reversible; no measurable effect on population viability; affects only common/non-threatened/non-target species.
Moderate	Low to medium magnitude; local or limited regional extent; short- to medium-term; reversible with mitigation; may cause minor, non-sustained reductions in local abundance but no long-term viability risk.
Substantial	Medium magnitude; regional extent or affecting key habitats; medium- to long-term; partially reversible; measurable reduction in local population size or productivity; medium risk to one or more avifaunal species of conservation concern (Endemic and Near-Endemic species) but unlikely to threaten overall population persistence.
Severe	High magnitude; regional to national extent; long-term or permanent; largely irreversible; substantial reduction in population size or productivity; high risk to one or more avifaunal species of conservation concern (Vulnerable and Near-Threatened species) potentially affecting viability of local or metapopulations.
Extreme	Very high magnitude; national or global extent; permanent and irreversible; threatens survival of Endangered and Critically Endangered avifaunal species or leads to local extinction; affects critical habitats for Endangered and Critically Endangered avifaunal species.

16 **7.3 How Risk Categories are Defined**

17 Risk to avifauna in the Namakwa Region is assessed for each identified impact (see Section 3),
 18 considering the different types of avifaunal habitat characteristic of the study area (as described in Section
 19 6.1), and incorporating the 44 priority avian species selected for this risk assessment (see Section 6.2),
 20 qualitatively against a predefined set of sensitivity criteria as described in Section 6.4 above. **Table**
 21 outlines the predefined risk categories utilised in this avifaunal risk assessment.

22

23

1 **Table 5:** Predefined risk categories applicable to the Avifaunal Risk Assessment for this SEA (Source: CSIR, 2025)

Risk (-) level	Category description
VERY LOW	Almost indiscernible negative impact
LOW	Slight negative impact, limited extent, and short duration, well within tolerance levels
MODERATE	Substantial impact, but less than major; within tolerance levels and below limits of acceptable change
HIGH	Major consequences, approaching tolerance and limits of acceptable change
VERY HIGH	Extremely negative impact, persistent/long lasting impact, beyond tolerance and limits of acceptable change

2

3 **7.4 Risk Assessment with and without Mitigation**

4 **Table 6** shows the risk associated with the potential negative (-) impacts to priority avifaunal species
 5 determined for each development scenario: S0: Baseline Scenario, S1: Small scale GH₂ development, and
 6 S2: Big scale GH₂ development, for each sensitivity criteria, both with and without mitigation management.

7 *It is important to note that the precautionary approach was exercised when following this risk assessment*
 8 *methodology and determining the risk associated with the potential negative (-) impacts to priority*
 9 *avifaunal species within the Namakwa Region.*

10

1

Table 6: Risk Assessment determined for negative impacts to Avifauna within the Namakwa Region for each proposed GH₂ development scenario

Negative (-) impact	Development Scenario	Spatial receiving environment / receptor	Without management/mitigation			With management/mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
Displacement due to disturbance such as noise, lighting and human activity	S0: BASELINE	Very High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH ₂		Substantial	Definitive	Very High	Moderate	More likely	High
	S2: BIG GH ₂		Severe	Definitive	Very High	Substantial	More likely	High
	S0: BASELINE	High Sensitivity	Moderate	Likely	Moderate	Slight	Likely	Moderate
	S1: SMALL GH ₂		Substantial	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH ₂		Severe	Definitive	Very High	Substantial	More likely	High
	S0: BASELINE	Medium Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: SMALL GH ₂		Moderate	More likely	High	Slight	Likely	Moderate
	S2: BIG GH ₂		Substantial	More likely	High	Moderate	Likely	Moderate
	S0: BASELINE	Low Sensitivity	Moderate	Likely	Moderate	Slight	Very unlikely	Very Low
	S1: SMALL GH ₂		Moderate	More likely	High	Slight	Likely	Moderate
	S2: BIG GH ₂		Substantial	More likely	High	Moderate	Likely	Moderate
Displacement due to Habitat loss/ fragmentation/ transformation	S0: BASELINE	Very High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH ₂		Extreme	Definitive	Very High	Severe	More likely	High
	S2: BIG GH ₂		Extreme	Definitive	Very High	Severe	Definitive	Very High
	S0: BASELINE	High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH ₂		Severe	More likely	High	Substantial	More likely	High
	S2: BIG GH ₂		Extreme	Definitive	Very High	Severe	Definitive	Very High
	S0: BASELINE	Medium Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate
	S1: SMALL GH ₂		Substantial	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH ₂		Severe	Definitive	Very High	Substantial	More likely	High
	S0: BASELINE	Low Sensitivity	Moderate	Unlikely	Low	Slight	Unlikely	Low
	S1: SMALL GH ₂		Substantial	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH ₂		Substantial	Definitive	Very High	Substantial	More likely	High
Injury or mortality due to	S0: BASELINE	Very High Sensitivity	Substantial	Likely	Moderate	Moderate	Likely	Moderate

