IUCN RED LIST
of
ECOSYSTEMS ASSESSMENTS

www.iucnrle.orgl

Mangroves of The Agulhas EN

Taryn Riddin[1, 2], Janine Adams[1, 2], Anusha Rajkaran[3], Anesu Machite[1, 2], Nasreen Peer[4] & Ena L. Suárez[5]

[1]*Botany Department, Institute for Coastal and Marine Research, Nelson Mandela University, Gqeberha 6031, South Africa*
[2]*DSI/NRF Research Chair in Shallow Water Ecosystems, Botany Department, Nelson Mandela University, Gqeberha 6031, South Africa*
[3]*Department of Biodiversity and Conservation Biology, University of the Western Cape, Private Bag X17, Bellville Cape Town, South Africa*
[4]*Department of Botany and Zoology, Stellenbosch University, Natural Sciences Building, Merriman Avenue, Stellenbosch, South Africa*
[5]*International Union for Conservation of Nature IUCN HQ, Gland, Switzerland*

Abstract:
Mangroves of the Agulhas is a regional ecosystem subgroup (Level 4 unit of the IUCN Global Ecosystem Typology). It includes the marine ecoregions of Agulhas Bank and KwaZulu-Natal that extend along the South African eastern coastline. The extent of the Agulhas mangroves in 2023 is 23.0 km^2, representing 0.02% of the global mangrove area. Mangroves in this province are limited to 31 estuaries which provide sheltered conditions as mangroves do not occur along the open coastline. The biota is characterized by three species of true mangroves, and 88 associated animal species.

The Agulhas province mangroves are classified as terrigenous sedimentary. Natural drivers of extent and distribution include sedimentation, floods, mouth dynamics, storm surges, marine sediment deposition and propagule distribution. The ecosystem is threatened by anthropogenic pressures including urban and industrial development, harvesting for wood, livestock browsing and trampling, restriction of tidal exchange by infrastructure, freshwater abstraction causing estuary mouth closures and lower salinity, and pollution (plastics, heavy metals, oils, fungal pathogens, and coal dust). Under climate change, an increased frequency of tropical storms poses additional risks to mangrove survival due to sediment deposition, estuary mouth closures and back-flooding.

The mangrove net area change has been positive since the 1970s (+51.5%), mainly due to flow modifications and an artificial mouth opening in the Mhalthuze Estuary, which contributes ~62.5% of the total mangrove area. Natural regeneration of mangroves has occurred in some estuaries previously impacted by mouth closure related to sea storms. There are also signs of a poleward shift to southern latitudes. However, the ecosystem has collapsed in 11 estuaries since the 1930s due to development, mouth closures and inundation of mangrove stands along with sediment deposition following floods. Similar losses are expected to increase under predicted climate change scenarios. Since mangrove stands are limited laterally by development, future sea-level rise will result in permanent losses.

Overall, the status of the Agulhas mangrove ecosystem is assessed as **Endangered (EN).**

Citation:
Riddin, T., Adams, J., Rajkaran, A., Machite, A., Peer, N., & Suárez, E. L. (2024). '*IUCN Red List of Ecosystems, Mangroves of the* Agulhas'.

Corresponding author:
Email: ena.suarez@iucn.org

Keywords:
Mangroves; Red List of ecosystems; ecosystem collapse; threats.

Ecosystem classification:
MFT1.2 Intertidal forests and shrublands
Assessment's distribution:
The Agulhas province
Summary of the assessment:

Criterion	A	B	C	D	E	Overall
Subcriterion 1	VU	EN	VU	DD	NE	
Subcriterion 2	LC	EN	LC	LC	NE	EN
Subcriterion 3	LC	LC	DD	DD	NE	

EN: Endangered, VU: Vulnerable, LC: Least Concern, DD Data Deficient, NE: Not Evaluated

Mangroves of The Agulhas EN

1. Ecosystem Classification

IUCN Global Ecosystem Typology (version 2.1, Keith *et al.*, 2022):

Transitional Marine-Freshwater-Terrestrial realm

MFT1 Brackish tidal biome

MFT1.2 Intertidal forests and shrublands

MFT1.2_4_MP_51 Mangroves of the Agulhas

IUCN Habitats Classification Scheme (version 3.1, IUCN, 2012):

1 Forest

1.7 Forest – Subtropical/tropical mangrove vegetation above high tide level *below water level*[1]

12 Marine Intertidal

12.7 Mangrove Submerged Roots

2. Ecosystem Description

Spatial distribution

The 'Mangroves of the Agulhas' include the marine ecoregions of Agulhas Bank and Natal. At the South at the African administrative level, it includes the national provinces of KwaZulu-Natal and the Eastern Cape, which extend along the South African coastline, including the areas previously known as Transkei and Ciskei. They cover two bioregions, namely subtropical and warm temperate (Adams and Rajkaran, 2020). Mangroves are limited to sheltered estuaries due to the high energy nature of the coastline. They occur in 31 estuaries extending from St Lucia (28 ° S) to Tyolomnqa, their natural southern limit (33 °S) (Figure 1). The mangroves that occur in the Nahoon Estuary were planted in 1969 (Hoppe-Speer *et al.*, 2015). Twenty four estuaries occur in the subtropical bioregion; and the remaining seven estuaries are in the warm temperate region. Mangroves occur predominantly in open estuaries (61%) where daily tidal exchange occurs but stands can also be found in estuarine bays (6%), estuarine lakes (3%), large and small temporarily closed estuaries (17%) and 13% in large fluvially-dominated estuaries according to the estuarine classification of Van Niekerk *et al.* (2020). In the temporarily closed estuaries, stands are small due to the limited tidal exchange and often form a narrow band along the estuarine channel.

[1]Note on the original classification scheme. This habitat should include mangrove vegetation below water level. Mangroves have spread into warm temperate regions to a limited extent and may occasionally occur in supratidal areas. However, the vast majority of the world's mangroves are found in tropical/subtropical intertidal areas.

The estimated extent of the mangroves of the Agulhas province was 25.75 km^2 in 2020, representing ~0.02% of the global mangrove area. This is based on the Global Mangrove Watch data of Bunting *et al.* (2022), which used remote sensing to estimate spatial extent. Site-specific digitised data show an area of 23.0 km^2 in 2023 based on Adams and Rajkaran (2020) with more recent updates (*in prep.* Riddin *et al*, 2024). The uMhlathuze Estuary contributes 14.4 km^2 (62.5% of this total); two estuaries have stands between 1 and 4 km^2; and the remaining 28 estuaries have stands of less than 1 km^2 (Figure 1). There has been a net increase of 51.5% from 15.31 km^2 in the 1930s (Macnae, 1963; Ward and Steinke, 1982; Colloty *et al.*, 2001; Adams and Rajkaran, 2020; *in prep* Riddin *et al*., 2024).

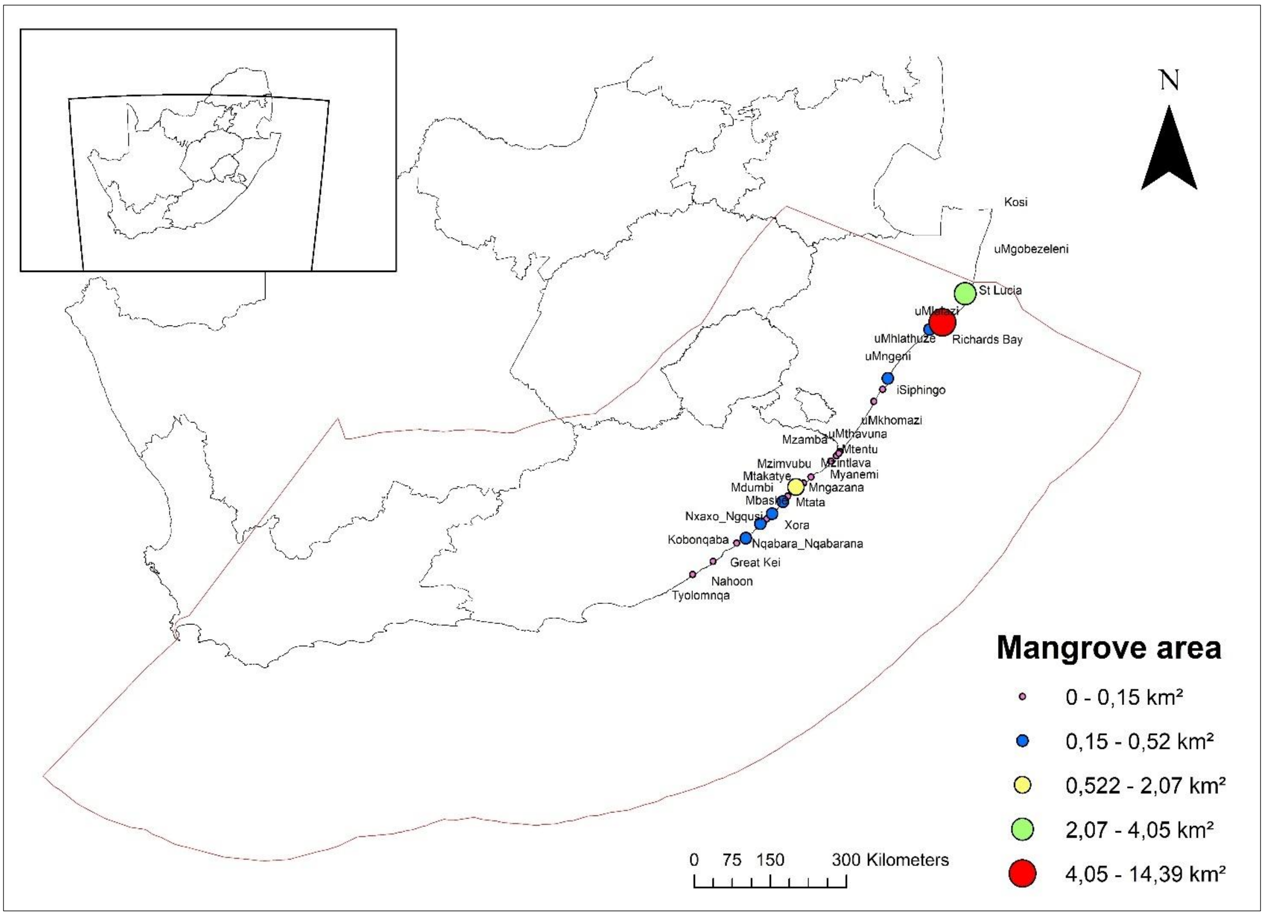

Figure 1. Distribution of mangrove area across the Agulhas province based on Adams and Rajkaran, (2020) with updates (Riddin et al. 2024). Comparison with GMW v.3 2020 spatial layer available in annex 4.

Natural drivers of mangrove extent in the Agulhas province are sedimentation, floods, estuary mouth dynamics, storm surges, marine sediment deposition and propagule dispersion (Adams and Rajkaran, 2020). The fragmented distribution of mangroves in Agulhas province is suggested to be due to limitations on dispersal, as well as narrow channel-like estuaries with little intertidal or floodplain areas for colonisation (Raw *et al*., 2022).

Narrow bands of mangroves in the Nxaxo/Ngqusi Estuary (top photo) and larger stands in the Mngazana Estuary (bottom three photos) with exposed beds of the seagrass Zostera capensis (Photo credits: Anesu Machite, Janine Adams, Taryn Riddin).

