CHAPTER 3

Biodiversity Offset Framework

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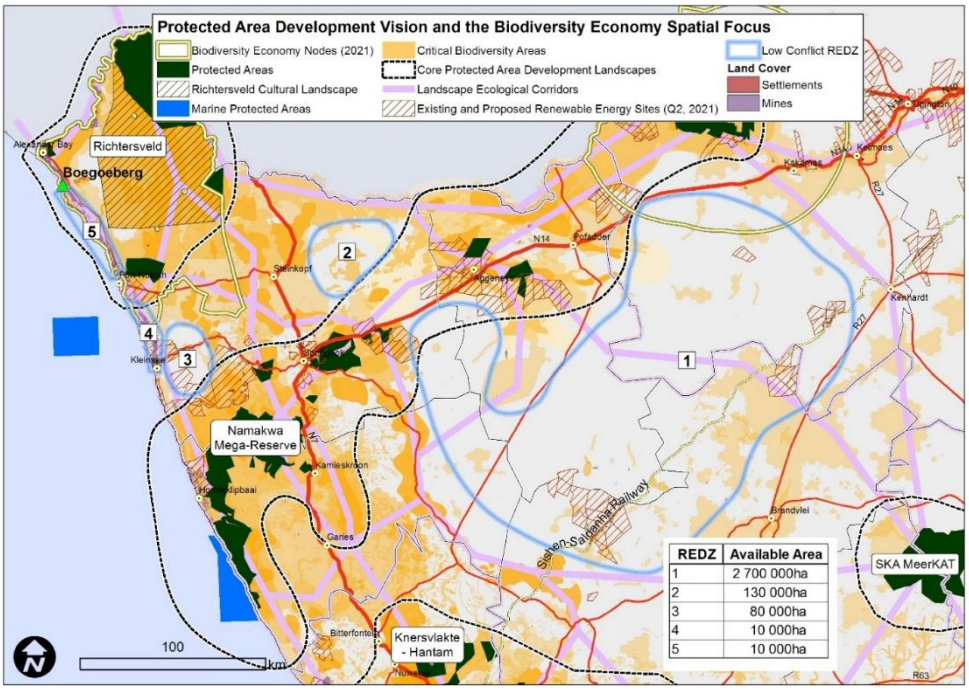

Figure S.1. A previous regional conservation development framework (SANParks 2019) overlain with the initial three large "low conflict" zones able to accommodate especially PV production (1-3) and two modest zones for Wind energy (4,5) on coastal mining scars for initial GH2 planning (NCEDA 2021). This study refines these areas to guide green hydrogen development away from areas demanding substantial offsets.

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Points of Departure & Assumptions

This report assumes that regulators and project proponents are familiar with the intention behind and, the optimal deployment of, biodiversity offsets[1]. It is also assumed that, beyond the formal regulatory Guideline (DFFE 2023), the general warnings around the constraints and pitfalls (e.g. Crous & Pryke 2024) and minimum criteria for biodiversity offsets (*e.g.* Pope *et a*l 2021) would be heeded as these are now internationally well established. Importantly, the challenge of using offsets to achieve certain desired outcomes (especially Net Gain Outcomes – zu Ermgassen *et al (*2023)) implies that for compliance with global financing standards, all efforts to avoid the impacts on 'Critical Habitat' must be taken. Offsets cannot be used to circumvent diligent and comprehensive adherence to the mitigation hierarchy.

The thematic scope of this Regional Biodiversity Offset Framework is restricted to terrestrial ecosystems (vegetation types), in terms of biodiversity features considered. It is limited by the challenges of framing (and assessing) biodiversity offset implications based on a suite of large-scale, semi-defined green hydrogen (GH_2) development scenarios. It is assumed that the footprint projections are reasonably accurate, although large scale infrastructure projects often underestimate the ultimate resulting impacts.

These developments would be in an area of high biodiversity sensitivity and competing landuses – some authorised, others not. Although an offset framework for the port precinct impacts (as a subcomponent of the regional-scale study) is potentially tractable (provided the guidance on location from the Port-specific SEA is heeded (i.e., Work Package 1 SEA)), the economic viability of the GH_2 development will demand large adjacent (including marine) and regional impacts, especially from renewable energy. These regional impacts are difficult to predict with the spatial resolution required for regulatorily- or lender-required offsetting. The sheer scale (~144 000 ha) alone of a medium to big GH_2 scenario is likely to be significant and trigger thresholds of environmental concern.

In the District there is ostensibly sufficient previously mined or otherwise damaged land, or land of relatively low biodiversity, cultural and ecosystem service value, on which to locate renewable wind energy infrastructure. A key point of departure is that the political will exists to resolve the long-standing issues of access, liability, illegal mining, and equity concerns around the coastal regions to accommodate a new infrastructure rollout and offset implementation process.

Inland, extensive areas of relatively low species richness could accommodate photovoltaic facilities (PV) with minimal biodiversity impact and hence low requirement for extensive offsets. In practice, however, the nature of the developments and linear infrastructure and the ancillary industries' impacts are almost certain to be of a scale and nature as to result in significant widespread biodiversity loss that is difficult - with current knowledge - to define and counterbalance.

Several assumptions had to be erected to assess the likely scope and location of much of the renewable energy fleet. These are endlessly debatable and only presented here to calibrate the implied challenge and cost of offsetting, and hence the political and technical attention that must be given to this upfront, in particular to address mitigation proactively and sufficiently.

An offset framework must be built on realistic opportunities and constraints. Institutional, budgetary and capacity limitations are likely to restrict offset development to within pragmatic distances of existing protected areas and operational management centres. All candidate receiving areas are thus a trade-off between biodiversity representation imperatives and the likelihood of effective establishment. The areas proposed have been guided by current reserve management inputs, but I acknowledge that greater ambition of offset-driven conservation action is also possible. An assumption is that sufficient resources

[1] Offsets aim to stop or reverse the decline in biodiversity and ecosystem function. Their deployment is best located where this outcome achieves on-balance optimal outcomes and likely long-term persistence.

and incentives exist for proponents to co-opt private and communal landowners to be active stewards of some offset receiving areas, and that conservation agencies have the staff and approach to service these areas in the long term.

An acknowledged gap in this framework is any treatment of the social implications of offset establishment at the scale required. Setting aside massive areas of land currently used for grazing, farming or other resource use in a manner that limits this use requires deep engagement, negotiation and compensation for those whose rights are curtailed. This is not covered here, as no engagement with indigenous people, local communities or landowners has occurred, and they need to establish the parameters of any compensation payable.

The eligibility criteria for green hydrogen are evolving. This study takes the view that hydrogen production with unacceptable impacts on threatened ecosystems or species (or land-owning communities) or which is insufficiently mitigated and offset, is unlikely to be tolerated by investors or the market. Hence, socially equitable, progressive and proactive offset approaches are required, coupled with a fastidious and transparent adherence to the mitigation hierarchy.

Executive Summary

The terrestrial biodiversity impacts associated with a big or even modest GH_2 scenario[2] will be significant but are difficult to circumscribe accurately given current uncertainties. All Scenarios would include some of the significant, negative biodiversity impacts and offset liabilities set out in previous work on the Boegoebergbaai Port and adjacent Special Economic Zone (i.e., Work Package 1 SEA). This study investigates prospective regional-scale direct impacts from related renewable energy (RE) development on sensitive biodiversity features. It identifies potential areas of low ecological importance that could accommodate developments with little offset implications, and proposes candidate offset sites ("offset receiving areas") catering for most priority biodiversity features that are likely to be impacted. At this scale of resolution (the area of interest is >5 million ha), definitive guidance is elusive, but mechanisms for streamlining site/project-level EIA offset studies are proposed and a biodiversity offset framework presented.

The big GH_2 scenario would result in a localised footprint of electrolysers, storage, transport and regional footprint of energy generation of >144 000 ha, while a small GH_2 scenario would still impact >21 000 ha. Associated linear infrastructure of multiple High Voltage transmission lines, a >500 km railway, and gas pipelines to Saldanha and Prieska would have extensive impacts in many different vegetation types and on specific vulnerable species.

While the optimal areas for locating GH_2 infrastructure to avoid impacts and, thus, offset implications, are constrained by logistics and product transport/handling considerations within the SEZ (Botha 2026), the regional location of renewable energy facilities is constrained by grid access and resource availability. Additionally, while there are large inland areas of the region potentially available for Photovoltaic (PV) development, Wind Energy Facilities (WEF) are constrained to the higher resource locales along the coast and escarpment. Even a modest or small GH_2 scenario demands extensive additional grid expansion.

The regional terrestrial sensitivity assessment for the SEA (Desmet 2026) sets out the global significance and uniqueness of this species rich area, and presents Critical Biodiversity Areas (CBAs), Key Biodiversity Areas (KBAs), Protected Area (PA) Expansion Priority Focus Areas, and expert mapped concentrations of species of conservation concern. Given the density of important biodiversity features and statutory planning designations in these areas (71% of the 5 million ha planning domain is sensitive), complete offset avoidance is unlikely, even with rigorous planning. The sheer scale of most impacts implies that few are likely to be rated of low negative significance, regardless of the status of underlying biodiversity features. Large impacts on some under-protected vegetation types where national targets are still attainable will likely be assessed as being of moderate or high negative significance – and can be offset in line with national guidance and using precautionary ratios.

In other cases, it is more likely that national targets for biodiversity features may be compromised (e.g., loss of ecosystem extent below thresholds required for continued functioning or persistence, contrary to constitutional and other legal imperatives), which demands 'Ecological Compensation[3]', IF the impact is allowed to proceed at all (DFFE 2023). Proposals for suitable ecological compensation for non-offsetable impacts are given in Section 3.4, but this does not suggest that the impacts should be authorised or would be acceptable to investors or be eligible under green hydrogen market rules.

[2] Scenarios include Sc0 = dynamic baseline business as usual, No GH2; Sc1 = "small H2"(0,05mtpa); and Sc2 = "big H2" (4 mtpa). See spatial data in Annexure B.

[3] In the South African context, ecological compensation is only allowed under very specific circumstances, including the overwhelming public interest, and requires extraordinary justification. The modality of compensation is often aligned with that off offsets, but involve dissimilar biodiversity features

A critical aspect of decision making (and offsetting) in an area of such rich species diversity is to ensure upfront planning of infrastructure on a regional scale. The density and distribution of plant and species of conservation concern across much of the region may otherwise present fatal flaws to individual project EIAs unless extensive effort at avoidance in upfront planning of regional infrastructure is pursued.

Linear disturbance and permanent infrastructure may also compromise landscape-scale ecological corridors and impede some ecosystem processes. Offset plans should therefore include ecological corridors and processes at a sufficient scale to allow for effective ecological functioning. Another essential regional scale consideration is large bird movement – some of the biggest and most challenging regional terrestrial impacts to mitigate may be on large birds (especially Bustards and some raptors). Many impacts on habitat-generalist bird species would likely be adequately catered for by vegetation type/ecosystem offsets (Kellerman et al 2026).

Adherence to the mitigation hierarchy would require that all options are pursued to use damaged land for infrastructure development (especially WEF) where available. Over 26700 ha of damaged and mined land exists along the coast from Kleinsee to Alexander Bay (Botha & Desmet 2022). If used efficiently, this is potentially sufficient to meet half the WEF footprint requirement for even a Big GH_2 scenario (given that wake effects and layout constraints must affect optimal usage of these mine scars). Increased powerlines along the coast (while more vulnerable to corrosion) would likely pose a smaller risk to avifauna than inland ones. Resolving rehabilitation liabilities on these mine scars and sterilising mineral and petroleum rights to accommodate the new energy economy will take nimble regulators and effective administration.

Due to fog prevalence, space and grid access constraints, PV facilities will need to be constructed inland where there are far fewer already impacted areas. The dry environment and lack of fire indicate that much construction could be done on poles above intact natural vegetation without needing to clear large areas. This approach would substantially reduce costs and offset liabilities – and should be required for any PV site supplying a green hydrogen plant. Notwithstanding minimisation measures, at this scale or PV construction, offsets will still likely be needed. Several precincts (ranging from 40 000 ha to >1 000 000 ha) able to receive this development are identified with likely low sensitivity and low offset implications. Focusing substation development and grid alignment with these areas would significantly reduce the most significant footprint biodiversity impacts.

