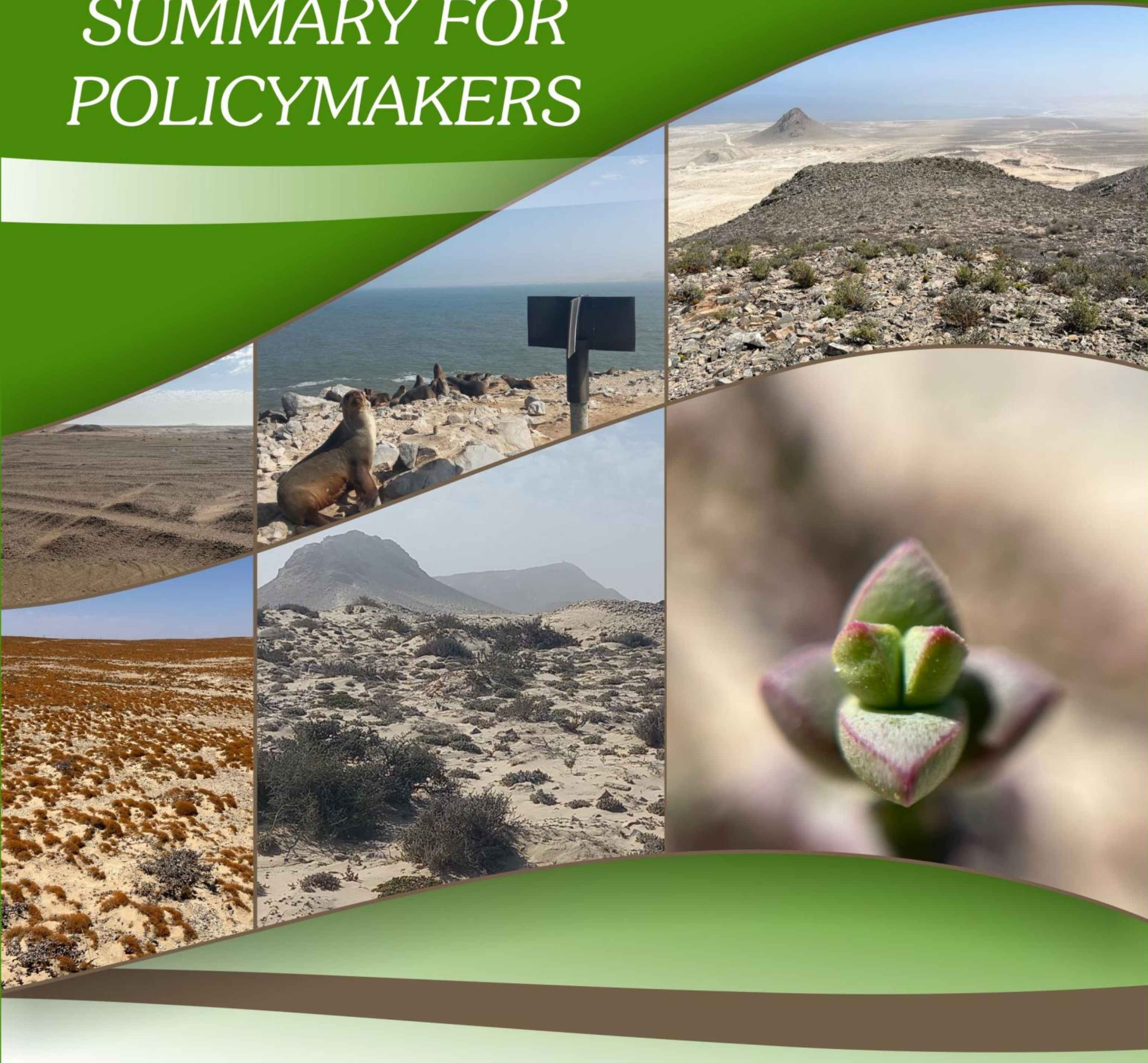
Work Package 2:
Strategic Environmental Assessment for the proposed Boegoebaai Port, Special Economic Zone and Namakwa Region

March 2026

SUMMARY FOR POLICYMAKERS



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** Note that the contents of the Work Package 1 and Work Package 2 reports produced as part of this SEA process do not necessarily reflect the views of the Working Group members, either in their individual capacities or as representatives of their respective institutions.*

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List of acronyms and abbreviations

CBA	Critical Biodiversity Area
CPA	Community Property Association
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
DFFE	Department of Forestry, Fisheries and the Environment
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EN	Endangered
EWR	Ecological Water Requirement
FPIC	Free, Prior and Informed Consent
GH_2	Green Hydrogen
GW	Gigawatts
Ha	Hectares
IDPs	Integrated Development Plans
KBA	Key Biodiversity Area
NCEDA	Northern Cape Economic Development, Trade and Investment Promotion Agency
NCGHM	Northern Cape Green Hydrogen Masterplan
PDIA	Problem-Driven Iterative Adaptation
PV	Photovoltaic
RQO	Resource Quality Objectives
SANEDI	South African National Energy Development Institute
SCC	Species of Conservation Concern
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SPM	Summary for Policymakers
PtX	Power-to-X
TPC	Thresholds of Potential Concern
TNPA	Transnet National Ports Authority
WP1	Work Package 1
WP2	Work Package 2

1. THE ORIGIN, SCOPE, PURPOSE AND METHODS OF THIS ASSESSMENT

Green[1] hydrogen (GH_2), and its derivative Power-to-X (PtX) products, such as green ammonia and green methanol, could assist South Africa's transition to a low-carbon economy by decarbonising hard-to-abate sectors and catalysing regional development.

The Northern Cape Green Hydrogen Masterplan (NCGHM, 2023) proposes that the Northern Cape is well positioned to lead this transition, given its' globally competitive solar and wind resources, large tracts of land, and a 300 km coastline where a deep-water port at Boegoebaai is being investigated. The province's ambition includes 5 gigawatts (GW) of electrolysers supported by 10 GW of renewables by 2033, scaling to 40 GW of electrolysers by 2050. The realisation of this ambition will require extensive infrastructure development across multiple municipalities and ecosystems, including energy generation sites, transmission corridors, desalination plant/s, and transport networks. These expansive developments could potentially intersect with sensitive ecological systems, heritage landscapes, and socio-economic dynamics across the Namakwa District.

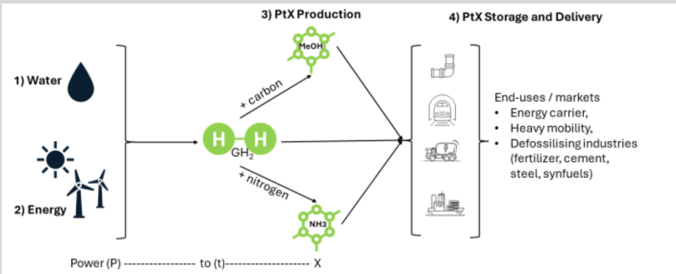
For this reason, a Strategic Environmental Assessment (SEA) was initiated through a collaboration between the South African National Energy Development Institute (SANEDI), the Northern Cape Economic Development, Trade and Investment Promotion Agency (NCEDA) and Transnet National Ports Authority (TNPA). The Council for Scientific and Industrial Research (CSIR) was appointed to lead and coordinate an independent SEA process, drawing on established expertise in SEA, renewable energy, port planning and GH_2.

Box SPM 1: What is Green Hydrogen (GH_2) and Power-to-X (PtX) products?

GH_2 is a form of hydrogen fuel produced via electrolysis (i.e., by splitting water into hydrogen and oxygen) using renewable energy sources (e.g., wind/solar). PtX is a broader concept that encompasses various technologies and processes (including GH_2) to convert electrical power, from renewable sources, into different forms of energy carriers, chemicals, or materials. This conversion enables the storage, transportation and use of hydrogen (Power-to-Hydrogen), synthetic fuels (Power-to-Liquid), and even chemicals (Power-to-Chemicals), broadening the scope of renewable energy applications, particularly crucial for industries and sectors where green electrification is challenging, such as heavy- duty transport, maritime shipping, and aviation ('hard-to- abate' sectors).

Infrastructure components and processes required to produce and deliver GH_2 and PtX products to potential end users:

1. **Water** (H_2O) source – desalinated seawater / wastewater produced for the purpose of GH_2/PtX production.
2. **Energy** source – electricity generation through wind / solar PV for the purpose of GH_2/PtX production, battery storage, transmission (Tx).
3. **GH_2/PtX production** – Electrolyser splits $H_2O \rightarrow H_2 + O$ to create GH_2. GH_2 can be stored and delivered or further synthesised into green *ammonia* (NH_3) with the addition of nitrogen, or to *methanol* (MeOH) with the addition of sustainably sourced carbon.
4. **GH_2/PtX Storage and Delivery** – storage tanks, trucks, railway, pipeline, and shipping to get the PtX products to market (for export or for use in local industries).



Key components in the GH_2 and PtX development process

[1]. There are many different definitions and perspectives on the concept of "green". Here, we use the term in the narrow sense, meaning a product developed where upstream production facilities are supplied by renewable energy sources.

This SEA considers a multi-component, phased programme of large-scale GH_2 and PtX development in the Northern Cape, comprising the proposed Boegoebaai Port, the Boegoebaai Special Economic Zone (SEZ), and regional renewable energy and linear infrastructure.

The Boegoebaai Port, in a proposed area of approximately 2 187 hectares (ha), is proposed to be developed in phases.

The short-term phase (**Phase 1A**) includes:

- A two-berth jetty for dry bulk, liquid bulk and multi-purpose cargo, connected to land by an access trestle and sheltered from wave energy by a concrete armoured breakwater.
- Supporting infrastructure includes:
  - closed stockpiles and enclosed warehouses for manganese, lead and zinc;
  - ship loaders, enclosed conveyor systems, and pipelines linking to diesel and ammonia storage tanks;
  - a multi-purpose terminal for containerised and break-bulk cargo, a dig-out Admin Craft Basin, port administration and emergency services buildings;
  - on-site desalination (~1 ML/day) plant, separated stormwater systems, sewer treatment systems;
  - electrical and Information and Communication Technology networks, security systems; and
  - truck staging and access control facilities.

Early operations would rely on the R382 road, serving as the primary route for imports and exports. The projected export volumes by 2033 include ~5 million tonnes per annum (Mtpa) dry bulk (manganese), 1 Mtpa break bulk (lead and zinc), 1.4 Mtpa GH_2 derivatives and various agricultural products (0.2 Mtpa). Diesel imports are expected to reach ~ 1.3 Mtpa.

Phase 1B (2035–2050) plans include extending the breakwater, additional liquid bulk and multi-purpose berths, a container terminal, a ship repair yard, expanding stockpiles and enclosed warehouses, and supporting road-over-rail bridges, rail links and tippler facilities. The longer-term vision for the Boegoebaai port (Phase 1B) is designed for flexibility to accommodate future changes in commodities and operations; with continued export of Phase 1A commodities and the potential inclusion of other GH_2 derivatives such as methanol, naphtha and e-kerosene, with total projected export volumes expected to increase to 2.15 Mtpa from 2035 to 2050.

The proposed Boegoebaai SEZ area, encompassing ~33 500 ha (inclusive of the port precinct), plans to host GH_2/PtX production, manufacturing, logistics and agro-processing. The SEZ area is envisaged to include 10 zones (Figure SPM 1), proposed by policymakers, inclusive of the port area (**Zone 1**) and the conservancy area (**Zone 2**). The **Zone 3** footprint includes the proposed green ammonia facility with ~188 ML/day desalination, electrolysers, ammonia synthesis units, air separation, storage for hydrogen, oxygen and ammonia, and marine discharge of brine from desalinated seawater within acceptable limits. **Zones 4–6** form an Industrial Park including a 2.7 ML/day desalination plant and two SEZ access points. **Zones 7–9** replicate GH_2/ammonia production at future stages, while **Zone 10** provides inland tank-farm storage. Initial SEZ development includes a 5 GW electrolyser build-out by 2030 and related water, storage and pipeline infrastructure.

Box SPM 2: Conservancy Area and Irreplaceable Environmental Features in SEZ

The SEZ area plans to include a conservancy area that has been provisionally delineated based on initial conservation priorities such as the Boegoeberg koppies and seal colony on the Boegoebaai point. WP1 of the SEA provides further recommendations for conservation areas in the proposed SEZ area. A habitat unit known as Swartvygie Heuweltjie Strandveld, located just inland of Boegoebaai, has suffered extensive damage from mining over the past century. The only intact areas are protected by the Buchuberg twins and hardened roads, which prevent sand scour. It is crucial for any port and GH_2 projects to avoid these intact portions and the other priority biodiversity and cultural features, as they cannot be offset. There is also an interesting archaeological site at the proposed development – the Boegoebaai cave/lair.

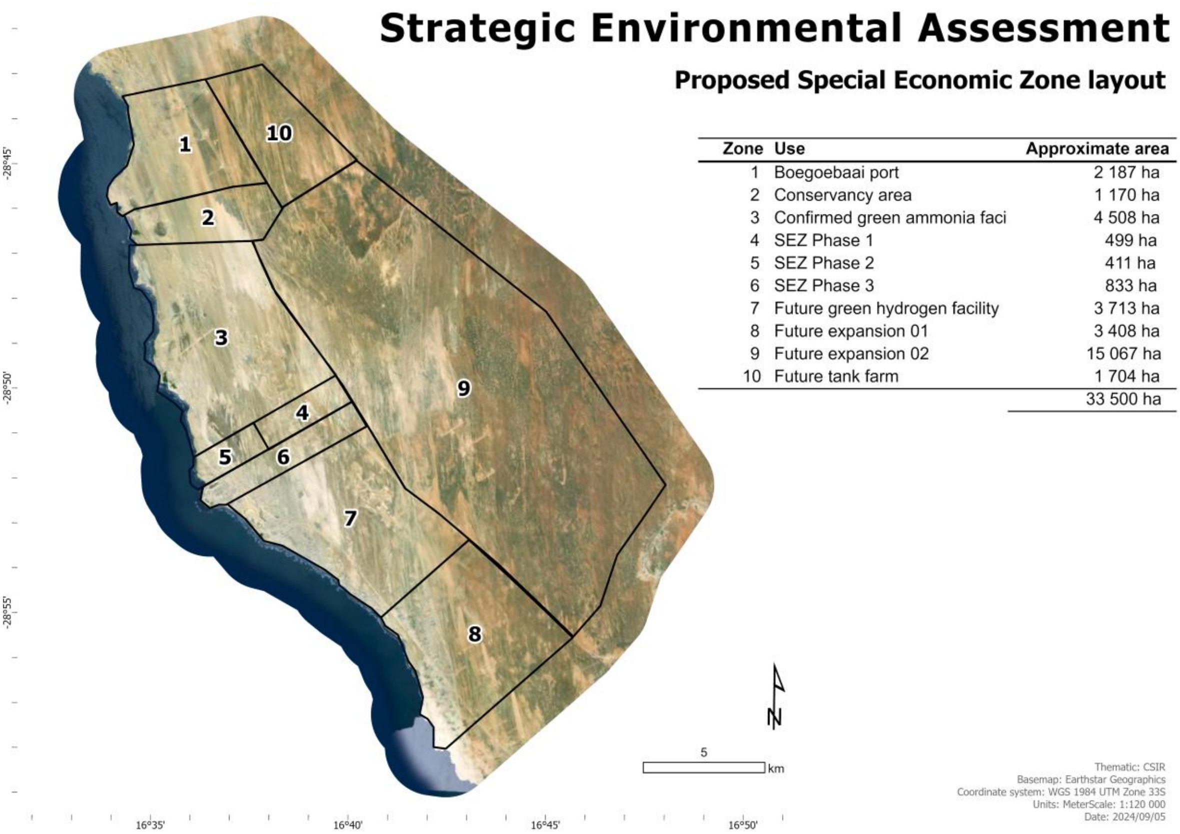


Figure SPM 1: The port footprint of the proposed Boegoebaai Port and phases of the proposed SEZ (Zones 1 – 10)

Beyond the SEZ, a dispersed renewable energy (RE) network [wind and solar photovoltaic (PV)] would be required to supply electricity to electrolysers, with projects located in reasonable proximity and far from Boegoebaai due to environmental sensitivity and corrosion risks. Electricity will be wheeled via new and existing transmission infrastructure, developed by Independent Power Producers (IPPs) and/or the National Transmission Company of South Africa. Linear infrastructure includes new transmission lines, dedicated hydrogen and ammonia pipelines (Boegoebaai<>Namibia, Boegoebaai<>Saldanha, and Boegoebaai<>Prieska), a new rail corridor proposed to connect Boegoebaai with Kenhardt, linking into the existing Saldanha–Sishen railway route, and new/upgraded roads to enable efficient transport of GH_2 derivatives, bulk commodities and RE components.

The purpose of the SEA is to guide strategic planning for the proposed infrastructure programme in and around Boegoebaai, as well as the broader Namakwa region of the Northern Cape. Readers must be reminded that the SEA is not a decision-making process in itself, in the same way that, for example, an Environmental Impact Assessment (EIA) is. The purpose of the SEA is to, in a transparent way, guide downstream planning and decision-making processes that may, or may not, occur over many years, if not several decades into the future. Integrating a variety of best practice science-policy processes, SEA should provide an evidence-based, cross-disciplinary perspective on the main opportunities and constraints associated with the proposed port, SEZ and network of regional RE generation facilities (wind and solar PV), electrical grid infrastructure, roads, pipelines and other GH_2 support infrastructure development. Given the multiscale scope of the SEA, its processes and outputs were split between two Work Packages (WPs) (**Error! Reference source not found.**): WP1 and WP2. Please note that only the findings from Work Package 2 are reported in this Summary for Policymakers (SPM) publication.

Table SPM 1: Summary of the SEA Work Packages across different spatial scales, methods, and data collection practices.

	Work Package 1	Work Package 2
Spatial scale	Local (33 500 ha) covering the extent of the proposed port and SEZ.	Regional (>5 million ha) across four Local Municipalities, including the 33 500 ha extent covered by Work Package 1.
Temporal scale	Introspective, fixed view on currently existing sensitivities in the receiving environments of the proposed port and SEZ.	Expansive, forward looking up to 2050 considering existing land-uses and trends in accumulation to any future regional GH2 infrastructure.
Methods	High resolution determination of receiving environment sensitivity with a view to practicing avoidance (top of the mitigation hierarchy).	Determination of the cumulative social and ecological impacts of a regional expansive GH_2 economy across development scenarios within a structured risk/opportunity framework.
Resolution	Fieldwork, coupled with desktop reviews (peer reviewed and grey literature) and other sources where necessary (e.g., interviews).	Desktop reviews (peer reviewed and grey literature, interviews etc.) and other publicly available data and sources.
Outputs	Local-scale feasibility and planning studies (especially for the new proposed port) and future decision-making processes, like EIAs and other local-scale planning exercises which may occur in the future.	Regional/national planning documents, through processes like Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs) and Environmental Management Frameworks (EMFs), national energy planning and any EIA processes that may be undertaken in the region.

1.1 Work Package 1

For context, WP1 focused on assessing the social and ecological sensitivities of the local-scale receiving environment around the proposed port and SEZ development, covering a spatial scale of approximately 33 500 ha. This was undertaken with the intention of informing local-scale feasibility and planning studies (particularly for the proposed port) and to guide future decision-making processes, including EIAs and other planning processes related to the port and SEZ. The social and ecological themes considered in the WP1 assessment include marine ecology, terrestrial and aquatic ecology, biodiversity offsets, heritage, sustainable port planning, and fisheries and coastal livelihoods impacts. WP1 SEA outputs were concluded in December 2025, available at: Individual Chapters | CSIR[2].

The WP1 assessment highlighted several important environmental and social constraints within the proposed port and SEZ footprint that are critical for informing strategic planning. These include the sensitivity of coastal and terrestrial ecosystems, the importance of breakwater positioning and port precinct and SEZ layout in avoiding high-value habitats, the need to prioritise already disturbed areas where feasible, and the potential implications for coastal livelihoods such as small-scale fisheries. These local-scale findings and recommendations (Box SPM 3) should be considered in conjunction with the broader regional findings and recommendations from WP2 when guiding planning and decision-making for port, SEZ and GH_2-related infrastructure development in the Namakwa region.

[2] https://www.csir.co.za/work-with-us/services-and-testing/environmental-management-services/individual-chapters

Box SPM 3: Key recommendations from WP 1

Recommendations - strategic planning:

1. Place the harbour breakwater so as to avoid sensitive Cape fur seal breeding colonies and rocky sea cliffs. The technical feasibility (e.g. regarding sea depth) of the harbour placement should of course be investigated and determined.
2. Place infrastructure in already disturbed areas, and avoid Very High and High sensitive areas – current estimates indicate that there could still be (more than) enough space to place infrastructure in already disturbed areas.
3. Manage shifting / wind-blown sands which present widespread ecological, social and engineering challenges.
4. Consider a strategic biodiversity offset framework, where specific areas, e.g. east of the R382, around the Holgat River and along the Orange River, are set aside as target areas for long-term conservation.
5. Commence environmental monitoring early, before development takes place, to enrich data in this isolated area.
6. Plan for a sustainable port, balancing economic growth, environmental protection and quality, and social development.
7. Establish and implement a comprehensive, transparent and ongoing consultation plan, from the earliest project planning and management phases. Aimed at fair consultation and negotiations (incl. "Free, Prior & Informed Consent (FPIC)" principles).

Recommendations – impact management

1. Prioritize diligent, proactive and best practice planning and EIA processes.
2. Avoid sensitive ecological and cultural areas, as identified in the SEA, and further confirmed through fine-scale investigation during project-specific EIA.
3. Consult with local communities, including fishers and herders, regarding areas and practices that are important to culture and livelihoods, as well as to establish mechanisms for coexistence.
4. Invest in local skills development.

1.2 Work Package 2

WP2 (the focus of this SPM) provides a more strategic, region-wide assessment of the cumulative social, economic, and ecological implications of an expansive GH_2 economy in the Northern Cape, extending beyond the localised footprint considered in WP1. The spatial scale of WP2 covers parts of the Namakwa District, delineated by the Richtersveld, Nama Khoi, Kamiesberg and Khâi Ma Local Municipalities.

The regional scope enables the identification and evaluation of systemic risks and opportunities that may not be apparent at the individual project level, providing a robust evidence base to support decision-making across multiple governance and planning frameworks. WP2 aims to guide local and regional planning, through processes like Spatial Development Frameworks (SDFs), Integrated Development Plans (IDPs) and Environmental Management Frameworks (EMFs), including any EIA processes that may be undertaken in the region. The strategic issues covered in WP2 include ecology, biodiversity and conservation planning (including biodiversity offsets), water resources and aquatic ecology, heritage, infrastructure and planning, and socio-economic impacts.

Box SPM 4: The contents of Work Package 2

WP2 represents a collaborative scientific effort, comprising of seven chapters developed by a team of thirty-four authors, peer-reviewed by thirteen independent experts. The content has also been enriched by contributions from a diversity of stakeholders engaged in the process via a formally constituted Working Group.

The WP2 chapters are as follows:

1. Introduction and context (Mqokeli et al., 2026)
2. Ecology, biodiversity and conservation planning (Desmet and Venter, 2026)
3. Biodiversity offset (Botha, 2026)
4. Water resources and aquatic ecology (Day et al., 2026)
5. Heritage (Orton et al., 2025)
6. Infrastructure and planning (Maritz et al., 2026)
7. Socio-economics (Atkinson et al., 2026)

1.2.1 Scenarios

A key gap in the current knowledge and decision-making base regarding GH_2 development in the Northern Cape is the absence of an integrated, cumulative, long-term understanding of what a medium- to large-scale GH_2 economy might entail. To address this, the WP2 SEA adopts an interdisciplinary, scenario-based assessment designed to explore both the scale and implications of GH_2 development in the region.

This scenarios assessment serves two main purposes:

1. To provide a concrete representation of what a large Northern Cape GH_2 economy could look like, in terms of the nature, scale, and spatial footprint of infrastructure and development.

2. To estimate the potential cumulative positive and negative impacts of GH_2 development and identify strategies to enhance benefits and mitigate adverse effects.