Biotic components of the ecosystem (characteristic native biota)

The mangroves of the Agulhas province are characterised by the presence of three mangrove plant species (IUCN, 2022): *Bruguiera gymnorrhiza*, *Rhizophora mucronata*, and *Avicennia marina*; all are classified by IUCN as Least Concern (CR). *Avicennia marina* (Forssk.) and *Bruguiera gymnorrhiza* (L.) Lam. occur in 25 estuaries and *Rhizophora mucronata* in 16 estuaries (Adams and Rajkaran, 2021). Mangroves often intermingle with salt marsh vegetation, reeds and sedges. On the landward side, *Juncus kraussii*, *Phragmites australis* and the mangrove fern *Acrostichum aureum* intermingle with *Bruguiera gymnorrhiza*, where freshwater seeps occur. Saline grasses such as *Sporobolus virginicus*, *Paspalum vaginatum* and *Stenotaphrum secundatum* may occur with mangroves, along with salt marsh species such as *Chenolea diffusa*, *Salicornia* spp., *Falkia repens*, *Triglochin striatum* and *Cotula coronopifolia*. Salt marsh species such as *Salicornia tegetaria* occur on the lower intertidal edges in association with the seagrasses *Zostera capensis* in the water column and *Halophila ovalis* on firm subtidal sands. *Avicennia marina* pneumatophores are colonised by *Bostrychietum* communities (Lambert *et al*., 1989), similar to studies elsewhere (García *et al*., 2016).

There are at least 88 animal species within the taxa Actinopterygii, Aves, Gastropoda, Mammalia and Reptilia associated with mangrove habitats in the Red List of Threatened Species database (IUCN, 2022) that have natural history collection records, or observations, within the distribution of this province (GBIF, 2022). The vertebrates in South African mangroves have scarcely been studied and are often recorded incidentally during estuarine-focused research. Mangrove-associated invertebrates, on the other hand, have been documented regularly since the mid-20th century. Only four of the characteristic invertebrates are included in the Red List of Threatened Species (IUCN, 2022). Many other invertebrate species are associated with South African mangroves, mainly Brachyura (in families Sesarmidae and Ocypodidae), Mollusca (*Cassidula, Melampus, Terebralia, Cerithidea, Cerithea)*, and mud prawns (*Upogebia africana*) (Peer *et al*., 2018a). Crustaceans and gastropod molluscs form an important link between producers and predators, by providing food for fish and birds (Emmerson and Ndenze, 2007; Peer *et al*., 2018a). In this way, these invertebrates form an integral trophic link, facilitate decomposition by breaking down detritus, and play a role in nutrient recycling within this generally nutrient-limited system (Emmerson and McGwynne, 1992; Cannicci *et al*., 2008).

Mangrove brachyurans are also considered ecosystem engineers as their burrowing and surface feeding activities lead to soil turnover and aeration of the substratum (Lee *et al*., 2008). Some of these species are not strictly mangrove inhabitants, including *Danielella edwardsii*, which is found on sandy flats all the way up to St Helena Bay; *Cyclograpsus punctatus*, which is a higher latitude rocky shore species; and *Cerithidea decollata* and *Parasesarma catenatum*, which inhabit saltmarshes as far west as the Knysna Estuary and Cape Agulhas, respectively (Branch *et al*., 2022). However, most of these species are strongly associated with mangroves, or they occur near mangrove stands, specifically the fiddler crabs and most sesarmids. Several factors influence presence and abundance of brachyurans in mangroves including sand grain size, estuary mouth state (open or closed mouth), canopy cover, tree density, and the presence of other mangrove-associated species (Peer *et al.*, 2018b). There is no strong latitudinal gradient driving the diversity of brachyurans or gastropods, although some species do conform to the delimitations of the northern and southern groups described by Macnae (1963) (Peer *et al*. 2018a). Although we generally see a poleward expansion in species distributions (Peer *et al.*, 2018a), some species have undergone a range contraction in the last few decades. Specifically, the giant mangrove whelk, *Terebralia palustris*, has declined in distribution and is currently found at only two sites: Kosi Bay (Western Indian Ocean province) and the Durban Harbour (Raw *et al.*, 2014).

Some of the most common mangrove-associated invertebrates. (a) Cerithidea decollata, (b) Littoraria sp., (c) Neosarmatium africanum, (d) Austruca occidentalis, (e) Paraleptuca chlorophthalmus (Photo credits: Nasreen Peer).

Abiotic Components of the Ecosystem

Mangroves are physiologically intolerant of low temperatures, which excludes them from regions where mean air temperature during the coldest months is below 20°C, where the seasonal temperature range exceeds 10°C, or where ground frosts occur. From south to north in the Agulhas province, the mean annual temperature ranges from 18.4°C to 22.7°C and the mean annual precipitation ranges from 850 to 1,014 mm (Mucina and Rutherford, 2006). At the latitudinal limits of their distribution mangroves might show plastic ranges with discontinuous or intermittent presence. Rainfall and sediment supply from rivers and currents promote mangrove establishment and persistence, while waves and large tidal currents destabilise and erode mangrove substrates, mediating local-scale dynamics in ecosystem distributions. Marine sediments, deposited at the mouths of estuaries following sea storms, can result in mouth closures and extended periods of back-flooding of mangroves. High rainfall reduces salinity stress and increases nutrient loading from adjacent catchments, while tidal flushing also regulates salinity. Increased freshwater input results in bank erosion and changes in species composition. The key processes and interactions are outlined in Figure 2.

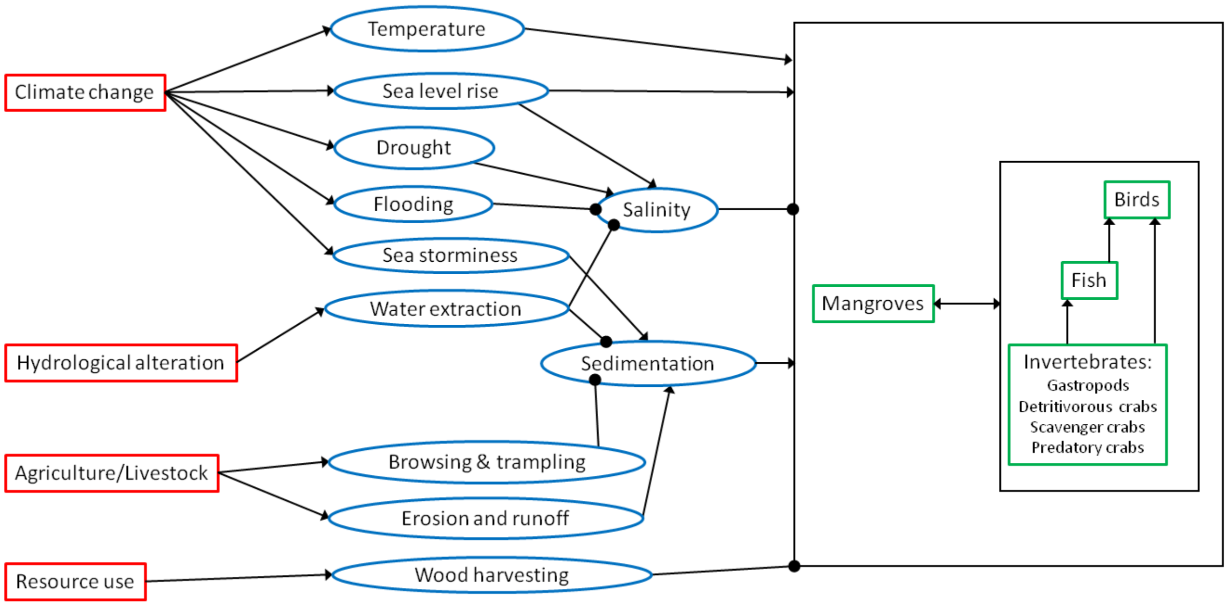

Figure 2. A simplified conceptual model of key processes relevant to the risk assessment for the mangroves of the Agulhas province. Only the most influential threats have been shown. Red boxes represent threats, blue represent the abiotic environment and processes (ellipses) and green boxes represent biotic components. Black boxes represent ecosystem components susceptible to threats. Lines with pointed arrowheads promote, and rounded arrowheads reduce, the subsequent variable. The dashed arrow indicates the context-dependent effect of temperature, sea-level rise, and sedimentation, which can affect the mangrove ecosystem positively or negatively.

Key processes and interactions

Mangroves are structural engineers and possess traits including pneumatophores, salt excretion glands, vivipary, and propagule buoyancy. These traits promote survival and recruitment in poorly aerated, saline, mobile, and tidally inundated substrata. Mangroves are also highly efficient in nitrogen use efficiency and nutrient resorption. They produce large amounts of detritus (e.g. leaves, twigs, and bark), which is either exported tidally, buried in sediments, or consumed by crabs, then decomposed further by meiofauna, fungi and bacteria, mobilising carbon and nutrients to higher trophic levels. Litter production in the Nxaxo/Ngqusi Estuary has been estimated at 1.24 g dry matter per m^2 per day (Steinke and Ward, 1990); and in the Mngazana Estuary between 0.1 to 2.4 g dry matter per m^2 depending on the season (Rajkaran and Adams, 2007).

Mangrove ecosystems also function as major blue carbon sinks, incorporating organic matter into sediments and living biomass. Sediment carbon storage values in South African mangroves range from 280.86 ± 28.1 to 1,627.57 ± 415.28 Mg C (Banda, *et al*. 2021; Johnson *et al.*, 2022; Raw *et al.*, 2019, 2021). Despite their high productivity, mangrove ecosystems exhibit lower species diversity compared to other coastal biogenic systems. They have a lower relative abundance of fish than salt marsh (Keur *et al*., 2019); however, crabs stand out as being particularly abundant and important mangrove-associated invertebrates.

3. Ecosystem Threats and vulnerabilities

Main threatening process and pathways to degradation

The main threats to Agulhas mangroves are from anthropogenic pressures, including urban and industrial development, harvesting for wood, livestock browsing and trampling, restriction of tidal exchange by infrastructure, freshwater abstraction causing estuary mouth closures, and a decrease in salinity, pollution (from plastics, heavy metals, oils and coal dust) and disease (Naidoo and Chirkoot, 2004; Osorio *et al*., 2017; Adams and Rajkaran, 2020; Govender *et al*., 2020; Johnson *et al*., 2023).

The location of mangrove forests in intertidal areas makes them susceptible to predicted sea-level rise due to climate change, especially because they are often backed by development on the landward side, or trampling by livestock has compacted the soil resulting in unfavourable conditions for propagule growth (Yang *et al*., 2014). They are further at risk because of limited propagule dispersion along the coastline. Although Raw *et al.* (2022) suggested that there are potentially six more estuaries where suitable conditions for mangroves occur, limited long distance propagule dispersal between these sites and existing mangrove stands restricts mangrove connectivity and their potential expansion.

Definition of the collapsed state of the ecosystem

Mangrove ecosystems are highly dynamic systems, with species distributions adjusting to local changes in sediment distribution, tidal regimes, and variations in local inundation and salinity gradients. Processes that disrupt these dynamics can lead to ecosystem collapse, which is defined as 100% loss of diagnostic true mangrove species. Ecosystem collapse may occur under any of the following: a) climatic conditions (low temperatures, extreme weather events, sea-level rise) that restrict recruitment and survival of diagnostic true mangroves; b) changes in rainfall and river inputs and/or waves and tidal currents that destabilise and erode soft substrata, or cause salinity stress, and disrupt mangrove recruitment and growth. Although mangroves in t he Agulhas province are small in their extent, they contribute significantly to estuarine biodiversity by providing important ecosystem services. These include coastal buffering, filtration and improvement of water quality and sequestration of large quantities of carbon in above and below ground biomass; mangroves also provide productive nursery habitats and refugia for many fish and invertebrates, with crabs and snails engineering the ecosystem by influencing benthic productivity (Adams and Rajkaran, 2020). Any disruption to these natural functions of mangroves may cause, or contribute to, ecosystem collapse. In the Agulhas province the main causes of disruption are: coastal development, wood harvesting, browsing and trampling by livestock, restriction of tidal water exchange, freshwater abstraction, pollution, fungal pathogens, reduced salinity, eutrophication and climate change (sea-level rise, sea storms and temperature change).