Assumptions[4] were made as to the percentage fixed and flexible infrastructure likely to trigger offsets. Using these assumptions and the proposed basic offset ratios (average of 2:1 for the areas impacted by PV and WEF (128 000 ha) and 10:1 for the impacts of fixed infrastructure (16 000 ha), unavoidably impacting on priority features), as interpreted from South Africa's National Biodiversity Offset Guideline, a combined Big GH_2 offset requirement of over **183 000 ha** of land would need to be secured. This is equivalent to creating new offset protected areas the size of Richtersveld and Namaqua National Parks combined. Even a Small GH_2 scenario could still require an offset of up to 40 000ha. Suitable areas exist for offsetting such impacts on most inland vegetation types, especially if done proactively and in collaboration with landowners and conservation agencies.

[4] Also refer to further assumptions in the preface and the Annexure B on footprint projections.

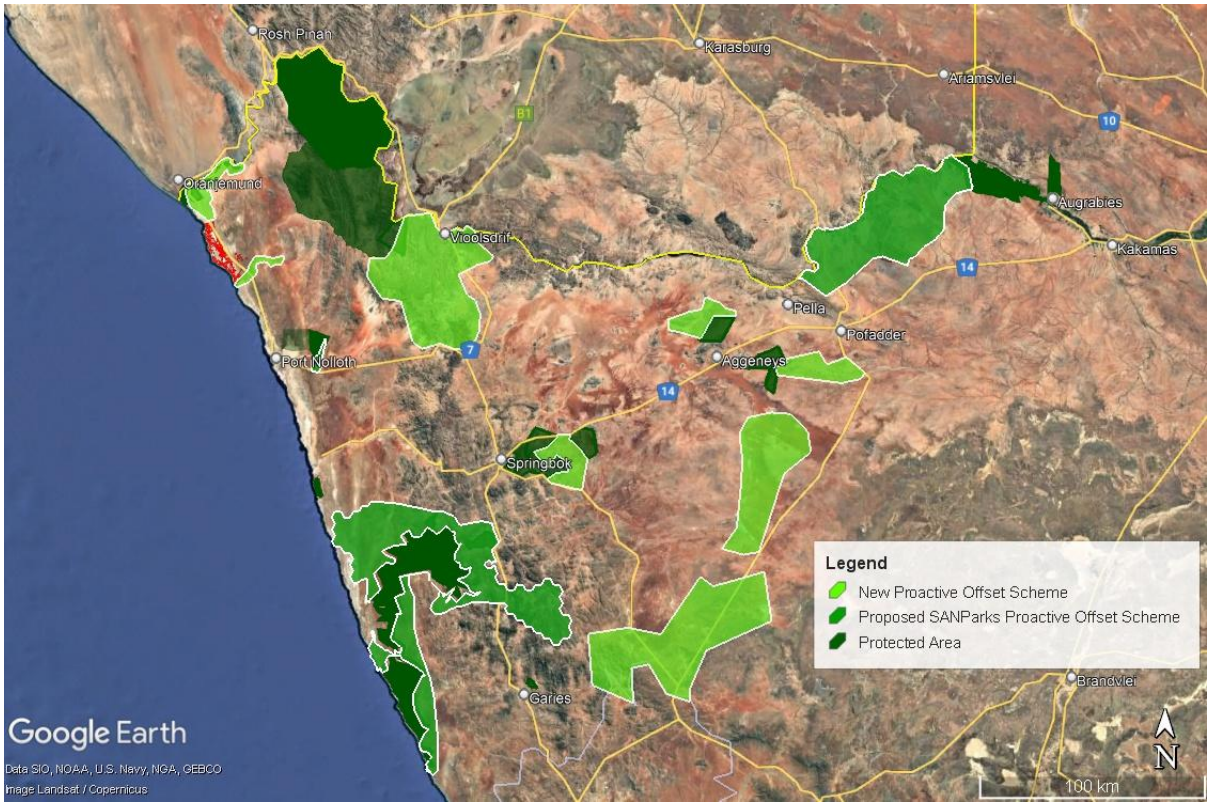

Figure S.2. Proposed Offset Receiving Areas for the broader WP2 study area. These are a combination of statutory Park Expansion Zones, NPAES priority focus areas for expansion, specialist mapped areas for threatened taxa and ecosystems, and project specific proposals from WP1. Note the receiving areas expand existing PAs where possible but don't necessarily create the landscape-scale ecological corridors required for long-term biodiversity persistence.

Biodiversity Offset Guidelines suggest that any regional CBAs or PA expansion priority focus areas may be suitable candidate offset sites provided exchange rules are adhered to (similar vegetation type or habitat). However, there is value in aggregating offsets for institutional and cost efficiency, as well as for reducing land use conflicts or competition where possible. Several areas are proposed for proactive offset schemes – a modality of upfront "banking" of offset areas and outcomes for subsequent use by development proponents in that region (UNDP 2025). These proactive scheme areas range from 3500 ha (Vyftienmylseberg) to 200 000ha (Namaqua and Augrabies National Park Expansion Zones). These would be best managed as declared Protected Areas to prevent loss to mineral exploitation and with improved access control to counter succulent poaching and other threats to species of conservation concern. Communal land and grazing systems could possibly be incorporated into some proactive offset schemes IF compatibility with biodiversity maintenance could be demonstrated and compensation arrangements agreed to. However, Desmet (2026), through analysis of grazing impacts on the regional flora over several decades, notes that this is unlikely to be the case.

Where offsets are technically not possible, Ecological Compensation would be required to mitigate impacts, including for some CBAs, range restricted ecosystems, species of conservation concern (SCC) and highly mobile species (especially avifauna) that are very difficult to effectively offset (see Section 3.4 below). Examples given include retrofitting existing infrastructure with impact mitigation devices (Kellerman *et al* 2026) or permanently reducing grazing pressure in sensitive areas by protecting larger areas. Calibrating the required ecological compensation accurately (and acceptably to regulators and I&APs) is fraught with challenges. Implementing the compensation without displacing existing state expenditures on biodiversity management in the region is unlikely – and would violate the key 'additionality' principle of offsets and ecological compensation.

Given the lack of resolution and clarity on the location and implications, the cumulative, indirect or induced impacts are unclear and hard to estimate for offsetting quantification. To what extent any indirect or induced impact could be linked to any particular project is also often very hard to determine. This complicates assigning offset liability and is a key reason why SEZ proponents should proactively mitigate impacts on behalf of tenants, and avoid contentious or mis-aligned project-level offset investigations or proposals. SEZ support for an investment in proactive offset schemes would be imperative to streamline implementation, avoid land use conflicts and manage the threat from illicit and poorly regulated mining on offset sites, ecological corridors and other unique features.

Successful accommodation of many of the planned developments and the persistence of nature in the region will rely on more detailed planning and negotiated trade-offs between key economic sectors. This is only likely to deliver ecological sustainability if biodiversity is catered for upfront, and not reactively after developments have been approved.

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3.1 DEVELOPMENT IMPACTS, BIODIVERSITY FEATURES TO BE OFFSET & RATIOS

3.1.1 Understanding the potential GH2 development scenarios

The small GH_2 scenario would impact >21 000 ha with a localised footprint of electrolysers, and storage, while a big GH_2 scenario would also result in a transport and regional footprint of energy generation of >144 000 ha, (Annexure B). The terrestrial biodiversity impacts associated with a big or even modest GH_2 scenario will be significant but are difficult to circumscribe accurately given current uncertainties. Associated linear infrastructure of multiple High Voltage transmission lines, a >500km railway, inevitable access roads, and gas pipelines to Saldanha and Prieska would have extensive impacts in many different vegetation types, ecological corridors, and on specific vulnerable species.

While the optimal areas for locating GH_2 infrastructure to avoid impacts and, thus, offset implications, are constrained by logistics and product transport/handling considerations within the SEZ (Botha 2026), regional location of renewable energy facilities is constrained by grid access and resource availability. Wind Energy Facilities (WEF) are constrained to the higher resource locales along the coast and escarpment.

Due to fog prevalence, space and grid access constraints, PV facilities will need to be constructed inland where there are far fewer transformed areas. The dry environment and lack of fire indicate that much construction could be done on poles above intact natural vegetation without needing to clear large areas. This approach would substantially reduce costs and offset liabilities – and should be required for any PV site supplying a "green hydrogen" plant. If this kind of construction, coupled with tight geographic limitations (i.e. not the current Springbok REDZ but rather the less sensitive zones outlined in the SEA[5]) and SEZ-stipulated offset parameters, could be included in a standardised Environmental Management Program, it would reduce the time, cost and possibly contestation around PV Environmental Authorisations and mitigation requirements.

Notwithstanding standard EMPrs or required minimisation measures, at the envisaged scale of infrastructure and PV construction, offsets will almost certainly be needed.

Sufficient renewable energy generation has already been approved in the District (13 GW) and Province (78 GW) to cover the needs of small and big GH_2 scenarios, respectively (DFFE REEA data analysed by CSIR February 2025). However, many of these projects were approved > 10 years ago and/or prior to the Biodiversity Offset guideline being in place (and might not be thus effectively mitigated) or would need to be re-authorised prior to construction (due to lapsed authorisations).

Even a modest or small GH_2 scenario demands extensive additional grid expansion. To power the GH2 fleet of any scenario using the widely dispersed RE projects elsewhere in the province would entail significantly more high Voltage power lines spanning the landscape to Boegoebergbaai than are currently set-out in the footprint projection assumptions (see Annex 2) or the national Transmission Development Plan (NTCSA 2024). Additional regional powerlines (>1300 km) would increase impacts on avifauna which are difficult to mitigate. National transmission development plans only refer to a 400 KV line to the Gromis Main Transmission Substation near Kleinsee – which is insufficient to cater for even the small GH_2 scenario.

While there is insufficient available, low-biodiversity conflict area within 100 km of Boegoebergbaai port for RE for Sc2, large areas of relatively low biodiversity sensitivity have been identified (by this and other studies) for regional power production which may not require substantial biodiversity offsets. Several precincts (ranging from 40 000 ha to >1 000 000 ha) able to receive this development are proposed for regulatory consideration and/or potential further refinement and adoption (see Botha & Desmet 2022 for initial work, and Figure 3.5). Focusing substation development and grid alignment in these areas would significantly reduce most biodiversity impacts. In practice, however, the nature of the developments and

[5] This study does not ignore the REDZ, but rather aims to refine the less sensitive areas within and around it.

linear infrastructure and the ancillary industries' impacts are almost certain to be of a scale and nature as to still result in significant widespread biodiversity loss.

3.1.2 Impacted areas suitable for development

An offset framework should ideally identify precincts suitable for development where biodiversity is already effectively lost and has little chance of recovery. Apart from the coastal zone, no definitive map of damaged areas with no remaining natural habitat is available to inform a regional opportunities analysis. Botha (2026) and Botha & Desmet (2022) noted that large areas are available along the coast to host WEF with little or no impact, and these should be pursued before any green fields WEF are developed. This would create a double dividend in reducing rehabilitation liabilities (including those of the state) and would assist in arresting the sand movement smothering large sections of the coastal plain.

3.1.3 Biodiversity Features: CBAs & ESAs and PA expansion Priority focus areas

Desmet (2026) sets out the various biodiversity features informing decision-making in the region see (Figure 3.1 and Figure 3.2).