Two development scenarios are considered in the WP2 assessment, each compared to, and on top, the Scenario 0 dynamic baseline (i.e., where no GH_2 development occurs). The scenarios are summarized further below:

- **Scenario 0 (Dynamic Baseline, 2023–2050)**: **No GH_2, no port, no SEZ**. Regional change continues via climate variability, ongoing development activities and proposals (**Error! Reference source not found.**), land-use pressures, biodiversity loss, water scarcity, municipal capacity and market dynamics. This reference case is used to assess additional effects in Scenarios 1–2.
- **Scenario 1 – "Small GH_2" (by 2030)**: **5 GW** electrolysis, **10 GW** renewables **(~60% solar/40% wind**), Phase 1A port functions, SEZ Phase 1 (including green ammonia), first linear pipeline/rail/powerline links.
- **Scenario 2 – "Big GH_2" (by 2050)**: **40 GW** electrolysis, **80 GW** renewables (**~60%/40% solar/wind**), expanded port (Phase 1B elements), SEZ replication zones, extended pipelines/rail/powerlines.

Scenario quantifications include estimated indicative footprints for electrolysers, GH_2/ammonia storage, desalination outputs (e.g., Sc1 ~ 35.7 ML/day for GH_2 production; Sc2 ~ 285.7 ML/day) and brine discharges, plus the lengths/servitudes of roads, rail, pipelines and powerlines.

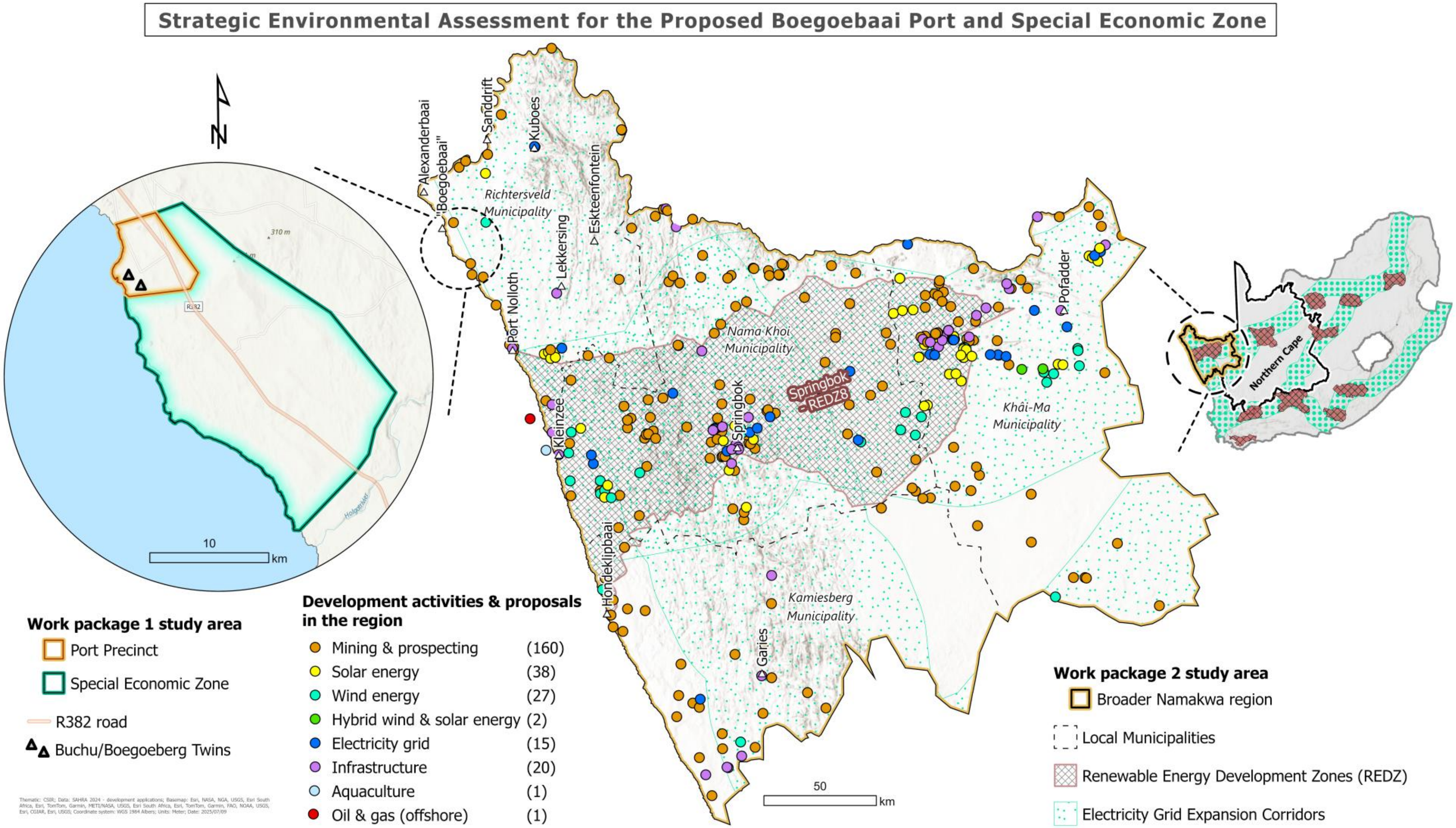


Figure SPM 2: The proposed Boegoebaai port and SEZ (WP1 study area) and Namakwa region study area (WP2 study area) in the Namakwa District of the Northern Cape Province. Economic activities include widespread mining and prospecting. A renewable energy sector is also emerging with established Renewable Energy Development Zones (REDZ) and Electricity Grid Infrastructure (EGI) Corridors. These ongoing and emerging development trends exist and continue regardless of new port, SEZ and GH2 development materialising, and forms part of Scenario 0 (Dynamic Baseline, 2023–2050) considered in the WP2 SEA.

1.3 Multi-author Team Model in the SEA

The SEA adopted a multi-author team[3] model to integrate specialist expertise for both Work Packages. The teams developed peer reviewed reports, with the WP1 teams focusing on identifying the key sensitivities and impacts associated with the port and SEZ development, and the Work Package teams undertook a broader, strategic assessment of cumulative risks and opportunities across the region. The writing teams collaborated closely throughout the SEA process to ensure comprehensive coverage of all salient issues across the two WPs. The findings from WP2 are summarised in Section 2 of this SPM, and the content has also been enriched by contributions from a diversity of stakeholders engaged in the process via a formally constituted Working Group (Box SPM 5).

1.4 Stakeholder Engagement

Stakeholder engagement is a central component of the SEA for the Boegoebaai Port, SEZ, and regional infrastructure development, and forms a core process element for both WP1 and WP2. It is being implemented through a structured, multi-channel participation programme that has included the dissemination of accessible information via the SEA website[4], local notices and posters, newspaper adverts, radio interviews, and formal Working Group meetings. Public meetings and multiple Working Group sessions have also been held to present and discuss the SEA process and emerging draft findings, including local public sessions across eight locations in the Richtersveld and surrounding areas for WP1, alongside the formal public review of the draft WP1 chapters. A similar approach has been undertaken for Work Package 2, comprising Working Group engagements to present and discuss the draft specialist findings and the currently underway formal public review period for the WP2 chapters (including the content of this SPM and associated chapters) supported by public meetings to be held in the affected municipalities within the Namakwa region.

Box SPM 5: The SEA Working Group

To ensure that the SEA process is informed by a broad spectrum of expertise and perspectives, an interdisciplinary Working Group has been established. This multi-sectoral team comprises experts drawn from national, provincial, and local government departments, state agencies, academic and research institutions, non-governmental and community-based organisations, as well as industry and the private sector. The Working Group serves two key functions:

1. Providing expert input throughout the SEA to ensure the assessment is informed by robust and context-specific knowledge; and
2. Acting as an information conduit, enabling two-way communication between members' constituencies and the SEA team, thereby supporting transparency, inclusive engagement, and consistent information sharing across sectors.

[3] A multi-author team, in the context of SEA refers to a structured, pluralistic authorship model designed to integrate diverse perspectives and expertise across an assessment process. For the Boegoebaai SEA, multi-author teams were constituted through a consultative process with the Working Group (which included representatives from government, academia, NGOs, and other stakeholders) to nominate researchers who possess the required niche knowledge of this remote region, along with an understanding of strategic infrastructure impacts, academic credibility, and expertise in high-level strategic assessments.

[4] https://www.csir.co.za/work-with-us/services-and-testing/environmental-management-services/strategic-environmental-assessment/boegoebaai-port

2. KEY FINDINGS FROM WORK PACKAGE 2

The following sections synthesise the key findings from the independent, peer reviewed specialist chapters of WP2, highlighting the regional-scale overview, sensitivities of the receiving environment (Table SPM 2, Figure SPM 7), risks and opportunities in relation to a potential future GH_2 economy.

Table SPM 2: Calibration of sensitivity categories for receiving environments across the study area.

Category	Description
VERY HIGH	Highly vulnerable to disturbance with little/no capacity for recovery. Includes endangered species, critical habitats, heritage/social resources, or ecosystems with very narrow tolerances for change.
HIGH	Sensitive to ecological and social change but with better recovery potential. Lower concentrations of endangered species, critical habitats, heritage resources, or ecosystems with some tolerance for change.
MODERATE	Some resilience to stress or change. Systems can absorb moderate impacts without long-term harm, or irreversible loss. Includes adaptable species, less valuable social/cultural resources and moderately sensitive habitats.
LOW	Likely already severely degraded by past disturbance, or higher adaptive resilience and low vulnerability. Includes widespread social resources, ecosystems or species with broad ecological niches and high regenerative capacity.

2.1 The Sensitivity of the Receiving Environment

2.1.1 Regional Ecology (after Desmet and Venter, 2026)

The Namakwa region is internationally recognised as a global biodiversity hotspot and represents a priority focus area for biodiversity conservation. It encompasses five of South Africa's biomes (Box SPM 6), dominated by the Succulent Karoo and Nama Karoo, and smaller extents of the Desert, Fynbos and Azonal biomes also present. The central and western parts of the study area form part of the Succulent Karoo biome of the Richtersveld, Namaqualand, the world's most species-rich arid region, with exceptionally high levels of plant endemism and diversity.

> **Box SPM 6: What Are Biomes?**
>
> Biomes are broad ecological units characterised by specific climate conditions, vegetation types, and associated fauna. South Africa comprises of nine major biomes, including Grasslands, Fynbos, Savanna, Nama Karoo, Succulent Karoo, Desert, Albany Thicket, Indian Ocean Coastal Belt, and Forests, and a tenth group of Azonal vegetation (vegetation that crosses climatic and geographic boundaries). Biomes are defined based on the plants and animals that inhabit that area, influenced by factors such as climate (temperature and precipitation), soil type and topography.

Across the Namakwa Region, biodiversity and ecosystems are already under pressure from a combination of drivers, including, but not limited to, widespread livestock grazing, historic and current mining activity, the anticipated growth of mineral sands extraction, and the rapid rollout of solar and wind energy (and associated linear infrastructure) to meet the current and future energy demands. Poaching of biodiversity is considered the most important threat currently facing biodiversity in the region, contributing to real-time population declines in species of conservation concern, including rare and endemic species. These pressures have resulted, or may result, in the degradation and loss of the natural environments, with implications for the region's ability to achieve sustainable development. Assessing the impacts of proposed developments therefore requires an understanding of the current state of biodiversity, the key anthropogenic pressures influencing ecological trends, and the ways in which new developments may interact with or exacerbate these pressures.

Overlaying these pressures is climate change, which emerges as the most significant (short-, medium- and long-term) threat to biodiversity in the region. Long-term vegetation productivity trend analyses show widespread "browning" of vegetation across much of the region, particularly in the Richtersveld. Based on these trends, approximately 62-65% of the 71 vegetation types in the region now qualify as threatened ecosystems under Red List of Ecosystems criteria, underscoring the urgency of proactive conservation planning (Box SPM 7).

Box SPM 7: Climate Change, Grazing Pressure and Vegetation Resilience in Namaqualand

Vegetation trends across Namaqualand show clear climate-driven declines, especially in the northwest, but different ecosystems respond differently depending on their underlying ecological characteristics. The vegetation analysis also reveals that land use, particularly livestock grazing, strongly intensifies these climate impacts, while lightly grazed protected areas remain more stable. Managing grazing pressure is therefore considered one of the most effective climate-adaptation actions available, and expanding well-managed protected areas will be essential for strengthening ecosystem resilience across the region.

Fewer than one-third (28%) of the region's ecosystems are considered well protected, while two-thirds (66%) are poorly or not protected at all. At the same time, more than 70% of the region has already been identified in protected area expansion strategies, reflecting its national significance for achieving South Africa's 30×30 conservation targets[5]. This further highlights the need for any large-scale development in the region, including GH_2-related infrastructure, to be carefully aligned with biodiversity priorities to avoid undermining long-term conservation objectives.

The avifaunal (birds) assessment identifies extensive VERY HIGH and HIGH avifaunal sensitivity zones across the Namakwa Region, particularly in relation to wind farm related impacts. These risk patterns are driven by (i) irreplaceable habitats in and around Key Biodiversity Areas (KBAs) (Box SPM 8) and protected areas, and (ii) the presence of 44 priority[6] bird species, including threatened, endemic and range-restricted species. Avifaunal sensitivity classifications **(LOW, MEDIUM, HIGH, VERY HIGH)** across the region are informed by a combination of conservation weighting (i.e., Red List Status, endemism, range size), habitat suitability, and susceptibility to four primary avifaunal impact pathways relevant to a GH_2-related development footprints: disturbance-driven displacement, habitat loss/fragmentation, collisions with wind turbines and powerlines, and electrocutions on electrical infrastructure.

Box SPM 8: What Are Key Biodiversity Areas (KBAs)?

KBAs are 'sites that contribute significantly to the global persistence of biodiversity', which means they are the most important places in the world for species and their habitats – whether these be in terrestrial, freshwater, estuarine, or marine ecosystems. Sites qualify as global KBAs if they meet the specific standardised criteria and quantitative thresholds focused on one or more of five trigger aspects: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability through quantitative analysis. The Namakwa Region comprises 15 KBAs (see Figure 3 of Chapter 2a – Avifauna).

[5] South Africa's 30×30 conservation target commits the country to effectively protecting at least 30% of its terrestrial, inland water, and coastal and marine areas by 2030, aligning with the Global Biodiversity Framework.

[6] Priority species were defined as species that are particularly sensitive to displacement due to disturbance and/or habitat loss, as well as risk of collisions and electrocutions; endemic and near-endemic species; all SCC; waterbirds; raptors; and range restricted species.

For bats, sensitivity zones are based on the relative importance of landscapes for bat roosting, foraging and conservation value. **VERY HIGH** sensitivity areas are effectively "no-go" at the strategic level, particularly for wind energy development, and are attributed primarily to open water sources and perennial rivers, wetlands, the coastline, protected areas and known bat roosts, all of which are important for bat activity by providing moisture, water, insect or fruit sources. Roosts are particularly important due the potential for large-scale impacts on bat populations. **HIGH** sensitivity zones are associated with limestone geology because of its potential to contain undiscovered cave systems (high roosting potential), and less substantial aquatic features. **MEDIUM** sensitivity is linked to non-perennial watercourses where seasonal moisture can elevate insect abundance and attract foraging bats. **LOW** sensitivity covers the remaining areas lacking these key features (i.e., with limited roosting and foraging potential), and is generally more compatible with development, subject to site confirmation at EIA stage. Two additional zones, namely Roost Investigation and Roost Caution zones (**Figure SPM 7e**), are identified around known bat roosts, representing areas that may be used extensively by bats and therefore require careful consideration, and where field verification becomes critical.

> **Box SPM 9: Importance of Bats in Ecosystems**
>
> Bats are an important component of biodiversity and provide key ecosystem services. Most South African bats are insectivorous and consume large quantities of insects, contributing to natural pest control. Other species play roles in pollination and seed dispersal, supporting vegetation regeneration and ecosystem functioning. Bats are also regarded as keystone species in cave ecosystems, where their guano supports specialised cave-dwelling organisms. In addition, bats can serve as ecological indicators of ecosystem health. However, bat populations are vulnerable to disturbance, habitat loss, and infrastructure such as wind turbines, and their low reproductive rates limit their ability to recover from large-scale impacts.

The faunal assessment maps the Namakwa Region into VERY HIGH, HIGH and MEDIUM sensitivity (with a gradient from coast to inland) based on the intersection of exceptional endemism, highly specialised habitat requirements, and intensifying development pressures typical of the Succulent Karoo biodiversity hotspot. **VERY HIGH** sensitivity is concentrated along the coastal dune belt and lower Orange River corridor, reflecting core habitats for narrowly endemic and Red-Listed fauna, particularly dune-dependent mammals and fossorial amphibians, including De Winton's Golden Mole (CR), Grant's Golden Mole (VU), Namaqua Dune Mole-rat (uplisted to EN), Desert Rain Frog (VU) and the micro-endemic Branch's Rain Frog[7]. Development in these areas is regarded as having a high probability of irreversible biodiversity loss and should be treated as "no-go/strict avoidance" zones unless exceptional justification exists. **HIGH** sensitivity extends inland across Namaqualand Hardeveld, succulent shrublands and rocky inselbergs where irreplaceable microhabitats (koppies/outcrops) and key ecological processes occur, driven by species such as the Speckled Padloper (EN), range-restricted girdled lizards, and amphibians associated with ephemeral pools and drainage lines, alongside pollination and soil-engineering processes. **MEDIUM** sensitivity covers broader inland plains that still support significant faunal diversity but are dominated by more disturbance-tolerant species assemblages; development may be feasible here subject to careful siting, maintenance of corridors, and project-level verification.

[7] Known only from red sands near the Holgat River. Although the precise range remains unconfirmed, the species is strongly associated with the northern coastal duneveld also classified as Very High Sensitivity.

The integrated biodiversity sensitivity analysis (Box SPM 10)**, drawing on existing biodiversity planning informants and specific biodiversity sensitivities developed as part of the SEA, identifies extensive areas of HIGH to VERY HIGH sensitivity across the Namakwa region. VERY HIGH** sensitivity areas comprise protected areas and other irreplaceable biodiversity features that underpin biodiversity pattern, ecological processes and climate-refugia functions. These landscapes support rare, endemic, and threatened species, and have no ecologically equivalent alternatives. Development in these areas would pose significant and often irreversible risks or impacts to biodiversity, with limited scope for effective mitigation or offsetting. Accordingly, it is strongly recommended that these areas should be avoided and kept intact as anchors for connectivity and climate resilience.

Box SPM 10: How the Integrated Biodiversity Sensitivity Analysis Was Produced

The WP2 regional biodiversity sensitivity analysis integrates six biodiversity informant groups onto a four-categories sensitivity scale (LOW, MEDIUM, HIGH, VERY HIGH). These informants include: (1) biodiversity planning datasets [Critical Biodiversity Area (CBA) maps, expert-mapped priority areas, ecological corridors, and plant species locality records]; (2) protected area expansion priorities; and WP2 SEA specialist sensitivity layers for (3) birds, (4) bats, (5) terrestrial fauna, and (6) aquatic ecosystems. Each layer was standardised to the same sensitivity classes and combined using two approaches:

- a **maximum-of-inputs** approach reflecting the highest sensitivity score present at a site; and
- a **cumulation-of-inputs** synthesis reflecting how many inputs identify a location as sensitive, producing a more finely resolved map of cumulative biodiversity sensitivity.

The resulting integrated map provides a strategic, regional-scale screening tool to highlight where biodiversity constraints are likely and where planning flexibility is greater. It does not replace site-level specialist studies or project-specific EIAs.

HIGH sensitivity areas are essential to meeting conservation targets and maintaining key ecological processes across the landscape. Development in these areas is generally undesirable and should be avoided wherever feasible. Where impacts are demonstrably unavoidable, following the full application of the mitigation hierarchy, only strictly controlled, like-for-like biodiversity offsets may be considered. Such offsets should be directed to ecologically equivalent sites within the same planning domain, with the explicit recognition that certain biodiversity features are not fully offsetable and that residual ecological risk may remain significant. **MEDIUM** sensitivity areas support ecological functionality and local-scale connectivity, including seasonal movement pathways and ecological buffer zones that help maintain the resilience of adjacent **HIGH** and **VERY HIGH** sensitivity landscapes. While these landscapes may accommodate some development, impacts remain possible and development proposals must be carefully sited and designed to maintain ecological flows, movement routes and key microhabitats, applying robust baseline screening, the mitigation hierarchy and best-practice construction and operational controls. **LOW** sensitivity areas occur predominantly in more homogeneous parts of the landscape where biodiversity features are less concentrated, ecosystem threat status is lower, and fewer spatial priorities overlap. These areas often include more resilient vegetation types or previously disturbed land, presenting comparatively lower conservation constraints and are therefore the preferred focus for directing new infrastructure, subject to confirmatory screening and good practice.

Overall, the integrated maximum inputs sensitivity analysis shows that at least 70% of the Namakwa Region is characterised by HIGH to VERY HIGH biodiversity sensitivity. This reflects its status as a global biodiversity hotspot, where ecologically important features are widespread and rarely absent. At the same time, the cumulative-inputs view reveals that only about 11.5% of the region is Very High sensitivity for three or more biodiversity inputs, indicating limited spatial overlap among taxa and ecological drivers. This means that while most of the landscape contains some form of biodiversity constraint, only a relatively small proportion contains multiple, co-occurring high-value sensitivities. From a development-planning perspective, this distinction is important, as areas classified as **VERY HIGH** for only one input may offer comparatively greater flexibility, subject to site-level assessment, than areas where several biodiversity priorities converge, and where the scope for acceptable impact or effective mitigation is substantially lower.

2.1.2 Water Resources and Aquatic Ecology (after Day et al., 2026)

The Namakwa Region is an extremely water-limited landscape, defined by Hyper-Arid or Arid conditions, very low rainfall (60-215 mm/annum), high evaporation rates and a high dependence on groundwater. Surface water resources are very limited and mostly comprise ephemeral streams and sporadic runoff events, with the Orange River being the only perennial surface water source in the area. Other rivers are seasonal to ephemeral[8], and although wetlands and pans occur in places, surface water remains spatially and temporally sparse.

Box SPM 11: Strategic Water Source Areas (SWSAs)

Strategic Water Source Areas (SWSAs) are defined as areas of land that either: (1) supply a disproportionately large quantity of mean annual surface water runoff in relation to their size and are therefore, considered nationally important; or (2) have high groundwater recharge and where groundwater forms a nationally important resource; or (3) areas that meet both criteria (1) and (2). SWSA aquifers sustain baseflow, contribute to runoff and, especially, contribute to dry season flows.

Groundwater recharge is generally low and water quality is relatively poor[9]. Groundwater occurs in sandy/alluvial aquifers, weathered zones (regolith), and fractured crystalline bedrock, which are hydraulically interconnected. However, the granite and gneissic bedrock has low primary porosity, with groundwater stored and transmitted mainly through fractures, resulting in generally low and variable hydraulic conductivities. Given the high reliance of communities on groundwater, several Groundwater Resource Units (GRUs)[10] have been identified as intermediate and high priority, and three identified Strategic Water Source Areas (Box SPM 11) (**Port Nolloth**, **Kommagas** and **Kamiesberg**) have been further classified as areas of **VERY HIGH** sensitivity (Figure SPM 3).

[8] Ephemeral rivers flow only after rainfall events and remain dry for most of the year, making them highly sensitive to disturbance and changes in hydrology.
[9] Groundwater recharge is generally 0.1–10 mm/a; electrical conductivity ranges from 70 to >1 000 mS/m.
[10] Most of the GRUs have been delineated in the Lower Orange WMA. A GRU, classified as a groundwater body that has been delineated or grouped into a single significant water resource, is based on one or more characteristics that are similar across that unit.