Threat Classification

IUCN Threat Classification (version 3.3, IUCN-CMP, 2022) relevant to mangroves of the Agulhas province:

1. Residential & commercial development
- 1.1 Housing & urban areas
- 1.2 Commercial & industrial areas
- 1.3 Tourism & recreation areas

2. Agriculture & aquaculture
- 2.1 Annual & perennial non-timber crops
- 2.3 Livestock farming & ranching

4. Transportation & service corridors
- 4.1 Roads & railroads

5. Biological resource use
- 5.1 Hunting & collecting terrestrial animals
- 5.3 Logging & wood harvesting
- 5.4 Fishing & harvesting aquatic resources

6. Human intrusions & disturbance
- 6.1 Recreational activities

7. Natural system modifications
- 7.2 Dams & water management/use

8. Invasive & other problematic species, genes & diseases
- 8.1 Invasive non-native/alien species/diseases

9. Pollution
- 9.1 Domestic & urban waste water
  - 9.1.1 Sewage
  - 9.1.2 Run-off
- 9.2 Industrial & military effluents
  - 9.2.1 Oil spills
- 9.3 Agricultural & forestry effluents
  - 9.3.1 Nutrient loads
  - 9.3.2 Soil erosion, sedimentation
- 9.4 Garbage & solid waste

11. Climate change & severe weather
- 11.1 Habitat shifting & alteration
- 11.4 Storms & flooding
- 11.5 Other impacts (sea-level rise)

4. Ecosystem Assessment

Criterion A: Reduction in Geographic Distribution

Subcriterion A1 measures the trend in ecosystem extent over the last 50-year time period. Country level assessments date back from the early 1980s (Appendix 3), along with site-specific datasets from work done by Adams and Rajkaran (2020), Raw *et al*. (2021) and Machite (2023) where South Africa's Blue Carbon Ecosystem spatial extent was mapped and is currently hosted by the National Biodiversity Assessment (http://bgis.sanbi.org/Projects/Detail/192) (Van Niekerk *et al*. 2019b). These datasets are based on detailed field research and are updated regularly as living documents. Mangrove extent for Amatigulu/iNyoni, uMhlathuze and Richards Bay estuaries were updated using methods outlined by Raw *et al*. (2023) in 2023, as were Mbashe, Great Kei and Tyolomnqa. We used these areas together with updates from Riddin et al. (2024), currently under preparation, to estimate the 2023 mangrove extent along with historical aerial imagery (http://www.cdngiportal.co.za/CDNGIPortal/) where it is possible to accurately estimate mangrove stands in each estuary as close as possible to the 1970s. Results from the analysis of subcriterion A1 (Table 1) show that the Agulhas province has gained approximately ~51.5% of its mangrove area over the last *circa* 53 years (1970s-2023) with a positive increase of 0.96% per year. Most pressures have occurred post 1970s.

Table 1. Mangrove area (ha) for stands occurring in the Agulhas province. *Information based on Adams and Rajkaran(2020) with **updated area calculations by Riddin et al. (2024), publication currently under preparation. Data available upon request to Riddin & Adams. ***The increase in mangrove area within the Mhlathuze estuary,17-fold between the 1970s and 2023, stands as the primary driver behind the province mangrove area increase. This growth is largely attributed to the development of a harbour, which has facilitated the creation of secondary mangrove habitat on a national scale.

Estuary	Type*	Mangrove Area 1970s* (ha)	Mangrove Area 2023 (ha)**
St Lucia	Estuarine lake	305.0	64.2
Mfolozi	Large Fluvially Dominated	78.2	78.2
Mhlathuze***	Predominantly open	80.0	1439.1
Richards Bay***	Estuarine bay	267.0	333.4
Mlalazi	Predominantly open	30.0	50.9
Mhlanga	Large temp closed	0.5	0
Mgeni	Predominantly open	20.3	26.5
Durban Bay***	Estuarine bay	451.1	18.1
Sipingo	Predominantly open	12.5	4.3
Little Manzimtoti	Large temporarily closed	0.5	0.0
Lovu	Large temporarily closed	2.0	0.0
Msimbazi	Large temporarily closed	0.5	0.0
Mgababa	Large temporarily closed	0.5	0.0
Ngane	Small temporarily closed	0.5	0.0
Mkomazi	predominantly open	2.0	0.7
Mahlongwa	Small temporarily closed	1.0	0.0
Kongweni	Small temporarily closed	0.5	0.0
Bilanhlolo	Small temporarily closed	0.5	0.0
Mhlangankulu	Small temporarily closed	0.5	0.0
Khandandlovu	Small temporarily closed	0.5	0.0
Mtamvuna	Large temporarily closed	1.0	0.2
Mzamba***	Predominantly open	1.0	0.4
Mnyameni	Large temporarily closed	3.0	3.5
Mtentu	Predominantly open	1.0	0.5
Mzintlava	Predominantly open	1.5	3.0
Mntafufu***	Predominantly open	10.0	12.0
Mzimvubu***	Large Fluvially Dominated	1.0	0.0
Mngazana	Predominantly open	145.0	147.0
Mtakatye	Predominantly open	7.7	10.9
Mdumbi***	Predominantly open	1.0	4.7
Mthatha	Predominantly open	42.0	29.3
Bulungula	Large temporarily closed	3.5	0.0
Xhora	Predominantly open	16.0	31.5

Estuary	Type*	Mangrove Area 1970s* (ha)	Mangrove Area 2023 (ha)**
Qhora	Predominantly open	0	1.1
Mbashe***	Large Fluvially Dominated	2.8	7.6
Nqabarana/Nqabara	Predominantly open	9.0	11.8
Nxaxo/Ngqusi	Large temporarily closed	14.0	16.4
Kobonqaba***	predominantly open	6.0	<0.01
Great Kei***	Large Fluvially Dominated	0.0	1.6
Kwelera	Predominantly open	0.0	0.5
Nahoon	Predominantly open	0.0	3.7
Tyolomnqa***	Large temporarily closed	0.0	0.6
	Total mangrove area (ha)	1519.1	2301.7

Most of these gains are due to increases in mangrove extent in the uMhlathuze Estuary (62.7% of the total gain), and an increase of over 50 ha at uMlalazi Estuary, with smaller gains also occurring in the Great Kei, Kwelera, Nahoon and Tyolomnqa estuaries. In the 1970s the uMhlathuze Estuary was divided into two with the Richards Bay port development taking place on the northern side, and a new mouth created on the southern side. The increased tidal exchange, from what was originally a shallow lagoon with a narrow mouth, has resulted in an increase of mangroves from 0.4 km^2 to 14.39 km^2 over the last *circa* 55 years. Initially mangroves expanded at a rate of 20 to 55 ha yr^{-1} from 1976 until 1982, decreasing to 5.4 ha yr^{-1} by 2000 (Bedin, 2001). The overall increase rate has been 34 ha yr^{-1}. Mangrove increase at uMlalazi Estuary was due to the management practice of keeping the mouth open to prevent back-flooding of low-lying agricultural areas (Taylor, 2020). Mangrove planting was done in the Tyolomnqa (*Avicennia marina* in 1991) and Nahoon (*Bruguiera gymnorrhiza* and *Rhizophora mucronata* in 1969 onwards) estuaries. In Tyolomnqa, an expansion rate of 0.12 ha between 2012 and 2016 was observed (Bolosha, 2017), while in Nahoon 0.06 ha yr^{-1} occurred (Hoppe-Speer *et al*., 2015a). Since the early study on the Eastern Cape estuaries completed in 2012 (Hoppe-Speer *et al*., 2015b), Machite (2023) found that mangrove cover along the Eastern Cape Coast of South Africa had increased by 7 ha, due to natural regeneration at Mzamba, Mntafufu, Mzimvubu, Mdumbi, Mbashe and Kobonqaba estuaries; these were identified as new, individual mangrove trees growing in salt marsh habitat. Similarly, isolated individual mangroves have also increased in Great Kei and Qhora estuaries where mangroves were not seen previously.

Table 2. Estimated mangrove area in 1970 and 2023 and rates of area change. Calculations based on values shown in table 1.

	Area 2023* (Km^2)	Area 1970* (Km^2)	Net area Change (Km^2)	% Net Area Change	Rate of change (%/year)
Mangroves of the Agulhas	23.0	15.2	7.8	51.5%	0.97%
Mangrove of the Agulhas excluding uMhlathuze	8.6	14.4	-5.8	-40.1%	-0.76%

**Mangrove area based on value shown in Table 1.*

However there has been a complete collapse of the mangrove ecosystems in eleven estuaries amounting to a loss of ~7 ha (Little Aamnzimtoti, Lovu, Msimbazi, Mgababa, Ngane, Mhlongwa, Kongweni, Bilanhlolo, Bulungula, Mhlangankulu, Khandandlovu estuaries) (Adams and Rajkaran, 2020). Mangrove loss through restriction of tidal exchange, and an increase of freshwater as a result of bridge construction, has occurred in many of the KwaZulu – Natal estuaries. This represents a loss of 25% of estuary-associated mangrove stands. By removing uMthlathuze there has been a ~40% loss of mangrove area in the remaining estuaries at an annual loss of –0.76% (Table 2).

Based on the collected data, the rate of change in this mangrove province was +0.96% per year (Table 2). Overall, the net change in geographic distribution is below the 30% risk threshold, classifying the ecosystem as **Least Concern (LC)** under subcriterion A1. However, there is a significant amount of new mangrove area in a single location (Mhlathuze) due to a harbor altering the estuarine dynamics. This masks other changes that may be occurring. Excluding the uMhlathuze area, which has increased as a result of anthropogenic activity, the ecosystem area has decreased by 40% over the last 50 years. As the new mangroves concentred in a single area are not necessarily equivalent to the old growth mangroves along the coast, the ecosystem is reclassified as **Vulnerable (VU)** with a range of confidence between **Least Concern and Vulnerable (LC-VU).**

Subcriterion A2 measures the change in ecosystem extent in any 50-year period, including from the present to the future. Hoppe-Speer *et al.* (2015) assessed the change in mangrove extent along the Eastern Cape coast of South Africa between 1982, 1999 and 2012. They found losses due to harvesting, trampling and browsing by cattle to be the main cause. They also found re-establishment of mangroves in three estuaries where previous losses had occurred due to extreme events such as floods and mouth closure due to sea storms. Machite (2023) re-assessed the same 17 estuaries and found an increase of 7 ha with natural regeneration occurring in several estuaries previously affected by mouth closure, inundation, and sediment deposition. This represents a net area change of +0.29 ha (0.003 km^2) over ten years (2011 to 2021).

Using the Global Mangrove Watch time series (Bunting *et al.*, 2022) the Agulhas province mangroves show a net area change of +3.21% (1996-2020). This value reflects the offset between areas gained (+ 0.47%/year) and lost (- 0.34%/year). Applying a linear regression to the area estimations between 1996 and 2020, we obtained a rate of change of +0.13 % year^{-1} (Figure 3). Assuming this trend continues in the future, it is predicted that the extent of mangroves in the Agulhas province will increase by +7.5% from 1996 to 2046; by +11.1% from 1996 to 2070 but by 7.6% from 2020 to 2070. Given that these predicted changes in mangrove extent are much less than the 30% risk threshold, the Agulhas mangrove ecosystem is assessed as **Least Concern (LC)** under subcriterion A2.