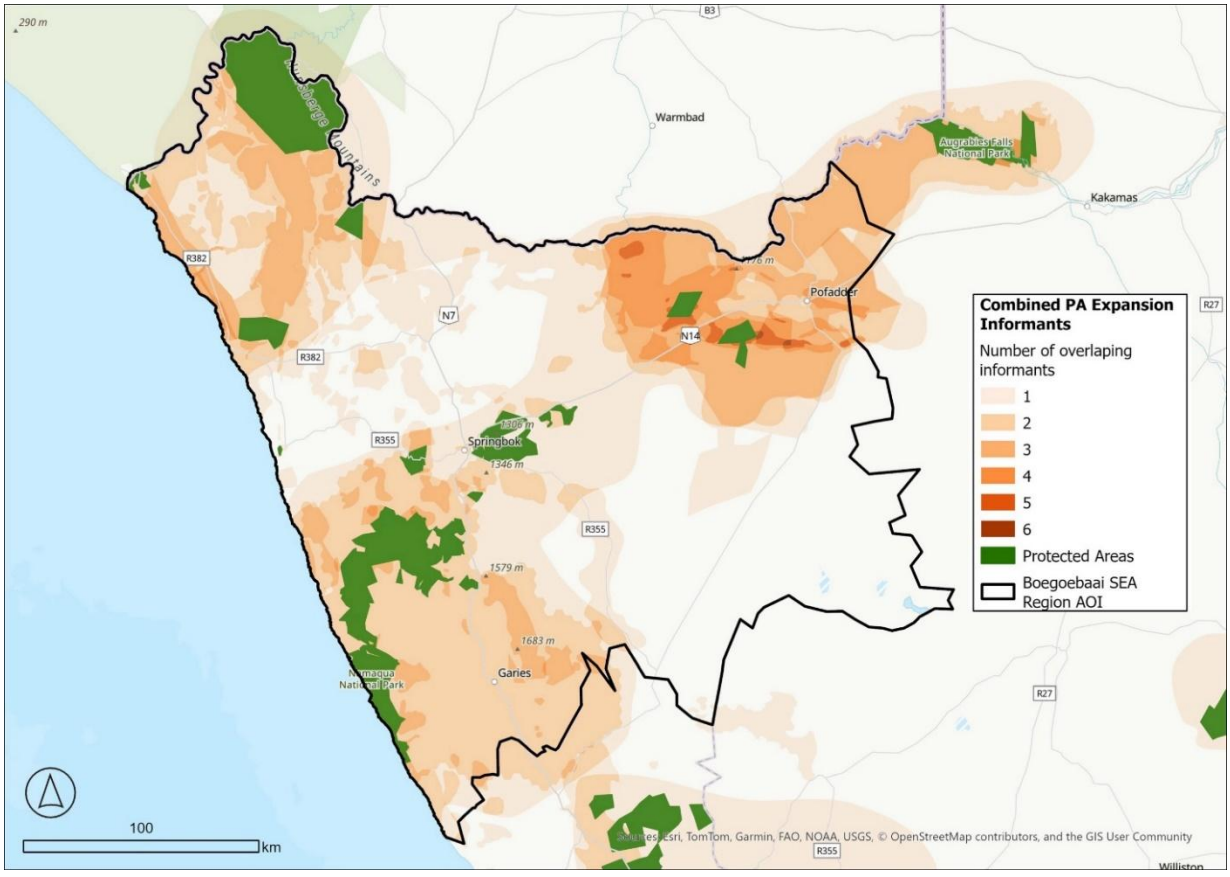

Figure 3.1: Major biodiversity informants, including CBAs, National Park Expansion Zones, prior PA expansion priority focus areas, listed ecosystems, expert mapped important biodiversity areas, and statutory protected areas. Some features not shown at this scale. (Desmet 2026).

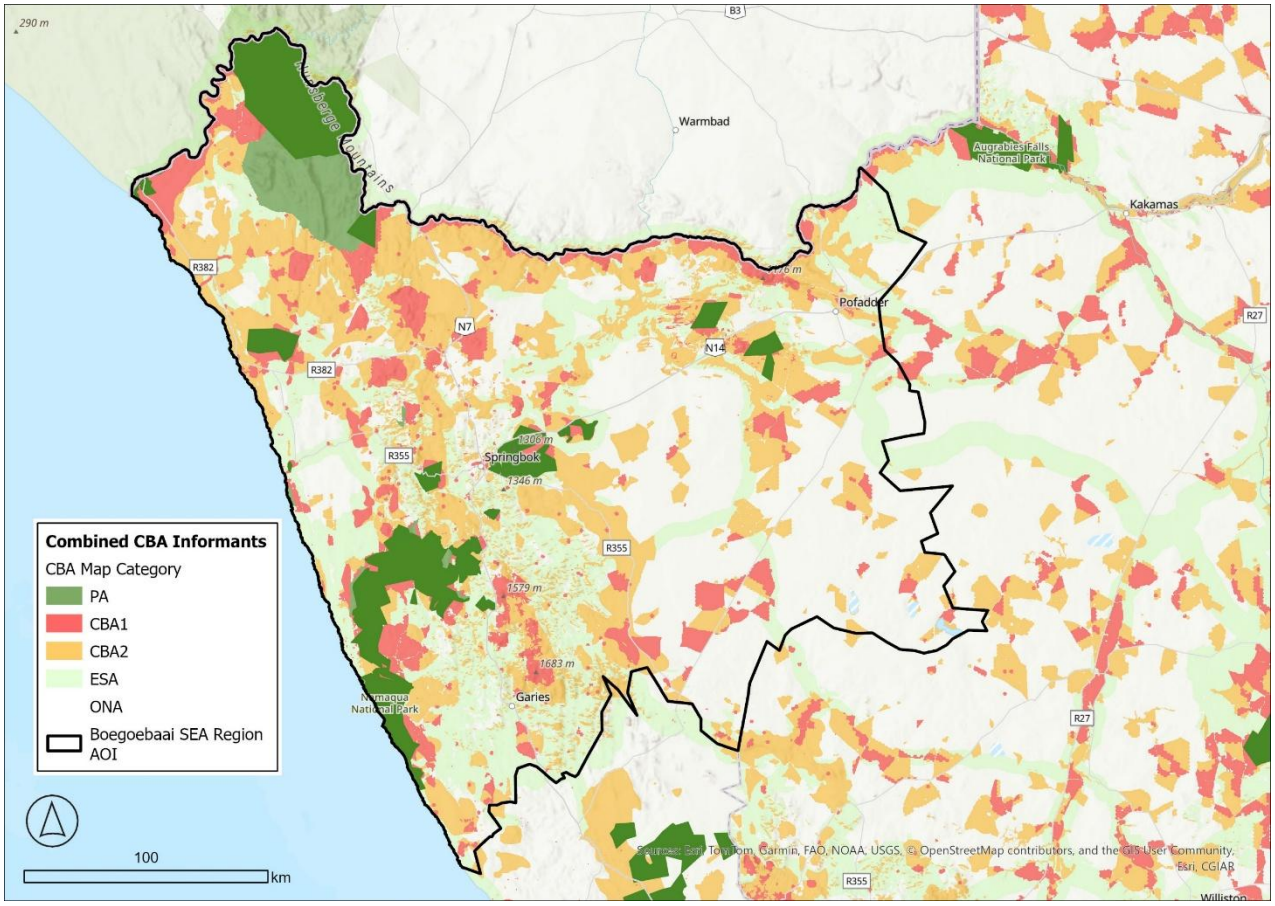

Figure 3.2: A Regional Sensitivity Map augmenting the current Biodiversity Spatial Plan (DAERL 2024 draft V2) with expert identified areas and PA expansion priorities (Desmet 2026). A departure point is that impacts are best located in the least sensitive areas and offset candidate sites are secured in the most sensitive areas, especially adjacent to existing PAs. Note: this approach is agnostic of land ownership and the assumes mutually beneficial agreements can be negotiated by SEZ proponents.

3.1.4 Biodiversity Features: Vegetation types

Although many of the impacted vegetation types are designated Least Concern (LC) in terms of their national Ecosystem Threat Status (SANBI 2025a), they are also amongst the least protected in the country. Recognising the likelihood of these ecosystems supporting Species of Conservation Concern (SCC[6]), a precautionary approach would suggest that even if a site is classified as Other Natural Area (ONA) it should still attract a basic offset ratio, unless: i) no SCC can be demonstrated to occur; ii) and the site does not play an important ecological function role; and iii) the site would not be considered 'Natural Habitat' in terms of Performance Standard 6 of the IFC. Below is a table of all the potentially impacted vegetation types (South Africa's proxy for ecosystems), with statistics relevant to determining a suitable or required offset ratio, and the final ratio proposed for use in this framework (Table 3-1). The Red Listing of Ecosystems (RLE) process used for ecosystem endangerment ratings under NEMBA has several criteria. One of these criteria (D1) is the measure of recent disruption of biotic processes in that ecosystem. These are important contributors to accurately assessing Ecosystem Threat Status (see Desmet 2026).

[6] Species of Conservation Concern include legislated threatened species, as well as other red listed species with narrow distribution ranges or otherwise conservation worthy (in a specialist assessor's opinion). This has implications for IFC Performance Standard 6, which demands Net Positive outcomes from offset for Critical Habitat of Threatened Species and Ecosystems. This is a higher bar than No Net Loss for other Natural Habitat.

Table 3-1: Vegetation Types (ecosystems) found in the WP2 planning domain, their extent degraded (Desmet 2026), Ecosystem Threat Status and Protection Levels (SANBI 2025a). Inferred Offset ratios align with the National Guideline (DFFE 2023). Note that CBA and other biodiversity feature status would override these baseline vegetation type-derived ratios (see Table 3-2).

Vegetation Type	Percent Degraded	RLE (D1)	ETS (NBA 2025)	EPL (NBA 2025)	Starting Offset Ratio	Final Offset Ratio
Alexander Bay Coastal Duneveld	86,96	CR	CR	NP	30	30
Namaqualand Seashore Vegetation	57,41	EN	CR	PP	30	30
Namib Seashore Vegetation	77,78	EN	CR	NP	30	30
Richtersveld Coastal Duneveld	77,23	EN	CR	NP	30	30
Southern Richtersveld Scorpionstailveld	62,43	EN	CR	NP	30	30
Namib Lichen Fields	14,17	LC	CR	WP	30	30
Upper Annisvlakte Succulent Shrubland	6,53	LC	CR	MP	30	30
Western Gariep Lowland Desert	34,55	VU	CR	NP	30	30
Northern Richtersveld Scorpionstailveld	58,5	EN	EN	WP	10	10
Bushmanland Inselberg Shrubland	82,43	CR	LC	PP	30	30
Lekkersing Succulent Shrubland	80,17	CR	LC	MP	30	30
Richtersveld Sandy Coastal Scorpionstailveld	81,64	CR	LC	NP	30	30
Vyftienmyl se Berge Succulent Shrubland	86,03	CR	LC	WP	30	30
Aggeneys Gravel Vygieveld	55,06	EN	LC	WP	10	10
Bushmanland Vloere	50,07	EN	LC	PP	10	10
Central Richtersveld Mountain Shrubland	56,09	EN	LC	WP	10	10
Kosiesberg Succulent Shrubland	65,18	EN	LC	NP	10	10
Namaqualand Shale Shrubland	65,54	EN	LC	NP	10	10
Noms Mountain Desert	52,05	EN	LC	WP	10	10
Northern Richtersveld Yellow Duneveld	53,32	EN	LC	NP	10	10
Oograbies Plains Sandy Grassland	51,19	EN	LC	NP	10	10
Platbakkies Succulent Shrubland	51,7	EN	LC	NP	10	10
Richtersveld Red Duneveld	49,66	EN	LC	NP	10	10
Rooiberg Quartz Vygieveld	73,14	EN	LC	WP	10	10
Rosyntjieberg Succulent Shrubland	59,49	EN	LC	WP	10	10
Southern Nababiepsberge Mountain Desert	59,8	EN	LC	NP	10	10
Southern Richtersveld Inselberg Shrubland	58,29	EN	LC	NP	10	10
Southern Richtersveld Yellow Duneveld	67,65	EN	LC	NP	10	10
Stinkfonteinberge Eastern Apron Shrubland	60,88	EN	LC	WP	10	10
Stinkfonteinberge Quartzite Fynbos	54,29	EN	LC	WP	10	10
Western Gariep Hills Desert	66,99	EN	LC	PP	10	10
Anenous Plateau Shrubland	32,34	VU	LC	NP	5	5
Bushmanland Basin Shrubland	45,47	VU	LC	PP	5	5
Eastern Gariep Plains Desert	44,25	VU	LC	PP	5	5
Eastern Gariep Rocky Desert	36,76	VU	LC	NP	5	5
Eenriet Plains Succulent Shrubland	46,95	VU	LC	NP	5	5
Goariep Mountain Succulent Shrubland	41,46	VU	LC	WP	5	5
Kahams Mountain Desert	43,16	VU	LC	WP	5	5
Kwaggarug Mountain Desert	45,66	VU	LC	WP	5	5
Namaqualand Heuweltjieveld	42,69	VU	LC	PP	5	5
Namaqualand Strandveld	30,74	VU	LC	PP	5	5
Northern Nababiepsberge Mountain Desert	43,26	VU	LC	NP	5	5
Richtersberg Mountain Desert	30,16	VU	LC	WP	5	5
Richtersveld Sheet Wash Desert	38,94	VU	LC	WP	5	5
Southern Namaqualand Quartzite Klipkoppe Shrubland	34,78	VU	LC	PP	5	5