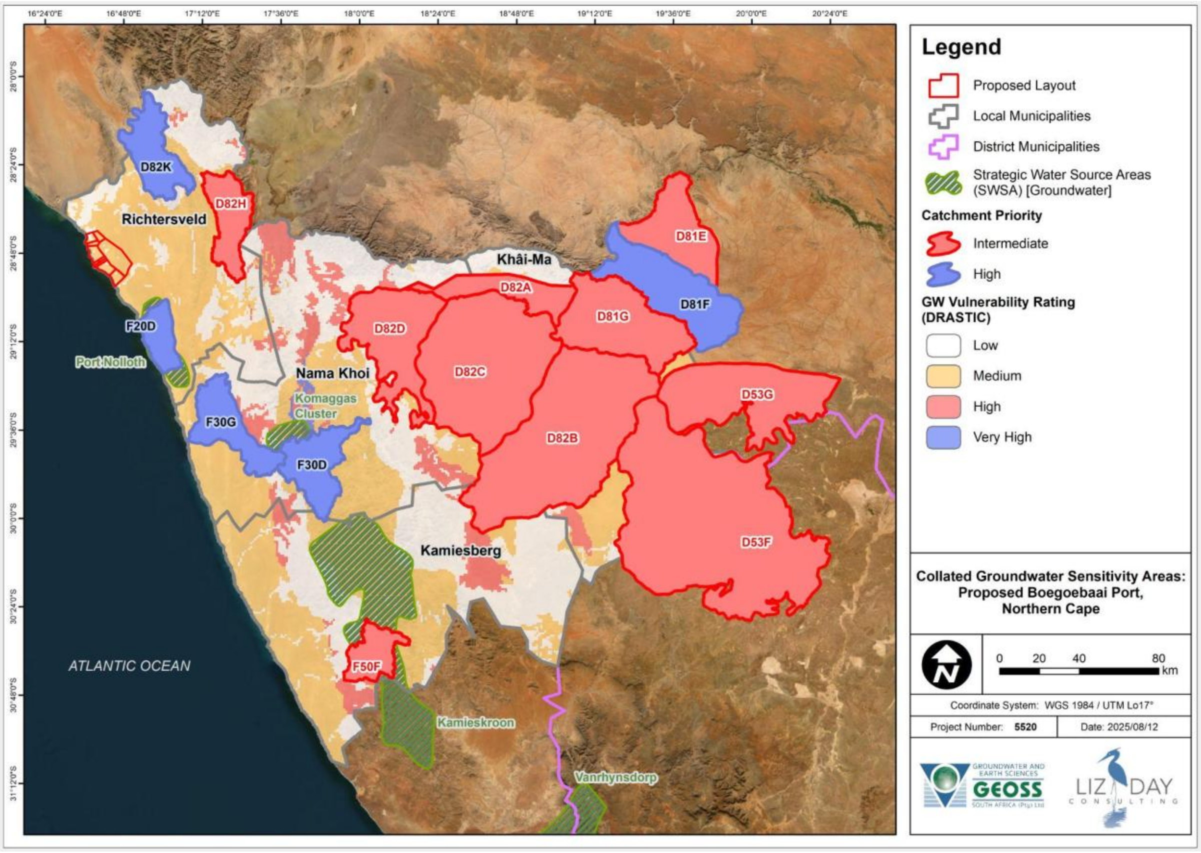


Figure SPM 3: Intermediate and high priority Groundwater Resource Units (GRUs) in the greater Namakwa Region, Northern Cape

Surface water resources in the interior are limited, with runoff occurring less than 10% of the time with long dry periods between events. The Orange River system yields less than its design demand, and approximately 18% of the study area is likely to change from Arid to Hyper-Arid in the near future[11]. Proposed new and expanded abstraction and reticulation systems are considered **EXTREMELY sensitive** to poor management and maintenance, as they represent the only viable water supply for much of the region. In addition, the very low frequency of runoff events and the long dry periods render rivers and floodplains highly sensitive, with limited ability to recover from disturbance for several decades, if at all.

Aquatic ecosystems in the region, including ephemeral rivers, pans, seasonal and perennial wetlands, are of high ecological importance but extremely sensitive to changes in hydroperiod, physical disturbance, water quality degradation, and fragmentation. Many of these inland aquatic ecosystems are classified as **Critically Endangered**[12] or **Endangered**[13]**,** and even subtle changes in hydrology (such as shorter inundation periods or nutrient enrichment from malfunctioning WWTWs) could cause irreversible ecological loss, especially for the specialised invertebrate communities adapted to transient water conditions. Wetlands are limited, although some areas such as Kamiesberg area contain important seasonal and perennial wetlands. Pans are the most common aquatic ecosystem type, with many of these pans classified as **Critically Endangered** or **Endangered** depending on their bioregion.

The Orange River Estuary, an internationally recognised Ramsar site, is the largest and most ecologically important estuary in the region. In addition, the study area includes four smaller Cool Temperate Arid Predominantly Closed (CTAPC) estuaries, the Buffels, Swartlintjies, Spoeg and Groen estuaries. Most rivers are in **good ecological condition** [Present Ecological State (PES) Categories B/C][14] except the Kwaganap, Bitter and parts of the Groen River. The Orange River Estuary and the four CTAPC estuaries in the study area are all rated as **Endangered** systems, of **high conservation priority.**

[11] Approximately 18% of the study area is projected to shift from Arid to Hyper-Arid conditions.
[12] Ecosystem at **extremely high** risk of extinction or collapse.
[13] Ecosystem at **very high** risk of collapse.
[14] Rivers in good ecological condition.

From a water demand perspective, and the potential for pollution of existing water supplies, existing water and wastewater treatment works (WWTW) and distribution infrastructure are noted as generally underperforming and in need of urgent upgrades. The Department of Water and Sanitation (DWS) information indicates that the District Municipality is already under significant water supply pressure, and any additional demand could significantly worsen pressures on water services.

Across groundwater, surface water, and aquatic ecosystems, the sensitivity mapping reveals extensive areas of **VERY HIGH** and **HIGH** Sensitivity, where development could lead to irreversible degradation.

2.1.3 Heritage Resources (after Orton et al., 2026)

Palaeontological[15] **sensitivity** is **ZERO** or **LOW** for most of the area, with **MODERATE** sensitivity in the east and **HIGH** sensitivity in the mountains northwest of Springbok and in the southeast part of the study area. In general, the surficial sediments of the coastal plain are of **LOW** sensitivity with more highly significant deposits present at depth close to the coast and below 100 m above sea level.

> **Box SPM 12: Heritage Resources Legislative Context**
>
> The National Heritage Resources Act (NHRA) (Act 25 of 1999) protects a wide range of heritage resources, including archaeological and palaeontological material, graves, cultural landscapes, and living heritage - requiring their consideration in all development planning. Under Section 38 of the NHRA, most GH_2-related infrastructure will trigger a Heritage Impact Assessment, as linear developments longer than 300 m and disturbances exceeding 5,000 m^2 fall within statutory thresholds. This means early heritage screening, avoidance planning, and engagement with heritage authorities are essential for compliant and responsible development in the region.

The region contains archaeological resources spanning Early, Middle and Later Stone Ages, with the coastline identified as an area of HIGH archaeological sensitivity due to the high density of sites. Terrestrial archaeological resources include Early Stone Age (ESA) material beneath the surface aeolian sands along the coastal plain and among the gravels of Bushmanland; Middle Stone Age (MSA) material recorded both along the coastline and in rare inland rock shelters such as Spitzkloof and in the basal layers of Wolfkraal cave and Keurbos Cave in the Kamiesberg; and abundant Later Stone Age (LSA) sites, occurring both along the coast and inland around deflation hollows in dunefields, rocky hills and pans in Bushmanland. Rock paintings are rare; with geometric rock engravings occurring along the Orange River. Historical archaeological remains, including those relating to the Anglo-Boer War, are found around old farmhouses, permanent or temporary settlement, copper mining areas, and prospecting locations.

Pre-colonial graves, while rare and highly localised, are automatically of VERY HIGH heritage sensitivity when encountered. Pre-colonial graves may be encountered across the study area and are more commonly associated with coastal dune contexts and areas of historically higher population density. Several graves are present in the region, including three known graves at the western foot of Boegoeberg South (refer to WP1). Most pre-colonial graves are unmarked and cannot be identified until disturbed, although rare stone-packed graves occur and are likely to represent very late/historical graves. While graves have high local cultural significance (Grade IIIA) and are automatically of **VERY HIGH** sensitivity when encountered, recorded occurrences in Namaqualand and Bushmanland are rare, highly localised, and generally unmarked, making spatial sensitivity mapping impractical.

Maritime heritage sensitivity is assessed as generally LOW along most of the coastline, with localised MEDIUM sensitivity zones associated with recorded and potential shipwrecks. MEDIUM sensitivity zones occur at locations referenced in shipwreck records, where one pre-1965 wreck is highly likely and several others may also be present offshore near the proposed SEZ study area between Port Nolloth and Alexander Bay.

[15] Palaeontological refers to fossilised remains of ancient plants, animals and other organisms preserved in the geological record. These remains are considered heritage resources under the NHRA due to their scientific, cultural, and historical significance.

Living heritage is identified as HIGH sensitivity in the communal areas of Richtersveld, Leliefontein, Steinkopf, Komaggas, Concordia and Pella, where transhumance traditions and seasonal grazing continue.

The region has HIGH cultural landscape and scenic sensitivity sensitivity, anchored by internationally and nationally significant heritage landscapes and iconic scenic routes. From a cultural landscape and/or sense of place perspective, the area consists of four distinct physiographic components, namely the coastline, coastal plain, granite mountains of the Kamiesberg, and the inland plains of Bushmanland. The Namaqualand Copper Mining Landscape forms part of the regional cultural landscape, with high significance. Important topographic features identified are the Boegoeberg Twins near Alexander Bay, the granite mountains around Springbok, Okiep and Concordia, Sneeukop overlooking Kamieskroon and Gamsberg near Aggeneys, which all have historical significance. The Richtersveld Cultural and Botanical Landscape (RCBL) World Heritage Site (WHS) (Box SPM 13) and its buffer zone, several National Parks and other reserves, the coastline, the Kamiesberg mountains, and the main regional routes (N7, N14, R382) are all identified as areas of HIGH sensitivity for their aesthethic value. The N7, N14 and R382 are identified as scenic routes as they provide access to the RCBL WHS, the Richtersveld National Park, the Orange River and Namibia. The region's landscape value is further enhanced during the spring flowering season, when many smaller western roads attract both local and international visitors seeking the iconic Namaqualand flower displays.

> **Box SPM 13: Significance of the Richtersveld Cultural and Botanical Landscape (RCBL)**
>
> The most significant aspect of the cultural landscape in the Namakwa Region is the **RCBL World Heritage Site**, located in the north-western part of the study area. The description of the RCBL is as follows (UNESCO 2024):
> *The 160,000 ha Richtersveld Cultural and Botanical Landscape sustains the semi-nomadic pastoral livelihood of the Nama people, reflecting seasonal patterns that may have persisted for as much as two millennia in southern Africa. It is the only area where the Nama still construct portable rush-mat houses (haru om) and includes seasonal migrations and grazing grounds, together with stock posts. The pastoralists collect medicinal and other plants and have a strong oral tradition associated with different places and attributes of the landscape.*

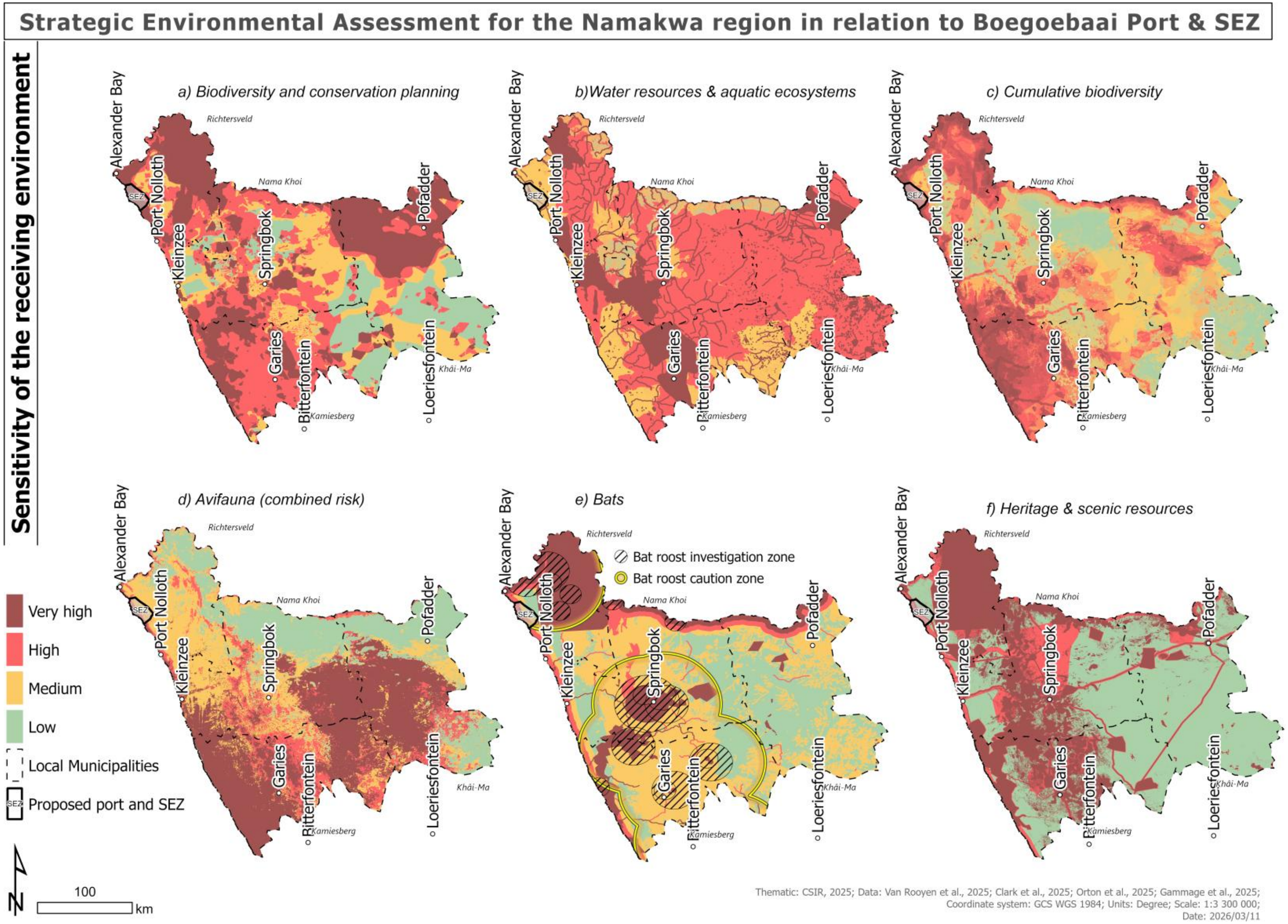


Figure SPM 4: Sensitivity of the receiving environment across the Namakwa Region study area (WP2) for the respective specialist themes – (a) biodiversity and coservation planning, (b) water resources and aquatic ecology, (c) cumulative biodiversity, (d) avifauna, (e) bats, and (f) heritage resources. Finer scale sensitivity mapping for the proposed port and SEZ was completed as part of WP1 of the SEA.

2.1.4 Socio-economics (after Atkinson et al., 2026)

The Namakwa Region presents a highly sensitive receiving environment, characterised by an arid climate, high ecological and cultural value, dispersed rural settlements, and structurally vulnerable socio-economic profile. The district is one of South Africa's largest geographically but least densely populated, with very low settlement density (~ 1 person/km^2), long travel distances, and small, isolated towns whose economies have historically depended on mining, pastoralism, and, increasingly, tourism. These conditions create an environment with limited institutional and economic capacity to absorb and adapt to rapid, large-scale industrial development.

From a socio-economic perspective, the region continues to experience high unemployment[16], low household incomes[17], and persistent youth unemployment, alongside long-term out-migration of skilled and economically active residents. Although poverty indicators have improved over time, a substantial proportion of households remain indigent and reliant on social grants and informal income sources. Population change has been accompanied by increasing urbanisation, with rural settlements declining and population and service demand concentrating in the Springbok, Okiep and Nababeep cluster, with Port Nolloth functioning as a key secondary node. Longer-term growth trends are also evident in Springbok, Port Nolloth, Pofadder and Garies, resulting in growing administrative and service pressure in these town despite limited infrastructure capacity.

Municipal baseline conditions reflect significant infrastructure and governance stress. Water supply systems are unreliable and costly to operate; sanitation backlogs persist; road infrastructure is deteriorating; and municipal capacity for financial management, spatial planning, land-use management and disaster preparedness remains limited. The Richtersveld Local Municipality, where the proposed port and GH_2-related development would be concentrated, faces constraints, including water supply challenges, a housing backlog of about 160 units, shortages of technical staff, and recurring audit and financial governance concerns. These institutional weaknesses substantially heighten sensitivity to rapid population in-migration and expanding service demands.

> **Box SPM 14: Mining Legacy, Employment Patterns and Sensitivity in the Namakwa Region**
>
> Mining has profoundly shaped the socio-economic trajectory of the Namakwa Region, leaving a complex legacy that continues to influence community wellbeing, land use, and local economic resilience. The decline and closure of major diamond operations at Alexander Bay and Kleinzee have contributed to long-term unemployment, town deterioration, and municipal management challenges, with illegal mining emerging as an associated risk factor in the affected areas.
>
> Over time, mining's contraction has reshaped regional employment patterns, with the economic structure shifting away from extraction and toward government services, trade/catering/accommodation (including tourism) and agriculture. However, the region's labour market remains constrained by low incomes, limited technical skills, and long-term out-migration of working-age people seeking opportunities in cities. Mining history can create long-lasting regional "path dependencies" that are difficult to re-orient toward new investment pathways, and reliance on narrow commodity profiles can leave local economies exposed to economic cycles and exogenous "shocks", with potentially severe knock-on employment effects.
>
> The proposed Boegoebaai Port, SEZ and GH_2 programme is considered to have the potential to generate substantial construction-phase employment, but the region remains sensitive to rapid economic change. Without careful planning and governance, in-migration linked to construction activity and uneven distribution of benefits could intensify social pressures, exacerbate inequality and place additional strain on local services and institutions.

[16] In 2022, Namakwa District had just under 35 000 people in employment, while more than 13 500 residents were unemployed and actively seeking work. This figure also includes unemployed people in the Hantam and Karoo-Hoogland local municipalities, many of whom could be drawn to potential employment opportunities associated with the proposed Boegoebaai Port and GH_2 development.

[17] The monthly income levels in Namakwa District are extremely low: average household incomes in Kamiesberg (R378.00), Khai-Ma (R420.00), Richtersveld (R528.00) and Nama Khoi (R2 239.00) – which is significantly higher than these towns.

Land ownership in the area, particularly in the Boegoebaai/Richtersveld area, constitutes a further critical sensitivity. Land associated with the proposed Boegoebaai development falls under the ownership of the Richtersveld Communal Property Association (CPA) following the 2007 restitution settlement (Box SPM 15).

> **Box SPM 15: The Richtersveld land restitution settlement**
>
> The Richtersveld Community lodged a land restitution claim in 1998 against the diamond mining company Alexkor, including compensation for diamonds extracted since the 1920s. The claim culminated in South Africa's largest land restitution settlement, confirmed by the Land Claims Court in 2007. The settlement entailed the return of approximately 194 600 ha of land, including about 84 000 ha of diamond-bearing coastal land, agricultural areas and the town of Alexander Bay, to the Richtersveld community. The land is held collectively through the Richtersveld Communal Property Association (CPA), which serves as the legal custodian of restitution land.

Governance within the CPA is fragile, characterised by internal contestation, administrative challenges and disputes over leadership, decision-making and benefit distribution. These challenges have, at times, constrained the outcomes of strategic development initiatives and eroded trust within the community. Given the CPA's legal authority over land access and approvals, unresolved governance issues pose a material risk to future development. Without targeted capacity-building, improved transparency and credible Free, Prior and Informed Consent (FPIC)-aligned engagement processes, CPA-related governance constraints could delay or complicate major investments and intensify social tensions.

Tourism is identified as the strongest growth sector in the Namakwa Region but is highly sensitive to congestion, noise, dust, heavy trucking, industrial viewshed impacts and changes to the sense of remoteness and "rustic" character that define the region's appeal. The region is increasingly recognised for its ecological, geological and cultural heritage values, contributing to its growing tourism appeal. Poorly managed logistics, settlement expansion and transport corridors therefore present a significant risk to one of the region's most resilient economic sectors.

Agriculture makes a proportionally larger contribution to the Namakwa District economy than at the national level[18], despite severe climatic constraints. Livestock farming remains a key livelihood activity with strong cultural and heritage significance for rural communities, while intensive irrigation along the Orange River supports high-value export crops, including table grapes, citrus fruits, raisins, dates and pecan nuts. These agricultural systems are, however, sensitive to water insecurity, land degradation and dust, and logistics impacts, reinforcing the region's overall socio-economic vulnerability.

2.1.5 Infrastructure and planning (after Maritz et al., 2026)

The Namakwa Region's planning environment is constrained, with few registered planners, limited geographic information system (GIS) capability, and planning documents that are often produced in terms of statutory compliance but exhibiting varying degrees of practical, innovative, or context-specific guidance. While most municipalities possess the required statutory planning instruments (including IDPs, SDFs and land-use schemes), capacity to proactively implement, update and align these instruments is limited, resulting in a largely reactive planning environment.

Settlement patterns are shaped by the region's aridity, limited water resources and economic opportunities, resulting in small, dispersed settlements with modest growth (typically under 2% per annum). Port Nolloth is the only settlement within the Richtersveld Municipality housing more than 5 000 residents, while clusters around Springbok and Steinkopf represent the other relatively larger settlements. Informal settlements occur, particularly on the peripheries of towns, driven by housing backlogs, slow urban expansion and limited availability of serviced stands.

[18] A contribution of about 10% of Gross District Product (GDP) compared to just under 3% of South Africa's GDP. In the Richtersveld Local Municipality, agriculture accounts for approximately 6% of the local economy, equivalent to around R96.8 billion in 2023 prices.

The region, particularly the settlements within it, currently face several infrastructure challenges. Municipal water and sanitation systems are highly stressed, with critical Blue Drop scores (below 31%[19] for three of the study area's local municipalities, with the exception of Nama Khoi at ~36%), aging pipelines, unreliable supply, and limited storage capacity (Box SPM 16). These systems remain functional largely because current demand is low, and they operate close to effective capacity limits.

> **Box SPM 16: What is the Blue Drop Certification Programme**
>
> By 2008, it became evident that many municipalities were not effectively managing, maintaining and operating their drinking water systems, resulting in poor water quality and sporadic water quality related disease outbreaks. Contributing factors included limited managerial and technical skills, aging and dilapidated infrastructure, rapid housing developments not aligned with infrastructure plans, and inadequate understanding of water purification processes. To address these challenges, the Department of Water and Sanitation introduced the Blue Drop Certification programme, which annually audits municipal water supply systems, including raw water pump stations and purification facilities, and scores their performance. The results are used to benchmark service delivery, identify municipalities at risk, and guide regulatory and support interventions, particularly for systems scoring below 30%, to improve compliance and ensure safe drinking water.

The road network represents a critical lifeline in this sparsely populated region. Several municipal roads require substantial repairs to meet acceptable standards. The R382 (between Steinkopf, Port Nolloth and Alexander Bay) has reached or exceeded its design life and requires upgrading, including over the Anenous Mountain pass. Gravel roads serving smaller settlements are often in poor condition and highly vulnerable to weather-related damage.

There is no existing rail infrastructure and no established gas or oil pipeline infrastructure in the region, resulting in an inherent reliance on road-based transport for freight and bulk materials. Electricity distribution is split between Eskom and local municipalities, with many municipalities operating at or above their Notified Maximum Demand thresholds. Electricity supply is constrained by a limited transmission grid making it difficult to evacuate power, including new renewable energy generation. Information and communication technology (ICT) coverage is also limited outside larger settlements, including the proposed port and SEZ site. These ICT constraints affect not only household connectivity, but also municipal coordination, regulatory oversight, infrastructure monitoring and emergency response capability.