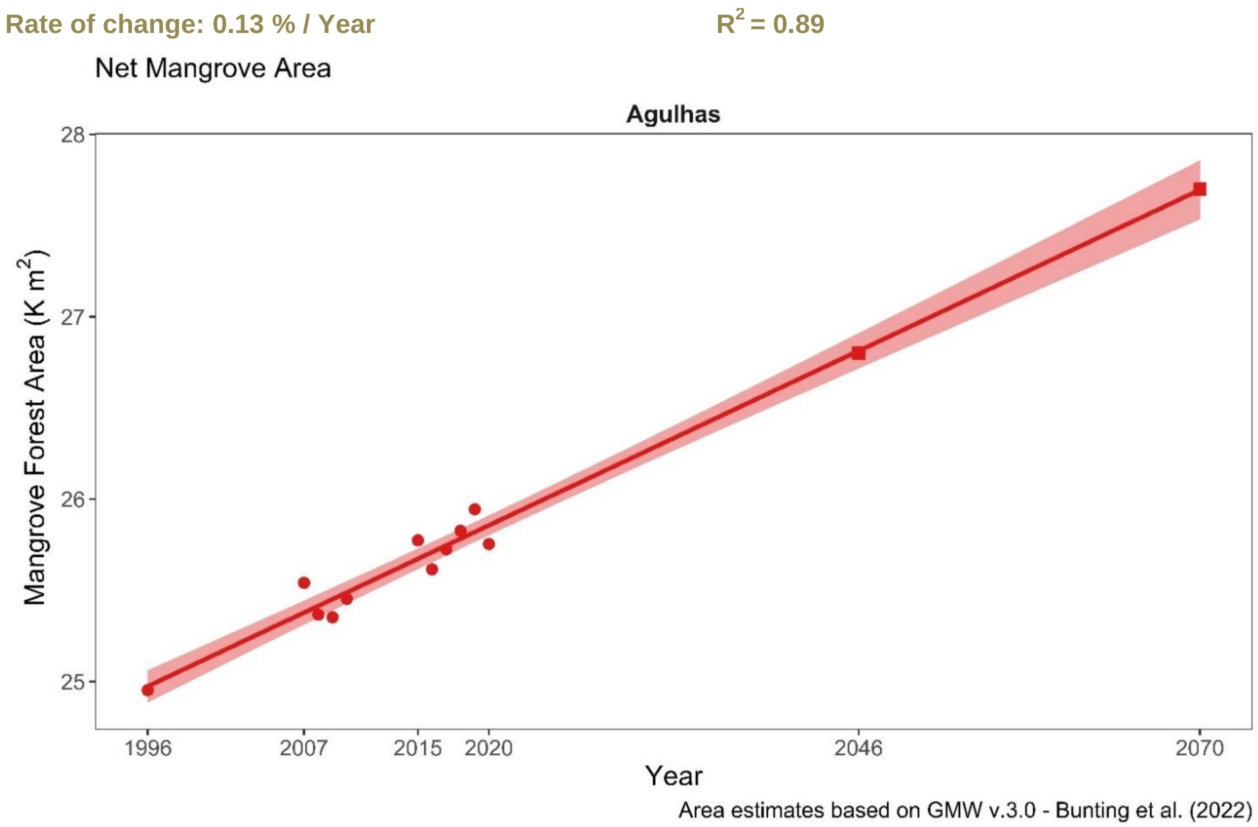

Figure 3. The Agulhas mangrove province extent projected to 2070. Circles represent the province mangrove area between 1996 and 2020 based on the GMW v3.0 dataset and equations in Bunting et al., (2022). The solid line and shaded area are the linear regression and 95% confidence intervals. Squares show the Agulhas province predicted mangrove area for 2046 and 2070. It is important to note that an exponential model (proportional rate of decline) did not give a better fit to the data (R^2 = 0.89).

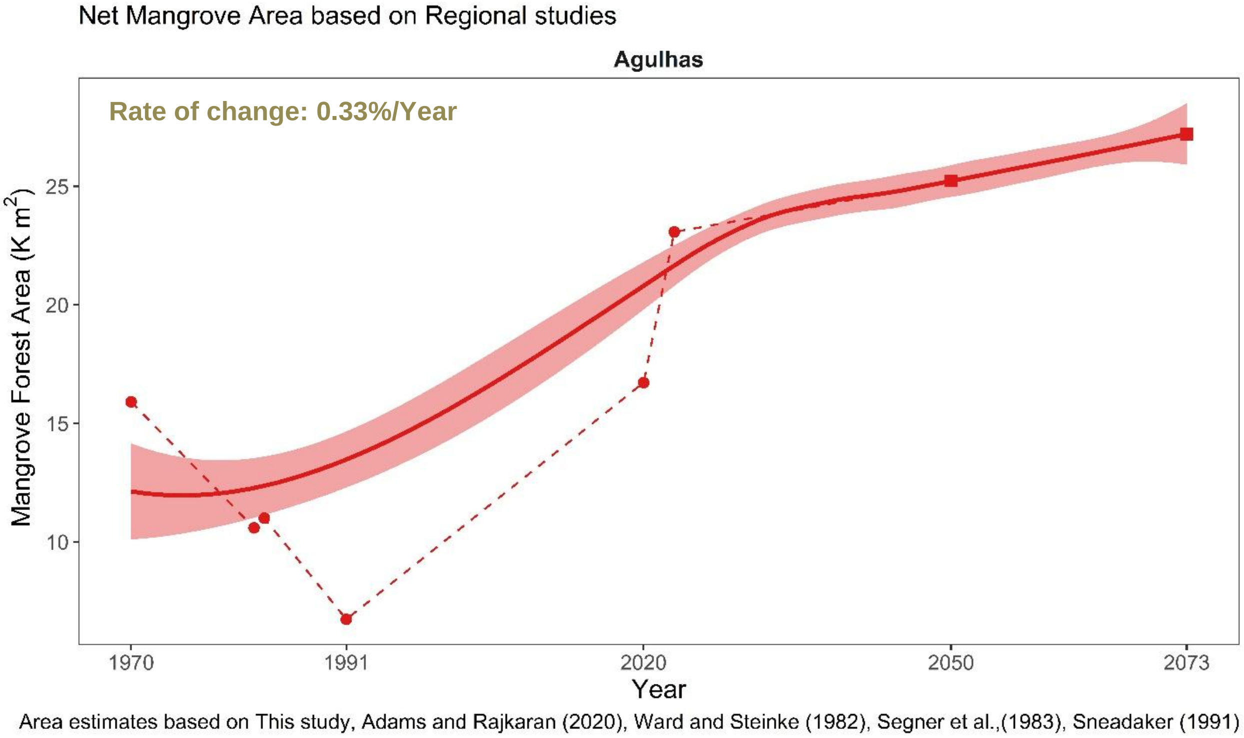

Figure 3b. The Agulhas mangrove province extent projected to 2073 assuming a proportional rate of decline. Circles and dashed line represent historic mangrove area estimates between 1970 and 2023 extracted from national statistics and regional studies (Riddin *et al.,* (2024, in prep), Adams and Rajkaran (2020), Ward and Steinke (1983), Segner et al. (1983), Sneadaker (1991)). Squares show the Agulhas province predicted mangrove area for 2050 and 2073. The solid line and shaded area are the loess regression for the whole period and the confidence interval respectively.

Subcriterion A3 measures changes in mangrove area since 1750. While we do not have reliable data on the entire mangrove extent for this period, we have estimates for the 1930s (Adams and Rajkaran, 2020, annex 3), a period likely to be similar in extent in 1750 due to the lack of anthropogenic influence. The analysis shows that Agulhas province has gained 50.3% of its mangrove area over the last *circa* 90 years (1930s-2023, Table 3). These results are mainly associated with the increase in Mangrove area in uMhlathuze (0.8 km^2 in 1930 vs 14.39 km^2 in 2023). Excluding this section there was a -40.4% decrease in mangrove area over the same period (Table 2). The ecosystem is classified as **Least Concern (LC)** for subcriterion A3.

Table 3. Estimated mangrove area in 1930 and 2023 and rates of area change. Calculations based on values shown in Table 2.

	Area 2023* (Km^2)	Area 1930* (Km^2)	Net area Change (Km^2)	% Net Area Change	Rate of change (%/year)
Mangroves of the Agulhas	23.0	15.3	7.7	50.3%	0.5%
Mangrove of the Agulhas excluding uMhlathuze	8.6	14.5	-5.9	-40.4%	-0.4%

**Mangrove area based on value shown in Annex 3. Table a.*

Overall, the ecosystem is assessed as **Vulnerable (VU)** under criterion A.

Criterion B: Restricted Geographic Distribution

The Agulhas mangroves are scattered along the east coast of South Africa in 31 estuaries. There are therefore spatially restricted and threatened by changes in the catchment or coastal dynamics such as freshwater inflow reduction and storm surges. A single or few threatening events could cause collapse.

Criterion B measures the risk of ecosystem collapse associated with restricted geographical distribution, based on standard metrics (Extent of Occurrence EOO, Area of Occupancy AOO, and Threat-defined locations). Both EOO and AOO in the Agulhas region were determined using the 2020 GMW v.3 spatial layer, along with site-specific data (Van Niekerk *et al.*, 2019) as shown in the table below.

For 2020, EOO and AOO were measured as 18,656 km^2 km^2 and 39 grid cells 10 x 10 km, respectively (Figure 4), based on site-specific information. However, after excluding those grid cells that collectively contain small patches covering less than 1% of the total mapped area of the ecosystem, the AOO is estimated as 19 grid cells (10 x 10 km) (Figure S2 - Annex 4).

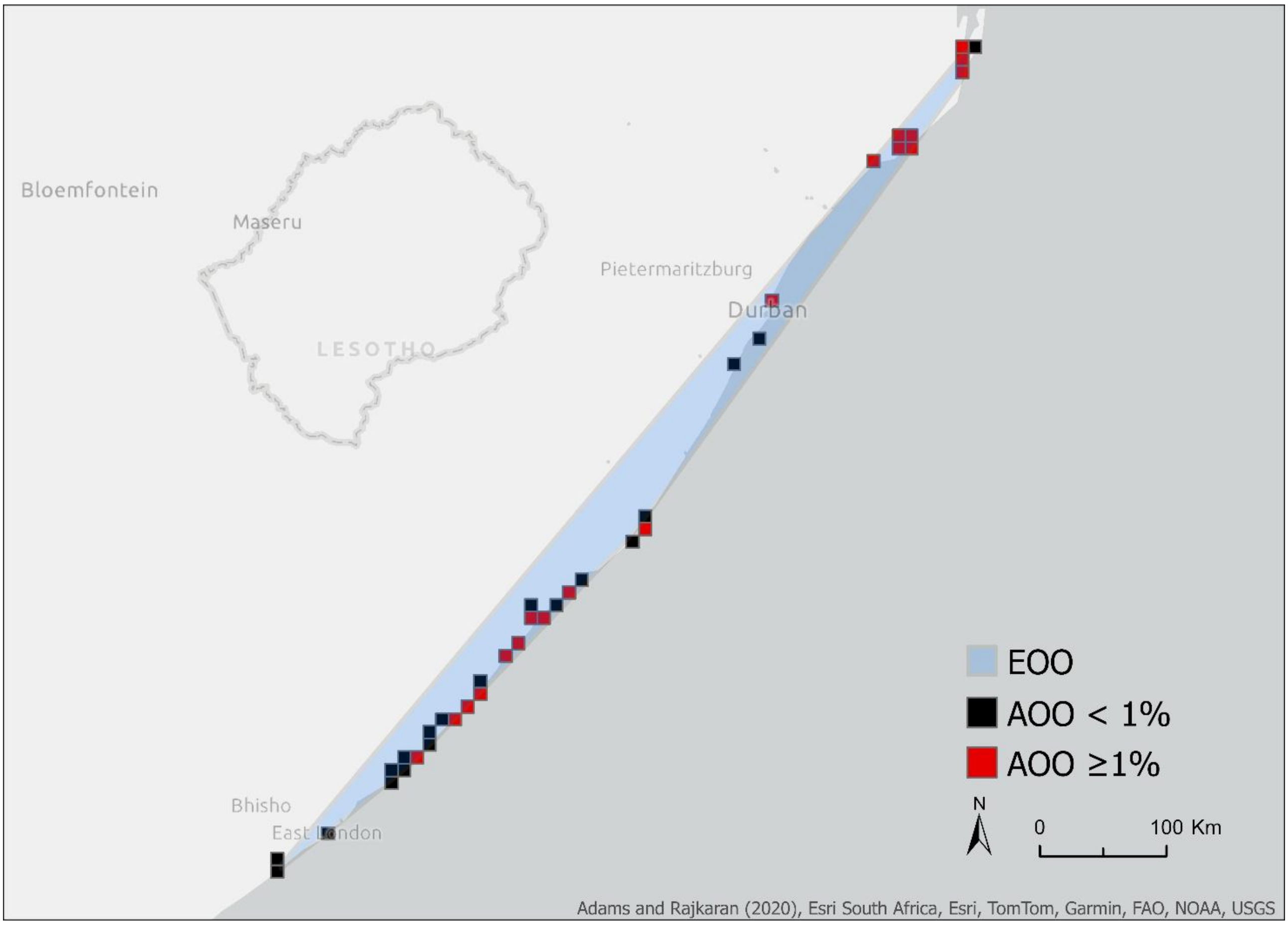

Figure 4. The Agulhas mangrove Extent of Occurrence (EOO) and Area Of Occupancy (AOO) in 2020. Estimates based on Adams and Rajkaran (2020) spatial layer. The red 10 x 10 km grids (n = 19) cover 99% of the ecosystem, accumulated area and the black grids 0 - 1% (n = 19). The map obtained using the GMW v3.0 spatial layer (Bunting *et al.*, 2022) is available in annex 4.