Vegetation Type	Percent Degraded	RLE (D1)	ETS (NBA 2025)	EPL (NBA 2025)	Starting Offset Ratio	Final Offset Ratio
Umdaus Mountains Succulent Shrubland	42,3	VU	LC	NP	5	5
Bushmanland Arid Grassland East	0,83	LC	LC	PP	2	3
Bushmanland Arid Grassland West	3,82	LC	LC	PP	2	3
Bushmanland Sandy Grassland	0,91	LC	LC	NP	2	3
Die Plate Succulent Shrubland	13,44	LC	LC	NP	2	3
Hantam Karoo	14,85	LC	LC	NP	2	3
Kamiesberg Granite Fynbos	5,17	LC	LC	NP	2	3
Kamiesberg Mountains Shrubland	8	LC	LC	NP	2	3
Lower Gariep Alluvial Vegetation	9,54	LC	LC	PP	2	3
Lower Gariep Broken Veld	4,19	LC	LC	PP	2	3
Namaqualand Blomveld	21,51	LC	LC	PP	2	3
Namaqualand Granite Renosterveld	18,21	LC	LC	NP	2	3
Namaqualand Heuweltjie Strandveld	23,6	LC	LC	PP	2	3
Namaqualand Inland Duneveld	22,35	LC	LC	PP	2	3
Namaqualand Klipkoppe Shrubland	22,48	LC	LC	PP	2	3
Namaqualand Riviere	17,76	LC	LC	PP	2	3
Namaqualand Sand Fynbos	20,8	LC	LC	PP	2	3
Western Bushmanland Klipveld	22,9	LC	LC	NP	2	3
Western Gariep Plains Desert	5,25	LC	LC	PP	2	3
Helskloof Canyon Desert	25,15	LC	LC	WP	2	2
Namaqualand Coastal Duneveld	9,88	LC	LC	MP	2	2
Northern Knersvlakte Vygieveld	1,78	LC	LC	MP	2	2
Riethuis-Wallekraal Quartz Vygieveld	10,87	LC	LC	WP	2	2
Tatasberg Mountain Succulent Shrubland	20,25	LC	LC	WP	2	2
Blouputs Karroid Thornveld	0,71	LC	LC	WP	2	0
Namaqualand Arid Grassland	2,08	LC	LC	WP	2	0

Only two ecosystems are LC on both RLE assessments, are well protected, and have >95% of their original extent intact, suggesting that no offsets should be required for impacts in them.

3.1.5 Species

Species impacts are so fine-grained and localized, that, given the uncertainty of exact development footprints (i.e., not being site-specific), species-specific impacts can't be forecast or provide any defensible framework for effective offset type mitigation. SANBI has data and mapping for a large range of Not Protected or Poorly Protected species that could be used to site developments to avoid impacts (or to locate some offset candidate sites). A key assumption is that the CBA map (DAERL 2024) and Sensitivity Mapping (Desmet 2026) identify most of these areas and habitats of SCC – this should be confirmed in project EIA level studies. A further assumption is that the applicable offset ratios and receiving areas would effectively and pragmatically cater for most impacted species, especially habitat generalists. Local expertise and taxon specialist experts continually identify new species or highly range-restricted species in the region[7]. Although the National Guideline suggests that Least Concern ecosystems may not require offsets, in this landscape most are "Not Protected" and would still need to be conserved to the national ecosystem targets (SANBI 2025a) to theoretically safeguard even 75% of their species complement. Avoidance is still the primary mitigation measure to address potential impacts on SCC, and it is highly unlikely that any offset framework could be judged adequate to conserve the full species complement of a site, without further diligent sampling at EIA stage, and augmentation of the proposals contained here.

[7] Pieter van Wyk *pers comm* October 2025.

3.1.6 Cumulative impacts

This is perhaps the most unclear impact that would result from the SEZ and RE roll out. There have been few previous developments anywhere in the country at this scale or cumulative impact studies I'm aware of that may give insight into what impacts might emerge. For these and other reasons a risk averse and proactive offsetting approach should be adopted, where:

- the ratios applied would be larger than just for an isolated, small scale development;
- greater attention is given to upfront offset design and location in the landscape;
- offset objectives and outcomes are put in place prior to impacts materialising; and
- performance and financial guarantees are provided by SEZ and/or project proponents to ensure long term attainment of offset outcomes.

3.1.7 Applicable ratios

A key issue in offset studies is often contention between proponents, specialists and regulators around the offset calculus, especially what footprint requires offsetting (e.g., only moderately significant impacts and higher versus the full development), and what ratios should apply. This has only partially been resolved by the National Guideline (DFFE 2023), although this does not adequately cater for extensive or broad-range ecosystems that need large areas in which to function effectively to maintain species complements, or for which cryptic species or function loss is not well captured in standard tools (such as Ecosystem Threat Status). Further the Guideline assumes a rigorous vetting of all CBA1 designated areas (DAERL 2024) – which is not currently feasible to do in a province the size and remoteness of the Northern Cape – and assigns an explicitly punitive ratio (i.e., 30:1) to any impacts in them. This might not be defensible in this region unless more diligent and ground-truthed verification of CBAs is undertaken. Similar arguments apply to CBA2 areas. Nevertheless, until assessed otherwise by specialists with conservation agencies' concurrence, it is required that CBA1 areas are offset at this ratio (see Table 3-2).

Proposed here are defensible offset (and Ecological Compensation) ratios, developed from the National Guideline, that could be prescribed for all developments within or supplying the SEZ and GH_2 fleet regardless of the scenario finally approved for construction. Prior stipulation of these ratios avoids contestation and drawn-out EIA processes, and is a key mechanism to streamline offset assessment and quantification (see Section 3.5).

If investors or tenants in the SEZ need to align with IFC standards on Biodiversity Conservation[8] (PS 6), the SEA would do well to identify areas that would be considered 'Natural Habitat' or 'Critical Habitat' to clarify expected mitigation. This is beyond the scope of this chapter, but the implications require elaboration. Critical Habitat requires impacts to be offset to result in Net Gain (as opposed to No Net Loss for Natural Habitat). Although interpretations differ, Net Gain is difficult to conceive with many South African ecosystems or the explicit Target Based Compensation Framework for Offsets that has been adopted here. There is little opportunity or value in restoration of ecosystem structure, diversity or function in most ecosystems in ecologically and socially meaningful timelines. One way Net Gain could be interpreted is in achieving additional offset outcomes over and above what would be required in terms of the guideline – at least for those ecosystems that are still above their targets. This informs the ratios proposed in Table 3-1.

[8] Others, such as PS 7 on Indigenous Peoples, are also relevant for offset implementation but a detailed discussion is out of scope here.

Table 3-2: Biodiversity features and proposed applicable ratios for the SEZ and related RE facilities. Prior adoption of clear mitigation metrics applicable to all projects would avoid case-specific contestation and divergent approaches by different specialists and/or for different competent authorities.

Feature	Description	Proposed Ratio	Modifiers
Listed CR ecosystem	Currently natural or near-natural remaining ecosystem listed as CR under NEMBA	1:30	In this region, 'condition' is not a useful modifier except in extreme circumstances
Listed EN ecosystem	Currently natural or near-natural remaining ecosystem listed as EN under NEMBA	1:10	
Listed VU ecosystem	Currently natural or near-natural remaining ecosystem listed as VU under NEMBA	1:5	
CBA1[9]	Currently natural or near-natural remaining ecosystem identified as CBA in the N Cape CBA Map	1:15 to 1:30	The higher ratio applies unless defensible rationale for re-designation exists
CBA2	Currently natural or near-natural remaining ecosystem identified as CBA2 in the N Cape CBA Map	1:5 to 1:10	The lower ratio applies unless defensible rationale for CBA2 designation exists
ESA	Currently natural or near-natural remaining ecosystem identified as ESA in the N Cape CBA Map	1:3	Offset design/ location more NB than extent
Expert identified sensitive areas[10]	Fine scale delineation of local priority sites housing significant SCC, in good condition. Overrides VU and ESA designation and should be used as an overlay zone	1:10	Can increase if likely to be designated CBA in future
Natural vegetation ONA[11]	Remaining Natural Areas of a vegetation type regardless of protection level in the NBA	1:2	If 'poorly protected' or 'not protected' this ratio increases by 50%
Degraded	Natural area overgrazed, trampled or otherwise impacted for > 10yrs but still capable of natural rehabilitation	1:1	Required only if the site is surrounded by CBA or ESA or is a Listed Ecosystem
Mining scar/ No Natural Remaining		None required	

[9] This designation is complicated in the N Cape as areas in the province, especially in Namaqualand District, inadequately reflect local conditions and state of biodiversity. It is thus risky to require the maximum offset ratio for any impact on an area designated as CBA in the 2016 version. A revision is underway but only a draft is available to inform this offset framework. This 2024/5 version may be more defensible and justify the maximum ratio.

[10] See Desmet 2026. Refinement of the areas, or explicit uptake in the CBA map revision is advised.

[11] See **Error! Reference source not found.** for specific ratios applicable to the vegetation type impacted

3.2 REGIONAL CONSTRAINTS AND ENVIRONMENTAL OPPORTUNITIES FOR CANDIDATE OFFSET RECEIVING AREAS

Further to any required offset quantum is the question of where prospective, preferred and optimum candidate sites may be found. Given biodiversity patterns and processes in this region, it would be worth durably conserving relatively small high-value, species-rich and/or high-endemicity areas over larger species-poor, low-priority areas in the same ecosystems. Locating candidate offset sites must be informed by what biodiversity features occur where, in combinations with the push and pull of regional constraints (e.g., approved, biodiversity-incompatible land uses and rights) and opportunities (e.g., where conservation agencies are keen to expand the protected area estate); these are outlined below.

3.2.1 Constraint: Impacted areas

There are substantial mine-impacted areas along the coast, which is also threatened by new, illegal mining and large mobilised sand plumes. Further, apart from the far North (Orange River Mouth Nature Reserve) and extreme South (Namaqua National Park south of Hondeklipbaai), there are no PAs or active conservation authorities who may be able to establish, expand or manage offsets. This constrains identification of suitable coastal areas for candidate offset sites.

3.2.2 Constraint: Existing Mineral & Exploration Rights

Unfortunately, the long-awaited mining cadastre[12] has still not been implemented, and it is impossible to get accurate spatial data on the extent of real Mining, Prospecting and Petroleum Exploration Rights. A layer was created by SAHRA (circulated by CSIR) of all known development rights, applications and current studies which is the only data to help avoid unnecessary land use conflicts between offset area establishment and existing rights (Figure 3.3). Many rights are purely speculative. Where possible all Offset receiving areas proposed avoid these rights.