Securing land or servitudes for regional infrastructure (including roads, transmission lines, pipeline or future rail corridors) is administratively complex, requiring coordinated engagement across multiple landowners, institutions and spheres of government. The southern part of the region is characterised by a larger degree of private land ownership, while the broader Richtersveld area consists largely of state land (58%) and CPA land (28%), with a smaller privately owned component (12%) (Figure SPM 5). Land tenure is fragmented, particularly in Richtersveld, where CPA, state, private and mining-related holdings interlock across extensive tracts. The Richtersveld CPA controls the land around Boegoebaai but faces internal governance disputes, while the municipality has historically been reluctant to assume full service responsibility for Alexander Bay due to ageing assets and compliance challenges within the legacy infrastructure network.

Municipal financial capacity represents an additional baseline sensitivity. Own-revenue bases are weak across the region, with municipalities heavily dependent on intergovernmental transfers to fund infrastructure and service delivery. Underspending and roll-overs of capital budgets reflect institutional and technical constraints rather than an absence of infrastructure need, limiting the ability of municipalities to proactively invest in bulk services or preventative maintenance.

Baseline disaster management and emergency response capacity is limited, particularly across remote settlements and long transport corridors. Long response times, limited staffing and constrained communication systems heighten sensitivity to road accidents, construction activities and the transport or handling of hazardous materials.

Taken together, the infrastructure and planning baseline reflects a system that remains functional largely because development demand has historically been low. Planning, infrastructure and service delivery systems operate with limited institutional capacity and constrained infrastructure systems, including ageing infrastructure, financial limitations and shortages of skilled personnel. Concurrent regional catalytic

[19] Scores below 31% are classified as being in a critical condition (Department Water and Sanitation, 2023).

projects are expected to place cumulative pressure on already constrained planning, infrastructure and institutional systems. **Collectively, these conditions indicate a highly sensitive receiving environment in which even moderate increases in development intensity could translate into disproportionate infrastructure, governance and service-delivery risks without early, coordinated and adequately resourced intervention.**

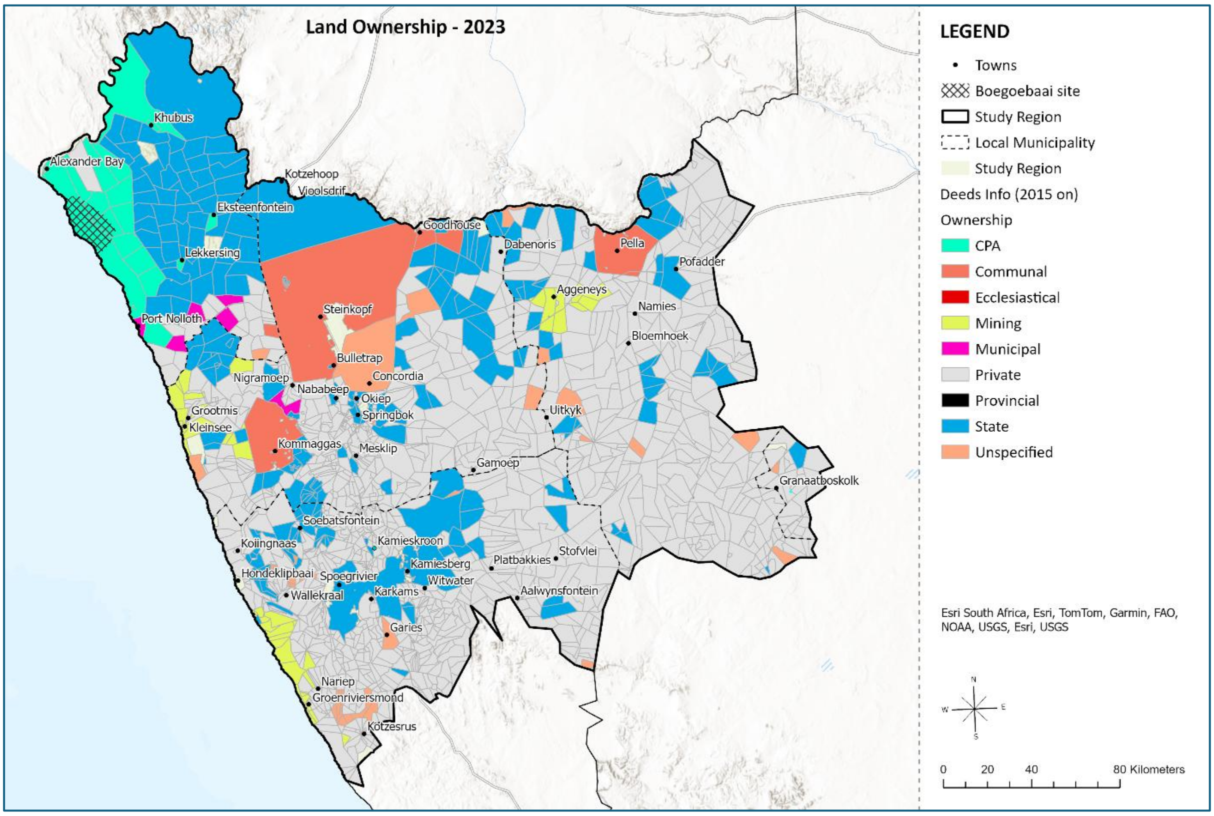


Figure SPM 5: Land ownership in the region based on the 2023 Richtersveld land audit and the Department of Rural Development and Land Reform landownership information (Source: Maritz, 2023)

2.2 Potential Impacts (positive and negative)

This section synthesises the potential negative and positive impacts associated with the three development scenarios [baseline (Sc0), small GH_2 development (Sc1), and large GH_2 development (Sc2)], in relation to the proposed Boegoebaai Port, SEZ and GH_2 development infrastructure components. The baseline scenario assumes that the planned GH_2 economy does not materialise and that current social, ecological, climatic and developmental trends continue.

Ecological and heritage related impacts are presented in Ecological and heritage impacts

Table SPM 3 (negative impacts) and Table SPM 4 (positive impacts) in Section 2.2.1, providing a consolidated, scenario-based comparison alongside recommended management actions. Socio-economic impacts and infrastructure and planning considerations are summarised narratively in Sections 2.2.2 and 2.2.3, respectively, reflecting their cross-cutting and system-level nature.

This integrated overview of specialist findings is intended to inform strategic planning and governance, subsequent project-level EIAs, guide the identification of areas and strategies to enhance positive outcomes and avoid or mitigate adverse effects, and highlight knowledge gaps requiring further fine-scale specialist investigation.

2.2.1 *Ecological and heritage impacts*

Table SPM 3: Consolidated summary of potential negative impacts to ecology and heritage, and recommended management actions for the Boegoebaai Port, SEZ and GH_2 development scenarios.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
TERRESTRIAL ECOLOGY	**Integrated Ecology**			
	In the absence of port, SEZ and GH_2 development -- • **Desertification and aridification,** driven by climate change and unsustainable land use, resulting in : ○ The **southward expansion of the Namib Desert** (biome shift), ○ **Reduced rangeland productivity and degrading ecosystems**, with the Richtersveld most severely affected. ○ **Vegetation loss and soil erosion intensifying**, resulting in declining soil stability, habitat degradation, and reduced nesting substrates for fauna. • **Declining populations** of rare and endemic species. • **Habitat fragmentation and protection gaps continuing** as land-use change and limited protected-area coverage weaken ecological connectivity, leaving already threatened ecosystems exposed to ongoing degradation. • **Persistent overgrazing**, particularly on communal land, simplifying vegetation structure and compounding climate-driven ecosystem decline, while **invasive species further homogenise habitats** and outcompete native biodiversity.	*In addition to impact trends under Sc0 --* • **Localised habitat loss**, concentrated where GH_2 infrastructure overlaps MEDIUM–HIGH sensitivity areas. • **Direct loss of species of conservation concern** in affected footprints. • **Increased fragmentation** from new roads, pipelines, transmission lines and other linear infrastructure • **Cumulative ecosystem degradation** where GH_2 facilities compound climate-driven browning and grazing pressure.	*In addition to impact trends under Sc0 –* • **Large-scale, high-magnitude habitat loss** directly affecting **HIGH** and **VERY HIGH** sensitivity zones. • **Major biodiversity pattern impacts:** loss of endemic species, SCC populations, and entire local centres of endemism. • **Severe fragmentation** of corridors, ecological process pathways, seasonal movement routes and climate-refugia linkages. • Increased pressure on **already degraded ecosystems**, amplifying climate-driven browning and pushing threatened vegetation types closer to collapse	• Continue building a **regional biodiversity information base** to support proactive planning. • Improve **livestock management** to reduce climate-amplified degradation. • **Strengthen anti-poaching**, monitoring, and restoration programmes. • **Complement regional-scale sensitivity mapping** with detailed, fine-scale ecological surveys of proposed development sites **before** infrastructure layout and design begin, to ensure that site planning avoids locally sensitive habitats and biodiversity features. • **Development type, site, ecosystem or species-specific mitigation measures** to reduce disturbance, prevent imposition of impermeable barriers to movement and eliminate incidental death of individuals. • **Avoidance of development in sensitive landscapes or habitats** at the project planning phase. ○ Avoid HIGH/VERY HIGH sensitivity in siting; in Medium areas apply fine-scale ecological mapping prior to design to avoid sensitive features. • Apply full **mitigation hierarchy;** consider offsets only when avoidance and minimisation are exhausted. Where possible align biodiversity offset implementation with the protected area expansion strategy • Where avoidance is not possible then **safeguard regional biodiversity using biodiversity offsets** to increase the extent of impacted ecosystems within formal protected areas. • Scale implementation of the regions protected area network (i.e. declaration of protected areas, stewardship sites, etc.) that conserves core biodiversity areas connected via a regional ecological corridor network within a scenically natural landscape (preserve natural sense of place) . • Implement **restoration of disturbed land**, especially around linear infrastructure. • **Minimise linear footprints**, align with existing servitudes, and restore/offset corridor pinch-points post-construction. • **Use cumulative-impact assessment** and pair projects with rangeland improvement agreements in the surrounding landscape.
	Avifauna			
	In the absence of port, SEZ and GH_2 development -- • **Rising temperatures may push arid-zone birds to exceed their physiological thresholds**, reducing survival potential, breeding success and chick survival and fledging. • **Further reductions in rainfall and higher evaporation may decrease food productivity and availability** (insects, seeds, nectar, fruit), leading to nesting failure, starvation risk and delayed or failed breeding. • **Desertification, vegetation loss and soil erosion may remove nesting substrates, increase dust/heat exposure, and reduce avifaunal abundance/diversity** (notably in the Richtersveld). • **Increased overgrazing, compounded by climate change stressors, simplifies vegetation structure, reducing foraging and nesting material for birds**, and **intensifying climate-related declines in bird diversity and abundance.** • **Shifting biome boundaries driven by climate change and**	*In addition to impact trends under Sc0 --* • **Disturbance-driven displacement** from construction/operations (port/SEZ, wind/solar, roads, pipelines, powerlines, masts). • **Displacement due to Habitat loss/ fragmentation/ transformation** from GH_2 and RE footprints and linear corridors. • **Collision mortality** (turbines, powerlines, towers) for priority SCC (raptors, bustards, larks, pelicans). • **Electrocution risk** on expanded grid/substations.	*In addition to impact trends under Sc0 –* • **Severe–extreme disturbance displacement** in **VERY HIGH sensitivity** areas. • Extreme habitat loss/fragmentation, including SCC core areas and KBAs. • Extreme collision risk for EN/CR species (e.g., Ludwig's Bustard, vultures, eagles) across turbines/powerlines. • **High electrocution risk** due to large-scale grid expansion. • **Cumulative impacts** nearing **population viability limits** for several SCC, with residual risk remaining substantial even after mitigation.	• **Expand protected areas and stewardship** in priority habitats; maintain microhabitats. • **Restore degraded habitat** to rebuild structure and minimise desertification effects. • **Improve rangeland management**, including drought-responsive destocking to prevent veld collapse. • **Control invasive plants** and **protect/restore wetlands, pans and seeps** to secure drinking/foraging sites. • **Avoid HIGH/VERY HIGH sensitivity** in siting and align lines with low-risk corridors. • **Bird-safe design and operations:** diverters, raptor-safe pylons, low-impact lighting, anti-perching devices. • **Shutdown-on-Demand and seasonal curtailment; pre-construction surveys and micro-siting** to avoid nests/roosts/flight corridors. • **GenEst[20]-based pre- and post-construction monitoring**, set Thresholds of Potential Concern (TPCs) and **adaptive responses; habitat restoration** & hydrology maintenance. • **Advanced collision-prevention** (curtailment regimes, high-performance diverters) and raptor-safe electrical designs.

[20] 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).

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
	anthropogenic pressures may result in habitat contraction and fragmentation within the Succulent Karoo, leading to reduced avifaunal abundance and diversity, population fragmentation, range shifts, community restructuring, and potential loss of endemic and habitat-specialist species. • **Increased frequency of hot, dry periods raises wildfire risk which may destroy nesting and foraging habitats**, exacerbating food and water shortages for resident birdlife. • **Drying of wetlands, pans and seep systems reduces drinking and foraging opportunities**, leading to dehydration, nest abandonment, failed breeding and range contractions. • **Increased alien invasive cover may homogenise habitats and displace natural vegetation**, potentially favouring generalist species while reducing suitable habitat, shelter, and persistence of range-restricted and specialist birds, with possible local extinctions in heavily invaded areas.			• **TPC-based adaptive management** with mandated corrective action when thresholds are exceeded
	Bats			
	In the absence of port, SEZ and GH_2 development -- • Declining natural foraging habitat due to desertification, overgrazing, soil erosion, and water scarcity, **leading to reduced insect prey and degraded hunting habitat**. • Reduced accessible open water, as hotter, drier conditions and lowered groundwater recharge **reduce surface water sources essential for drinking and insect availability.** • **Declining insect availability** because of hotter, more arid conditions and altered habitat structure. • **Light pollution increases**, favouring light-tolerant generalist species while deterring photophobic and specialist bat species and shifting species composition. • Wind energy expansion (occurring even under the baseline due to Springbok REDZ) may **increase risks of collision/barotrauma if unmanaged.** • Agricultural shifts **may create limited, localised bat foraging opportunities** through irrigated croplands and livestock activity, while declining chemical pesticide use could benefit bats by reducing toxin exposure; **however, these benefits are spatially limited and do not offset broader climate- and water-driven habitat constraints.** • **Expansion of protected areas may help conserve natural bat foraging habitat and insect prey diversity**, partially buffering bats against broader climate- and land-degradation pressures. • Overall, these interacting drivers are expected to **restructure bat communities, with adaptable generalist species persisting or increasing locally, while specialist and water-dependent species decline.**	*In addition to impact trends under Sc0 --* • **Destruction or disturbance of bat roosts** (natural & artificial) due to construction of turbines, PV fields, roads, substations and GH_2 infrastructure. • **Loss & fragmentation of foraging habitat**, both permanent (clearing) and temporary (construction disturbance). • **High collision & barotrauma mortality risk**, especially in **VERY HIGH** and **HIGH** Sensitivity areas; species at greatest risk include *Tadarida aegyptiaca, Sauromys petrophilus, Miniopterus natalensis*. • Attraction to turbines due to insects congregating around lighting or low-pressure air pockets, **increasing collision exposure**. • Fruit bat movement routes (poorly known) may intersect turbines, **increasing mortality risk**, particularly near date farms and riparian corridors.	*In addition to impact trends under Sc0 –* • **Extreme destruction/disturbance of roosts**, with irreversible loss of macro-roosts possible. • **Large-scale foraging habitat loss**, potentially affecting critical habitat supporting high bat diversity. • **VERY HIGH mortality risk**, with **potential collapse of local bat populations** if unmanaged. • **High risk to cave-dwelling species**, where turbine impacts may affect energy input to cave ecosystems via guano reduction. • **Cumulative, region-wide displacement of sensitive species**; potential local extinction of common species.	• **Avoid all VERY HIGH** Sensitivity zones and apply buffers for roosts (500 m–20 km depending on colony size). • Apply **site-specific sensitivity mapping** and 12-month **pre-construction monitoring** (including rainy season). • Areas disturbed during construction should be **rehabilitated following completion**, using appropriate ecological restoration techniques. • Implement **curtailment (increased cut-in speeds)** during high bat-activity conditions. • **Minimise lighting** and **avoid creating artificial water bodies** near turbines. • The design and construction of new buildings and infrastructure should **prevent the creation of artificial bat roosts.** • **Prohibit wind development within major buffers** around confirmed and potential roosts (up to 20–50 km). • If undiscovered bat roosts are encountered during the construction phase, **the respective Environmental Compliance Officer (ECO) must be notified immediately** and a **bat specialist consulted** to advise the appropriate action • Conduct **operational fatality monitoring** and adaptively manage turbines. • Long-term operational monitoring, including **fruit bat monitoring near agricultural corridors**.
	Fauna			
	In the absence of port, SEZ and GH_2 development -- • Habitat loss and fragmentation from existing land uses (mining, overgrazing, roads, powerlines, settlements) **disrupt movement corridors, burrow networks and dispersal pathways** - most acute for dune/coastal specialists and fossorial mammals/reptiles (e.g., golden moles, dune mole-rat, tortoises, sand lizards). • **Disturbance (noise, lighting, human activity) elevates displacement and roadkill risk**, particularly for nocturnal mesocarnivores (e.g., bat-eared fox, Cape fox) and slow-moving reptiles (adders, tortoises). • **Degradation of ecosystem processes** (pollination, soil	*In addition to impact trends under Sc0 --* • Construction/operations footprint causing **habitat loss/fragmentation and disturbance across MEDIUM–HIGH** sensitivity plains and into **HIGH/VERY HIGH** sensitivity areas if poorly sited, elevating displacement for burrow-dependent guilds and rock specialists (girdled lizards, padlopers). • **Process-level impacts:** altered ground temperature/structure (PV platforms, roads, hardstands) and fencing disrupt soil engineers (termites, ants, rodents) and amphibian pulse breeders tied to ephemeral pools.	*In addition to impact trends under Sc0 --* • **Scale-driven, cumulative habitat loss and fragmentation** with **Severe–Extreme** consequences in **VERY HIGH/HIGH** zones (coastal dune SCC, lichen fields, koppie complexes); high probability of **irreversible losses** and **local extinctions** if avoidance is not achieved. • **Process disruption at landscape scale: collapse risks** for soil engineering, pollination networks, and amphibian breeding dynamics; widespread fencing/roads increase barrier effects and roadkill.	• **Avoid and buffer all VERY HIGH sensitivity features** (coastal duneveld, lichen fields, SCC roost/burrow complexes, rocky inselbergs). • **Species-specific survey & design before layout finalisation** (golden moles, dune mole-rat, padloper tortoises, rain frogs); **re-align footprints** accordingly. • **Route linear infrastructure via least-path routing**; use **existing servitudes** where possible; include **fauna underpasses/culverts** under roads in conjuction with “fauna barriers”/guiding barriers; **crow-proof substation/line designs** near tortoise habitat to reduce corvid predation; mandatory **EMPr** and **roadkill monitoring** with adaptive triggers. • **Hydrology protection**: keep ephemeral pans/sand rivers functional (setbacks, crossing design, no pan infilling); **soil restoration**

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
	engineering, amphibian pulse breeding) through overgrazing, soil compaction, hydrological alteration and cumulative linear infrastructure. • Climate change intensification (heat, aridity) **pushes amphibians beyond hydro-ecological thresholds** (shortened hydroperiods), skews reptile Temperature-dependent sex determination outcomes, and reduces forage for herbivores/insectivores.			post-works. • Landscape-level avoidance: exclude all **VERY HIGH** and the majority of **HIGH** sensitivity areas; set development caps to avoid breaching viability thresholds for SCC. • Scenario 2 (big GH_2) may result in high residual impacts which will require biodiversity offsets. • **Mandatory cumulative impact assessment, adaptive management embedded in approvals**, and **monitoring beyond the footprint** (fauna passage efficacy, roadkill, amphibian breeding success, soil process indicators).
WATER RESOURCES AND AQUATIC ECOLOGY	**Groundwater**			
	In the absence of port, SEZ and GH_2 development -- • **Decline in groundwater availability** driven by hotter and drier climatic conditions, including reduced MAP[21], increased MAPE[22], long periods without rainfall and reduced recharge, especially in alluvial aquifer systems. • **Deterioration in groundwater quality** caused by rising salinity from marine aerosol deposition and flushing of salts from heuweltjies during heavy rainfall events, compounded by contamination from failing wastewater treatment works. • **Increasing groundwater abstraction** caused by population growth places additional pressure on aquifers that are already stressed and experiencing declining water levels.	*In addition to impact trends under Sc0 --* • **Significant additional pressure on groundwater resources** caused by increased population influx and water demand from GH_2 operations in towns such as Alexander Bay and Port Nolloth. • **Elevated contamination risks** introduced by high-risk GH_2 infrastructure such as chemical storage facilities, pipelines and hydrogen production systems. • **Reduced groundwater security** in priority GRUs where supply is already insufficient to meet existing demand.	*In addition to impact trends under Sc0 --* • **Severe groundwater depletion** driven by large-scale GH_2 development, with water demand exceeding aquifer supply capacity across several high-sensitivity units. • Heightened **groundwater contamination risks** caused by the expanded industrial footprint and increased potential for spills and effluent leakage. • **Increased likelihood of long-term or irreversible salinisation** of aquifers due to reduced recharge, higher evaporation, and increased abstraction.	• **Avoid high-risk activities** (chemical storage, pipelines, GH_2 processing infrastructure) **in areas of HIGH or VERY HIGH groundwater sensitivity**, including SWSAs and priority GRUs. • **Invest in municipal water infrastructure**, including refurbishment of bulk supply systems and groundwater reticulation networks. • **Implement groundwater and seawater desalination** to augment supply where aquifers cannot meet demand. • **Improve borehole management** through specialised training (e.g., addressing iron biofouling). • **Introduce managed aquifer recharge schemes** to reduce long-term salinisation and stabilise aquifer yields. • **Strengthen regulatory protection** for groundwater quality and **enforce adherence to restrictions** in sensitive areas.
	Surface water resources			
	In the absence of port, SEZ and GH_2 development -- • **Declining surface water availability** caused by reduced rainfall, reduced runoff, and increased evapotranspiration, resulting in long periods with no flow in streams and rivers. • **Increasing vulnerability of towns and agriculture** due to aging, underperforming Orange River abstraction and reticulation systems.	*In addition to impact trends under Sc0 --* • **Increased stress on surface water systems** caused by rising population and GH_2-related water demand that exceeds existing abstraction and reticulation capacity. • **Higher risk of water supply shortfalls** due to dependence on already strained Orange River bulk water schemes.	*In addition to impact trends under Sc0 --* • **Severe surface water scarcity** resulting from large-scale GH_2 expansion, where water demand far exceeds available supply, particularly during long dry periods. • **Increased systemic failure risk in surface water supply infrastructure** due to overwhelming demand during extreme climatic conditions.	• **Develop and optimise new or expanded Orange River abstraction schemes** aligned with ecological flow requirements (EWRs and RQOs). • **Implement and adequately fund desalination for both seawater and saline groundwater** to supplement limited surface water availability. • **Improve operation, maintenance and reliability of abstraction, treatment, reticulation and storage infrastructure.** • **Prevent pollution at abstraction works**, particularly where subsurface filtration is used.
	Inland aquatic ecosystems & estuaries			
	In the absence of port, SEZ and GH_2 development -- • **Loss of biodiversity in ephemeral pans** caused by shortened hydroperiods that prevent invertebrate and plant communities from completing life cycles. • **Decline in riparian vegetation** driven by reduced shallow groundwater availability, making rivers more vulnerable to erosion during sporadic flood events. • **Degradation of watercourses** caused by nutrient enrichment and contamination from failing wastewater treatment works, along with increasing alien plant invasion. • **Continued decline in estuarine condition**, particularly in the Orange River Estuary, driven by reduced flood frequency, elevated salinity and nutrient enrichment from failing wastewater treatment works.	*In addition to impact trends under Sc0 --* • **Increased erosion and sediment disruption** in rivers and wetlands caused by concentrated stormwater flows from hardened GH_2 infrastructure such as roads, turbine pads and solar arrays. • **Fragmentation of aquatic and estuarine habitats** due to new roads, transmission lines and GH_2 infrastructure interrupting natural hydrological and ecological connectivity. • **Increased nutrient pollution** caused by higher effluent volumes from expanding formal and informal settlements. • **Growing human pressure** through fishing, grazing, disturbance and recreational activities on estuarine systems, associated with population growth.	*In addition to impact trends under Sc0 --* • **Widespread and potentially irreversible degradation of Critically Endangered and Endangered aquatic ecosystems** caused by extensive landscape fragmentation and hydrological alteration. • **Significant deterioration of water quality** from increased effluent loads linked to major population expansion and urban footprint growth. • **Increased hypersalinity and reduced breaching in estuaries**, limiting fish recruitment and further degrading ecological functioning in arid West Coast systems.	• **Avoid all development in VERY HIGH Sensitivity aquatic and estuarine areas**, including CR/EN wetlands, NFEPA rivers and estuarine functional zones. • **Apply ecosystem buffers** (20 m for artificial pans/dams; 50 m for natural pans, wetlands and rivers; 100 m for NFEPA rivers). • **Ensure road crossings and stormwater systems maintain natural hydrological pathways** and avoid concentrated flows and erosion. • **Upgrade WWTWs prior to population or settlement expansion** to prevent nutrient pollution and contamination. • **Implement Orange River Estuary rehabilitation actions** and maintain EWRs and RECs to sustain estuarine function. • **Use biodiversity offset banking** where unavoidable impacts occur, especially under large-scale GH_2 development.