Province	Source	Extent Of Occurence (Km^2)	Area Of Occupancy (AOO >1%)	Criterion B
The Agulhas	GMW 2020	19,765	29	EN
	NMU 2023	18,656	19	EN

Site-specific data show that only three estuaries have extents over 1 km^2 (uMhlathuze, Richards Bay and Mngazana). All 31 estuaries are prone to the effects of human activities or stochastic events within a very short time period resulting in an uncertain future (mouth closure, changes in tidal connectivity and a decrease in salinity). Many mangrove stands are showing continuing decline in environmental quality due to wood harvesting, cattle harvesting and trampling (Van Niekerk *et al.*, 2019, Machite, 2023). Continued reduction of base flows into estuaries through abstraction further increases the possibility for mouth closure and mangrove destruction through inundation. Under climate change where water inflow is predicted to decrease and storm surges and the associated deposition of sediment at the mouth of estuaries is likely to increase, mouth closure will occur more frequently. While mangroves in the Agulhas province occur in more than five locations, and therefore not considered threat defined, the ecosystem is facing several threats in some locations where collapse can occur due to a single stochastic events like mouth closure. This is particularly plausible in the smaller estuaries which don't have large tidal exchanges. While this could be considered a natural variability, human pressures are increasing the occurrence of these events. As a result, the Agulhas mangrove ecosystem is assessed as **Endangered (EN)** under subcriterion B1, **Endangered (EN)** under subcriterion B2 and **Least Concern** under subcriterion B3.

Criterion C: Environmental Degradation

Criterion C measures the environmental degradation of abiotic variables necessary to support the ecosystem. Subcriterion C1 measures environmental degradation over the past 50 years. Numerous studies have assessed the pressures and degradation of mangroves in the Agulhas province (Adams *et al*., 2004; Forbes and Demetriades, 2008; Rajkaran and Adams, 2011; Hoppe-Speer *et al*., 2014; Peer *et al*., 2018; Adams and Rajkaran, 2020; Raw *et al*., 2021; Machite 2023). The pressures per estuary are summarised in the National Biodiversity report (Van Niekerk *et al.*, 2020). Machite (2023) has shown that anthropogenic pressures have continued to impact mangroves along the Eastern Cape coast of South Africa over the last 24 years since the studies of Adams *et al*. (2004) and Colloty *et al.* (2002). The continued persistence of impacts from livestock browsing and predation, footpaths, trampling and wood harvesting of the three main species has resulted in degradation and mangrove loss. These pressures have occurred mainly in large, predominantly open, estuaries such Mngazana, Mtata and Xora where wood harvesting occurs. Low mangrove tree seedling and sapling density, indicative of restricted recruitment, was also found in many estuaries. With continued pressure from urban development and agricultural land use, coastal squeeze will decrease the potential for lateral expansion of mangroves in response to sea-level rise.

In addition to anthropogenic pressures, mangrove loss has also occurred from natural pressures such as droughts, the closed state of some estuary mouths, and floods and rainfall, particularly in dynamic temporarily closed estuaries.

Abiotic changes have resulted in the permanent loss of mangroves from 11 estuaries, which represents a 35% loss (Adams and Rajkaran, 2020). Natural mouth closure due to sediment deposition from sea storm events, or through drought conditions limiting freshwater inflow, has also caused the loss of mangroves in a number of estuaries (Bulungula, Kobonqaba, Mbashe, Mnyameni Mzamba, Ngabarha, St Lucia, Xora). Mouth closure due to marine sediment deposition in the Mbashe Estuary in 2011 resulted in the loss of *Avicennia marina*. Three years later the dead mangrove habitat was replaced by salt marsh (James *et al*., 2020). Similar events have occurred in the Mzamba and Nqabara estuaries (Hoppe-Speer *et al*., 2015b). In Kobonqaba, 95% of mangroves died due to mouth closure between 2008 and 2011 caused by drought and low freshwater inflow, as well as freshwater abstraction, which resulted in water inundating *Avicennia* pneumatophores by 50 cm for extended periods (Mbense *et al*., 2016).

Dead mangroves at Kobonqaba Estuary following an extended period of mouth closure and the subsequent intrusion of salt marsh habitat with natural regeneration of Bruguiera gymnorrhiza (left) (image: February 2020); dead mangroves at Bulungula Estuary following mouth closure and back-flooding (right)
(Photo credits: Janine Adams, Anesu Machite).

These natural events, leading to estuary mouth closures and flooding, are unpredictable and have the potential to cause large scale die-back of mangroves in estuaries (Adams and Rajkaran, 2020). Under climate change the closure of estuaries following marine sediment deposition, and back-flooding of stands with freshwater following extreme rainfall events, is likely to increase in frequency, and it is suggested that 30% of South African estuaries are at risk (Adams *et al*., 2020, Raw *et al*., 2022). Estuary mouth closures are also expected to increase as more freshwater for human consumption is abstracted under climate change (Adams *et al*., 2020).

In some estuaries, such as the iSipingo, diversion of freshwater from the catchment has resulted in a loss of

Avicennia marina trees and an increase in *Barringtonia racemosa*, along with changes in faunal species composition. This increase in freshwater has eliminated fiddler crabs (*Uca* spp.) and snails (Macnae, 1963). Fiddler crabs were also lost because they can only feed during intertidal exposure by ebbing tides. Other anthropogenic pressures on mangroves include developments across estuary channels which restrict water flow. Harvesting of mangrove wood occurs in a number of Agulhas estuaries where different species are targeted for different uses (Rajkaran *et al*., 2004). Harvesting pressures continue in many of the smaller unprotected estuaries despite there being an increase in mangrove colonisation (Rajkaran and Adams, 2011; Machite, 2023). Therefore, the Agulhas Mangrove ecosystem is assessed as **Vulnerable (VU)** for subcriterion C1.

Subcriterion C2 measures environmental degradation in the future, or over any 50-year period, including from the present. The predicted rate for sea-level rise on the east coast of South Africa is 2.74 mm yr^{-1} (Mather *et al.*, 2009; Van Niekerk and Turpie, 2012). Under these conditions this might lead to an increase in estuary open mouth conditions thereby favouring the development of mangrove stands in intertidal areas. However increased occurrence of sea storms/storm surges could also result in erosion and deposition of sediment and smothering of pneumatophores as has already occurred in some estuaries. This would lead to the collapse of the ecosystem.

Most of the present mangrove area in the Agulhas province is contained in one estuary, the uMhlathuze, and this is currently increasing in extent. Because many catchments are developed the input of nutrients may also increase under climate change with an increase in floods. Similar increases in extreme weather events like droughts would in contrast result in the mouth closure of many estuaries, with the resultant inundation of mangrove stands and their subsequent loss. Adams and Rajkaran (2020) also predict increases in CO_2 and temperature that would increase plant growth and productivity, with mangrove replacing salt marsh habitat, an increase in distributional range and a change in species diversity. A study by Raw *et al.* (2022) showed that despite mangrove propagules being able to disperse across long distances, there is limited connectivity between existing stands and potential new stands in other estuaries. It was also predicted that ten estuaries (30%) will become unsuitable for mangroves under climate change (relative severity > 80%), due to limited connectivity and a total collapse with a possible gain in six other estuaries. This represents a 12% loss in distribution by 2050. This study used rainfall, temperature, flushing rate, and estuary mouth state as their variables, without considering sea-level rise.

Furthermore, the impact of future sea-level rise (SLR) on mangrove ecosystems was also assessed by adopting the methodology presented by Schuerch *et al.* (2018). The published model was designed to calculate both absolute and relative change in the extent of wetland ecosystems under various regional SLR scenarios (i.e medium: RCP 4.5 and high: RCP 8.5), with consideration for sediment accretion. Therefore, Schuerch *et al*. (2018) model was applied to the Agulhas mangrove ecosystem boundary, using the spatial extent in 2010 (Giri *et al.*, 2011) and assuming mangrove landward migration was not possible. Given that no mangrove recruitment is possible in a submerged system, we assumed a 100% relative severity. Under an extreme sea-level rise scenario of a 1.1-meter rise by 2100, the projected submerged area is ~ 4.9% by 2060, which remains below the 30% risk threshold.

The Agulhas mangrove ecosystem is classified as **Least Concern (LC)** for subcriterion C2, as both evaluated parameters fall below the 30% threshold, whether due to climate change (12% unsuitable) or extreme sea-level rise (4.6% extent submerged).

Subcriterion C3 measures change in abiotic variables since 1750. There is a lack of reliable historic data on environmental degradation, and therefore the Agulhas province is classified as Data Deficient (DD) for this subcriterion, although it is likely that condition in 1970 were similar to 1750 as most of the losses in the province have occurred post 1970.

Overall, the ecosystem is assessed as **Vulnerable (VU)** under criterion C.

Criterion D: Disruption of biotic processes or interactions

The global mangrove degradation map developed by Worthington and Spalding (2018) was used to assess the level of biotic degradation in the Agulhas province. This map is based on degradation metrics calculated from vegetation indices (NDVI, EVI, SAVI, NDMI) using Landsat time series (≈2000 and 2017). These indices represent vegetation greenness and moisture condition.

Mangrove degradation was calculated at a pixel scale (30 m resolution), on areas intersecting with the 2017 mangrove extent map (GMW v2). Mangrove pixels were classified as degraded if two conditions were met: 1) at least 10 out of 12 degradation indices showed a decrease of more than 40% compared to the previous period; and 2) all twelve indices did not recover to within 20% of their pre-2000 value (detailed methods and data are available at: maps.oceanwealth.org/mangrove-restoration/). The decay in vegetation indices has been used to identify mangrove degradation and abrupt changes, including mangrove die-back events, clear-cutting, fire damage, and logging; as well as to track mangrove regeneration (Lovelock *et al.,* 2017; Santana, 2018; Murray *et al.,* 2020; Aljahdali *et al.,* 2021; Lee *et al.,* 2021). However, it is important to consider that changes observed in the vegetation indices can also be influenced by data artefacts (Akbar *et al.,* 2020). Therefore, a relative severity level of more than 50%, but less than 80%, was assumed.

The results from this analysis show that over a period of 17 years (~2000 to 2016), 0.8% of the Agulhas mangrove area is classified as degraded, resulting in an average annual rate of degradation of 0.05%. Assuming this trend remains constant, +2.3% of the Agulhas mangrove area will be classified as degraded over a 50-year period. As less than 50% of the ecosystem will meet the category thresholds for criterion D, the Agulhas mangrove province is assessed as **Least Concern (LC)** under subcriterion D2b. Other threats such as coal dust and disease caused by e.g., fungal pathogens also threaten local mangrove populations

(Naidoo and Chirkoot, 2004; Osorio *et al*., 2017). However there is no historical data available for evaluating criterion D.

No data were found to assess the disruption of biotic processes and degradation over the past 50 years (subcriterion D1) or since 1750 (subcriterion D3).