3.2.3 Constraint: RE Developments Approved or Applied For.

Unlike mining and petroleum, an accessible, relatively up to date spatial database of renewable energy applications and approved projects is maintained by the DFFE. Although there are errors, and the authorised footprints are not captured (which is something to be addressed for future planning), it does provide some intelligence around which to build spatial design into an offset framework. However, complicating issues are the fact that: (1) too few of these RE projects were approved with sufficient offset mitigation, (2) where mitigation requirements were incurred the context has changed, and (3) it is unclear which of these projects can or will still be built. This can play out in a manner that further constrains this framework or provides a strategic opportunity, depending on the regulator's and SEZ proponent's appetite to proactively address the likely offsets imperative. An ad hoc and opportunistic RE build is likely to result in ongoing biodiversity loss in this region. Little spatial information is available for other large scale regional infrastructure developments (e.g., a proposed dam at Vioolsdrif, grid infrastructure expansion). The locations of known rights or applications are shown in Figure 3.3 (courtesy SAHRA and CSIR).

[12] An easily and publicly accessible, spatially explicit database of mining and related rights and applications

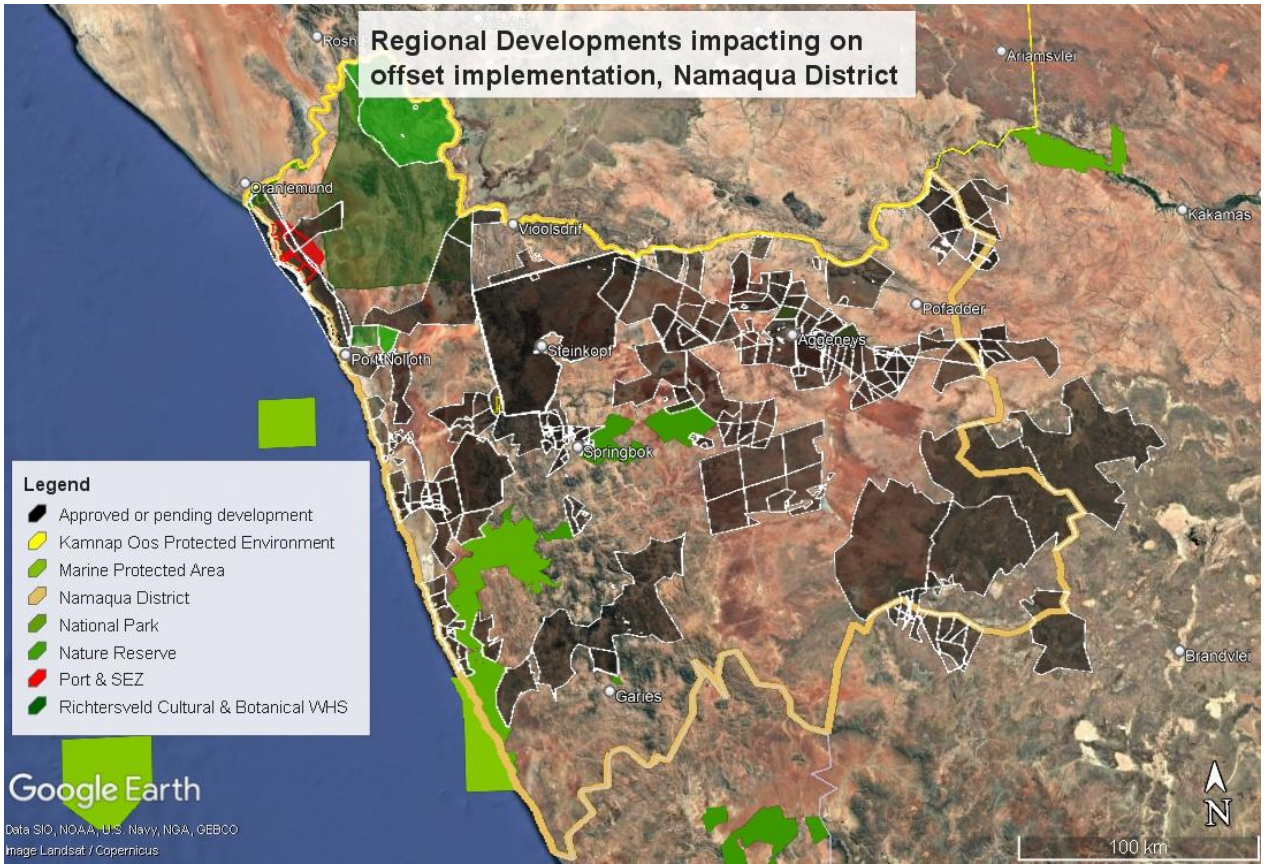

Figure 3.3: Approved, pending or exploratory studies for enhanced development rights in the WP2 study area. Note that the rights attach to or are coded by entire cadastres, which inaccurately portrays the scale of proposed development in this region with massive farm portions. A recommendation for future databases is to more accurately capture approved footprints to aid planning, compliance monitoring and enforcement and assess offset sufficiency.

3.2.4 Opportunity: Priority areas for biodiversity and PA expansion

The National PA Expansion Strategy[13] was approved by Cabinet in 2020 for implementation. Building on this is Vision 2040 (SANParks 2024), an approach to conserving living landscapes. It seems imperative to avoid unnecessary developments in these areas and set aside parts of the landscapes as cornerstones of this vision. In this region, the priority focus areas are land hungry (see Desmet 2026 for an explanation) and would stretch even an ambitious and exceedingly well-funded suite of conservation agencies to implement. The NPAES priority focus areas and Vision 2040 are key design informants of the offset receiving areas and the proposed proactive offset schemes.

It is difficult to compare offset implications from any GH2 scenario with the No-Go option of Business-as-Usual. The current offset liabilities required by all three competent authorities in the region are poorly known. The National Offsets Register (SANBI 2025b) lists only two from the district although many more are known. There is no mechanism for offset planning, and no means of aligning Competent Authorities' Offset approvals or guidance without an EMF or SEMP that a SEA would bring. To my knowledge, no other regulatory tool or decision support structure exists to achieve this.

[13] The PA expansion priority focus areas identified in the NPAES represent the best locales in which to pursue PA expansion generally, and should not be viewed as some form of proto-PA.

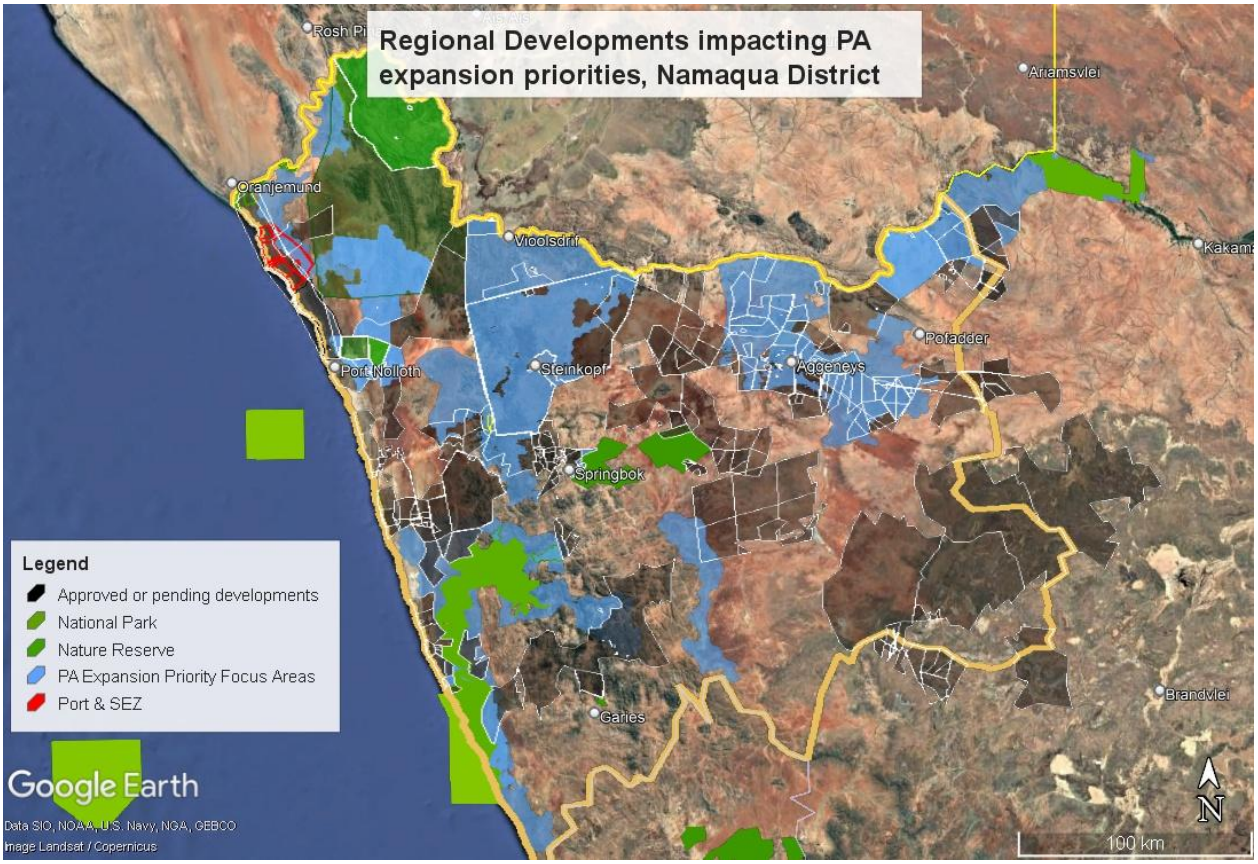

Figure 3.4: The protected areas and PA expansion priority focus areas (2018) in Namaqualand overlaid with approved or pending development applications. White outlines over the blue PA Expansion Priority Focus Areas indicate overlap or potential conflicting landuses.

3.3 OFFSET IMPLEMENTATION OPTIONS AND CRITERIA

3.3.1 Indicative Offset Size

To deliberate on whether sufficient offset candidate area exists (and make the likely total offset liability explicit for the Sc2 Big Green Hydrogen scenario), assumptions were made as to the percentage fixed[14] (80%) and flexible[15] infrastructure (20%) likely to trigger offsets. This is hard to predict with any precision, but is useful as a heuristic exercise, and essential to arriving at indicative offset sizes.

Using these assumptions and the proposed basic ratios (average of 2:1 for the areas impacted by PV and WEF (i.e. 20% of 128 000 ha) and 10:1 for the impacts of fixed infrastructure (i.e. 80% of 16 000 ha) unavoidably impacting on priority features) yields a combined Sc2 offset requirement of ~**180 000 ha** of land that needs to be secured. This is equivalent to creating new offset protected areas the size of Richtersveld and Namaqua National Parks combined. No offset on this scale has been attempted in South Africa.

[14] The SEZ, Electrolyser, storage, road, substations and related infrastructure occupy 16000 ha (Annexure B.)

[15] The WEF, PV and Grid connections cover 128 000 ha for the Big GH_2 Scenario. (Annexure B)

3.3.2 Offset receiving areas

A previous study (Botha & Desmet 2022) identified the optimum places to locate terrestrial offsets as being in the two already published and approved National Park Expansion Zones. It also proposed a new protected area expansion corridor from Richtersveld National Park (Klein Duin section) to Harras mountains along the R382 towards Steinkopf. Further areas in which to locate offset receiving sites for the SEZ are elaborated on in WP1 (Botha 2026), summarised in Table 3-3.

Guidance from the SEZ site-based framework (WP1) noted that to offset the Port and Sc1 impacts in the SEZ to achieve requisite outcomes for Listed Ecosystems requires that both restoration and protection efforts are needed as ecological compensation to satisfy offset principles and to reach biodiversity targets. It is unclear if this approach would be needed for regional impacts, but there appears to be enough low-sensitivity land available to avoid impacting ecosystems classified as CR, EN or VU in the first place.

For WP1 and the SEZ, fine scale delineation of offset receiving areas acknowledged local community priority sites combined with expert mapping. This has not been possible at the scale of WP2.