[21] Mean Annual Precipitation (MAP) is projected to decrease by between 10-20% in most places, but between 0-10% in other locations.
[22] Mean Annual Potential Evapotranspiration (MAPE) will increase by 6-10%.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
HERITAGE	**Palaeontology**			
	In the absence of port, SEZ and GH_2 development – • Desertification and increased mining may **expose fossiliferous strata and create a risk of fossil loss**, particularly where coastal plain sediments are disturbed.	*In addition to impact trends under Sc0 –* • Most development affects surficial sediments of **LOW** palaeontological sensitivity, so impacts are generally insignificant; **exceptions occur near the coast** where buried marine formations of **HIGH sensitivity** may be intersected by deeper excavations.	*In addition to impact trends under Sc0 –* • Impacts are similar to Sc1 but of higher intensity because a larger overall footprint increases pressure on land and reduces avoidance options, with **the coastal plain most at risk if deep cuts intersect HIGH-sensitivity units**.	• Every project **must be evaluated by a palaeontologist** at EIA stage to determine the need for a palaeontological specialist study, especially along the coast. • No fixed "No-Go" fossil areas are identified at regional scale; **control impacts through case-specific assessment and management**.
	Terrestrial archaeology			
	In the absence of port, SEZ and GH_2 development – • **Archaeological sites threatened** due to an increase in agricultural development along the Orange River and diamond mining along the coast. • Renewed copper mining in Okiep **may impact the historic Copper Mining Landscape**. • Potential artisanal mining licences, oil and gas exploration, and additional prospecting/mining (manganese, iron and granite) **may impact heritage resources**. • Continued development of renewable energy facilities in the REDZ, new roads and industrial corridor along the N14 **may impact archaeological resources.**	*In addition to impact trends under Sc0 –* • Area-wide **impacts to surface resources are possible** but generally not highly significant, except along the coastline where sites of higher significance are more concentrated. • Inland sites will be more dispersed, with opportunity to avoid them during development.	*In addition to impact trends under Sc0 –* • Impacts similar to Sc1 but with **higher intensity** due to the larger footprint, resulting in increased land pressure and reduced likelihood to avoid impacts, **particularly along the coastline.** • Expanded land requirements increase the likelihood of impacts on communal areas.	• Undertake **archaeological specialist studies in all EIAs** and detailed surveys of each project footprint. • **Monitor construction in coastal dune areas** where middens are buried. • Coastal impacts cannot all be mitigated; **archaeologists should determine sites to sample** in order to best characterise the archaeology in each development footprint. • Consider high-density coastal areas during EIAs **for protection**.
	Maritime Heritage			
	In the absence of port, SEZ and GH_2 development – • Potential offshore mining and gas exploration **may impact unknown wrecks and result in destruction**.	*In addition to impact trends under Sc0 –* • **Impacts unlikely to significantly increase** due to generally low probability of wrecks being found; however, there is always **a chance of impacts.**	*In addition to impact trends under Sc0 –* • As with Sc1, impacts remain **generally unlikely**, but a **larger footprint raises the chance** of intersecting sensitive localities near historically recorded foundering points.	• Maritime Heritage **specialist study required for developments affecting marine environment** (e.g., undersea pipelines). • Fieldwork needs should be determined based on the development proposal, with most **underwater fieldwork conducted during the pre-construction or micrositing phase.**
	Graves			
	In the absence of port, SEZ and GH_2 development – • **Impacts unpredictable** as graves are generally completely unmarked; **impacts occur sporadically and can be severe when discovered late.**	*In addition to impact trends under Sc0 –* • Impacts are **unpredictable**; **several graves may be affected, or none at all,** depending on exact siting.	*In addition to impact trends under Sc0 –* • With **a larger land footprint, the chance of encountering graves increases**, escalating the potential for significant to extreme negative outcomes if not managed early.	• Consider graves along with archaeology in any EIA. • **Early consultation** with the Northern Cape Heritage Resources Authority and representatives of local communities **to determine if reburial should be considered, and the identification of suitable locations. Exhumation should only occur when no other mitigation options are possible.** • When retained close to development(s), **graves should be fenced** to enhance their long-term protection.
	History and Built Environment			
	In the absence of port, SEZ and GH_2 development – • Incremental increases in mining and infrastructure development **may damage or destroy historic places, structures and buildings older than 60 years.**	*In addition to impact trends under Sc0 –* • Significant impacts are **unlikely due to relatively small footprint.** • **Potential threat could be the insensitive 'restoration' of historical structures or demolition in towns where new residential areas are required** (Steinkopf, Okiep, Springbok).	*In addition to impact trends under Sc0 –* • Impacts similar to Sc1 but with higher intensity due to the larger footprint, resulting in **increasing cumulative risks to historic fabric and context where avoidance is constrained.**	• All historical and built environment sites should be **evaluated during EIAs**; restoration may be recommended to enhance protection and cultural significance. • **Farmsteads should be avoided**, with a buffer large enough to not render the structures 'uninhabitable' due to the close proximity of undesirable development.
	Living Heritage			
	In the absence of port, SEZ and GH_2 development – • Small stock farmers likely to continue traditional grazing practices despite **poor environmental conditions and overgrazing.** • Infrastructure and mining in communal grazing lands may further **threaten traditional land-use patterns.**	*In addition to impact trends under Sc0 –* • **Communal areas of Steinkopf, Concordia and the Richtersveld are potentially most at risk** as they are located near potential centres of development.	*In addition to impact trends under Sc0 –* • With far **larger land requirements**, the **likelihood of using communal areas** increases, raising risks to transhumant practices and living heritage; nonetheless, **financial benefits** could accrue to affected communities if negotiated properly.	• BZB **communities should be consulted** to determine their response to the loss of their grazing lands, and understand reasons for areas chosen for grazing, value of the pasturage in terms of seasonal grazing requirements, alternative options, and how the local environment and culture are intertwined within their world view.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (mitigation)
	Cultural Landscape			
	In the absence of port, SEZ and GH_2 development -- • Population growth and associated development will **gradually alter historical and cultural landscapes** (notably around Springbok/Okiep and Aggeneys), in contrast to seasonal tourism that relies on natural aesthetic and heritage preservation.	*In addition to impact trends under Sc0 –* • The small overall footprint should not have significant landscape impacts **unless projects sit near prominent, aesthetically sensitive features such as the RCBL World Heritage Site** (and buffer), National Parks/reserves, the Kamiesberg and the coastline.	*In addition to impact trends under Sc0 –* • Similar to Sc1 but **more intense**, as a larger footprint increases pressure near **high-sensitivity scenic areas** and reduces avoidance flexibility	• **Consult with the SANParks, UNESCO, SAHRA and local tourism operators** regarding developments near the RCBL Heritage Site or its buffer, or near scenic routes (N7, N14, R382), National Parks/reserves and other iconic landscapes. • The entire **RCBL and its buffer zone should be considered as No-Go area.** • All landscapes in the region have high cultural and natural "sense of place" that needs to be preserved. Include a **Visual Impact Study in every EIA** where landscape effects are a concern; prepare **site-specific management plans** when heritage sites are reused or preserved in close proximity to development.

Table SPM 4: Consolidated summary of potential positive impacts and recommended management actions for the Boegoebaai Port, SEZ and GH_2 development scenarios.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (enhancement)
TERRESTRIAL ECOLOGY	**Integrated Ecology**			
	• Opportunity to **stabilise ecosystems** if improved protected-area management, grazing management and restoration interventions are implemented. • Baseline offers spatial **flexibility for long-term conservation planning.**	• Scope **for strategic biodiversity offsets that expand the protected area network** or secure high-value priority landscapes. • Potential **development of large-scale biodiversity economy initiatives** linked to offsets and stewardship	• **Expand protected-area and stewardship networks** using existing biodiversity priorities.	• Where residual impacts remain after avoidance/minimisation, **implement like-for-like biodiversity offsets in mapped priority areas** within the same planning domain
	Avifauna			
	• Expansion of protected areas/stewardship buffers climate and land-use threats, **safeguarding breeding/foraging/roosting habitats and microhabitats for rare species.**	• **Early, targeted avoidance and mitigation** via sensitivity maps and technology-specific standards. • **Offsets** can secure high-value habitat if correctly applied (same planning domain; like-for-like).	• Potential for **large, programmatic offsets** to secure corridors, refugia and high-value habitats. • Scope to **establish regional monitoring/governance/financing platforms** for ongoing conservation	• **Expand protected areas & stewardship** in priority habitats; maintain microhabitats. • **Landscape-scale avoidance** of all **VERY HIGH** sensitivity areas; set development caps to limit cumulative risk.
	Bats			
	• Increase in artificial roosting structures (buildings, mines, Namakwa SEZ-linked settlement growth) **may create new roosting opportunities** for several bat species. • Agricultural irrigation areas can **locally increase insect abundance**, offering supplemental foraging habitat. • Livestock farming (where it persists) **can attract insects associated with dung, benefiting foraging bats.** • Protected areas preserve natural foraging habitat and insect diversity, **aiding bat diversity.** • Reduced pesticide use (trend toward organic farming) **reduces toxin accumulation risk for bats.**	• **Expanded artificial roost opportunities** from GH_2-related infrastructure (if unintentionally created). • **Opportunities for research and monitoring**: bat EIA monitoring and curtailment trials generate new regional knowledge. • **Regional planning improvements**: sensitivity maps enable steering of GH_2 projects away from Very High bat sensitivity zones.	• **Large-scale strategic research and monitoring programmes** become feasible (migration routes, species behaviour, risk mitigation). • **Opportunity to protect regional corridors** via spatial planning.	• Research programmes to **map cave-dwelling bat migration routes.**
	Fauna			
	• **Protected areas and intact koppies/dune belts still buffer key SCC** (e.g., De Winton's golden mole, Namaqua dune mole-rat, Speckled padloper) where habitat remains intact; these areas anchor **VERY HIGH/HIGH** sensitivity.	• Site-level **SCC surveys enable micro-avoidance and targeted design.**	• **Opportunity to establish programmatic, region-wide offsets,** corridor protection and **long-term monitoring platforms,** but these do not negate permanent losses where avoidance fails.	• **Avoid and buffer all VERY HIGH sensitivity features** (coastal duneveld, lichen fields, SCC roost/burrow complexes, rocky inselbergs). • **Programmatic offsets** (like-for-like; time-bound; independently verified) prioritising **corridors, coastal dune SCC habitat, lichen fields,** and **rocky inselbergs**; integrate with Protected Area expansion.
WATER RESOURCES AND AQUATIC ECOLOGY	**Groundwater, Surface water resources, Inland aquatic ecosystems & estuaries**			
	• **None expected in baseline;** no additional water sources will come online without intervention.	• **Desalination plants could provide new sources of freshwater that reduce pressure on groundwater and surface water systems,** provided it is developed and implemented responsibly and effectively. • **Upgraded WWTWs improve effluent quality and reduce nutrient pollution,** which benefits rivers and estuaries downstream, provided naturally ephemeral systems are not transformed into seasonal or perennial systems from effluent discharges • Economic growth associated with GH_2 may also enable municipalities to strengthen environmental governance and maintenance of water networks, indirectly enhancing water resource resilience.	• The Sc1 potential positive impacts become larger but rely heavily on strong mitigation and advanced planning. • Large-scale **desalination could substantially increase freshwater availability across the region,** ensuring that both human and ecological needs are met even under severe climate stress, and provided that naturally ephemeral systems are not transformed. • Offset banking. if properly implemented, **could support long-term conservation of high-value aquatic ecosystems** by securing protection and restoration at landscape scale. • Integrated infrastructure upgrades, including water reticulation, storage and treatment, **could improve long-term water security for towns and ecosystems alike.** **These benefits materialise **only if significant investment and governance improvements accompany GH_2 expansion.**	• **Investigate the ecological, practical and financial feasibility of supplying treated, desalinised water** to nearby communities. • Invest in water supply, wastewater infrastructure and staff training. • Strict siting to **avoid sensitive areas.** • Large-scale **investment in desalination and managed aquifer recharge.** • Implement proactive watercourse and terrestrial offset banking programmes. • **Maintain ecological flow requirements** for the Orange River and estuary. • Implement proper **upgrading, expansion, and maintenance of wastewater treatment works.** • **Improvements to water treatment and distribution** (reticulation) systems.

	Baseline scenario (Sc0)	Small GH_2 development (Sc1)	Big GH_2 (Sc2)	Principles/actions for management (enhancement)
HERITAGE	**Palaeontology**			
	N/A	Discovery, recording and scientific sampling of fossils during development can increase knowledge and benefit science.		
	Terrestrial Archaeology			
	N/A	Discoveries, recording and sampling of archaeological sites can substantially **increase scientific knowledge; responsible restoration and reuse** of historical structures linked to development can prevent neglect and disuse; tourism growth can bolster conservation incentives.		
	Graves			
	N/A	Identification and protection of previously unknown marked graves can occur where systematic surveys are done, improving heritage records and safeguarding culturally significant places.		
	History and Built Environment			
	N/A	**Responsible restoration and reuse** tied to development or accommodation needs can stabilise historic structures and raise their cultural significance; tourism growth can amplify conservation incentives.		
	Maritime Heritage			
	N/A	Discovery and recording of wrecks can **enhance maritime heritage knowledge** where sites are identified and managed.		
	Living Heritage			
	N/A	Where development catalyses **formal recognition and protection** of living-heritage sites and practices, positive outcomes can emerge; well-structured agreements in Sc2 can produce direct community benefits alongside impact management.		
	Cultural Landscape			
	N/A	Rehabilitation associated with development **can improve previously disturbed areas**, and in some cases, expansions of protected areas can strengthen long-term landscape conservation.		

2.2.2 Socio-economic Impacts

2.2.2.1 Potential negative impacts

- <u>Pressure on local housing, services and municipal systems.</u>

The development of the port, GH_2 facilities and associated infrastructure is expected to attract in-migration during construction and early operations. This is likely to place increasing pressure on housing availability, bulk services, health care and municipal administration in the Richtersveld and surrounding towns. Without early spatial planning and investment, these pressures could exacerbate existing service backlogs, contribute to informal settlement growth, and deepen fiscal and governance challenges in municipalities with limited capacity.

> **Box SPM 17: Boomtown dynamics and uneven development outcomes**
>
> Large infrastructure projects often generate rapid in-migration during construction as jobseekers, contractors and service providers move into the area. This phenomenon, commonly referred to as "boomtown" dynamics, can result in sudden increases in housing demand, rental and food prices, and pressure on basic services. While construction activity may generate substantial short-term employment, benefits are often unevenly distributed, with those unable to access project-related jobs experiencing rising living costs without corresponding income gains.

- <u>Rising living costs and social inequality.</u>

Improved employment opportunities and higher wage levels associated with port and GH_2-related activities may stimulate local economies, but are also likely to drive up food, rental and property prices. These dynamics may disproportionately affect poorer households and those not directly benefiting from project-related employment, increasing inequality and potentially generating social tension if inclusive access to opportunities is not ensured.

- <u>Risks to tourism from logistics and transport impacts.</u>

Increased freight transport, particularly if dominated by road-based ore and bulk hauling, could undermine the tourism appeal of the Namakwa region by increasing traffic volumes, noise, dust and landscape disturbance. Tourism is one of the region's most important growth sectors and is highly sensitive to these changes, which may affect visitor safety and degrade the experiential qualities that underpin conservation- and heritage-based tourism.

- <u>Impacts on agricultural production and viability.</u>

Port-related ore handling increased heavy vehicle traffic and associated air quality impacts may pose risks to crop quality and export standards, particularly for irrigated agriculture. Agriculture in the region is already constrained by aridity and is sensitive to dust, water availability and transport reliability. Poorly managed logistics could therefore have knock-on effects for employment and rural livelihoods.

- <u>Institutional and governance capacity constraints.</u>

The scale and complexity of the proposed developments will place significant demands on municipal planning, financial management, disaster risk management and public participation systems. In municipalities where capacity is already constrained, there is a risk that development pressures outpace institutional readiness, weakening oversight, accountability and community trust.

> **Box SPM 18: Institutional capacity as a binding development constraint**
>
> Institutional capacity refers to the ability of local government to plan, finance, implement and regulate development effectively. This includes staffing, technical skills, financial management, spatial planning, disaster preparedness and public engagement. In small or rural municipalities, capacity constraints can limit the ability to respond to rapid growth, even where development opportunities exist.

- <u>Social disruption and community cohesion risks.</u>

Rapid economic change and in-migration may give rise to "boomtown" dynamics, including increased crime, pressure on social and health services, and erosion of social cohesion. These risks are more likely to emerge if community engagement and social support mechanisms are not proactively implemented.

2.2.2.2 Potential opportunities (positive impacts)

- <u>Employment creation and skills development.</u>

The construction and operation of the proposed port, SEZ and GH_2 facilities are expected to create employment opportunities across a range of skill levels. With appropriate training, apprenticeships and career development pathways, these projects could strengthen the regional skills base, reduce out-migration and support longer-term employment beyond the construction phase.

- <u>Regional economic growth and diversification.</u>

The port and associated developments have the potential to act as a new economic anchor for the Namakwa region, stimulating various multiplier effects in sectors such as logistics, manufacturing, services, training, and supplier industries. Over time, agglomeration effects along key transport corridors and around regional hubs such as Springbok could contribute to a more diversified and resilient regional economy.

- <u>Infrastructure investment with shared benefits.</u>

Strategic investments in transport, energy, water and digital infrastructure, if planned in an integrated manner, could generate significant co-benefits for local communities, agriculture and tourism. Examples include improved connectivity, expanded renewable energy access, and desalination infrastructure that supports both industrial and domestic water needs.

- <u>Opportunities for agricultural upgrading and resilience.</u>

Improved port access, enhanced logistics and access to renewable energy may support agricultural diversification and improved competitiveness, particularly for export-oriented irrigation schemes. Corporate social investment and partnerships could further support climate-resilient farming practices and local agricultural development.

- <u>Tourism enhancement and diversification.</u>

Tourism could benefit indirectly from improved access, upgraded regional airports, enhanced destination marketing and the emergence of new heritage- and green-energy-related tourism offerings. These benefits are more likely to be realised if industrial development is spatially separated from key tourism nodes and freight impacts are carefully managed.

- <u>Institutional strengthening and governance innovation.</u>

The scale and visibility of the Boegoebaai GH_2 programme provide an opportunity to strengthen intergovernmental coordination, municipal capacity and public engagement practices. Approaches such as iterative problem-solving and meaningful community participation could help ensure that development outcomes are more inclusive, transparent and durable. Building institutional will require strong leadership and support by national and provincial governmentt, as well as other stakeholders.

2.2.3 Infrastructure and planning impacts

2.2.3.1 Spatial development planning, land use management and governance

- Baseline Scenario (no port, SEZ or GH_2 development)

Municipal planning systems in the region already operate under significant capacity constraints, limiting their readiness to manage future development pressures. Municipalities have few professional planners, limited GIS capability, and rely on a District Municipal Planning Tribunal (DMPT) (Box SPM 19) that convenes only quarterly to make key planning decisions, which can result in delays.

Existing planning instruments (IDPs, SDFs and land-use schemes) function largely as statutory compliance documents, offering limited proactive spatial guidance. As a result, municipalities face a heightened risk of ad-hoc land-use decisions and limited ability to anticipate spatial or infrastructure pressures.

> **Box SPM 19: What is a District Municipal Planning Tribunal (DMPT) and why does it matter?**
>
> The District Municipal Planning Tribunal (DMPT) is the legally mandated body that adjudicates land-use and land-development applications under the Spatial Planning and Land Use Management Act (SPLUMA). In the Namakwa region, the DMPT sits quarterly, which is sufficient under low development pressure but becomes a critical bottleneck when volumes spike. Where municipal capacity is already limited, the DMPT's meeting frequency and technical support directly shape how fast large projects can progress.

- Sc1 (Small GH_2)

The initiation of the proposed programme of developments is expected to drive significant land use change, including new housing, bulk infrastructure, RE facilities, construction camps, and road upgrades, alongside population growth in towns such as Port Nolloth and Alexander Bay. This will increase demand for land, coordinated spatial and service planning, and coordinated decision-making across multiple authorities, including engagement on communal land in the Richtersveld.

The scale and diversity of development may exceed existing municipal planning capacity, creating risks of application backlogs and institutional bottlenecks. Strengthened regional coordination and additional provincial and national support will be critical to manage the anticipated surge in development over the next 5–10 years.

- Sc2 (Big GH_2)

The increased scale of GH_2 production and associated development is expected to place considerably greater pressure on municipal systems and processes. A high volume of land use, infrastructure, and regulatory applications across all spheres of government may impose a substantial burden on less-equipped municipalities. Continued implementation of the planning support mechanisms established under the Small GH_2 scenario will be necessary to sustain investment and manage the increased workload.

Major infrastructure requirements, including a rail link from Kenhardt to Boegoebaai, inland hydrogen pipelines, and expanded wind and solar energy facilities, will intensify land use pressures, servitude requirements, construction impacts, and impacts on affected landowners. Careful spatial planning will also be necessary to prevent over-concentration of investment in a few growth towns, necessitating balanced investment and attention to the preservation of Nama and traditional communities in remote areas.

2.2.3.2 Settlement development and service delivery implications

- Baseline Scenario (no port, SEZ or GH_2 development)

Opportunities/Positive Impacts: **Large-scale regional investments could stimulate modest settlement growth and service improvements in key towns across the Namakwa region.** The Namakwa SEZ is expected to attract skilled workers, influencing settlements such as Aggeneys and Pofadder, while the potential Vioolsdrift Dam and Namakwa irrigation projects could affect settlements along the N7 corridor and the Orange River. Incremental growth may also occur in Port Nolloth and Alexander Bay, while Springbok, as the regional anchor town, could experience modest expansion due to its range of services and proximity to mining activity. Additional projects, such as the revitalisation of Port Nolloth harbour, regional solar and wind developments, a new regional hospital, and the Springbok airport upgrade, could also influence settlement patterns and service demands across the region, providing limited opportunities for economic and infrastructure improvement.

Negative Impacts: **Many settlements in the region remain vulnerable due to constrained municipal infrastructure and limited economic diversification.** Alexander Bay, in particular, faces uncertainty and potential decline without continued financial support from Alexkor or the state. Local service infrastructure, including water supply, waste management, and sanitation, requires urgent upgrades to meet current population demands. Without investment and economic diversification, towns may remain dependent on existing industries or government support, limiting their long-term resilience.