Overall, the Agulhas ecosystem remains **Least Concern (LC)** under criterion D.

Criterion E: Quantitative Risk

No model was used to quantitatively assess the risk of ecosystem collapse for this ecosystem; hence criterion E was **Not Evaluated (NE)**.

5. Summary of the Assessment

CRITERION			
A. Reduction in Geographic Distribution	**A1** Past 50 years	**A2** Future or any 50y period	**A3** Historical (1750)
	VU	**LC**	**LC**
B. Restricted Geo. Distribution	**B1** Extent of Occurrence	**B2** Area of Occupancy	**B3** # Threat-defined Locations < 5
	EN	**EN**	**LC**
C. Environmental Degradation	**C1** Past 50 years (1970)	**C2** Future or any 50y period	**C3** Historical (1750)
	VU	**LC**	**DD**
D. Disruption of biotic processes	**D1** Past 50 years (1970)	**D2** Future or Any 50y period	**D3** Historical (1750)
	DD	**LC**	**DD**
E. Quantitative Risk analysis	**NE**		
OVERALL RISK CATEGORY	**EN**		

EN= Endangered; VU= Vulnerable; LC = Least Concern; DD = Data Deficient; NE = Not Evaluated

Overall, the status of the Agulhas mangrove ecosystem is assessed as **Endangered (EN).**

6. References

Adams, J. B., Colloty, B. M., & Bate, G.C. (2004). The distribution and state of mangroves along the coast of Transkei, Eastern Cape Province, South Africa. Wetlands Ecology and Management, 12(5), 531-41.

Adams, J. B. & Rajkaran, A. (2020). Changes in mangroves at their southernmost African distribution limit. Estuarine, Coastal and Shelf Science: 106862.

Akbar, M. R., Arisanto, P. A. A., Sukirno, B. A., Merdeka, P. H., Priadhi, M. M., & Zallesa, S. (2020).

Mangrove vegetation health index analysis by implementing NDVI (normalized difference vegetation index) classification method on sentinel-2 image data case study: Segara Anakan, Kabupaten Cilacap. In IOP Conference Series: *Earth and Environmental Science* (Vol. 584, No. 1, p. 012069). https://doi.org/10.1088/1755-1315/584/1/012069

Allan, D. G., Sinclair, J. C. & Rossouw, J. (1999). The waterbirds (Aves) of Durban Bay: current status and historical trends. Durban Museum Novitates, 24(1), pp.1-21.

Banda, S. P., Adams, J. B., Rajkaran, A., Johnson, J. L., & Raw, J. L. (2021) Blue carbon storage comparing mangroves with salt marsh and seagrass habitats at a warm-temperate continental limit. In: Dynamic Sedimentary Environments of Mangrove Coasts. Sidik F, Friess DA (eds) Elsevier. pp. 447–471.

Berjak, P., Campbell, G., Huckett, B., & Pammenter, N. (2011). In the mangroves of South Africa. Durban, South Africa: Wildlife and Environment Society of South Africa.

Bedin, T. (2001). The progression of a mangrove forest over a newly formed delta in the Umhlatuze Estuary, South Africa. South African Journal of Botany, 67, 433-438.

Bolosha, U. (2017). Revising the distribution of mangrove forests in South Africa and changes in growth of mangrove species along a latitudinal gradient. MSc thesis, Department of Botany, Rhodes University, South Africa, 139 pp.

Blaber, S. J. M. (1978). Fishes of the Kosi system. Lammergeyer, 24, 28-41.

Branch, G. M., Griffiths, C. L., Branch, M. L., & Beckley, L. E. (2022). Two oceans: a guide to the marine life of southern Africa. Struik Nature; Cape Town, p. 464.

Bruton, M. (1980). An outline of the ecology of the Mgobezeleni lake system at Sodwana, with emphasis on the mangrove community. Studies on the ecology of Maputaland, 408-426.

Bruton, M. N. & Appleton, C. C. (1975). Survey of Mgobezeleni lake-system in Zululand, with a note on the effect of a bridge on the mangrove swamp. Transactions of the Royal Society of South Africa, 41, 283-294.

Bunting, P., Rosenqvist, A., Hilarides, L., Lucas, R. M., Thomas, N., Tadono, T., Worthington, T. A., Spalding, M.D., Murray, N. J., & Rebelo, L.-M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15), 3657. https://doi.org/10.3390/rs14153657

Cannicci, S., Burrows, D., Fratini, S., Smith III, T.J., Offenberg, J. & Dahdouh-Guebas, F. (2008). Faunal impact on vegetation structure and ecosystem function in mangrove forests: a review. Aquatic Botany, 89(2), 186-200.

Colloty, B. M., Adams, J. B., & Bate, G. C. (2001). The botanical importance rating of the estuaries in the former Ciskei/Transkei. Water Research Commission Report No.: TT 160/01.

Emmerson, W. & Ndenze, T. (2007). Mangrove Tree Specificity and Conservation Implications of the Arboreal Crab Parasesarma leptosoma at Mngazana, a Mangrove Estuary in the Eastern Cape, South Africa. Wetlands Ecology and Management, 15, 13-25.

Emmerson, W. D. & McGwynne, L. E. (1992) Feeding and assimilation of mangrove leaves by the crab Sesarma meinerti de man in relation to leaf litter production in Mngazana, a warm-temperate southern African mangrove swamp. Journal of Experimental Marine Biology and Ecology, 157, 41–53.

Forbes, A. T. & Demetriades, N.T. (eds). (2008). Estuaries of Durban, KwaZulu-Natal, South Africa. Report for the Environmental Management Department, eThekwini Municipality.

Govender, J., Naidoo, T., Rajkaran, A., Cebekhulu, S., Bhugeloo, A. & Sershen. (2020). Towards characterising microplastic abundance, typology and retention in mangrove-dominated estuaries. Water, 12(10), 2802; https://doi.org/10.3390/w12102802 (registering DOI).

GBIF: The Global Biodiversity Information Facility. (2022). Species distribution records [Data set]. https://www.gbif.org [September 2022].

García, A. F., Bueno, M. & Leite, F.P.P. (2016). The Bostrychietum community of pneumatophores in Araçá Bay: an analysis of the diversity of macrofauna. Journal of the Marine Biological Association of the United Kingdom, 96(8),1617-24.

Giri, C. et al. (2011). Status and distribution of mangrove forests of the world using earth observation satellite data. Global Ecology Biogeography, 20, 54–159.

Heemstra, P.C. & Heemstra, E. (2004). Coastal fishes of southern Africa. NISC (PTY) LTD.

Hoppe-Speer, S., Adams, J. & Rajkaran, A. (2015a). Mangrove expansion and population structure at a planted site, East London, South Africa. Southern Forests: Journal of Forest Science, 77, 1-9.

Hoppe-Speer, S. C. L., Adams, J.B., & Bailey, D. (2015b). Present state of mangrove forests along the Eastern Cape coast, South Africa. Wetlands Ecology and Management, 23, 371-383.

Izegaegbe, J. I., Vivier, L. & Mzimela, H. M. M. (2020). Macrobenthic community structure of the Mhlathuze Estuary, a permanently open estuarine embayment in KwaZulu-Natal, South Africa. African Journal of Aquatic Science, 45(1-2), 95-107.

IUCN (2012). IUCN Habitats classification scheme (3.1). [Data set]. https://www.iucnredlist.org/resources/habitat-classification-scheme.

IUCN (2022). The IUCN Red List of Threatened Species. (Version 2022-2) [Data set]. https://www.iucnredlist.org

IUCN-CMP (2022). Unified Classification of Direct Threats (3.3) [Data set]. https://www.iucnredlist.org/resources/threat-classification-scheme.

James, N. C., Adams, J. B., Connell, A. D., Lamberth, S. J., MacKay, C. F., Snow, G. C., van Niekerk, L., & Whitfield, A. K. (2020). High flow variability and storm events shape the ecology of the Mbhashe Estuary, South Africa. African Journal of Aquatic Science, 45, 131-151.

Janna, J. (2023). A comparison of mangrove and estuarine fish diversity using eDNA metabarcoding and baited remote underwater visual surveys in South Africa and Mozambique. MSc Thesis, Stellenbosch University.

Johnson, J., Peer, N., Naidoo, S. & Rajkaran, A. (2023). Microplastic abundance in urban vs. peri-urban mangroves: The feasibility of using invertebrates as biomonitors of microplastic pollution in two mangrove dominated estuaries of southern Africa. Marine Pollution Bulletin, 196, 115657. 10.1016/j.marpolbul.2023.115657.

Keith, D. A., Ferrer-Paris, J. R., Nicholson, E., & Kingsford, R. T. (Eds.) (2020). IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups. IUCN, International Union for Conservation of Nature. https://doi.org/10.2305/IUCN.CH.2020.13.en

Keur, R., James, N., Rajkaran, A. (2019). A tale of two habitats: preliminary comparison of fish abundance and diversity between saltmarsh- and mangrove-dominated creeks in the Nahoon Estuary, South Africa. African Journal of Marine Science, 41(4), 449-54.

Lambert, G., Steinke, T. D., & Naidoo, Y. (1989). Algae associated with mangroves in southern African estuaries: Cyanophyceae. South African Journal of Botany, 55, 476-491.

Lee, S.Y. (2008). Mangrove macrobenthos: assemblages, services, and linkages. Journal of Sea Research, 59(1-2), 16-29.

Machite, A. (2023). Changes in mangroves along the Eastern Cape coast of South Africa. MSc dissertation at the Faculty of Science, Nelson Mandela University. Gqeberha, South Africa.

Macnae, W. (1963). Mangrove Swamps in South Africa. Journal of Ecology, 51, 1-25.

Mather, A. A., Garland, G. G., & Stretch, D. D. (2009). Southern African sea levels: corrections, influences and trends. African Journal of Marine Science, 31(2), 45-56.

Mbense, S., Rajkaran, A., Bolosha, U., & Adams, J. (2016). Rapid colonisation of degraded mangrove habitat by succulent salt marsh. South African Journal of Botany, 107, 129-136.

Mbande, S., Froneman, P. W. & Whitfield, A. (2004). The primary carbon sources utilised by fishes in the Mngazi and Mngazana estuaries, South Africa: A preliminary assessment. African Journal of Aquatic Science. 29. 10.2989/16085910409503810.

McGregor, S. & Strydom, N. (2018). The abundance, diversity and distribution of small fishes in mangrove and non-mangrove estuaries in warm temperate South Africa. Scientia Marina. 82. 81. 10.3989/scimar.04744.31A.

Moll, E., Ward, C., Steinke, T., & Cooper, K. (1971). Our mangroves threatened. African Wildlife, 25(3), 103-7.

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

Naidoo, G., & Chirkoot, D. (2004). The effects of coal dust on photosynthetic performance of the mangrove, Avicennia marina in Richards Bay, South Africa. Environment Pollution, 127(3), 359-66. doi: 10.1016/j.envpol.2003.08.018. PMID: 14638296.

Naidoo, T., Sershen, Thompson, R.C., & Rajkaran, A. (2020). Quantification and characterisation of microplastics ingested by selected juvenile fish species associated with mangroves in KwaZulu-Natal, South Africa. Environmental Pollution 257, 113635.

Osorio, J. A., Crous, C. J., Wingfield, M. J., de Beer, Z. W., & Roux, J. (2017). An assessment of mangrove diseases and pests in South Africa. Forestry: An International Journal of Forest Research 90, 343-358.

Peer, N., & Perissinotto, R. (2015). A review of fiddler crabs (genus Uca Leach, 1814) in South Africa. African Zoology, 50, 87-204.

Peer, N., Rishworth, G.M., Miranda, N.A. & Perissinotto, R. (2018b). Biophysical drivers of fiddler crab species distribution at a latitudinal limit. Estuarine, Coastal and Shelf Science, 208, 131-139.