Negative (-) impact	Development Scenario	Spatial receiving environment / receptor	Without management/mitigation			With management/mitigation		
			Consequence (-)	Likelihood	Risk	Consequence (-)	Likelihood	Risk
collisions with wind turbines, solar panels, powerlines and masts/towers	S1: SMALL GH ₂		Extreme	Definitive	Very High	Severe	More likely	High
	S2: BIG GH ₂		Extreme	Definitive	Very High	Extreme	More likely	Very High
	S0: BASELINE	High Sensitivity	Substantial	Likely	Moderate	Moderate	Unlikely	Low
	S1: SMALL GH ₂		Severe	More likely	High	Substantial	Likely	Moderate
	S2: BIG GH ₂		Extreme	Definitive	Very High	Severe	Likely	High
	S0: BASELINE	Medium Sensitivity	Moderate	Likely	Moderate	Slight	Unlikely	Low
	S1: SMALL GH ₂		Severe	More likely	High	Moderate	Likely	Moderate
	S2: BIG GH ₂		Severe	More likely	High	Substantial	Likely	Moderate
	S0: BASELINE	Low Sensitivity	Moderate	Unlikely	Low	Slight	Very unlikely	Very Low
	S1: SMALL GH ₂		Substantial	Likely	Moderate	Moderate	Very unlikely	Low
	S2: BIG GH ₂		Substantial	More likely	High	Moderate	Likely	Moderate
	Injury or mortality due to electrocution on powerlines and substation infrastructure	S0: BASELINE	Very High Sensitivity	Severe	More likely	High	Substantial	Likely
S1: SMALL GH ₂		Extreme		Definitive	Very High	Severe	More likely	High
S2: BIG GH ₂		Extreme		Definitive	Very High	Extreme	More likely	Very High
S0: BASELINE		High Sensitivity	Severe	More likely	High	Substantial	Unlikely	Moderate
S1: SMALL GH ₂			Extreme	Definitive	Very High	Severe	Likely	High
S2: BIG GH ₂			Extreme	Definitive	Very High	Extreme	More likely	Very High
S0: BASELINE		Medium Sensitivity	Substantial	Likely	Moderate	Moderate	Unlikely	Low
S1: SMALL GH ₂			Severe	More likely	High	Substantial	Unlikely	Moderate
S2: BIG GH ₂			Severe	More likely	High	Severe	Likely	High
S0: BASELINE		Low Sensitivity	Moderate	Unlikely	Low	Slight	Very unlikely	Very Low
S1: SMALL GH ₂			Substantial	Likely	Moderate	Moderate	Unlikely	Low
S2: BIG GH ₂			Severe	Likely	High	Substantial	Likely	Moderate

1 **7.5 Recommended Management Responses for Risk Categories**

2 The sensitivity mapping and risk categories used only provides a broad, strategic overview of the relative
 3 suitability and potential for development within and across the Namakwa Region. Even in areas of low
 4 sensitivity it is important that some form of project-level environmental impact assessment be undertaken
 5 to confirm and refine the outputs as presented in this SEA.

6 Where relevant, it is critical that implementation of one and/or more of the following recommended best
 7 practice measures be considered for the effective mitigation and management of negative impacts to
 8 avifauna when GH₂-related development activities are proposed:

- 9 • Habitat management and restoration (by restoring indigenous vegetation, re-establishing natural
 10 hydrology, and reconnecting fragmented patches outside the development footprint, while actively
 11 removing or mitigating on-site attractants such as open water or livestock/wildlife carcasses, bird
 12 species are drawn away from areas where potential collision, entanglement or disturbance risks
 13 are greatest).
- 14 • Anti-perching devices on tall infrastructure (bird-friendly pylon designs, insulated electrical
 15 components, meteorological masts and communication towers).
- 16 • Bird flight diverters (powerlines).
- 17 • Livestock/game carcass removal management.
- 18 • Shutdown on Demand (observer-led and automated including cameras and radar).
- 19 • Proactive curtailment (diurnal and nocturnal).
- 20 • Blade patterning.
- 21 • Monitoring, mitigation and proactive conservation beyond the facility footprint.