For WP1 (see Figures 4-6 and 4-8 in Botha 2026), the protection and restoration efforts are best focused on:

1- expanding the existing Orange River Mouth Nature Reserve to join the disparate sections along the lower Orange River around Grootderm and to create and rehabilitate buffers around the most sensitive features (such as the Namib Lichen Fields). Arresting the mobilised sand is of primary importance. (this could reach **19 000 ha**)

2- Establishing a new PA along the Holgat river from Daberas to the coast, potentially as a contractual extension of the Richtersveld National Park (up to **7 400 ha**). In theory, this could be linked up to the existing Oograbies Wes/Klein Duin section through the inland portion of Farm 1 as per the existing SANParks Land Inclusion Plan (although it creates an unwieldy PA with low tourism potential and high management costs)

3- Securing and managing future impacts on the larger expert identified priority areas of Visagiesfontein, Swartbank, Rooibank, and the unique Whistling Rat colony. Alignment between experts and conservation authorities is required to agree on the rationale and specifics of this priority, but at least **20 000 ha** could be available for offsets.

4- Around 560 ha of expert identified priority areas found around Namakwakop, Boegoeberge, and the other smaller priority sensitive areas around the Port should be set aside[16].

For WP2, offset receiving zones (i.e. where most suitable offset candidates are likely to be found) were delineated based on i) where existing Parks or Reserves are expanding or could feasibly be expanded; ii) where priority sites (CBA1 in Desmet 2026) persist; and iii) representing those vegetation types likely to receive the bulk of the RE roll out. These are also set out in Table 3-3 and Figure 3.5, and could also form the foundations of creating large landscapes aligned to Vision 2040 (see Desmet 2026)**Error! Reference source not found.**.

Large offset receiving areas are proposed in the Koa Valley – Stofbakkies – Kliprand corridor (area 1, Figure 3.5). This large corridor would secure several CBA1 patches while anchoring a future landscape corridor to the W Cape border and Kamiesberg Park Expansion Zone. This would cater for impacts across most of the Bushmanland Basin vegetation types and several of the most species rich Namaqualand types. Whether these areas need to be so large or could ever be managed as formal PAs is questionable, even with offset funding in place. Some other effective conservation measure, effective at a landscape scale at reducing biodiversity loss and catering for ecosystem processes and species movement, may be required. This receiving area could also cater for the intended expansion of the Vaalputs Radioactive Waste Storage Facility 15 km away.

[16] These could effectively count as set asides towards offset liabilities if they are actively protected and the surrounding buffers restored (van Wyk 2024) but are not viewed as offset sites *sensu strictu.*

Where prudent and supported by the SANParks Regional Manager and environmental management staff, several Park Expansion Zones are identified as offset receiving areas: Augrabies – Pella (area 2), Kleinduin section-Richtersveld (area 3); and Namaqua Park (area 4 in Figure 3.5). A subset of the Vioolsdrif-Steinkopf NPAES Focus Area is also proposed as an offset receiving site (area 5), although the ability of SANParks to take on its management was queried[17].

A large-scale consolidation of priority areas between Goegap and Kangnas Nature Reserves (area 6) would also seem prudent and offers flexibility in management authority options. Expanding the Gamsberg Nature Reserve (itself an offset site) to encompass the priority inselberg habitats surrounding the two sections (area 7) would also safeguard most of the priority sites in that bioregion.

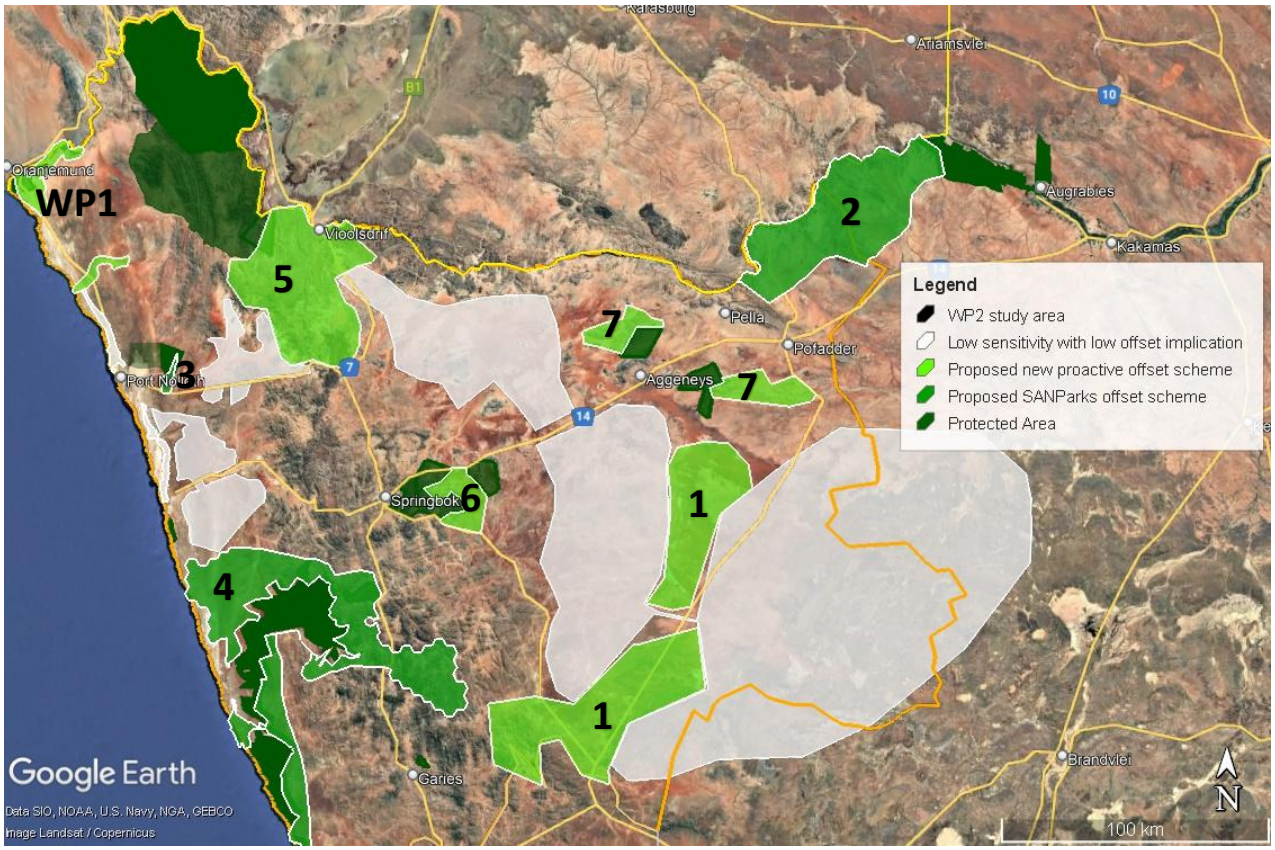

Figure 3.5: Proposed Proactive Offset Scheme receiving areas around existing PAs. Constraints imposed by already approved developments will complicate offset implementation. Areas of low sensitivity and therefor low offset implication are shown in white. The need to avoid land use conflict wherever possible indicates joint planning for and adherence to a regional plan. Note boundaries are approximate, not resolved in the East, and need fine scale delineation. Mine damaged coastal land suitable for wind energy not visible at this scale.

Although some receiving areas have some form of legal status (the Park Expansion Zones), others need to be confirmed and refined by broader specialist consultation, community engagement, and conservation authority input[18]. The initial identification in this report is necessarily broad and illustrative and avoids identifying specific property parcels prematurely, which could unnecessarily hinder implementation. A subsequent planning process or EMF (or provincial Spatial Plan for implementing the GH_2 pathway) could deepen the engagement around these proposed offset zones, codify them, and build implementation

[17] Discussions are underway to transfer the Richtersveld WHS core area and potentially Nababiep Nature Reserve to SANParks for management, but it's unclear if this would extend further East in Farm 22.

[18] Although input was solicited from SEA specialists, time constraints prevented thorough consultation. Only preliminary input was obtained from DAERL and SANParks. Detailed consultation, landowner engagement and agreements are required prior to formalising these areas in a policy document.

modalities (through landowner agreements etc.) that is beyond the scope of the SEA. It should, however, accompany any SEZ implementation plan developed.

There are unfortunately still certain vegetation types that would not be well covered by these proposed receiving areas. Namaqualand Strandveld (VU *sensu* Desmet 2026) and Richtersveld Duneveld (CR sensu SANBI 2025a) types are poorly represented. This may not be an issue if the coastal WEF are predominantly located on mine scars and the proposed WP1 Offset and Namaqua National Park northern receiving areas are effectively protected and rehabilitation initiated prior to SEZ build out. Using the basic assumptions in Section 3.3.1**Error! Reference source not found.**, offsetting the small GH_2 scenario still might entail as much as **40 000 ha** of offsets. This would require two thirds of all the local offset receiving areas identified in WP1 to be secured.

Table 3-3: Potential offset receiving areas for developments at Boegoebergbaai, the SEZ and associated regional renewable energy projects. *Note that only local features are likely to be suitable for Port & SEZ linked offsets. **Regional features could provide offsets for SC2 big GH2 impacts. Although sufficient area might seem available, not all the impacted ecosystems are protected by these receiving areas..

WP1 Local Feature/Priority*	Area (ha)		WP2 Regional Feature**	Area (ha)
Pagvlei-Grootderm-Brandkaros	19 600		1. Kliprand - Stofbakkies – Koa Valley	200 000
Rooibank heuweltjies	14 000		2. NPAES focus area Augrabies - Pella	195 000
Swartbank heuweltjies	3 500		3. NPAES focus area Vyftienmylseberg Kleinduin/ Richtersveld NP	3 600
Farm 1 (natural portion) NW of Kleinduin Section Richtersveld NP	10 000		4. NPAES surrounding Namaqua NP	300 000
Visagiefontein & Kop	3 300		5. NPAES Vioolsdrif-Steinkopf-	200 000
Holgat river & catchment	7 400		6. Goegap Reserve - Kangnas consolidation	28 000
			7. Gamsberg Reserve extension	54 000
Total	**≈ 60 000**		**Total**	**≈ 990 000**

Mitigation trade-offs between biodiversity features are an unfortunate reality. Some development sites with low ecosystem offset liabilities will impact avifauna more than plants (see for example Figure 3.6), and others will impact invertebrates or reptiles more than birds. Similarly, some offset receiving areas are likely to serve some biodiversity features better than others. This is unavoidable and can only be addressed by comprehensive offset and protected area expansion in the region, covering diverse landscapes and biophysical features, key gradients, and known hotspots.

It is risky at this scale of analysis to provide detailed guidance on trade-offs. DFFE has previously indicated to the South African Wind Energy Association that decisions on approving impacts and mitigation measures on irreplaceable features (e.g. CBA 1) that would involve trade-offs are made on a case-by-case basis. Trade-offs demand careful, systematic and transparent evaluation of the potential consequences in undermining the country's biodiversity targets as well as the resilience of sensitive features or ecosystems services to further loss. The purpose of trade-off rules is to safeguard nature, not facilitate loss or impact leakage. The burden of justification always falls on proponents of trade-offs, and should attract independent review and public scrutiny.