Peer, N., Rajkaran, A., Miranda, N. A. F., Taylor, R. H., Newman, B., Porri, F., Raw, J. L., Mbense, S. P., Adams, J. B. & Perissinotto, R. (2018). Latitudinal gradients and poleward expansion of mangrove ecosystems in South Africa: 50 years after Macnae's first assessment. African Journal of Marine Science, 40, 101-120.

Rajkaran, A., & Adams, J. B. (2007). Mangrove litter production and organic carbon pools in the Mngazana Estuary, South Africa. African Journal of Aquatic Science, 32, 17-25.

Rajkaran, A., & Adams, J. B. (2011). Mangrove forests of northern KwaZulu-Natal: Sediment conditions and population structure of the largest mangrove forests in South Africa. Western Indian Ocean

Journal of Marine Science, 10, 25-38.

Raw, J. L, Perissinotto, R., Taylor, R. H., Miranda, N. A. F. & Peer, N. (2014). Decline of Terebralia palustris in South African mangroves. African Journal of Marine Science, 36(4), 517-522.

Raw, J. L., Julie, C. L., & Adams, J. B. (2019) A comparison of soil carbon pools across a mangrove-salt marsh ecotone at the southern African warm-temperate range limit. South African Journal of Botany, 127, 301–307.

Raw, J. L., Riddin, T., Wasserman, J., Lehman, T. W. K., Bornman, T. G., & Adams, J. B. (2020). Salt marsh elevation and responses to future sea-level rise in the Knysna Estuary, South Africa. African Journal of Aquatic Science, 45(1-2), 49-64.

Raw, J. L., van Niekerk, L., Riddin, T., Tsipa, V., Banda, S. P., & Adams, J. B. (2021). Scoping Study: A Blue Carbon Sinks Assessment for South Africa. Pretoria, South Africa.: Department for Environment, Forestry & Fisheries (DEFF.

Raw, J., Van der Stocken, T., Carroll, D., Harris, L., Rajkaran, A., van Niekerk, L. & Adams, J. (2022). Dispersal and coastal geomorphology limit potential for mangrove range expansion under climate change. Journal of Ecology, 111. 10.1111/1365-2745.14020.

Raw, J. L., Van Niekerk, L., Chauke, O., Mbatha, H., Riddin, T., & Adams, J.B. (2023). Blue carbon sinks in South Africa and the need for restoration to enhance carbon sequestration. Science of The Total Environment, 859, 160142.

Schuerch, M., Spencer, T., Temmerman, S., Kirwan, M. L., Wolff, C., Lincke, D., McOwen, C. J., Pickering, M. D., Reef, R., Vafeidis, A. T., Hinkel, J., Nicholls, R. J., & Brown, S. (2018). Future response of global coastal wetlands to sea-level rise. Nature, 561(7722), 231–234. https://doi.org/10.1038/s41586-018-0476-5

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Halpern, B. S., Jorge, M. A., Lombana, A., Lourie, S. A., Martin, K. D., McManus, E., Molnar, J., Recchia, C. A., & Robertson, J. (2007). Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. BioScience, 57(7), 573–583. https://doi.org/10.1641/B570707

Smith, M. M., & Heemstra, P. C. (2003). Smith's Sea Fishes. Struik Publishers, Cape Town.

Steinke, T. D. & Ward, C. J. (1990). Litter production by mangroves. III. Wavecrest (Transkei) with predictions for other Transkei estuaries. South African Journal of Botany, 56, 514–519.

Taylor, R. (2016). Dynamics of the macrophyte vegetation of the Mgobezeleni floodplain and estuary, Northern KwaZulu-Natal. South African Journal of Botany, 107,170-8.

Taylor, R. H. (2020). Mangrove colonisation of the Mlalazi Estuary, South Africa: a response to artificial breaching. African Journal of Aquatic Science, 45, 109-120.

Van der Elst, R. (2010). A Guide to the Common Sea Fishes of Southern Africa. Struik Publishers.

Van Niekerk, L., & Turpie, J. K. (2012). South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component. Pretoria: South African National Biodiversity Institute. Stellenbosch: Council for Scientific and Industrial Research.

Van Niekerk, L., Adams, J.B., Lamberth, S.J., MacKay, C.F., Taljaard, S., Turpie, J.K., et al. (2019). South African National Biodiversity Assessment 2019: Technical Report. Volume 3: Estuarine Realm. CSIR report number CSIR/SPLA/EM/EXP/2019/0062/A. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Van Niekerk, L., Adams, J. B., James, N. C., Lamberth, S. J., MacKay, C. F., Turpie, J. K., Rajkaran, A., Weerts, S. P. & Whitfield, A. K. (2020) An Estuary Ecosystem Classification that encompasses biogeography and a high diversity of types in support of protection and management. African Journal of Aquatic Science, 45:1-2, 199-216, doi: 10.2989/16085914.2019.1685934

Ward, C. J., & Steinke, T.D. (1982). A note on the distribution and approximate areas of mangroves in South Africa. South African Journal of Botany, 1, 51-53.

Worthington, T.A., & Spalding, M. D. (2018). Mangrove Restoration Potential: A global map highlighting a critical opportunity. Apollo - University of Cambridge Repository. https://doi.org/10.17863/CAM.39153

Yang, S-C., Riddin, T., Adams, J. B., & Shih, S-S. (2014). Predicting the spatial distribution of mangroves in a South African estuary in response to sea-level rise, substrate elevation change and a sea storm event. Journal of Coastal Conservation, 18, 459-469.

Authors:

Riddin, T., Adams, J., Rajkaran, A., Machite, A., Peer, N., & Suárez, E. L.

Acknowledgments

The development of the Agulhas Mangrove Red List of Ecosystems was made possible through the collaboration and dedication of Catherine Meyer and Michael Sievers provided input on the conceptual model. The DSI/NRF Research Chair in Shallow Water Ecosystems (UID 84375) supported Janine Adams and provided running costs for this research.

We would like to thank the IUCN SSC Mangrove Specialist Group and the Global Mangrove Alliance Science Working group, for their support in the delineation of the level 4 mangrove units that were the basis for this analysis. Special thanks to José Rafael Ferrer-Paris for his contribution to the production of the general ecosystem description template for the RLE mangrove assessments. We also wish to acknowledge Thomas Worthington for kindly providing the spatial data on mangrove degradation.

Peer revision:

Donald Macintosh
Marcos Valderrábano

Web portal:

http://iucnrle.org/

7. Appendices

1. List of Key Mangrove Species

List of plant species considered true mangroves according to the IUCN (2022) Red List of Threatened Species (RLTS) spatial data. We included species whose range maps intersect with the boundary of the marine provinces/ecoregions described in the Ecosystem Distribution section.

Class	Order	Family	Scientific name	RLTS category
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera gymnorhiza*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora mucronata*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia marina*	LC

2. List of Associated Species

List of taxa that are associated with mangrove habitats in the RLTS database. We included only species with entries for Habitat 1.7: "Forest - Subtropical/Tropical Mangrove Vegetation Above High Tide Level"; Habitat 12.7 "Marine Intertidal - Mangrove Submerged Roots" or for Habitat 13.4 "Marine Coastal/Supratidal – Coastal Brackish/Saline Lagoons/Marine Lakes"; and with suitability recorded as "Suitable"; and with any value of seasonality except "Passage". We further filtered species with spatial point records in GBIF (some species are excluded due to a mismatch in taxonomic names, or lack of georeferenced records). Records were cross-referenced with personal; observations and peer-reviewed publications that definitively noted species associated with mangrove habitats (Actinopterygii – Blaber, 1978; Smith and Heemstra, 2003; Heemstra and Heemstra, 2004; Mbande *et al*., 2004; van der Elst, 2010; McGregor and Strydom, 2018; Keur *et al*., 2019; Naidoo *et al*., 2020; Janna, 2023; Aves – Allan *et al*., 1999).

Class	Order	Family	Scientific name	RLTS category	Common name
Liliopsida	Alismatales	Hydrocharitaceae	*Halophila ovalis*	LC	Species Code: Ho
Liliopsida	Alismatales	Cymodoceaceae	*Halodule uninervis*	LC	Species Code: Hu
Liliopsida	Alismatales	Zosteraceae	*Zostera capensis*	VU	Species Code: Zp
Liliopsida	Alismatales	Cymodoceaceae	*Halodule wrightii*	LC	Species Code: Hw
Liliopsida	Alismatales	Cymodoceaceae	*Thalassodendron ciliatum*	LC	Species Code: Tc
Polypodiopsida	Polypodiales	Pteridaceae	*Acrostichum aureum*	LC	Golden leather fern
Gastropoda	Ellobiida	Ellobiidae	*Melampus semiaratus*	LC	
Gastropoda	Ellobiida	Ellobiidae	*Cassidula labrella*	LC	
Gastropoda	Sorbeoconcha	Potamididae	*Terebralia palustris*	DD	Mangrove whelk
Gastropoda	Sorbeoconcha	Potamididae	*Cerithidea decollata*	LC	
Actinopterygii	Perciformes	Ephippidae	*Platax orbicularis*	LC	Orbiculate batfish
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Chelonodontops laticeps*	LC	Bluespotted blaasop
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Amblyrhynchote honckenii*	LC	Evileye blaasop
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulviflamma*	LC	Dory snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulvus*	LC	Blacktail snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus monostigma*	LC	One-spot snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus argentimaculatus*	LC	Mangrove red snapper

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus ehrenbergii*	LC	Blackspot snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus sebae*	LC	Red emperor snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus russellii*	LC	Russell’s snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus gibbus*	LC	Humpback red snapper
Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus Gibbosus*	LC	Brown sweetlips
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus nebulosus*	LC	Spangled emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus harak*	LC	Thumbprint emperor
Actinopterygii	Gobiiformes	Gobiidae	*Parachaeturichthys Polynema*	LC	Lancet-tail goby
Actinopterygii	Gobiiformes	Gobiidae	*Paratrypauchen Microcephalus*	LC	Comb goby
Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus Plagiodesmus*	LC	Barred rubberlip
Actinopterygii	Perciformes	Terapontidae	*Terapon jarbua*	LC	Tiger perch
Actinopterygii	Perciformes	Cichlidae	*Oreochromis mossambicus*	VU	Mozambique tilapia
Actinopterygii	Perciformes	Ambassidae	*Ambassis dussumieri*	LC	Malabar glassy perchlet
Actinopterygii	Perciformes	Ambassidae	*Ambassis ambassis*	LC	Commerson’s glassy perchlet
Actinopterygii	Perciformes	Sparidae	*Rhabdosargus holubi*	LC	Cape stumpnose
Actinopterygii	Perciformes	Sparidae	*Rhabdosargus sarba*	LC	Goldlined seabream
Actinopterygii	Perciformes	Sparidae	*Acanthopagrus vagus*	VU	Riverbream
Actinopterygii	Perciformes	Carangidae	*Caranx sexfasciatus*	LC	Bigeye trevally
Actinopterygii	Pleuronectiformes	Paralichthyidae	*Pseudorhombus arsius*	LC	Largetooth flounder
Actinopterygii	Clupeiformes	Clupeidae	*Gilchristella aestuaria*	LC	Estuarine round herring
Actinopterygii	Clupeiformes	Clupeidae	*Hilsa kelee*	LC	Kelee shad
Actinopterygii	Clupeiformes	Engraulidae	*Thryssa vitrirostris*	LC	Orangemouth anchovy
Actinopterygii	Elopiformes	Elopidae	*Elops machnata*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Caffrogobius gilchristi*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Favonigobius reichei*	LC	Indo-pacific tropical sand goby
Actinopterygii	Gobiiformes	Gobiidae	*Glossogobius callidus*	LC	River goby
Actinopterygii	Gobiiformes	Gobiidae	*Periophthalmus argentilineatus*	LC	Barred mudskipper
Actinopterygii	Perciformes	Haemulidae	*Pomadasys commersonnii*	LC	Smallspotted grunter
Actinopterygii	Perciformes	Monodactylidae	*Monodactylus falciformis*	LC	
Actinopterygii	Perciformes	Monodactylidae	*Monodactylus argenteus*	LC	Silver moony
Actinopterygii	Mugiliformes	Mugilidae	*Chelon dumerili*	DD	Grooved mullet
Actinopterygii	Mugiliformes	Mugilidae	*Planiliza macrolepis*	LC	Largescale mullet
Actinopterygii	Mugiliformes	Mugilidae	*Planiliza alata*	LC	
Actinopterygii	Mugiliformes	Mugilidae	*Mugil cephalus*	LC	Flathead mullet
Actinopterygii	Mugiliformes	Mugilidae	*Pseudomyxus capensis*	LC	Freshwater mullet