- Sc1 (Small GH_2)

Opportunities/Positive Impacts: **The development of the Port, SEZ, and associated RE projects is expected to stimulate settlement growth and local economic activity in nearby towns.** Port Nolloth and Alexander Bay are likely to attract both permanent residents and temporary construction workers, while Steinkopf and Springbok may benefit from spillover demand for accommodation and services. Workforce settlement is expected to increase demand for rental housing, estate development, and commercial services, creating opportunities for property investment and business diversification. Aggeneys and Pofadder may continue to benefit from economic activity associated with the Namakwa SEZ.

Negative Impacts: **Increased development activity is expected to place growing pressure on housing markets and municipal services in nearby settlements**. Limited onsite accommodation at the SEZ and Port area means that workers are likely to reside primarily in Alexander Bay, Port Nolloth and possibly Springbok, with commuting patterns shaping settlement choices. Rising demand for accommodation may lead to increased property prices, expansion of temporary housing or site camps, and the potential growth of informal settlements. Municipalities may face increased demand for water, electricity, sanitation, waste services and social facilities, while heavy vehicle traffic associated with construction and freight transport could create safety concerns and reduce the tourism appeal of Port Nolloth.

- Sc2 (Big GH_2)

Opportunities/Positive Impacts: **At full development scale, the Boegoebaai GH_2 programme could drive sustained regional investment and more stable settlement growth.** Fully operational port facilities and transport networks may attract significant public and private investment, while the operational phase reduces construction-related pressures such as heavy vehicle traffic. Residential settlement by operational employees and their households is likely to increase demand for housing, commercial services and social infrastructure, supporting local economic diversification. Continued investment in green energy infrastructure may also strengthen regional skills development and long-term employment opportunities, with towns such as Steinkopf and Springbok potentially expanding as residential hubs.

Negative Impacts: **Continued population growth and settlement expansion could place sustained pressure on municipal infrastructure and social services**. Increased demand for water, sanitation, waste management and social facilities may exceed existing municipal capacity if upgrades are not implemented. Without targeted skills development and economic inclusion, some households may remain dependent on government support. Inadequate housing provision may contribute to the expansion of informal settlements, while smaller and more remote settlements are likely to experience only marginal benefits from regional growth.

2.2.3.3 Construction of large economic infrastructure projects (Rail, hydrogen pipeline, electricity transmission & green energy, and Port & SEZ site)

- Baseline Scenario (no port, SEZ or GH_2 development)

Under the baseline scenario, the proposed port and SEZ do not materialise. Infrastructure development in the region remains limited and largely maintenance driven. Existing freight flows continue to utilise established export corridors, including rail links to ports such as Port of Saldanha Bay, Port of Ngqura and Port of Lüderitz. Freight movement remains dependent on the existing road and rail systems, with no new railway link constructed to Boegoebaai.

Road infrastructure, including the N7, N14 and R382, continues to function at relatively low freight volumes. While SANRAL has incorporated sections such as the R382 into its maintenance programme, broader funding constraints limit upgrades, particularly for municipal gravel roads serving smaller settlements. As a result, infrastructure conditions largely remain unchanged, with ongoing deterioration in some areas due to financial limitations.

No new rail line is constructed to Boegoebaai, and regarding the hydrogen economy, the baseline scenario assumes that South Africa's GH_2 transition progresses independently of Boegoebaai, with other hubs (i.e., Lüderitz and Saldanha) continuing to develop. A cross-national hydrogen pipeline remains conceptually possible, although the feasibility of its design may change if Boegoebaai does not contribute hydrogen volumes. Additionally, the absence of Boegoebaai as a hydrogen hub could significantly affect the proposed east–west pipeline, which would depend on Boegoebaai-linked hydrogen production.

- Sc1 (Small GH_2)

In the short to medium term, freight transport to the port is expected to rely predominantly on road-based haulage. Mining commodities, especially manganese, are transported via the N14, N7 and R382 corridors. **Heavy vehicle volumes increase substantially, potentially reaching more than 500 trucks per day in early operational years. This places pressure on the R382 in particular, which has reached the end of its design life and was not engineered for sustained heavy-haul traffic.** This is likely to curtail tourism and agriculture along that route, particularly east of Augrabies Falls. Reconstruction, strengthening, and the addition of climbing lanes at Anenous Pass become critical interventions.

Construction activities associated with the port, SEZ, RE facilities, pipelines and supporting road upgrades generate further impacts, including:

- Increased risk of traffic accidents and congestion through towns such as Springbok, Steinkopf and Port Nolloth;
- Deterioration of existing road surfaces;
- Temporary disruption due to roadworks;
- Demand for borrow pits, construction camps and bulk materials.

Rail infrastructure is not immediately developed due to high capital costs, and road freight remains dominant until export volumes exceed approximately 10 Mtpa. Planning for a future rail link begins during this stage/phase.

Pipeline infrastructure becomes more defined under this scenario. A north–south hydrogen corridor linking Lüderitz, Boegoebaai and Saldanha is advanced, with feasibility assessments and environmental authorisations underway. **Land acquisition, servitude establishment and routing decisions introduce potential land use conflicts**, although the 2019 Gas pipeline SEA guidance seeks to minimise displacement and ecological disturbance.

Renewable energy generation expands to approximately 10 GW to support a 5 GW electrolyser. This requires extensive land areas for solar and wind facilities, much of which must be located outside the immediate Boegoebaai footprint due to land ownership patterns and ecological constraints. **Increased demand for electricity transmission capacity emerges, requiring alignment with national Transmission Development Planning and potentially new grid infrastructure**.

- Sc2 (Big GH_2)

The big GH_2 scenario reflects full industrial maturation and large-scale regional transformation. At this stage, the port is fully operational, GH_2 production has expanded significantly, and freight volumes increase substantially. **Heavy vehicle traffic on the N14, N7 and R382 remains high, but a new rail line (justified once freight volumes exceed 10 Mtpa) is constructed to relieve pressure on the road network.**

The proposed 500 km standard-gauge rail line connects Boegoebaai to the Sishen–Saldanha corridor, including tunnels, bridges and major earthworks. **While this reduces long-term road freight impacts, it introduces substantial construction-phase disturbances, land acquisition requirements, and environmental authorisation risks.**

Hydrogen pipeline infrastructure expands further to include both north–south and west–east corridors, positioning Boegoebaai as a national and transnational energy hub. **The scale of construction increases spatial impacts across the province, with potential effects on biodiversity areas, land use patterns, and settlements along the corridors.** Strategic routing within gazetted corridors should be prioritised to reduce spatial resistance and environmental risk.

Renewable energy requirements escalate dramatically to approximately 80 GW to support a 40 GW electrolyser. This entails very large land footprints for solar and wind installations, potentially distributed across multiple provinces to ensure energy security and grid stability. Transmission infrastructure expansion becomes critical, with new high-voltage lines required to wheel power to the site. **The adequacy and timing of national electricity grid expansion become a key risk factor**.

While this scenario offers significant economic integration and export capacity for the Northern Cape, it also presents heightened environmental, financial and planning risks due to the scale, cost and complexity of infrastructure implementation.

2.3 Risk/Opportunity Assessment

WP2 applied a structured qualitative framework to evaluate the risks (negative impacts) and opportunities (positive impacts) associated with a regional GH_2 economy under different scenarios (Section 2.2). Risk or opportunity was determined by combining the likelihood of an event occurring with the severity of its consequence or benefit (refer to WP2 Chapter 1). Consequence and benefit thresholds were defined for each theme (e.g., biodiversity, water resources, socio-economic systems) using categories ranging from Slight to Extreme, while risk and opportunity levels were classified into predefined categories from **VERY LOW** to **VERY HIGH** (Table SPM 5).

Table SPM 5: Predefined risk/opportunity categories.

RISK (-)		OPPORTUNITY (+)	
VERY LOW	Almost indiscernible negative impact.	Almost indiscernible positive impact.	VERY LOW
LOW	Slight negative impact, limited extent, and short duration, well within tolerance.	Slight positive impact, very localised, well below expectations.	LOW
MODERATE	Substantial impact, but less than major; within tolerance and below limits of acceptable change.	Substantial positive impact, but mostly short term, and spatially limited.	MODERATE
HIGH	Major consequence, approaching tolerance and limits of acceptable change.	Highly desirable impact, major medium to long term positive impacts across a broad range of stakeholders at local or regional scales.	HIGH
VERY HIGH	Extremely negative impact, persistent/long lasting, beyond tolerance and limits of acceptable change.	Highly desired, grandiose long term positive impacts across a broad range of stakeholders at local, regional, national, and/or international scales.	VERY HIGH

Each impact was assessed across three scenarios [baseline (Sc0), small GH_2 development (Sc1), and large GH_2 development (Sc2)] and for different receiving environments, both before and after management interventions. Results are presented in structured outputs for risks (negative) and for opportunities (positive). Table SPM 6 and Table SPM 7 below provide consolidated systematic assessments of the impacts associated with GH_2 development across the specialist themes, presenting the key risks (Table SPM 6) and opportunities (Table SPM 7).

Across most themes, risks were found to be HIGH to VERY HIGH without mitigation, particularly in areas of HIGH or VERY HIGH sensitivity and under the larger GH_2 development scenarios. Implementation of appropriate planning, design and mitigation measures can reduce many risks to MODERATE, LOW or VERY LOW, although residual risks remain in sensitive environments. In a similar way, opportunities generally increase with development scale and are most pronounced in key economic nodes such as Port Nolloth, Alexander Bay, and the SEZ area.

Within the ecology theme, both biodiversity pattern (direct habitat and species loss) and ecological processes show VERY HIGH risks without mitigation across most sensitivity classes. Even under smaller GH_2 scenarios, impacts remain **HIGH** in landscapes of higher ecological value. With mitigation, risks generally reduce to **MODERATE or LOW**, particularly in areas of lower sensitivity. These findings highlight the importance of avoiding sensitive ecosystems and maintaining ecological patterns and connectivity where possible.

For avifauna, key risks include displacement and disturbance caused by infrastructure and human activity, as well as collision and electrocution risks associated with wind turbines, powerlines and substations. These impacts were frequently assessed as **HIGH to VERY** HIGH without mitigation, especially in highly sensitive environments. With mitigation measures, such as careful siting of turbines, bird-safe powerline design and monitoring, risks can be reduced to **MODERATE or LOW**, although highly sensitive areas may still experience unacceptable residual impacts despite mitigation.

For bats, risks relate primarily to destruction or disturbance of roosts, loss or fragmentation of foraging habitat and bat fatalities due to collision or barotrauma caused by wind turbines during foraging and migration. Without mitigation, these impacts range from MODERATE to VERY HIGH, depending on landscape sensitivity and development scale. Mitigation measures can reduce risks to **LOW or VERY LOW** in lower sensitivity areas, and to **LOW or MODERATE** in medium-sensitivity areas, through measures such as avoiding roosts and implementing controls. However, in high and very high sensitivity areas, impacts may remain **MODERATE to HIGH or VERY HIGH** even after mitigation, particularly where important roosting habitats occur.

Impacts on terrestrial fauna relate to habitat loss and fragmentation, disruption of ecological corridors and migration pathways, and increased mortality risks associated with roads, fencing and infrastructure. In highly sensitive landscapes these impacts are assessed as **VERY HIGH** without mitigation, but can be reduced to **MODERATE or LOW** where effective mitigation and spatial planning measures, such as wildlife corridors, buffer zones and fauna-friendly infrastructure, are implemented.

Within the water resources theme, risks vary across groundwater and surface water systems in a region. Groundwater availability and security generally show LOW to MODERATE risks, while groundwater quality may experience MODERATE risks where development intersects sensitive hydrogeological environments. Surface water resources and inland aquatic ecosystems, including rivers, wetlands and pans, show **MODERATE to HIGH** risks without mitigation, particularly where infrastructure intersects aquatic systems. Potential impacts on estuaries, including the Orange River estuary and associated micro-estuaries, are also noted as **MODERATE to HIGH** without mitigation, although these can be reduced through appropriate management. Opportunities associated with groundwater availability and security and surface water resources are generally assessed as **LOW to MODERATE** with management, particularly in higher sensitivity areas where improved water infrastructure and management systems may be required to support development.

For heritage resources, archaeological resources show VERY HIGH risks without mitigation, reflecting the high density of archaeological material across the region. Palaeontological resources show **MODERATE** to **HIGH** risks, while risks to the built environment and cultural landscapes range from **MODERATE to VERY HIGH** depending on sensitivity. With mitigation, these risks generally reduce to **MODERATE or LOW.** Opportunities are generally **LOW to MODERATE.** Palaeontological and archaeological resources show LOW opportunities, mainly associated with improved documentation, research, and heritage management resulting from development-related studies. Within the built environment and living heritage, opportunities increase to **MODERATE or HIGH** with management, particularly where investment in heritage conservation, tourism infrastructure, and cultural recognition accompanies regional development. Cultural landscapes may experience **MODERATE to HIGH** opportunities, particularly where development stimulates heritage-sensitive tourism and landscape interpretation initiatives.

For infrastructure and planning, risks associated with development planning pressure, road corridors, rail corridors, and energy project corridors/sites are consistently rated VERY HIGH without mitigation due to the scale of infrastructure required. With effective strategic spatial planning, corridor consolidation and infrastructure management, these risks can be reduced to **MODERATE or LOW.** Settlement infrastructure development presents **MODERATE to HIGH** opportunities, particularly in emerging development clusters such as the Steinkopf–Springbok corridor and settlements near the proposed development zones. Investments in housing, services, and supporting infrastructure could strengthen regional development capacity and improve living conditions in key settlements.

Within the socio-economic theme, GH_2 development presents both risks and opportunities. Population shifts, pressure on housing and municipal services, pressure on health services show **LOW to MODERATE** risks, although larger scenarios may result in HIGH risks in key nodes such as Port Nolloth and Alexander Bay, where population influx and construction activity are expected to concentrate. Tourism presents opportunities and risks; while new infrastructure and increased regional visibility may support tourism development, particularly in the Port Nolloth–Alexander Bay area and the Springbok region, heavy trucking, industrialisation and loss of the region's remote character could negatively affect tourism if not carefully managed. Export agriculture shows significant opportunities, particularly where improved logistics, port access and regional connectivity support agricultural value chains linked to the Orange River irrigation areas, although risks such as dust contamination of export crops must be managed. Job creation represents one of the most significant opportunities associated with GH_2 development.

Employment opportunities are rated HIGH to VERY HIGH, particularly in the larger GH_2 scenarios and in key development nodes. These opportunities arise from construction activities, energy generation infrastructure, port development, logistics, and associated service industries. Additional socio-economic benefits include improved regional broadband roll-out, where development-driven investment could lead to **MODERATE to HIGH** opportunities for improved digital connectivity across the region, particularly in rural settlements and development corridors.

1 **Table SPM 6**: Theme-specific risk assessment of the impacts across the baseline scenario (Sc0) and two GH_2 development scenarios (Sc1 & Sc2).

WATER RESOURCES & AQUATIC ECOLOGY

Chapter	Impact		Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
WATER RESOURCES	Groundwater	Groundwater Availability and Security	S0: Baseline	Very high sensitivity	High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		Very High	High
			S0: Baseline	High sensitivity	Moderate	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate
			S0: Baseline	Medium sensitivity	Low	N/A
			S1: Small GH2		Moderate	Very Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Low sensitivity	Very Low	N/A
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
		Groundwater Quality	S0: Baseline	Very high sensitivity	Low	N/A
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Moderate
			S0: Baseline	High sensitivity	Low	N/A
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Medium sensitivity	Low	N/A
			S1: Small GH2		Low	Low
			S2: Big GH2		Low	Low
			S0: Baseline	Low sensitivity	Very Low	N/A
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
	Surface Water Resources		S0: Baseline	Very high sensitivity	Very High	Moderate
			S1: Small GH2		Very High	Moderate
			S2: Big GH2		Very High	Moderate
			S0: Baseline	High sensitivity	High	Low
			S1: Small GH2		High	Low
			S2: Big GH2		High	Low
			S0: Baseline	Medium sensitivity	Moderate	Low
			S1: Small GH2		Moderate	Low
			S2: Big GH2		Moderate	Low
			S0: Baseline	Low sensitivity	Low	Very Low
			S1: Small GH2		Low	Very Low
			S2: Big GH2		Low	Very Low
	Inland Aquatic Ecosystems (Rivers, Wetlands and Pans)		S0: Baseline	Very high sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Very Low
			S2: Big GH2		High	Moderate to High
			S0: Baseline	High sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate to High
			S0: Baseline	Medium sensitivity	Moderate	N/A
			S1: Small GH2		Moderate	Low to Moderate
			S2: Big GH2		Moderate to High	Moderate
			S0: Baseline	Low sensitivity	Low to Moderate	N/A
			S1: Small GH2		Low to Moderate	Very Low
			S2: Big GH2		Moderate	Low to Moderate
	Estuaries (including the Orange River Estuary) and Micro-outlets		S0: Baseline	Very high sensitivity	Low to Moderate	N/A
			S1: Small GH2		High	Very Low
			S2: Big GH2		High	Moderate to High
			S0: Baseline	High sensitivity	Moderate to High	N/A
			S1: Small GH2		High	Moderate
			S2: Big GH2		High	Moderate to High
			S0: Baseline	Medium sensitivity	Moderate	N/A
			S1: Small GH2		Moderate	Low to Moderate
			S2: Big GH2		Moderate to High	Moderate
			S0: Baseline	Low sensitivity	Low to Moderate	N/A
			S1: Small GH2		Low to Moderate	Very Low
			S2: Big GH2		Moderate	Low to Moderate

AVIFAUNA

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
Displacement due to Habitat loss/ fragmentation/ transformation	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Low sensitivity	Low	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
Injury or mortality due to collisions with wind turbines, solar panels, powerlines and masts/towers	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
Injury or mortality due to electrocution on powerlines and substation infrastructure	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate

TERRESTRIALECOLOGY

Biodiversity pattern	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate
Ecological process	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	Moderate

BATS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Destruction/disturbance of bat roosts	S0: Baseline	Very high sensitivity	Moderate	N/A
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Medium sensitivity	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Very Low	N/A
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low
Bat foraging habitat loss	S0: Baseline	Very high sensitivity	Moderate	N/A
	S1: Small GH2		High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Medium sensitivity	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Very Low	N/A
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low
Bat mortalities	S0: Baseline	Very High	High	N/A
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High	Moderate	N/A
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Low	Low	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low

FAUNA

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Displacement due to habitat loss & fragmentation	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	High
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
Displacement due to disturbance such as noise, lighting and human activity	S0: Baseline	Very high sensitivity	High	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate
Changes to Ecological functioning and processes	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Very High
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Moderate

HERITAGE

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Paleontological Resources	S0: Baseline	Very high sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Medium sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Low sensitivity	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Archaeological Resources	S0: Baseline	Very high sensitivity	Very High	High
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	High sensitivity	Very High	Moderate
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Medium sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Low sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low
Maritime Resources	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Low sensitivity	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Graves	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Built Environment	S0: Baseline	Very high sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Moderate	Low
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
Living Heritage	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
Cultural Landscape	S0: Baseline	Very high sensitivity	Moderate	Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		High	Moderate
	S0: Baseline	High sensitivity	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Very High	High
	S0: Baseline	Medium sensitivity	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Moderate	High
	S0: Baseline	Low sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Low

SOCIO-ECONOMICS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Population Shifts	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	SEZ area	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Pressure on housing and municipal services	S0: Baseline	Port Nolloth, Alexander Bay	Low	Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Rural settlements	Low	Low
	S1: Small GH2		Low	Low
	S2: Big GH2		Low	Low
Pressure on health services	S0: Baseline	Port Nolloth, Alexander Bay	Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Low	Very Low
	S1: Small GH2		Moderate	Very Low
	S2: Big GH2		Moderate	Very Low
	S0: Baseline	Rural settlements	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
Social ills due to boomtown conditions	S0: Baseline	Port Nolloth, Alexander Bay	Moderate	Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Springbok area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	SEZ area	Moderate	Very Low
	S1: Small GH2		Moderate	Very Low
	S2: Big GH2		High	Moderate
	S0: Baseline	Rural settlements	Low	Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low

SOCIO-ECONOMICS *Cont…*

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Tourism (includes ore rail transport as key management option)	S1: Small GH2	Port Nolloth, Alexander Bay	Very High	Moderate
	S2: Big GH2		Very High	High
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	Springbok area	Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	SEZ area	Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S1: Small GH2	Rural settlements	Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Export Agriculture (includes railway as management option)	S1: Small GH2		Very High	Very Low
	S2: Big GH2		Very High	Very Low
Municipal capacity - technical	S0: Baseline	Port Nolloth, Alexander Bay	Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Springbok area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	SEZ area	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Rural settlements	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
Municipal capacity - political engagement and facilitation	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
Skills development	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Springbok area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	SEZ area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High

1

INFRASTRUCTURE AND PLANNING

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Development Planning Pressure	S0: Baseline	Richtersveld (Primary Receiver)	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Kamiesberg, Nama Khoi, Khai-Ma (Rest Of Region)	Very Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	District, Province and National (Incl. Agencies: NCEDA, COGSTA)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		High	Moderate
Settlement Infrastructure Development & Management	S0: Baseline	Richtersveld (Alexander Bay And Port Nolloth)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Nama Khoi (Steinkopf and Springbok Settlement Cluster)	Very Low	Very Low
	S1: Small GH2		High	Moderate
	S2: Big GH2		High	Moderate
	S0: Baseline	Khai-Ma (Poffadder And Aggeneys)	High	Moderate
	S1: Small GH2		High	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rest of Settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Low
	S2: Big GH2		Moderate	Low
Construction of Economic Infrastructure Projects	S0: Baseline	Port & SEZ	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Road Corridor (focus on R382)	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Low	Low
	S0: Baseline	Pipeline Corridors	Very Low	Very Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	High
	S0: Baseline	Rail Corridor	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very High	High
	S0: Baseline	Transmission Corridors	Very Low	Very Low
	S1: Small GH2		Very High	Moderate
	S2: Big GH2		Very High	Moderate
	S0: Baseline	Green Energy Projects/ Corridors/Sites	Moderate	Low
	S1: Small GH2		Very High	High
	S2: Big GH2		Very High	Moderate

1 **Table SPM 7**: Theme-specific opportunity assessment of the impacts across the baseline scenario (Sc0) and two GH2 development scenarios (Sc1 & Sc2).