22

23 **8. RECOMMENDED STRATEGIC MANAGEMENT ACTIONS TO MINIMISE**
 24 **AVIFAUNAL IMPACTS IN REGIONAL PLANNING**

25 A regional approach should embed avifaunal risk management into Environmental Management
 26 Frameworks (EMFs), Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs), and
 27 downstream project-level Environmental Impact Assessments (EIAs) and Environmental Management
 28 Programmes (EMPrs) by setting clear spatial priorities, technology standards, and adaptive management
 29 rules. EMFs and SDFs can define strategic sustainability objectives, indicators, and targets that guide land-
 30 use and infrastructure planning across municipal IDPs and sector plans, improving consistency and
 31 decision quality at the EIA stage.

32 **8.1 Sensitivity Mapping and Spatial Controls**

- 33 • *Tiered sensitivity layers:* Map ecological features such as KBAs [previously Important Bird Areas
 34 (IBAs)], Red List species' status and their ranges, known flyways, nests, roosts/colonies,
 35 wetlands/pans, shorelines and key foraging corridors, and then classify each as no-go, conditional /
 36 compatible or exclusion zones.
- 37 • *Buffers and setbacks:* Establish evidence-based buffers for wetlands, rivers, roosts/colonies, raptor
 38 and ground-dwelling species nests, coastal dunes, and pans (freshwater and saline). These buffers
 39 and setbacks require robust specialist motivation to deviate from.

- 1 • *Linear-infrastructure alignment*: Predefine preferred corridors for electricity grid, pipelines, roads, and
2 rail to avoid high-risk avian areas and maintain landscape connectivity.
- 3 • *Cumulative “caps”*: Set development density/throughput thresholds for wind energy, solar energy,
4 powerlines, GH₂ and port development within avian-sensitive landscapes to prevent cumulatively
5 exceeding acceptable limits.

6 8.2 Mitigation Hierarchy and Policy Standards

- 7 • *Avoidance first*: Prioritise site screening to exclude high-risk features (e.g., vulture flight paths, crane
8 breeding territories, tern islands, cormorant colonies).
- 9 • *Design optimisation*: Require technology-specific design standards (see Section 8.3 below) embedded
10 as SDF/EMF overlays and standard EIA conditions.
- 11 • *Minimisation measures*: Implement recommended mitigation measures as included in the
12 Environmental Management Programme (EMPr) for each proposed development application (see
13 Section 7.5 above).
- 14 • *Offsets as last resort*: If residual impacts remain significant, apply like-for-like offsets with measurable,
15 time-bound outcomes and independent verification (DFFE, 2023).

16 8.3 Technology-Specific Design Requirements

17 8.3.1 Wind Energy:

- 18 • *Siting controls*: Assign no-go buffers to critical habitat, key flight path corridors, nests and
19 roosts/colonies, and apply micro-siting to avoid ridge saddles and thermalling zones.
- 20 • *Operational curtailment*: Mandatory automated/observer-based Shutdown-on-Demand protocols
21 for high-risk wind priority species; implement seasonal curtailment where warranted.
- 22 • *Turbine specs*: Minimise hub-height/ rotor-diameter (shorter blade length) constraints to reduce
23 risk of collision where species profiles support it.

24 8.3.2 Solar PV Energy:

- 25 • *Anti-attraction design*: Panel orientation/anti-reflective treatments; avoid “lake effect” near
26 waterbird habitats.
- 27 • *Habitat retention*: Set aside vegetated corridors; manage fencing to permit small-fauna
28 permeability, where safe.

29 8.3.3 Powerlines and Substations:

- 30 • *Collision mitigation*: High-performance (phosphorescent and staggered) bird flight diverters on
31 high-risk spans; alignments parallel to topography and flyways to reduce crossings.
- 32 • *Electrocution mitigation*: Raptor-safe pole designs, adequate phase-conductor spacing, insulated
33 jumpers, and perch guards where needed.
- 34 • *Substation aversion*: Netting and design to prevent perching/nesting in hazardous zones.