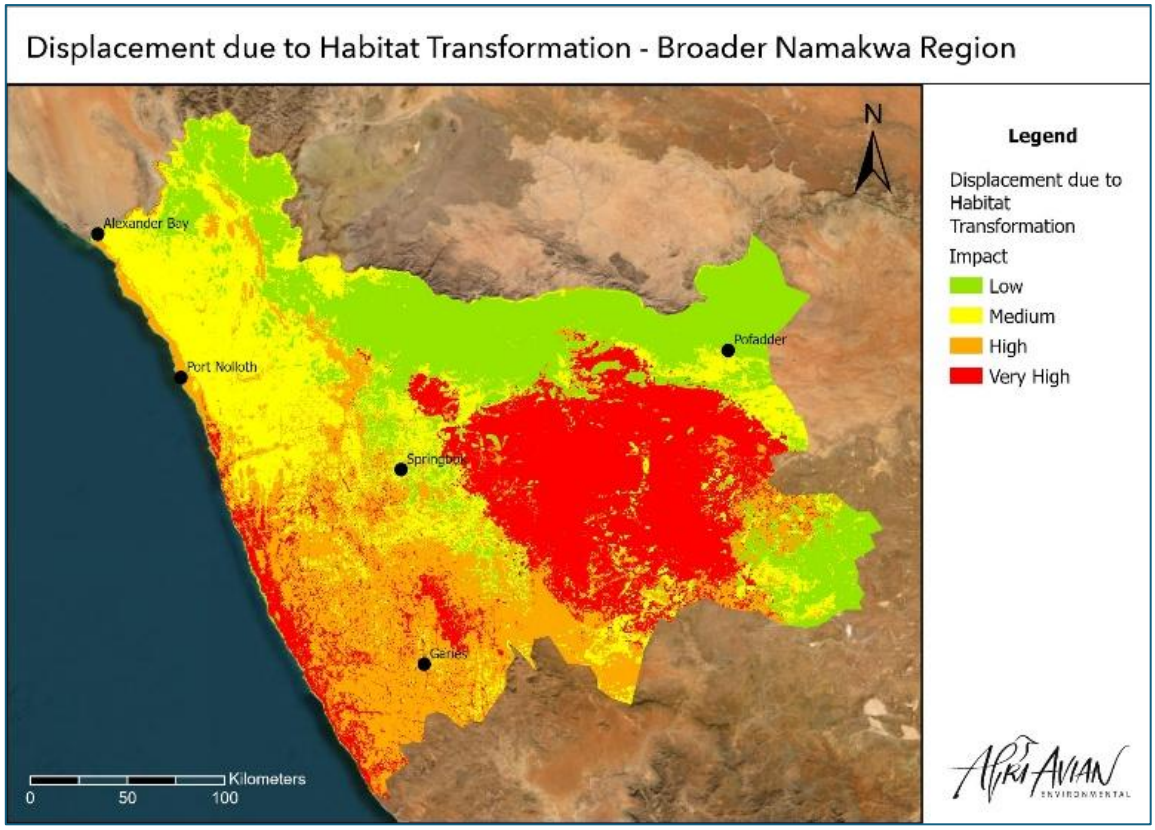

Figure 3.6: Map of bird species displacement due to habitat loss. An example of a mitigation trade-off between biodiversity features. Areas of greatest sensitivity for bird impact through habitat loss (Bushmanland basin shrubland) are those of low importance for plant species and other taxa. Siting PV facilities here would incur little offset liability but could cause significant bird habitat loss. Figure from Kellerman et al (AfriAvian) 2026 – this volume.

3.3.3 Proactive offset scheme options

The SANParks' pilot proactive offset scheme (UNDP 2025) around their Parks is a useful model on which to build. This model allows clarity on offset outcomes for regulators, I&APs and investors, and provides clear cost implications for budgeting, planning and compliance by proponents. While the basic mechanics of the pilot proactive scheme have been resolved, it would need additional capacity (in terms of scheme administration and on-ground park management and restoration) in SANParks for effective scaling. Long term implementation/collaboration agreements between SANParks and the SEZ proponents would be needed to ensure the suitable staff are recruited (especially for landowner engagement, financial administration, and conservation operations management). This would allow additional properties to be contracted in or purchased, effective rehabilitation and park management, administration of the capital and management fees, and auditing of and reporting on the scheme.

While proactive schemes may seem expensive and cumbersome upfront, experience indicates that they are a way to guarantee outcomes for biodiversity, landowners and the public. Piecemeal offset development and implementation have proven expensive, complex, and time-consuming in Northern Cape landscapes, even where land transactions are relatively straightforward (WFA 2018, M Botha *pers obs*). In the WP2 region the likelihood of competition for offset land, conflicts with other land uses, and possible rent-seeking behaviour due to information asymmetry and power dynamics is high.

3.4 ECOLOGICAL COMPENSATION FOR NON-OFFSETABLE IMPACTS

Some impacts, especially on SCC or range-restricted habitats and vegetation types are not readily offsetable. A key assumption is that, at least for WP2, there are sufficient low-sensitivity areas to not trigger highly significant vegetation or CBA impacts that would demand Ecological Compensation under the Guideline. However, **IF** any such impacts were approved based on overwhelming national economic importance[19], then Ecological Compensation mitigation is required. This would likely be for those biodiversity features that are not catered for by large scale ecosystem offsets, being very localised, habitat-specific fauna and flora that for some unknown reason can't be avoided, or avifauna specifically impacted by renewable energy and associated infrastructure of a GH_2 roll out.

The Avifauna report (Kellerman et al 2026) recommended region-wide implementation of various conservation actions, including retrofitting of existing infrastructure to reduce bird mortality[20]. Establishing or capitalising existing Conservation Trust Funds to support effective ecological compensation for some avifauna impacts could be considered appropriate, provided the interventions met the following criteria. A sound, high-integrity ecological compensation activity is one:

- Built on explicit (usually species-specific) interventions to reach targets that contribute to enhanced survival and population recovery,
- Coupled with a clear implementation plan with responsibilities and compliance monitoring incorporated,
- That is clearly additional and doesn't displace existing budgets or activities, and
- With contingency planning, alternative strategies, adaptive management, and performance guarantees in case planned interventions don't work.

International reviews have also set out general criteria for robust offset-type mitigation measures that would apply to ecological compensation in the SA context (Pope *et al* 2021; Penca 2024).

In summary, specific proposals from this SEA for ecological compensation for unavoidable but technically unoffsettable include:

1- additional proactive expansion of regional protected areas to achieve other biodiversity targets especially for threatened ecosystems (and their nearest analogues) and aggregations of species of conservation concern (including in the Proactive Offset Schemes),

2- endowing sustainable funding mechanisms to secure long term (>99 years) conservation management of the offset areas (and potentially also the expanded PAs) – provided these come with commitments to maintain existing budgets from statutory conservation authorities that may be managing the schemes,

3- upgrading/retrofitting existing RE facilities and powerlines to reduce bird species impact by:

   a. reconductoring the existing grid and bunching new lines for visibility;

   b. staggering adjacent transmission line pylons across the spans to improve bird collision avoidance;

[19] This would be a difficult argument to make due to other, overwhelmingly more suitable, less damaging, and more readily mitigated GH2 sites exist elsewhere or are already under-development.

[20] Measures addressing direct species mortality could be viewed as offsets, as is done elsewhere in the world. In this instance, Ecological Compensation may be a more accurate term, as the measures are broadly targeted and indirect (numerous species benefit, and it's not certain that CR species will be saved) and the fact that some of the impacted spp. are listed as EN and CR, and that the additional grid and WEF may well drive their populations down further, implying offsets are not appropriate

c. retrospective installation of line flappers and other avoidance technologies, especially on sections of line with known high mortalities;

d. blade painting/patterning of existing WEF or those that have just reached financial close and were approved without such mitigation; and

e. installing at least single axis tracking for existing PVs to reduce "mirage and lake effects" (as well as dust deposition).

However, ecological compensation is difficult to quantify and administer and creates serious challenges around assigning liability, moral hazard, performance auditing, and compliance monitoring and enforcement. The region is one of the centres of RE development due to the solar and wind resources, even without the SEZ. Approved facilities (≈ 13GW in the district, 76GW in the N Cape province as of February 2025 DFFE) are likely a fraction of what is currently being investigated for development by proponents. All new facilities should be required to install the mitigation noted in the Avifauna Chapter. Approved RE facilities may well have permits lapse prior to commencement and re-permitting may trigger additional mitigation due to the updated regulatory regime and evolving standards. These factors complicate judgements of what infrastructure could be retrofitted and indicate that the ecological compensation opportunities for the SEZ-linked RE facilities are relatively low and/or are very complex.

3.5 RECOMMENDED STREAMLINING OF BIODIVERSITY OFFSETS

Compliance with the mitigation hierarchy is imperative, which demands "Avoidance" (alternative sites are exhaustively explored), "Minimisation"[21] (alternative technologies and other mitigation measures) and even "Rehabilitation" be attempted before offsetting can be considered. How to ensure any "streamlined offsets" process in any regulatory tool is not used to short cut the mitigation hierarchy, and then to incorporate this imperative in the SEA guidance framework, is not clear. Specific guidance is provided below (see Section 3.5.2) to ensure that regional developments cater for biodiversity as far as possible, and don't rely on offsets alone for mitigation. These build on the guidance from Desmet (2026).

3.5.1 Clarify offset requirements and metrics/exchange rules upfront

The SEA should inform the broader planning framework for the Green Hydrogen pathway through an established environmental management instrument like an EMF. From an offset perspective, an EMF could avoid typical project level challenges (assessment disagreements, difficulty securing candidate sites in tight timeframes, and concluding funding and implementation agreements prior to issuance of an environmental authorisation). Clear rules, exchange metrics and implementation modalities (such as required participation in a dedicated proactive offset scheme) would clarify for investors and proponents upfront the imperative and realistic costs of biodiversity mitigation. An overarching offsets instrument would also ensure equity (all applications/projects would be treated similarly), ensure avoidance of highly significant impacts, and reduce land use conflict. It would also give conservation agencies clarity on impending impacts and where to best invest their capacity and resources – including to plan and execute any proactive schemes.

Perhaps most importantly, upfront clarification of what impacts are unacceptable and thus not offsetable and, for the rest, where offset implementation would emerge would allow a unitary negotiation process with the different landowning communities. This would provide all members with insight into what long term land use constraints and opportunities would apply, what compensation would be available for this, and what role they could play in offset scheme (and the broader biodiversity economy) implementation in the region. A piecemeal approach to this engagement by multiple different actors of project-level EIAs is likely to cause confusion, unmet expectations, and competition. This is almost certain to have poor outcomes for biodiversity.

[21] The are very limited opportunities for rehabilitation of impacts in this environment that would deliver substantial biodiversity returns.

3.5.2 Focus on securing large landscape conservation outcomes

All told, the priority for candidate offset receiving areas may meet the spatial targets but may not quite capture all the SCC and the local ecological processes that need to be maintained for long term biodiversity persistence. Additional smaller sites for SCC or important features may need to be secured and managed as isolated PAs to ensure no unacceptable loss and meet performance standards for "critical habitat". Planning for large landscape scale outcomes (and the wider contribution of the biodiversity economy) may also require focusing on a "sense of place" and "wilderness" that are not adequately covered by blunt offset metrics.

Specific opportunities exist to demand that any infrastructure element of either a small or big GH_2 scenario conform to design parameters to support nature's persistence. For instance, all PV structures should be pole mounted and not built on cleared ground. This allows continued species movement, seed dispersal, grazing, and ecological functioning. Linear infrastructure (roads and railways, gas pipelines) must include multiple and regular areas of overpass or underpass at a scale that would ensure animals can move relatively freely (and reduce collision mortality or migration disruption).

Although it is not possible to be exhaustive at an SEA level, to reduce the main impacts and risks to biodiversity, it could be stipulated that any PV facility wishing to conclude a power purchase agreement with the SEZ and green hydrogen fleet must be constructed without clearing ground. And all engineering and design specifications for linear infrastructure include stipulations for minimising biodiversity impact in the earliest stages.

3.5.3 Proactive schemes around National Parks (and provincial reserves)

To what extent the cumulative, indirect or induced impacts from the entire GH_2 fleet and SEZ could be linked to any particular project is unclear. This complicates assigning offset liability and reinforces the suggestion that the SEZ proponents should proactively mitigate impacts on behalf of future tenants. SEZ support for an investment in proactive offset schemes would be imperative to streamline implementation, avoid land use conflicts and manage the threat from illicit and poorly regulated mining to offset sites, ecological corridors and the persistence of unique features. The SANParks' pilot proactive offset scheme (UNDP 2025) around their Parks would appear to be a useful model on which to build. This allows clarity on offset outcomes and cost implications for budgeting, planning and compliance purposes.

3.5.4 Recommendations for project-level offset studies

- Focus on demonstrating adherence to the mitigation hierarchy (and avoidance of non-offsetable impacts as a priority),

- Require a precautionary approach, that even if a site contains ONA, it should still attract a basic offset ratio unless: i) there is demonstrable evidence that no SCC occur on the site; ii) the site does not play an important ecological function role; and iii) the site would not be considered as 'Natural Habitat' in terms of Performance Standard 6 of the IFC [i.e. despite some degradation, it still largely contains the principal characteristics and functions of a native ecosystem].