WATER RESOURCES AND AQUATIC ECOLOGY

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Groundwater Availability and Security	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
Surface Water Resources	S0: Baseline	Very high sensitivity	N/A	Moderate
	S1: Small GH2		N/A	Moderate
	S2: Big GH2		N/A	Moderate
	S0: Baseline	High sensitivity	N/A	Low
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Medium sensitivity	N/A	Low
	S1: Small GH2		N/A	Low
	S2: Big GH2		N/A	Low
	S0: Baseline	Low sensitivity	N/A	Very Low
	S1: Small GH2		N/A	Very Low
	S2: Big GH2		N/A	Very Low
Inland aquatic ecosystems and Estuaries:	No positive opportunities identified			

SOCIO-ECONOMICS

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Tourism (includes ore rail transport as key management option)	S0: Baseline	Port Nolloth, Alexander Bay	Moderate	High
	S0: Baseline	Springbok area	Moderate	High
	S0: Baseline	SEZ area	Low	Low
	S0: Baseline	Rural settlements	Low	Moderate
Export Agriculture (includes railway as management option)	S0: Baseline	Port Nolloth, Alexander Bay, Orange River	Moderate	High
Job creation	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Very High	Very High
	S2: Big GH2		Very High	Very High
	S0: Baseline	Springbok area	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	SEZ area	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		High	High
	S2: Big GH2		High	High
Skills development	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Springbok area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	SEZ area	Low	Moderate
	S1: Small GH2		Low	Moderate
	S2: Big GH2		Low	Moderate
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
Regional broadband roll-out	S0: Baseline	Port Nolloth, Alexander Bay	Very Low	Very Low
	S1: Small GH2		High	Very High
	S2: Big GH2		High	Very High
	S0: Baseline	Springbok area	Very Low	Low
	S1: Small GH2		High	Very High
	S2: Big GH2		High	Very High
	S0: Baseline	SEZ area	Low	Low
	S1: Small GH2		High	Very High
	S2: Big GH2		Very Low	Low
	S0: Baseline	Rural settlements	Very Low	Very Low
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate

HERITAGE

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Palaeontological Resources	S0: Baseline	Very high sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Moderate
	S0: Baseline	High sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Moderate
	S0: Baseline	Medium sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Low
	S0: Baseline	Low sensitivity	Very low	Low
	S1: Small GH2		Very low	Low
	S2: Big GH2		Very low	Low
Archaeological Resources	S0: Baseline	Very high sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	High sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	Medium sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
	S0: Baseline	Low sensitivity	Very Low	Low
	S1: Small GH2		Very Low	Low
	S2: Big GH2		Very Low	Low
Maritime Resources	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	Low	Very Low
	S1: Small GH2		Low	Very Low
	S2: Big GH2		Low	Very Low
	S0: Baseline	Low sensitivity	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low
Graves	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Built Environment	S0: Baseline	Very high sensitivity	Low	High
	S1: Small GH2		Low	High
	S2: Big GH2		Moderate	Very High
	S0: Baseline	High sensitivity	Low	High
	S1: Small GH2		Low	High
	S2: Big GH2		Moderate	Very High
	S0: Baseline	Medium sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	High
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	Moderate
Living Heritage	S0: Baseline	Very high sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	High sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Low	High
	S0: Baseline	Medium sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
	S0: Baseline	Low sensitivity	N/A	N/A
	S1: Small GH2		N/A	N/A
	S2: Big GH2		N/A	N/A
Cultural Landscape	S0: Baseline	Very high sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	High sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	Medium sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High
	S0: Baseline	Low sensitivity	Very Low	Moderate
	S1: Small GH2		Very Low	Moderate
	S2: Big GH2		Very Low	High

INFRASTRUCTURE AND PLANNING

Impact	Scenario	Spatial Receiving Environment	Risk / Opportunity Without Management	Risk / Opportunity With Management
Settlement Infrastructure Development	S0: Baseline	Port Nolloth and Alexander Bay	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Steinkopf and Springbok cluster	Very Low	Very Low
	S1: Small GH2		Moderate	High
	S2: Big GH2		Moderate	High
	S0: Baseline	Pofadder and Aggeneys	Moderate	Moderate
	S1: Small GH2		Moderate	Moderate
	S2: Big GH2		Moderate	Moderate
	S0: Baseline	Rest of Settlements	Very Low	Very Low
	S1: Small GH2		Very Low	Very Low
	S2: Big GH2		Very Low	Very Low

3. STRATEGIC PLANNING AND GOVERNANCE RECOMMENDATIONS

Given the scale, spatial footprint and transformative potential of the proposed Boegoebaai Port, SEZ and associated GH_2 programme, strategic planning and governance alignment are essential to ensure that development decisions are robust, equitable and environmentally responsible. This section synthesises the multidisciplinary findings of the WP2 SEA into strategic management and regional planning actions to guide policymakers, planners, regulators and project developers. The evidence emanating from WP2 is that development feasibility in the Namakwa Region is not primarily constrained by a lack of space or land availability, but by the need for informed spatial selectivity, institutional readiness and well considered developmental sequencing. While large areas of the region are environmentally and socially sensitive, sometimes extremely so, there are landscapes of lower sensitivity where development could be considered, provided that strict avoidance of critical areas, proactive mitigation, spatial design standards, and coordinated governance arrangements are applied. Additionally, there are landscapes in the region—of which the proposed SEZ is one—where prior ecological degradation has progressed to such an extent that the 'do nothing' alternative is no longer viable for protecting biodiversity, and some scale of restoration intervention is required, whether market-driven or state-funded. This is especially true in the context of shifting climatic patterns in the region and loss of resilience in areas which are already partly or fully degraded.

3.1 Climate Change, Ecosystem Degradation, and Implications for Planning

Land-use planning must move beyond impact minimisation and actively promote ecosystem resilience. Strategic planning frameworks should explicitly integrate climate change refugia and areas of existing ecological degradation into spatial decision-making, ensuring that development is steered away from systems that are already under stress and does not exacerbate ongoing decline. Climate change is potentially the most significant long-term threat to biodiversity in the Namakwa Region, acting as a pervasive pressure that amplifies the impacts of land-use change, infrastructure development and habitat fragmentation. Vegetation productivity trend analyses indicate widespread signals of declining productivity and ecological stress throughout the region, with particularly pronounced trends in the Richtersveld and adjacent landscapes. A high proportion of the region's vegetation types trigger Red List of Ecosystems (RLE) risk thresholds, reflecting disruption of key ecological processes rather than historical habitat loss alone. These patterns signal declining ecosystem resilience and reduced capacity to absorb additional disturbance.

3.2 High Sensitivity Areas that must be Avoided

Extensive VERY HIGH sensitivity areas across the region contain irreplaceable biodiversity features, concentrations of SCC, and critical ecological processes, and are not suitable for development. These areas underpin regional ecological integrity and are central to achieving biodiversity conservation targets.

a) **HIGH and VERY HIGH biodiversity sensitivity landscapes**: much of the region falls within the Succulent Karoo Biome, a global biodiversity hotspot characterised by exceptional endemism and ecological uniqueness. Areas that should be avoided include (Box SPM 20):

- Core biodiversity areas and protected areas, including national parks, nature reserves and formally identified expansion areas;
- Landscapes with concentrations of threatened or endemic plant species, quartz patches, gravel plains, south-facing slopes and mountain systems;
- Areas identified as having **VERY HIGH** cumulative biodiversity sensitivity where multiple ecological receptors (plants, fauna, birds, bats and aquatic systems) overlap.

Development in these areas would result in irreversible biodiversity loss and would likely trigger offset requirements of a scale that is ecologically and institutionally impractical.

b) **Avifauna- and bat-sensitive areas**: these are extensive areas of **VERY HIGH** sensitivity for avifauna and bats, particularly in relation to wind energy development. These include:

- Flight corridors used by large raptors and bustards;

- Areas supporting endemic or threatened bird species;
- Water-associated landscapes critical for bat foraging and movement;
- Limestone and cavernous geological formations with high roosting potential.
- Large bat roosts, caves and their associated buffers.

Wind energy and tall infrastructure should be excluded from these landscapes, with avoidance being prioritised over reliance on post-construction mitigation.

c) **Water resource protection areas:** given the extreme aridity of the region, groundwater systems, strategic water source areas, wetlands and the Orange River corridor are highlighted as critical constraints. Development should avoid:

- Strategic Water Source Areas around Port Nolloth, Kommagas and the Kamiesberg;
- Floodplains, pans and ephemeral river systems (these are highly vulnerable to disturbance);
- Areas where pollution risks could compromise already stressed water supply systems.

Overall, water scarcity and the extreme ecological sensitivity of the region's aquatic systems represent some of the most significant constraints on future development. Sustainable expansion of renewable energy and GH_2 infrastructure would only be feasible if paired with major investment in desalination, water treatment, reticulation upgrades, and strict avoidance of high-sensitivity aquatic and groundwater recharge areas, alongside a shift toward a circular water economy designed to prevent unintended changes to natural hydrological regimes.

Box SPM 20: Location of biodiversity features requiring strict avoidance

Irreplaceable and non-offsettable biodiversity features are not uniformly distributed, but are concentrated in distinct parts of the Namakwa Region, including:

- **The Richtersveld**, including the Richtersveld National Park, the Richtersveld Cultural and Botanical Landscape World Heritage Site, and adjacent communal lands, which contain centres of endemism, climate refugia, mountain systems and living cultural landscapes.
- **The Kamiesberg mountain system**, where quartzite mountains, south-facing slopes, high plateaus and relict ecosystems support exceptional levels of plant endemism and act as key climate refugia.
- **The Bushmanland Inselberg Region**, where isolated inselbergs and gravel plains host narrowly distributed endemic species concentrated in discrete microhabitats.
- **Intact Sandveld dune systems along the west coast**, which support Sandveld endemic mammals such as De Winton's golden mole, Van Zyl's golden mole and the Namaqua dune molerat, and are highly vulnerable to disturbance and sand mobilisation.
- **The Alexander Bay lichen fields**, located in the far north-western coastal zone, internationally recognised for their unparalleled lichen diversity and extreme sensitivity.
- **Protected areas and formally identified protected area expansion priority zones**, including landscapes required to meet long-term conservation targets and maintain ecosystem representation.

d) **Heritage and cultural landscapes**: the Namakwa Region contains dense and often unmarked heritage resources, particularly along the coast and within communal lands. Areas to be avoided include:

- The Richtersveld Cultural and Botanical Landscape World Heritage Site and its buffer zones;
- Coastal dune systems with high densities of archaeological material and unmarked graves;
- Recognised cultural landscapes, scenic routes and areas of high sense-of-place value.

Avoidance is especially important because many heritage resources are only detected once disturbed, making post-impact mitigation largely ineffective.

3.3 Targeted Low Sensitivity Development Areas

A defensible approach to enabling development while safeguarding ecological systems, heritage and social systems is to concentrate infrastructure and land-intensive activities in landscapes that are already transformed, degraded, or of comparatively lower sensitivity (Box SPM 21)**, and to avoid expansion into intact, high-value systems.** At a regional scale, areas of comparatively lower sensitivity have been considered. These areas provide opportunities to reduce additional habitat loss, limit fragmentation, and contain impacts within landscapes that have already absorbed substantial historical disturbance. Based on the WP2 findings, three key locational principles emerge to guide spatial decision-making:

> **Box SPM 21: Why 'lower sensitivity' does not mean 'low risk'**
>
> Lower-sensitivity areas identified in WP2 provide relatively greater flexibility for development, but they are not impact-free landscapes. Even in these areas, poorly planned or cumulative development can result in significant ecological, hydrological and social consequences. The designation of lower sensitivity should therefore be understood as a comparative planning signal, not a blanket approval for development. All projects remain subject to site-specific assessment, mitigation and monitoring.

a) **Coastal zone landscapes: historic diamond mining along the Namaqualand coast has left an extensive belt of disturbed land, particularly between Kleinzee and Alexander Bay.** These landscapes exhibit substantially altered geomorphology and biodiversity condition, with ongoing challenges related to sand mobilisation and long-term rehabilitation. Within this coastal mining belt, there is comparatively greater flexibility for siting wind energy infrastructure and associated facilities, provided that:
   - Development is restricted to already disturbed footprints;
   - Turbine foundations and access infrastructure are designed to integrate with engineered sand stabilisation measures;
   - Setbacks from sensitive coastal features, estuaries and intact dune systems are strictly enforced;
   - Development avoids avifaunal and bat movement corridors, sensitive heritage resources, and climate refugia; and is spatially configured to minimise any additional fragmentation and disruption of coastal geomorphological processes.

   The proximity of these areas to the proposed Boegoebaai Port also reduces the need for extensive new transmission corridors, thereby limiting additional and sprawling landscape fragmentation.

   This principle requires that turbine placement, access roads, hardstands and transmission infrastructure are confined to existing disturbance envelopes, that new linear infrastructure is minimised and co-located with

> **Box SPM 22: Wind turbines and coastal fog dynamics**
>
> Coastal fog dynamics are vital for sustaining life in arid landscapes like the Richtersveld because many uniquely adapted plants and animals rely on the moisture delivered by regular fog rolling in from the cold Atlantic Ocean (locally called "Ihuries" or "Malmokkies") as a primary water source in an otherwise extremely dry environment (SANParks, 2026).
>
> Although fog plays an important ecological role along the coast, especially in arid environments, scientific research specifically examining how land-based coastal wind turbines influence fog movement inland is currently lacking, and no studies have quantified whether turbines disrupt, delay, or enhance the inland penetration of fog into arid ecosystems. This represents a significant research gap for regions where fog-dependent biodiversity is both unique and vulnerable.
>
> However, evidence from offshore wind farms shows that turbines can alter fog formation and atmospheric behaviour, including cases where windfarm induced blockage and wake effects have triggered or shaped fog patterns (Hasager et al, 2023). While this offshore evidence does not directly confirm similar effects for land based coastal turbines, it suggests plausible mechanisms by which they *could* alter fog dynamics near the shore.
>
> The importance of fog in arid ecosystems, combined with offshore evidence of turbine related fog modification, underscores the need for dedicated research to understand potential impacts of coastal wind development on inland fog dependent biodiversity.

existing disturbed routes, and that development does not exacerbate sand mobilisation, interfere with fog-driven ecological processes, or encroach into adjacent intact coastal systems. Where these spatial conditions cannot be met, wind development should not proceed, irrespective of perceived energy potential.

b) **Inland low-sensitivity plains for PV development:** inland of the coastal escarpment are extensive tracts of arid plains with **comparatively lower biodiversity sensitivity, particularly where vegetation productivity is already low and where threatened ecosystem representation is less concentrated**. These areas are **generally more suitable for large-scale PV installations**, which have a lower vertical footprint and reduced collision risk compared to wind energy. However, even within these lower-sensitivity areas, development must avoid:

- Drainage lines, pans and ephemeral river systems;
- Areas associated with groundwater recharge, wetlands or strategic water source areas;
- Known heritage landscapes, including palaeontologically sensitive formations and archaeological site clusters;
- Priority biodiversity features.

Strategic planning should therefore **promote PV development as clustered precincts** within these inland plains, **rather than dispersed individual projects**, to **reduce cumulative land transformation** and simplify monitoring and governance.

This principle requires that PV arrays are configured to maintain unbuilt corridors and landscape permeability, avoid continuous blanket coverage of large areas, and avoid grading, stripping and sealing of soils critical to arid-zone ecological function. Development suitability is contingent not only on location but on layout and spacing at precinct scale, and on demonstrated feasibility of water supply and servicing without compromising ecological or municipal resilience.

c) **Infrastructure corridors and nodal consolidation**: a corridor-based development model is strongly supported, particularly along the N14 and the proposed SEZ logistics routes. Concentrating pipelines, transmission lines, roads and (where feasible) rail infrastructure within shared servitudes reduces landscape fragmentation, limits repeated disturbance and improves regulatory oversight. This approach is especially critical given the scale of linear infrastructure required under the larger GH_2 scenarios.

This principle requires proactive co-location of linear infrastructure, avoidance of parallel or duplicated corridors, and alignment that prioritises ecological process integrity over shortest-route or least-cost considerations. Clustering is not appropriate where it would concentrate impacts beyond ecological or social thresholds, compromise sensitive systems, or exceed the institutional capacity required for coordinated planning, monitoring and adaptive management.

3.4 Strategic approach to biodiversity offsets and ecological compensation at a regional scale (after Botha, 2026)

The Namakwa region is characterised by **exceptionally high biodiversity sensitivity at a landscape scale**, combined with widespread existing and proposed development pressures. Approximately **71% of the regional planning domain contains sensitive biodiversity features**, including CBAs, Protected Area Expansion Priority Focus Areas, under-protected vegetation types, and concentrations of SCC. As a result, **complete avoidance of biodiversity impacts is unlikely**, even under relatively modest GH_2 development pathways.

> **Box SPM 23: Offset versus ecological compensation**
>
> Biodiversity offsets aim to achieve no-net-loss or net-gain outcomes for biodiversity features, and ecological compensation may be considered only where residual impacts cannot be fully offset. Ecological Compensation carries significantly higher regulatory, financial and governance risks and should be avoided through early spatial planning and avoidance wherever possible

The WP2 SEA biodiversity framework emphasises that **biodiversity offsets and ecological compensation** (Box SPM 23) **are not a substitute for avoidance or minimisation**, and cannot be used to justify development in areas where impacts on Critical Habitat or irreplaceable biodiversity features are unavoidable. For developments seeking alignment with international finance standards and GH_2 market requirements, **demonstrable application of the mitigation hierarchy is non-negotiable**, with **offsets positioned strictly as a mechanism of last resort to address residual impacts**.

At a regional scale, biodiversity offsets are most likely to be **triggered by the cumulative footprint of GH_2-related infrastructure**, rather than by any single facility. Even relatively **modest GH_2 development pathways (e.g. under Sc1) are expected to result in extensive cumulative land use, with larger or more accelerated development pathways substantially increasing the scale of residual biodiversity impacts, particularly when linear infrastructure is included**, excluding indirect and induced effects. Linear infrastructure, such as transmission lines, pipelines, rail corridors and access roads, substantially amplifies both the spatial extent and ecological significance of impacts, particularly where these intersect with ecological corridors, bird movement pathways or under-protected vegetation types.

Offsets are therefore most likely required where development unavoidably affects (i) CBAs and ESAs, (ii) habitats supporting SCC, (ii) vegetation types that are poorly protected within the national protected area network, and (iv) landscape-scale ecological processes, including connectivity. Where impacts compromise ecosystem persistence thresholds or affect Critical Habitat, **standard biodiversity offsets may be insufficient or inappropriate**, and the framework identifies the possible need for **ecological compensation**, subject to stringent justification and regulatory oversight. This significantly elevates regulatory, financial, and governance risk.

The WP2 Biodiversity Offset Framework does not designate specific offset sites, but identifies **strategic offset opportunity areas** at a regional scale. These receiving areas are defined to guide planning and sequencing decisions, recognising that offset requirements are likely to be large, cumulative, and long-term.

Potential offset receiving areas (Figure SPM 6) are located primarily within:

- **Protected Area Expansion Priority Areas**, particularly where these adjoin existing national or provincial protected areas and can contribute to consolidation of the protected area network;
- **large, intact inland landscapes** with relatively low current development pressure and high ecological integrity; and
- **areas capable of supporting contiguous offset landscapes**, rather than fragmented, isolated parcels.

Areas subject to existing or legacy mining and prospecting rights are explicitly identified as poor candidates for offsets, due to the risk of future land-use conflict and the difficulty of securing durable, enforceable conservation outcomes. Similarly, **degraded or previously mined coastal landscapes, while appropriate for development, are not considered suitable for offset receiving areas**, as they are unlikely to deliver additional biodiversity gains.

The spatial pattern illustrated in Figure SPM 6 highlights that offset receiving opportunities are limited and highly constrained, reinforcing the need for early, coordinated regional planning. The map is indicative and explanatory and is intended to inform strategic decision-making rather than to define approved offset sites.

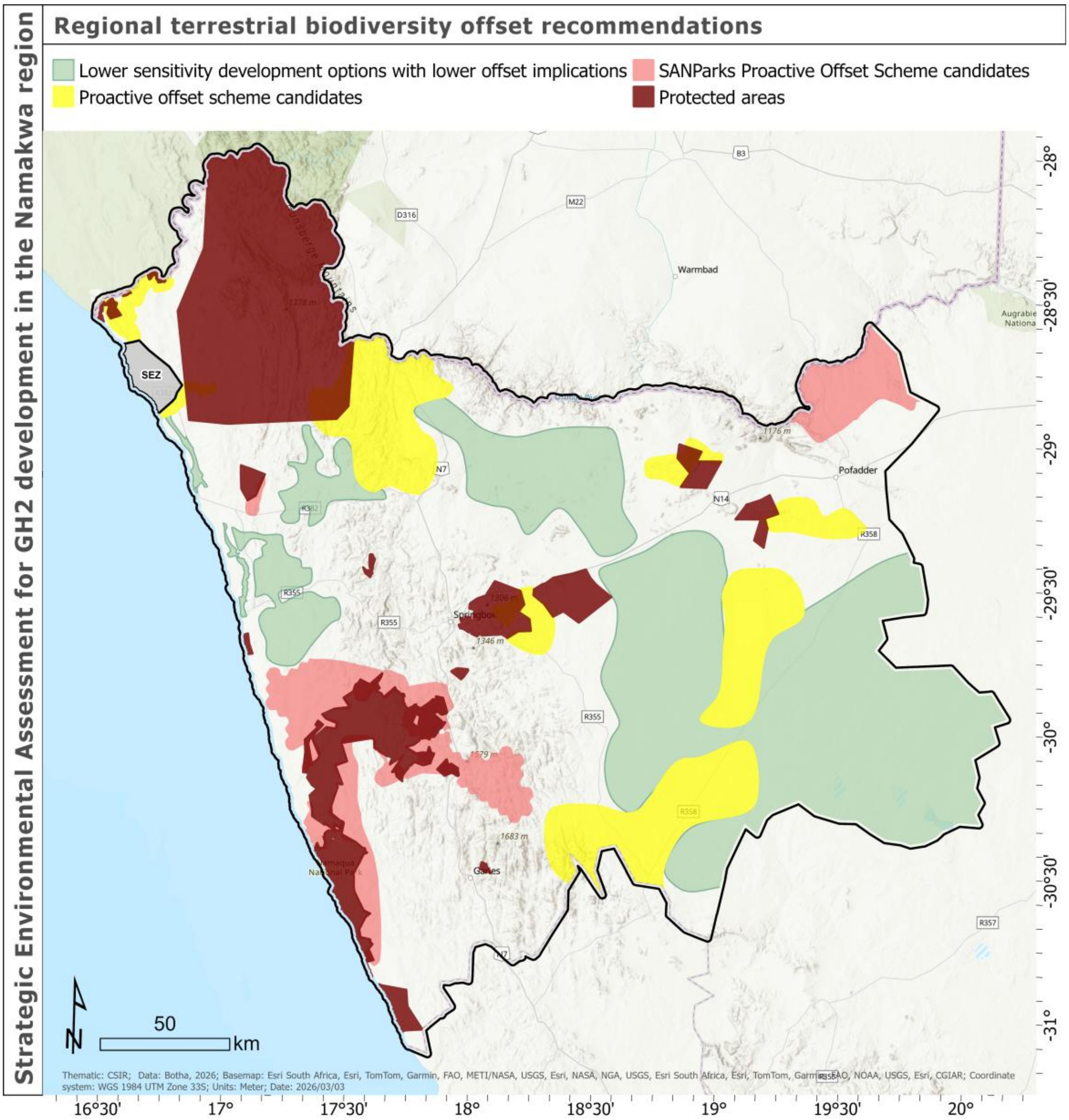


Figure SPM 6: Indicative biodiversity offset receiving opportunity areas and constraints within the WP2 planning domain, highlighting Protected Area Expansion Priority Areas, biodiversity priority features and areas excluded due to mining and development constraints (Botha, 2026)

The determined **scale of potential offset requirements is unprecedented in the regional context**. Applying nationally aligned offset ratios indicates that large-scale GH_2 development could require securing **in excess of 180 000 ha of offset land**, while even smaller development pathways could require **tens of thousands of hectares**. These magnitudes render **project-by-project offsetting impractical** (Box SPM 24), particularly in a region characterised by fragmented land tenure, legacy mining rights and limited institutional capacity.

To address this, a **proactive, aggregated and regionally coordinated approach to biodiversity offsets** is recommended, including:

- early identification of large, contiguous offset receiving areas;
- prioritisation of Protected Area Expansion Priority Areas and NPAES focus areas;
- resolution of conflicts with existing mining and prospecting rights in prospective offset zones; and
- establishment of durable stewardship, management and financing arrangements to ensure long-term biodiversity outcomes.

Box SPM 24: Why project-by-project offsets are not viable at scale

When offset requirements reach landscape scale, negotiating, securing and managing offsets on a project-by-project basis becomes inefficient, slow and conflict-prone. The biodiversity offset framework shows that without aggregation and coordination, offsets risk becoming a major bottleneck to development while failing to deliver meaningful biodiversity outcomes.

Offset considerations must be embedded in regional planning and governance frameworks upfront, rather than deferred to downstream project-level assessments. Spatial planning instruments such as SDFs, EMFs, SEZ master plans and renewable energy corridors should explicitly:

- steer development toward **already degraded or previously mined landscapes**, particularly along the coastal mining belt;
- align renewable energy generation, grid infrastructure and associated corridors with **areas of lowest biodiversity sensitivity**;
- and delineate **areas where development would trigger unmanageable offset or compensation liabilities**, effectively functioning as strategic avoidance zones.