1 **8.3.4 Masts and Towers:**

- 2 • *Design/marketing:* Minimise guyed masts; mark guy wires; use low-intensity, downward-shielded
3 lighting.
- 4 • *Placement:* Avoid migratory corridors, wetlands, and ridgelines frequently used by soaring birds.

5 **8.3.5 Roads, Rail and Pipelines:**

- 6 • *Routing:* Avoid core/ critical habitats; maintain wetland hydrology with adequate culverts;
7 minimise night works near breeding areas.
- 8 • *Operations:* Speed controls, carcass removal to deter scavenger activity, lighting management.

9 **8.3.6 Desalination and Ports (where relevant):**

- 10 • *Intakes/outfalls:* Low velocity screened intakes; offshore diffusers to protect prey bases; time
11 construction to avoid breeding seasons.
- 12 • *Lighting and vessel traffic:* Shielded lighting; navigation protocols to reduce disturbance and strike
13 risk.

14 **8.4 Monitoring, Thresholds and Adaptive Management**

- 15 • *Standardised monitoring:* Pre- and post-construction monitoring surveys, carcass searches with
16 correction factors, carcass persistence/detection and searcher efficiency trials that are integrated
17 into municipal data repositories.
- 18 • *Thresholds of potential concern (TPCs):* Define species- and site-specific trigger levels (e.g.,
19 collision risk rates, displacement indices, breeding success, fatality thresholds) that mandate
20 corrective/ adaptive management actions during construction and operations.
- 21 • *Adaptive responses:* Graduated measures such as enhanced diverters, additional curtailment
22 windows, route adjustments of linear infrastructure, habitat management, and increased
23 monitoring protocols must be activated when TPCs are exceeded.
- 24 • *Population context:* Link monitoring to Potential Biological Removal (PBR) rates and population
25 viability analysis (PVA) for priority species; adjust development pacing if cumulative risk
26 approaches viability thresholds.

27 **8.5 Governance, Permitting, and Data Management**

- 28 • *Standard conditions:* Include avifaunal design standards and fatality monitoring, construction
29 method statements, seasonal constraints, and independent Environmental Control Officer (ECO)
30 oversight in approvals.
- 31 • *Cumulative reviews:* Require project-level EIAs to assess cumulative effects against EMF/SDF caps
32 and regional monitoring data, not only project-alone impacts.
- 33 • *Open data:* Mandate submission of monitoring datasets (incl. GenEst⁵ inputs/outputs) to a
34 provincial repository to inform ongoing planning.

⁵ A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at

- *Capacity and coordination:* Establish a regional avifaunal technical forum (municipality, conservation NGOs, grid operators, developers) to review data and recommend adaptive policy updates.

8.6 Incentives and Financing

- *Performance-based approvals:* Fast-track low-risk sites and designs meeting gold-standard avifaunal criteria.
- *Mitigation funding:* Create a regional levy or biodiversity fund for retrofitting legacy powerlines, securing buffer habitats, and managing predator control where appropriate.

9. CONCLUSIONS AND RECOMMENDATIONS

The Namakwa Region, located mostly within the Succulent Karoo Biodiversity Hotspot, is of exceptional avifaunal importance and contains 15 Key Biodiversity Areas crucial for many threatened, endemic and range restricted avifaunal species. Spatial sensitivity mapping confirms extensive Very High and High avian sensitivity zones across the study area, particularly for wind farm related impacts.

The risk assessment shows that without mitigation, both Small GH₂ and Big GH₂ development scenarios present High to Very High risks to priority avifaunal species, especially in very high sensitivity areas. The Big GH₂ scenario carries the greatest cumulative risk, with potential severe to extreme consequences for Endangered and Critically Endangered species. Even with best practice mitigation, residual impacts remain substantial in habitats, especially high and very high sensitivity for the priority avifaunal species assessed.

Key impact pathways relating to priority avifauna include:

- Displacement from disturbance and habitat loss/fragmentation.
- Collisions with wind turbines, powerlines, and other tall structures.
- Electrocutions on transmission and distribution infrastructure.

The Namakwa Region's exceptional avifaunal diversity faces substantial risk from large scale GH₂ and associated infrastructure development given the scale of the proposed infrastructure required. Strategic avoidance of high and very high sensitivity areas, rigorous application of the mitigation hierarchy, and the implementation of robust monitoring frameworks are essential to balance renewable energy ambitions, associated with the GH₂ development proposal for the Boegoebaai Port and SEZ, with biodiversity conservation in the broader Namakwa Region. The SEA and this avifaunal risk assessment therefore provide a defensible, spatially explicit framework to guide sustainable regional planning for development and safeguard irreplaceable bird populations.