- Explicit reference to SANBI data and mapping for Not Protected or Poorly Protected species must be made, and DAERL (2024) mapping AND the SEA Sensitivity Mapping (Desmet 2026) should be used as a departure point for updating in all cases and checked by specialists in the EIA process, together with diligent baseline surveys.

- Proactive engagement at pre-application stage with conservation authorities, landowners, and communities potentially depending on candidate offset sites is imperative. This cannot wait until late in Scoping or start of Assessment phase.

- Use the proactive offset focus areas as a departure point for all candidate offset site selection and assessment.

- Use of the set of standard offset ratios presented here for any SEZ aligned development, with any deviation requiring a substantial burden of proof and broad consultation

- Performance and financial guarantees should be required as standard to ensure achievement of objectives and outcomes specified upfront in the EIA process.

- Require no clearing of land for PV structures, unless a well-argued case, that has been independently reviewed by experts, can be made.

- Require provision of regular, sufficiently wide wildlife crossing structures on linear infrastructure (new fenced, tarred roads, railway lines), as a standard mitigation measure.

- SEZ proponents investigate establishment of proactive offset schemes to streamline implementation, avoid land use conflicts and manage several threats, and EIA studies confirm the participation liability of each project.

3.6 CONCLUSION

The likely scale and significance of impacts by the Boegoebergbaai port, GH_2 infrastructure and regional RE fleet on several threatened, rare or otherwise conservation-worthy biodiversity features on land, some of which are likely to be strictly "not offsetable", imply that substantial regulatory and political attention is required to safeguard biodiversity. Sufficient low sensitivity areas are available in the region, and a pragmatic offset framework with proposed ratios for various features is provided. Several proposed offset schemes adjoining existing protected areas that do not significantly impact existing rights holders could be established in consultation with landowners. However, this implementation would best be done proactively by SEZ proponents on behalf of tenants and prior to the complex and unpredictable outcomes of project-level EIAs. A clear commitment from development proponents and upfront resourcing and land access agreements are needed. Such schemes could also put in place the foundations for larger nature-based visions for sustainable development in the region.

Several features (Listed CR vegetation types and Species of Conservation Concern) may be impacted beyond acceptable thresholds where offsets are not suitable. Appropriate mitigation is better framed as Ecological Compensation and although initial suggestions are given, this approach is always undesirable compared to more rigorous avoidance and minimisation in the first place. Proactively addressing offset and compensation commitments clarifies upfront to investors, clients and product markets that the biodiversity imperatives are being safeguarded and are not collateral damage in the pursuit of an energy transition.

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3.8 ANNEXURES

A. BRIEF

"*Work Package 2:*

Scope summary:

… The primary objective of the Biodiversity Offsets Framework chapter for the regional-scale development scope is to outline the required offsets, where required, for mitigating the biodiversity impacts of development proposals linked to the Northern Cape green hydrogen economy and identify opportunities for proactive biodiversity offset planning in the region. The chapter will also provide recommendations or guidelines to streamline the process in offset assessment, design, and approval at the subsequent project level.

Role:

- *Liaison with Work Package 2 Author on "Regional Ecology, Biodiversity and Conservation Planning", with possible specific or high-level input as required.*
- *Review of the Work Package 2 report chapter on "Regional Ecology, Biodiversity and Conservation Planning".*

Specific tasks:

1. *Plan of Study*
    - *Outline the approach, data requirements, assumptions, limitations and timeframe of tasks.*
    - *Provide report / chapter framework.*
2. *Description of the receiving environment:*
    - *Describe the land use dynamics and change trends of the receiving environment and broader region as it relates to your topic. This will feed into the dynamic baseline scenario (Sc0) – "how is the social-ecological system changing even if a GH2 economy does not realise?".*
    - *Describe the key characteristics of the receiving environment as it pertains to your area of expertise – "what, where, why is it important?"*
    - *Spatially explicit as far as possible.*
3. *Sensitivity analysis:*
    - *Outline the spatial extent of biodiversity features that would trigger offsets*
        i. *Spatial layers distinguishing relative sensitivity or offset categories of the receiving environment (Low = Biodiversity offsetting not required, Medium/High = Biodiversity offset required, Very High = Biodiversity offset not possible).*
4. *Aspects and impacts register*
    - *Potential impacts (negative and positive) on biodiversity that may arise from the planned activities and infrastructure, based on a project description provided by CSIR.*
    - *Identify key biodiversity features at risk, where applicable, and prioritise them for offset planning.*
    - *Consider cumulative impacts in the region, across three scenarios using a risk framework methodology that will be provided by CSIR.*
        i. *Scenarios will include Sc0 = dynamic baseline considering inevitable dynamics and trends (e.g. climate, land use, societal); Sc1 = "small H2"(1mtpa); Sc2 = "big H2"*

(7 mtpa). Sc1 and Sc2 will be elaborated and provided by CSIR based on the project description.

5. *Offset requirements definition and selection of offset receiving areas*
    - *Define the specific biodiversity offset requirements necessary to mitigate identified impacts.*
    - *Develop criteria or mechanisms for determining and implementing appropriate offsets.*
    - *Identify potential offset receiving areas within the regional study area that can compensate for biodiversity losses.*
6. *Recommended strategic management actions*
    - *Develop practical recommendations or guidelines for future EIA studies, design and approval of biodiversity offsets at the project level.*
    - *Practical recommendations to inform and align with national policy and regional planning.*
    - *Recommend strategies for integrating offsets into broader land-use planning and conservation initiatives. "*

B. FOOTPRINT PROJECTIONS FOR SMALL AND BIG GREEN HYDROGEN SCENARIOS

Table 3-4: Impact quantifications for small and big Green Hydrogen scenarios. (as at Sept 2024). Note, this is probably a minimum footprint and excludes indirect and induced impacts. For instance, a 600km pipeline to Saldanha with a 20m servitude would impact at least 1200 ha (not 600). Prieska is another 600km.

	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 mpta GH2
	GH2 storage footprint	ha	250	2 000	10 ha per 20 000 tpa (500 ha for 1 mpta)
	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 mpta)
	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	600	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

C. ACRONYMS

a.m.s.l	Above mean sea level
CBA	Critical Biodiversity Area
CPA	Community Property Association
CR	Critically Endangered – a Red List category for ecosystems or species
DAERL	Department of Agriculture, Environment, Rural Development & Land Reform – N Cape.
DEDAT	Department of Economic Development and Tourism – parent department of NCEDA
DFFE	Department Forestry, Fisheries and the Environment. (Previously DEA)
DMRE	Department of Mineral Resources and Energy
DTSL	Department Transport, Safety and Liaison – N Cape
EGI	Electricity Grid Infrastructure
EIA	Environmental Impact Assessment
EN	Endangered - a Red List category for ecosystems or species
ESA	Ecological Support Area
ESBA	Ecological or Biologically Significant Area (in the ocean or coastal region)
GH2	Green Hydrogen – being H_2 produced and transported with renewable energy
LUMS	Land Use Management System
NBA	National Biodiversity Assessment (produced by SANBI every 5 yrs. Next due end 2025)
NCEDA	Northern Cape Economic Development and Investment Promotion Agency
NPAES	National Protected Area Expansion Strategy
NEMA	National Environmental Management Act (Act 101 of 1998) as amended
NEMBA	National Environmental Management Biodiversity Act (Act 10 of 2004)
NEMPA	National Environmental Management Protected Areas Act (Act 57 of 2003)
PA	Protected Area
PBO	Public Benefit Organisation
PFA	Priority Focus Area (of the National Protected Area Expansion Strategy)
PV	Photovoltaic
RE	Renewable Energy
REDZ	Renewable Energy Development Zone
REIPPP	Renewable Energy Independent Power Producer Programme
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SDF	Spatial Development Framework
SEZ	Special Economic Zone
VVVT	Vrywillige Voor Verligte Toestemming (Afrikaans for Free Prior Informed Consent)
WEF	Wind Energy Facility

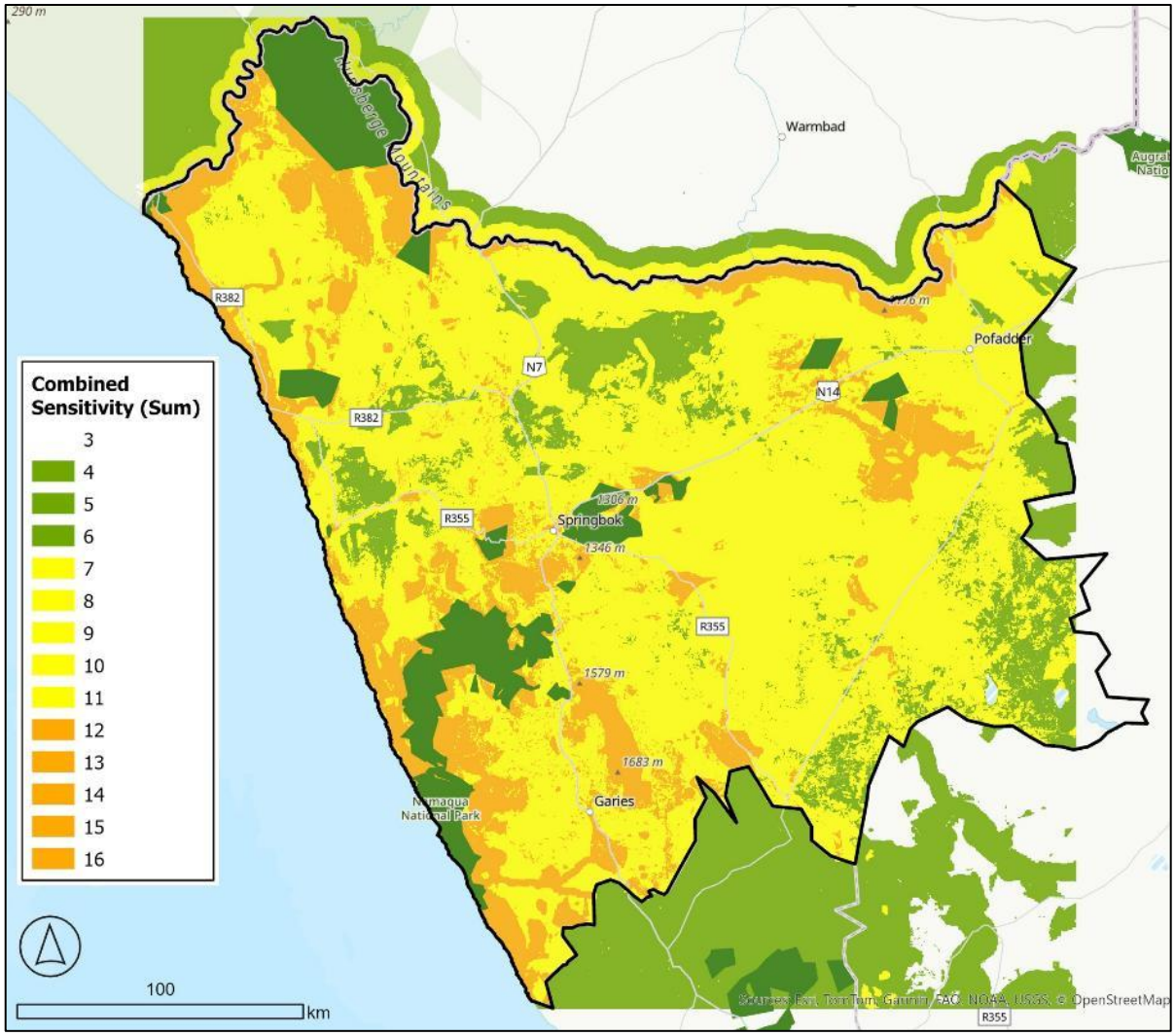

Figure 3.7: The combined biodiversity sensitivity rank with an alternative legend grouping summed ranks in 3 combined sensitivity categories: Low-Medium, Medium-High and High-Very-High.