It must be noted that large-scale offsetting is fundamentally a governance challenge. Without early spatial direction, coordinated institutional arrangements and regulatory certainty, offsets can delay projects, increase investor risk, and fail to secure conservation outcomes. Proactive regional offset planning reduces uncertainty for both developers and regulators while improving biodiversity outcomes. It is recommended that **proactive strategic and/or pooled offset mechanisms** are explored, potentially linked to existing protected areas, to reduce fragmentation, improve efficiency, and enhance conservation effectiveness. Such mechanisms must be additional to, and not a substitute for existing public conservation funding.

3.5 Infrastructure and strategic planning recommendations (after Maritz et al.,2026)

Infrastructure capacity and planning readiness are among the most significant limiting factors for sustainable development in the Namakwa Region. **Corridor-led infrastructure planning should be prioritised to align roads, rail, pipelines and transmission infrastructure with the spatial clustering principles and to reduce cumulative impacts**.

Where large-scale ore and bulk material transport is envisaged, **early investment in rail infrastructure is strategically preferable to long-term reliance on heavy road haulage, which poses severe risks to road condition, safety, tourism and settlement amenity. Water availability, treatment capacity and operational management must be recognised as binding constraints on development, with desalination and augmentation schemes planned and governed as regional systems rather than project-specific add-ons.**

Infrastructure investment should prioritise nodal settlements such as Port Nolloth, Alexander Bay, and Springbok to avoid dispersed informal growth. Implementation of these recommendations requires strengthened planning and regulatory capacity at municipal and district levels, proactive land access and tenure resolution, and coordinated inter-governmental governance arrangements.

3.6 Preliminary development planning guidance

Based on the integration of WP2 thematic assessments, preliminary development planning guidance is drawn (**Figure SPM 7**). The spatial guidance does not identify preferred or approved development areas, but rather differentiates areas and development options that, from a preliminary, strategic level, could present opportunities.

Theoretically, enough space of lower environmental sensitivity and lower offset implications exist in the Namakwa region to support RE development needed to meet the Boegoebaai GH2 ambitions. Despite the region's high overall ecological sensitivity, comparatively lower-sensitivity land exists across the inland plains, providing sufficient spatial opportunity to accommodate the 52,000–416,000 ha of RE footprints required under the small and large GH_2 scenarios. The identified RE development options (**Figure SPM 7**) are characterised by lower concentrations of priority biodiversity features, reduced heritage density, and fewer hydrological constraints, making them the most defensible areas for large-scale solar PV and associated RE infrastructure.

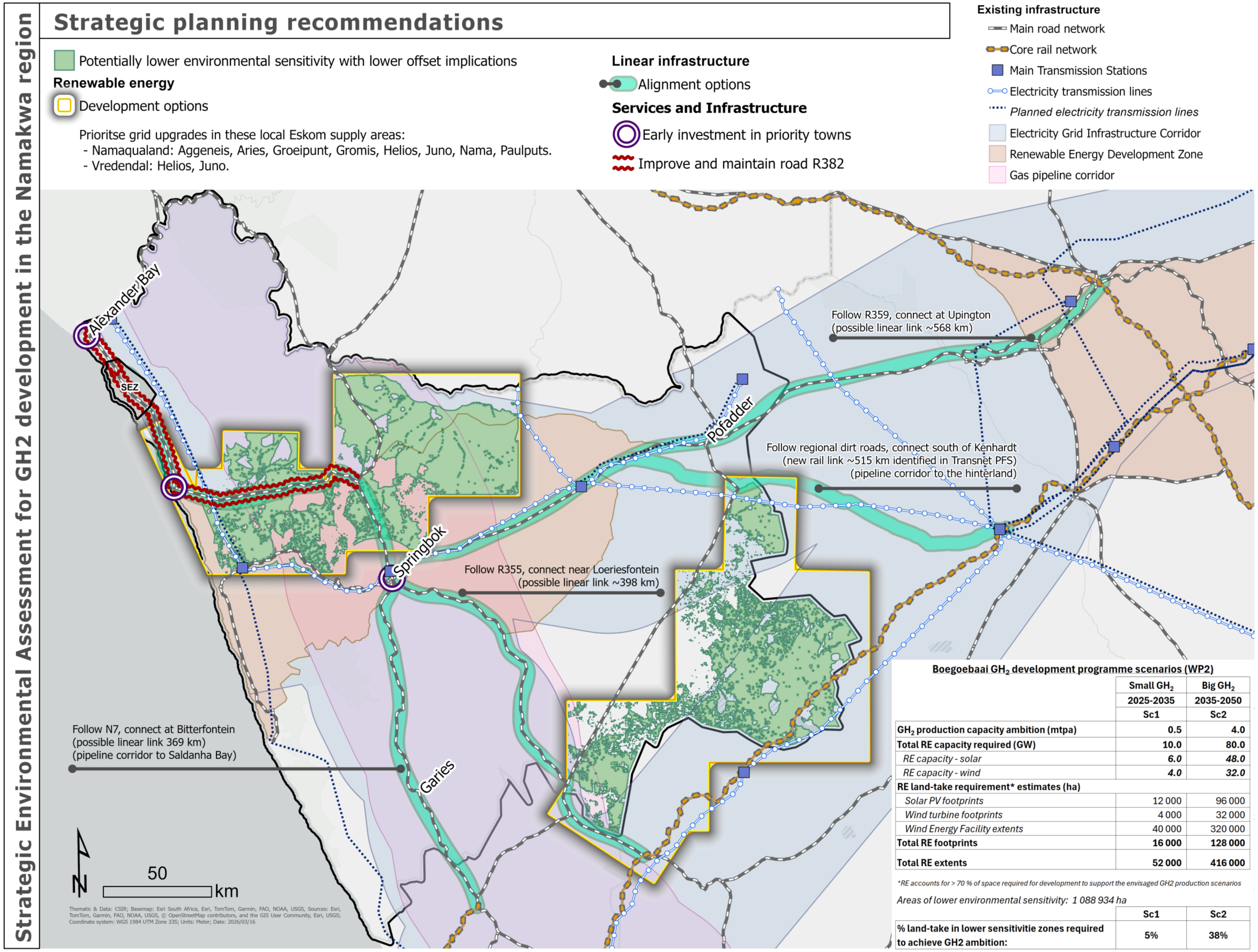
Although the areas exhibit relatively lower sensitivity at regional scale, all development must be subject to project-level environmental assessment and site-specific field verification, as these regions will still contain highly sensitive social and ecological features. While these areas still require site-level verification, the regional mapping confirms that theoretical land availability is not the binding constraint; instead, strategic siting within these lower-conflict zones is the key to enabling the green hydrogen vision without imposing unmanageable offset obligations.

It is necessary to target disturbed areas and existing linear corridors for development. New development footprints should first be directed toward already transformed areas and established infrastructure servitudes, where ecological and heritage sensitivities have already been substantially altered. Co-locating new roads, pipelines, transmission lines and rail within existing linear corridors such as the R382, N7, and N14 (**Figure SPM 7**) can minimise additional fragmentation and helps contain cumulative regional impacts. This approach ensures that development intensification occurs within landscapes already carrying ecological disturbance rather than creating new, parallel disturbance pathways.

Grid infrastructure and capacity availability is one of the most significant limiting factors for realising the Boegoebaai GH_2 programme. While lower-sensitivity land is available for renewable energy generation, the current grid has insufficient capacity and is spatially constrained to evacuate the scale of power required to support 5–40 GW of electrolysis. New and strengthened transmission infrastructure, particularly in the Eskom supply areas of Vredendal and Namaqualand (Eskom, 2023), must be prioritised early and strategically aligned within low-sensitivity zones and existing corridors to avoid high-impact areas. Without early grid expansion the region risks a scenario where RE potential exists but cannot be connected, effectively stalling GH_2 production and undermining the feasibility of the SEZ and port-related industrial development.

Upgrade and maintain upgrading and maintenance of key transport routes, particularly the R382 which would act as primary freight and mobility link to the Boegoebaai coastline. Under the small GH_2 scenario, truck volumes could exceed 500 heavy vehicles per day, placing unsustainable strain on a route that traverses multiple medium to highsensitivity zones near the coast. Upgrading, resurfacing, and maintaining the R382—especially at Anenous Pass—is nonnegotiable, both to support construction logistics and to safeguard settlement safety, tourism routes, and emergency response capacity. Strengthening this corridor also avoids the need to carve new roads through intact dune systems, thereby aligning infrastructure development with the least conflict spatial envelope.

Early catalytic investment in anchor towns is necessary to support port and Special Economic Zone (SEZ) development. Port Nolloth, Alexander Bay, and Springbok area critical spatial nodes that must receive early investment to manage inmigration, construction phase demand, and long-term operational support for the proposed port and SEZ. These towns are relatively isolated settlement nodes surrounded by high-sensitivity landscapes, meaning outward expansion is limited and inward upgrading is essential. Prioritised investment in water supply, wastewater treatment, housing, roads, social services, and administrative capacity is needed to prevent unmanaged growth, informal settlement expansion, and local service pressures. Because these settlements could bear the brunt of Boegoebaai GH_2related economic and demographic pressures, proactive strengthening of their infrastructure and governance systems forms the foundation of a socially and environmentally viable development pathway.



Boegoebaai GH_2 development programme scenarios (WP2)

	Small GH_2 2025-2035 Sc1	Big GH_2 2035-2050 Sc2
GH_2 production capacity ambition (mtpa)	**0.5**	**4.0**
Total RE capacity required (GW)	**10.0**	**80.0**
RE capacity - solar	***6.0***	***48.0***
RE capacity - wind	***4.0***	***32.0***
RE land-take requirement* estimates (ha)		
Solar PV footprints	12 000	96 000
Wind turbine footprints	4 000	32 000
Wind Energy Facility extents	40 000	320 000
Total RE footprints	**16 000**	**128 000**
Total RE extents	**52 000**	**416 000**

**RE accounts for > 70 % of space required for development to support the envisaged GH2 production scenarios*

Areas of lower environmental sensitivity: 1 088 934 ha

	Sc1	Sc2
% land-take in lower sensitivitie zones required to achieve GH2 ambition:	**5%**	**38%**

Figure SPM 7: Preliminary regional development guidance for the Boegoebaai GH_2 economy. Approximately 1 million hectares of comparatively lower environmental sensitivity were identified (light green shading). In principle, this area could accommodate the renewable energy (RE) inputs required under the two scenarios: ~10 GW (≈52,000 ha) for Sc 1 and ~80 GW (≈416,000 ha) for Sc 2. Although the areas exhibit relatively lower sensitivity at regional scale, all development must be subject to project-level environmental assessment and site-specific field verification, as these regions will still contain highly sensitive social and ecological features. Enabling infrastructure will be critical to responsible regional build-out, including: (i) expansion and strengthening of the electricity grid within the identified lower sensitivity zones; (ii) upgrading and maintenance of key transport routes, particularly the R382; and (iii) early catalytic investment in anchor towns to support port and Special Economic Zone (SEZ) development. Where feasible, new linear infrastructure should be co-located within existing disturbance corridors to minimise impact.

3.7 Socio-economic strategic recommendations and governance principles (after Atkinson et al. 2026 and Maritz et al., 2026)

The findings of the SEA demonstrate that socio-economic risks and opportunities are core determinants of whether environmentally defensible spatial decisions can be implemented successfully. The Socio-economics Chapter identifies six interrelated strategic themes that should explicitly guide planning, consultation and decision-making for the Boegoebaai Port, SEZ and associated GH_2 economy.

> **Box SPM 25: Why socio-economic risks can be managed through strategic planning.**
>
> The Socio-economics assessment demonstrates that many of the most significant risks associated with the Boegoebaai Port and GH_2 programme arise not from the physical footprint of development, but from the pace, sequencing and governance of change. In-migration, service overload, land access disputes and unmet employment expectations can undermine environmental management, erode institutional capacity and generate conflict that delays or derails projects. Addressing socio-economic risks at the strategic planning stage, through spatial differentiation of receiving areas, early consultation, realistic employment planning and strengthened governance, is therefore essential to ensuring that development remains socially acceptable, implementable and sustainable.

1) Receiving-area differentiation and spatial targeting of impacts

The Richtersveld Local Municipality is identified as the primary receiving environment for or construction-phase impacts, land access pressures and social change associated with the port, SEZ and linear infrastructure. Springbok is expected to function as the regional administrative, service and economic hub, with secondary coastal settlements such as Port Nolloth and Alexander Bay playing more specialised roles linked to port-related activity. **Strategic planning and investment must recognise these differentiated roles, ensuring that impact management, service provision and benefit distribution are spatially targeted rather than applied uniformly across the region**.

2) Sequencing of development to manage in-migration and service pressure

The Socio-economics assessment highlights construction-phase in-migration as one of the most significant social risk drivers. Where housing, water, sanitation, health, safety and policing infrastructure lag behind construction activity, unmanaged settlement growth, service backlogs and social conflict are likely to emerge. **Strategic planning must therefore sequence development so that bulk services, housing and social infrastructure are in place ahead of peak construction phases, particularly in high-pressure receiving areas.**

3) Consultation, legitimacy and consent as strategic risk management tools

Compliance-based consultation is insufficient for development of this scale and complexity. In areas characterised by communal land tenure, living heritage and customary land use, **consultation processes must begin early, continue throughout planning and implementation, and be sufficiently transparent to support informed participation. Strategic engagement approaches aligned with Free, Prior and Informed Consent (FPIC) principles are essential to maintaining legitimacy, reducing conflict and avoiding delays that can undermine both social and environmental outcomes**.

4) Land access, tenure complexity and negotiation frameworks

Land access emerges as a binding constraint in the Namakwa Region, given the prevalence of communal land, CPA arrangements, state land and historical mining legacies. **Ad hoc, project-by-project negotiations increase uncertainty, delay and inequitable outcomes**. Strategic planning should therefore be **supported by clear, upfront negotiation frameworks that address land access, compensation, benefit-sharing and long-term land use arrangements in a consistent and transparent manner**.

5) Employment realism and avoidance of boom–bust dynamics

The Socio-economics assessment **cautions against over-reliance on construction-phase employment as a measure of long-term socio-economic benefit**. While construction activity may generate short-term employment, operational employment opportunities are limited and highly skilled. Strategic planning should therefore **focus on expectation management, skills development, local procurement and economic diversification to avoid boom-bust cycles and post-construction socio-economic decline**.

6) Institutional and governance capacity as a limiting factor

Weak institutional capacity significantly amplifies socio-economic risk. Municipalities in the region are already under pressure, and even the smaller GH_2 development scenario is expected to strain planning, regulatory and service delivery systems. **Strengthening institutional capacity, clarifying roles across spheres of government and aligning socio-economic planning with spatial and infrastructure decision-making are therefore prerequisites for sustainable outcomes.**

3.8 Equitable consultation and negotiations (after Atkinson et al., 2026)

The long-term viability and legitimacy of the proposed Boegoebaai Port, Green Hydrogen and SEZ developments are critically dependent on equitable, well-structured and sustained consultation and negotiation processes. Given the scale, duration and transformative nature of the proposed developments, **consultation and negotiation processes that are equitable, inclusive and sustained over time are essential.** In contexts where communal and restituted land, Indigenous rights and culturally embedded livelihoods are implicated, meaningful engagement is a critical determinant of social legitimacy and long-term project viability.

Communities directly affected by the proposed developments particularly those holding communal land rights, need to be engaged as legitimate negotiating counterparts. In the Boegoebaai context, community acceptance functions as a social licence to operate, and inadequate or poorly structured engagement presents a material risk of contestation, delay and loss of trust.

The assessment highlights the importance of early and deliberate engagement design, particularly in contested institutional environments. This includes clarity regarding representative structures, mandates and decision-making processes, as well as attention to power asymmetries between project proponents, government institutions and local communities. **Independent facilitation is identified as an important enabling mechanism to support transparent dialogue, trust-building and constructive negotiation.**

Where proposed decisions have long-term or irreversible implications for land use, livelihoods or cultural heritage, **The assessment recommends that engagement processes be guided by the principles of Free, Prior and Informed Consent (FPIC) principles** (Box SPM 26). FPIC is framed as a process-oriented governance approach that emphasises early engagement, access to adequate and understandable information, sufficient time for internal deliberation, and respect for collective decision-making systems, rather than as a single procedural event.

Box SPM 26: FPIC Principles

- **Free:** Consent must be voluntary and without coercion.
- **Prior:** Engagement must occur before any project decisions or activities begin.
- **Informed:** Communities must receive full, accessible, and culturally appropriate information.
- **Consent:** Communities have the right to approve or reject, and to withdraw consent.

Consultation processes should avoid technocratic or once-off engagement models and instead adopt adaptive and iterative engagement approaches, such as Problem-Driven Iterative Adaptation (PDIA)[23], which allow dialogue and negotiation processes to evolve over time in response to emerging concerns, changing project parameters and shifting local priorities.

[23] An approach to policy design and implementation that focuses on solving locally defined problems through incremental learning and adaptation, rather than applying pre-packaged solutions. Applied to consultation and negotiation processes, PDIA recognises that complex, contested development contexts (such as large-scale infrastructure and green hydrogen programmes) cannot be managed through fixed consultation templates. Instead, engagement processes must evolve in response to emerging social, institutional and governance challenges.

The capacity of local institutions to participate meaningfully in consultation and negotiation processes is identified as an important contextual constraint. that limited municipal and community institutional capacity can undermine continuity, credibility and responsiveness in engagement processes. **Strengthening institutional readiness and governance capability is therefore integral to sustaining effective engagement across planning, construction and operational phases**.

Overall, equitable consultation and negotiation are **foundational to achieving socially legitimate, resilient and just development outcomes in the Boegoebaai region**, and should be embedded strategically across subsequent planning, approval and implementation phases.

3.9 Concluding remarks

The findings from the SEA highlight that while GH_2 development could contribute substantially to South Africa's energy transition and regional economic diversification, the receiving environment is characterised by high ecological, cultural and socio-economic sensitivity. At the ecological level, the Namakwa Region forms part of a globally significant biodiversity hotspot, containing exceptional levels of plant endemism, important habitats for threatened fauna, and landscapes that function as climate change refugia. VERY HIGH and HIGH sensitivity areas are widespread, particularly along the coastal belt, mountain systems, and key ecological corridors. Development within these areas carries a substantial risk of irreversible biodiversity loss and should therefore be avoided wherever possible. Although most of the landscape contains some form of biodiversity constraint, only a smaller proportion of the region contains overlapping high-value biodiversity features. This creates opportunities for strategic spatial planning that directs infrastructure toward comparatively lower-sensitivity areas, while safeguarding critical ecological assets.

The Namakwa Region is an extremely water-limited landscape with high dependence on groundwater and limited surface water availability. Several groundwater resource units and strategic water source areas are already under pressure, and municipal water infrastructure is fragile. Without careful planning, additional water demand associated with GH_2 development could exacerbate existing water scarcity and service delivery challenges, although substantial opportunities exist for the creation of new water resources in the form of seawater desalination. Heritage and cultural landscapes are also prominent features of the region.

The Richtersveld Cultural and Botanical Landscape World Heritage Site, alongside numerous archaeological resources, graves, and historically significant mining landscapes, contribute to a strong sense of place and cultural identity. These features require early identification and avoidance planning to ensure that development does not undermine heritage values.

From a socio-economic perspective, the region exhibits both high vulnerability and significant development opportunity. Long-standing unemployment, economic restructuring following mining decline, limited municipal capacity, and governance complexities create a sensitive development context. At the same time, GH_2-related infrastructure investment could stimulate employment, infrastructure improvements, and economic diversification. Realising these benefits will depend heavily on effective governance, inclusive consultation processes, and careful management of in-migration, service demand, and local expectations.

A future GH_2 economy in the Northern Cape is not constrained by a single environmental or social factor, but rather by the cumulative interaction of ecological sensitivity, water scarcity, institutional capacity, and spatial planning considerations. Findings emphasise the importance of strategic planning, early environmental/social screening, and strong governance frameworks to ensure that any future development proceeds in a manner that maximises socio-economic benefits while safeguarding the region's globally significant ecological and cultural heritage.

For the voluminous findings of the SEA to be most saliently applied, policymakers should consider various instruments through which scientific findings can be best used to guide policymaking. In this case, **several**

policy instruments, aligned to supporting a regional GH_2 economy, are already in place in the Namakwa region, for example:

- Springbok **REDZ** (Figure SPM 7) within the SEA WP2 study area, as well as the Upington REDZ further north, were gazetted under Government Notice (GN) 114, dated 16 February 2018. Benefits for large scale RE development (> 20 MW) include: BA Process instead of a full Scoping and EIA Process and reduced authority decision-making time on EA applications from 107 days to 57 days.
- **Electricity Grid Infrastructure Corridors** (GN 113, dated 16 February 2018) (Figure SPM 7) within the SEA WP2 study area. Benefits for high-voltage transmission and distribution infrastructure (> 275 kV): BA Process instead of a full Scoping and EIA Process; reduced authority decision-making time on EA applications from 107 days to 57 days on routings pre-negotiated with landowners; Generic EMPr available, must be populated with site-specific information, applies to EGI development anywhere in the country; no EA required if located in verified areas of Medium/Low environmental sensitivity in which case an EGI standard applies (GN 2002, dated 7 April 2022).
- The *Boegoebaai Port and Rail Infrastructure Project*: Northern Cape and the *Boegoebaai Green Hydrogen Development Programme*, designated **Strategic Integrated Project (SIP)** status under the Infrastructure Development Act (GN 812, dated 24 July 2020; GN 2835, dated 6 December 2022, respectively). Benefits include reduced authority decision-making time on permitting from 107 days to 57 days.
- **Gas pipeline corridors** (Figure SPM 7) within the SEA WP2 study area were published under GN 836, dated 31 July 2020, with procedures confirmed under GN 411, dated 7 May 2021. Benefits for development and related operation of facilities or infrastructure for the bulk transportation of dangerous goods in gas, liquid or solid form using pipelines (e.g. hydrogen) include: BA Process instead of a full Scoping and EIA Process; reduced authority decision-making time on EA applications from 107 days to 57 days; availability of a generic EMPr which must be populated with site-specific information (applies to gas transmission pipeline infrastructure development in the entire country).
- **Solar exclusion norm** (GN 4558, dated 27 March 2024) which excludes solar PV development from the requirement of obtaining EA, proposed in areas of low or medium sensitivity as identified by the national web-based environmental screening tool (ST) and verified by qualified specialists.

Further policy actions to operationalise the outcomes of this SEA could include, but are not limited to:

1. **Mandate integration of SEA outputs into statutory planning instruments such as municipal, regional and provincial SDFs, IDPs, EMFs and biodiversity conservation planning** to ensure consistent decisions across government, for example sensitivity maps, avoidance zones, and development corridors as national planning reference tools. **Specifically, a regional biodiversity offset / compensation mechanism should be** adopted which provides for a pooled offset bank enables large-scale, long-term conservation outcomes and meets lender requirements.
2. **Develop environmental management instruments** which is provided for in Section 24 (2) of NEMA in conjunction with the Environmental Management Instruments Regulations:
    a. **Minimum Information Requirements for GH_2 development in the Namakwa region** i.e. the minimum information that must be provided by project proponent for EA applications and EIA processes when proposing to undertake specific GH_2-related development activities.
    b. **Integration of the SEA study area in National Web-based Screening Tool** (ST) such that proponents using the ST when planning their development proposals or as required for EA Applications are directed to the SEA reporting for consideration.
3. **Establish a multi-sphere Boegoebaai Intergovernmental Steering Committee** – a political and administrative forum to oversee responsible and consequent consideration of SEA recommendations, coordinate development sequencing, permitting, land access, offsets, FPIC engagement and bulk infrastructure.
4. **Implement a formal FPIC and Community Negotiation Framework**, which is essential to secure social licence and avoid delays linked to Richtersveld CPA governance constraints.
5. The SEA findings provide new evidence that could support future updates to the national Red List of Ecosystems (RLE). **South African National Biodiversity Institute (SANBI) could, at their own discretion, in collaboration with the SEA technical team and independent experts, review the degradation analysis and assess potential updates to the RLE, particularly for ecosystems in the Namakwa Region.**

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Work Package 2:

Strategic Environmental Assessment for the proposed Boegoebaai Port, Special Economic Zone and Namakwa Region

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