Key recommended strategic management actions resulting from this avifaunal risk assessment include:

1. Spatial Planning & Sensitivity Controls

Embed avifaunal sensitivity mapping into planning tools (such as EMFs, SDFs, IDPs), designate no-go zones for critical habitats, apply science-based buffers, align infrastructure to avoid very high and high-risk areas, and cap cumulative development in sensitive landscapes.

facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (<https://www.usgs.gov/software/genest-a-generalized-estimator-mortality>).

- 1 2. *Technology-Specific Standards*
- 2 Adopt bird-safe design and operational mitigation measures for wind, solar, powerlines, masts, and
3 port/desalination facilities to minimise collisions, electrocution, and disturbance risks through siting,
4 engineering, and seasonal restrictions.
- 5 3. *Monitoring & Adaptive Management*
- 6 Use standardised pre- and post-construction monitoring protocols with GenEst⁶, set Thresholds of
7 Potential Concern (TPCs), link results to Potential Biological Removal (PBR) rates and Population Viability
8 Analysis (PVA), and trigger adaptive measures when thresholds are exceeded.
- 9 4. *Governance & Data Management*
- 10 Mandate avifaunal standards and independent oversight in approvals, require cumulative impact reviews,
11 ensure open data sharing, and establish a regional technical forum for coordinated decision-making.
- 12 5. *Incentives & Financing*
- 13 Fast-track low-risk, high-standard projects and fund biodiversity actions, such as retrofitting hazardous
14 infrastructure and securing key habitats, through a dedicated conservation fund.
- 15

⁶ A Generalized Estimator of Mortality is a free, open-source statistical model and software tool, most notably named GenEst, that is used to accurately estimate the total number of wildlife (bird) fatalities in a specific area, particularly at facilities like wind or solar farms, especially when not all mortalities are directly observed and where discovery probability is less than one (<https://www.usgs.gov/software/genest-a-generalized-estimator-mortality>).

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1 **11. ANNEXURE A**

2 **ANNEXURE A:** Table detailing the species-impact scoring framework that defines the sensitivity categories underpinning the multiplicative weighting system used to
 3 enable the spatial risk mapping for this avifaunal specialist assessment—see Section 6.4 to Section 6.6 for a detailed description.

Priority Species Name	Red Data List 2025	Endemism 2025	Habitat_area_hectares	Species_range	Red_Data_multiplier	Range_multiplier	Endemism_multiplier	Conservation_multiplier	Displacement - Disturbance	Displacement_disturbance_weighted_score	Displacement due to Habitat Loss/Transformation	Displacement_habitat_weighted_score	Collisions turbines and infrastructure	Collisions_weighted_score	Electrocutions	Electrocutions_weighted_score
Jackal Buzzard		NE	4549885	Large	1	1	3	3	1	3	2	6	4	12	3	9
Ludwig's Bustard	EN		4431321	Large	8	1	1	8	2	16	3	24	4	32	1	8
Karoo Eremomela		NE	3480362	Medium	1	5	3	15	1	15	2	30	1	15	1	15
Black-headed Canary		NE	3477791	Medium	1	5	3	15	1	15	2	30	2	30	1	15
Black Harrier	EN	NE	2541556	Medium	8	5	3	120	2	240	3	360	4	480	1	120
Karoo Korhaan	NT		2223362	Large	2	1	1	2	1	2	2	4	4	8	1	2
Black-eared Sparrow-Lark		NE	1969719	Medium	1	5	3	15	1	15	3	45	1	15	1	15
Burchell's Courser	VU		1899542	Medium	4	5	1	20	1	20	3	60	2	40	1	20
Secretarybird	EN		1730344	Medium	8	5	1	40	2	80	3	120	3	120	2	80
Cape Clapper Lark		NE	1257024	Medium	1	5	3	15	1	15	3	45	1	15	1	15
Red Lark	VU	E	1255419	Small	4	10	5	200	2	400	4	800	3	600	1	200
Lanner Falcon	NT		1202044	Large	2	1	1	2	1	2	2	4	4	8	2	4
Cape Eagle-Owl			1063543	Medium	1	5	1	5	2	10	3	15	3	15	2	10
Sclater's Lark	NT	NE	994121	Medium	2	5	3	30	2	60	3	90	1	30	1	30
Southern Black Korhaan	VU	E	876964	Medium	4	5	5	100	1	100	2	200	4	400	1	100

Priority Species Name	Red Data List 2025	Endemism 2025	Habitat_area_hectares	Species_range	Red_Data_multiplier	Range_multiplier	Endemism_multiplier	Conservation_multiplier	Displacement - Disturbance	Displacement_disturbance_weighted_score	Displacement due to Habitat Loss/Transformation	Displacement_habitat_weighted_score	Collisions turbines and infrastructure	Collisions_weighted_score	Electrocutions	Electrocutions_weighted_score
Verreaux's Eagle	VU		681532	Large	4	1	1	4	1	4	2	8	4	16	4	16
Cinnamon-breasted Warbler		NE	648753	Medium	1	5	3	15	2	30	3	45	1	15	1	15
Cape Spurfowl		NE	647396	Medium	1	5	3	15	1	15	2	30	2	30	1	15
Ground Woodpecker	NT	SLS	614111	Medium	2	5	5	50	2	100	3	150	1	50	1	50
Martial Eagle	EN		522475	Large	8	1	1	8	1	8	2	16	4	32	4	32
Cape Long-billed Lark		E	500163	Medium	1	5	5	25	1	25	3	75	1	25	1	25
African Fish Eagle			339981	Large	1	1	1	1	1	1	2	2	3	3	2	2
Black Harrier	EN	NE	267195	Medium	8	5	3	120	2	240	3	360	4	480	1	120
Cape Rock Thrush		SLS	202608	Large	1	1	5	5	1	5	3	15	1	5	1	5
Grey-winged Francolin		SLS	183958	Medium	1	5	5	25	1	25	3	75	2	50	1	25
Maccoa Duck	EN		148242	Medium	8	5	1	40	1	40	2	80	2	80	1	40
African Rock Pipit	NT	SLS	143003	Medium	2	5	5	50	1	50	2	100	2	100	1	50
Blue Crane	VU		131653	Medium	4	5	1	20	2	40	3	60	4	80	1	20
Greater Flamingo	NT		129414	Large	2	1	1	2	2	4	3	6	4	8	1	2
Curlew Sandpiper	VU		105250	Medium	4	5	1	20	1	20	2	40	1	20	1	20
Caspian Tern	VU		73302	Large	4	1	1	4	1	4	2	8	2	8	1	4
Peregrine Falcon			66138	Large	1	1	1	1	1	1	2	2	4	4	2	2
Black Stork	EN		60809	Medium	8	5	1	40	2	80	2	80	4	160	2	80
Sentinel Rock Thrush	NT	SLS	39864	Medium	2	5	5	50	1	50	3	150	1	50	1	50

Priority Species Name	Red Data List 2025	Endemism 2025	Habitat_area_hectares	Species_range	Red_Data_multiplier	Range_multiplier	Endemism_multiplier	Conservation_multiplier	Displacement - Disturbance	Displacement_disturbance_weighted_score	Displacement due to Habitat Loss/Transformation	Displacement_habitat_weighted_score	Collisions turbines and infrastructure	Collisions_weighted_score	Electrocutions	Electrocutions_weighted_score
Damara Tern	EN		32984	Small	8	10	1	80	1	80	2	160	2	160	1	80
African Marsh Harrier	VU		30611	Medium	4	5	1	20	2	40	3	60	3	60	1	20
Great White Pelican	VU		30565	Medium	4	5	1	20	1	20	2	40	3	60	3	60
Black Stork	EN		26412	Medium	8	5	1	40	2	80	2	80	4	160	2	80
Bateleur	EN		23835	Small	8	10	1	80	2	160	2	160	3	240	3	240
Barlow's Lark			20149	Small	1	10	1	10	1	10	3	30	1	10	1	10
Chestnut-banded Plover	VU		15181	Medium	4	5	1	20	1	20	3	60	1	20	1	20
Cape Vulture	VU		10238	Large	4	1	1	4	1	4	2	8	4	16	4	16
Cape Sugarbird		E	8336	Medium	1	5	5	25	1	25	3	75	1	25	1	25
Orange-breasted Sunbird		E	5151	Medium	1	5	5	25	1	25	3	75	1	25	1	25

1