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Mugiliformes	Mugilidae	*Valamugil buchanani*	LC	Bluetail mullet
Actinopterygii	Perciformes	Sciaenidae	*Argyrosomus japonicus*	EN	Dusky meagre
Actinopterygii	Perciformes	Sparidae	*Acanthopagrus berda*	LC	Picnic seabream
Actinopterygii	Perciformes	Sparidae	*Diplodus capensis*	LC	Blacktail
Actinopterygii	Perciformes	Haemulidae	*Pomadasys olivaceus*	LC	Olive grunt
Actinopterygii	Pleuronectiformes	Soleidae	*Heteromycteris capensis*	NT	Cape sole
Actinopterygii	Pleuronectiformes	Soleidae	*Solea turbynei*	LC	Blackhand sole
Actinopterygii	Gobiiformes	Gobiidae	*Periophthalmus kalolo*	LC	Kalolo mudskipper
Actinopterygii	Perciformes	Gerreidae	*Gerres longirostris*	LC	Strongspine silver-biddy
Actinopterygii	Perciformes	Gerreidae	*Gerres filamentosus*	LC	Whipfin mojarra
Actinopterygii	Perciformes	Acanthuridae	*Acanthurus xanthopterus*	LC	Yellowfin surgeonfish
Actinopterygii	Perciformes	Acanthuridae	*Acanthurus triostegus*	LC	Convict surgeonfish
Actinopterygii	Perciformes	Carangidae	*Alepes djedaba*	LC	Shrimp scad
Actinopterygii	Perciformes	Chaetodontidae	*Chaetodon auriga*	LC	
Actinopterygii	Gonorhynchiformes	Chanidae	*Chanos chanos*	LC	Milkfish
Actinopterygii	Clupeiformes	Dorosomatidae	*Herklotsichthys quadrimaculatus*	LC	
Actinopterygii	Perciformes	Leiognathidae	*Leiognathus equula*	LC	Common ponyfish
Actinopterygii	Perciformes	Pomacentridae	*Abudefduf vaigiensis*	LC	
Actinopterygii	Perciformes	Sillaginidae	*Sillago sihama*	LC	Silver sillago
Actinopterygii	Perciformes	Sparidae	*Crenidens crenidens*	LC	Karenteen seabream
Actinopterygii	Perciformes	Sphyraenidae	*Sphyraena jello*	LC	Pickahndle barracuda
Actinopterygii	Perciformes	Sphyraenidae	*Sphyraena barracuda*	LC	Great barracuda
Actinopterygii	Elopiformes	Megalopidae	*Megalops cyprinoides*	DD	Indo-pacific tarpon
Actinopterygii	Albuliformes	Albulidae	*Albula glossodonta*	VU	Shortjaw bonefish
Actinpoterygii	Perciformes	Epinephelidae	*Epinephelus malabaricus*	LC	
Actinpoterygii	Perciformes	Epinephelidae	*Epinephelus rivulatus*	LC	Halfmoon grouper
Actinpoterygii	Tetraodontiformes	Tetraodontidae	*Arothron immaculatus*	LC	Immaculate puffer
Aves	Coraciiformes	Alcedinidae	*Halcyon senegaloides*	LC	Mangrove kingfisher
Aves	Coraciiformes	Alcedinidae	*Ceryle rudi*	LC	Pied kingfisher
Aves	Coraciiformes	Alcedinidae	*Alcedo semitorquata*	LC	Half-collared kingfisher
Aves	Coraciiformes	Alcedinidae	*Corythornis cristatus*	LC	Malachite kingfisher
Aves	Pelecaniformes	Pelecanidae	*Pelecanus rufescens*	LC	Pink-backed pelican
Aves	Pelecaniformes	Ardeidae	*Ardea goliath*	LC	Goliath heron
Aves	Pelecaniformes	Ardeidae	*Ardea cinerea*	LC	Grey heron
Aves	Pelecaniformes	Ardeidae	*Egretta ardesiaca*	LC	Black heron
Aves	Accipitriformes	Accipitridae	*Haliaeetus vocifer*	LC	African fish-eagle
Aves	Passeriformes	Platysteiridae	*Playsteira peltata*	LC	Black-throated wattle-eye
Aves	Passeriformes	Nectariniidae	*Cinnyris bifasciatus*	LC	Purple-banded

Class	Order	Family	Scientific name	RLTS category	Common name
					sunbird
Aves	Passeriformes	Nectariniidae	*Cyanomitra verreauxii*	LC	Mouse-coloured sunbird
Reptilia	Crocodylia	Crocodylidae	*Crocodylus niloticus*	LC	Nile crocodile
Reptilia	Squamata	Varanidae	*Varanus niloticus*	LC	Nile monitor
Mammalia	Cetartiodactyla	Hippopotamidae	*Hippopotamus amphibious*	VU	Hippopotamus

3. National Estimates for subcriterion A3

Subcriterion A3 measures changes in mangrove area since 1750. While we do not have reliable data on the entire mangrove extent for this period, we have estimates for the 1930s (Adams and Rajkaran, 2020)[2], a period likely to be similar in extent in 1750 due to the lack of anthropogenic influence. To estimate the Agulhas mangrove ecosystem extent in 1930, we gathered reliable information on the mangrove area within the province around this period (Table b). We then estimated the mangrove area in 1930, assuming a linear relationship between mangrove extent and time. Finally, we summed up the estimates to determine the total mangrove area in the Agulhas province (Table a).

Table a. Estimated mangrove area in 1930 and 2023. Estimates for 2023* mangrove area are based on a site-specific dataset (sites with mangrove area >10 ha). The references used to calculate mangrove area in 1930 are listed below in Table b.**

Year	Country total 2023*	Within province 2023*	Country total 1930**	Within province 1930**
South Africa	23.017	23.016	15.37	15.31
The Agulhas		**23.016**		**15.31**

Table b. List of selected studies considered to have reliable information on mangrove area for the period around 1930-2030 in the Agulhas Mangrove province.

Country	Year	Mangrove Area (Ha)	Reference
South Africa*	1930	1537	Adams JB, Rajkaran A. (2020). Changes in mangroves at their southernmost African distribution limit. *Estuarine, Coastal and Shelf Science*: 106862. From *Table 3. Past and present mangrove areas (ha) in South Africa for estuaries with greater than 10 ha.
South Africa*	2019	1672	Adams JB, Rajkaran A. (2020). Changes in mangroves at their southernmost African distribution limit. *Estuarine, Coastal and Shelf Science*: 106862. From *Table 3. Past and present mangrove areas (ha) in South Africa for estuaries with greater than 10 ha.
South Africa	2021	2086.7	Raw JL, Van Niekerk L, Chauke O, Mbatha H, Riddin T, Adams JB. (2023). Blue carbon sinks in South Africa and the need for restoration to enhance carbon sequestration. *Science of The Total Environment*, 859: 160142.
South Africa	2023	2301.7	Updated mapping by Nelson Mandela University (available on request from Riddin et al. 2024).

[2] Adams and Rajkaran, (2020). Changes in mangroves at their southernmost African distribution limit. Estuarine, Coastal and Shelf Science: 106862.

4. Spatial distribution of the Agulhas Mangrove ecosystem according to different sources

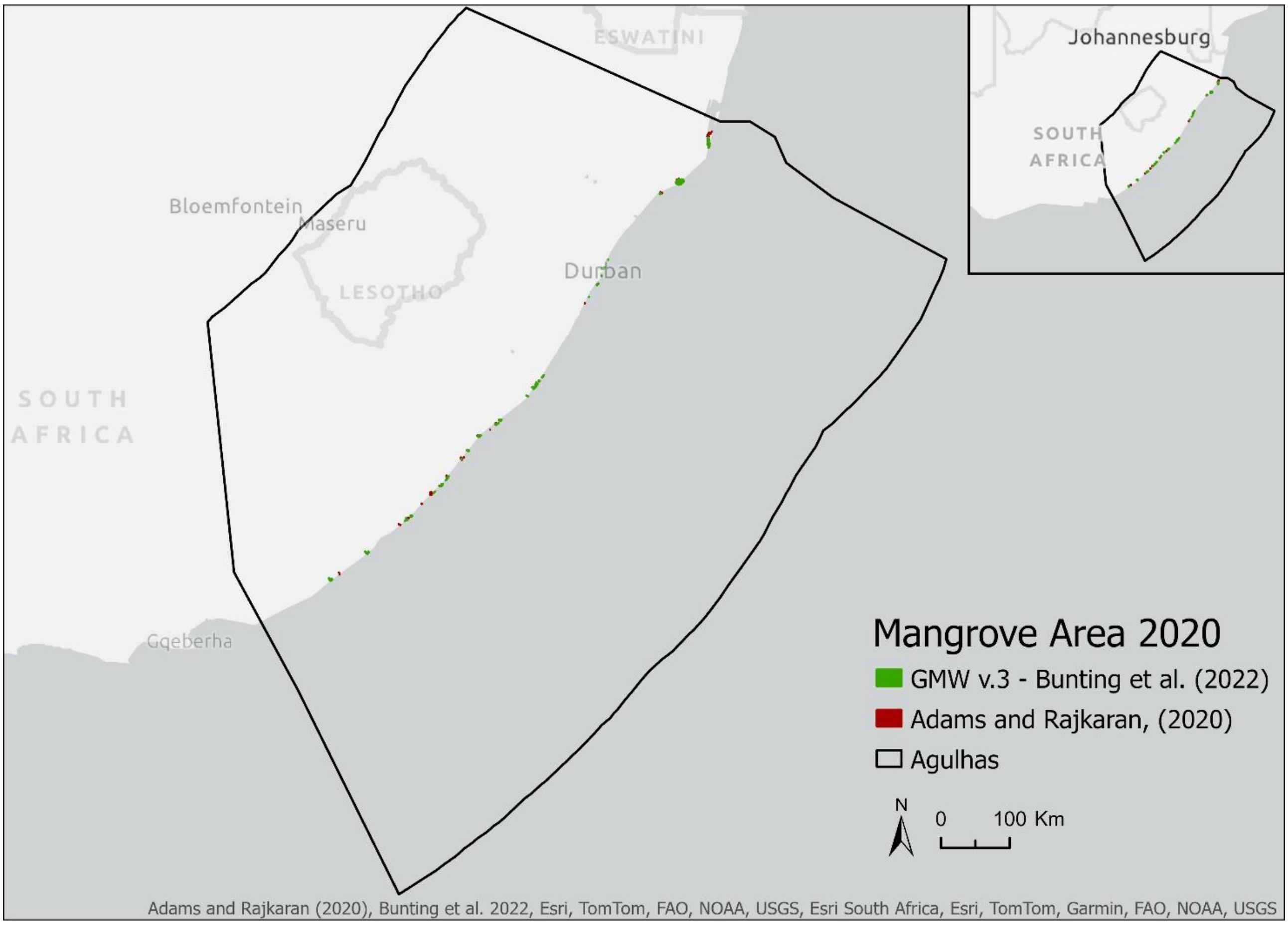

Figure S1. Map showing the distribution of mangrove area in the Agulhas Province according to Bunting et al. 2022 (GMW v.3 for 2020) and the Adams and Rajkaran (2020) dataset with updates from Riddin et al. (2024).

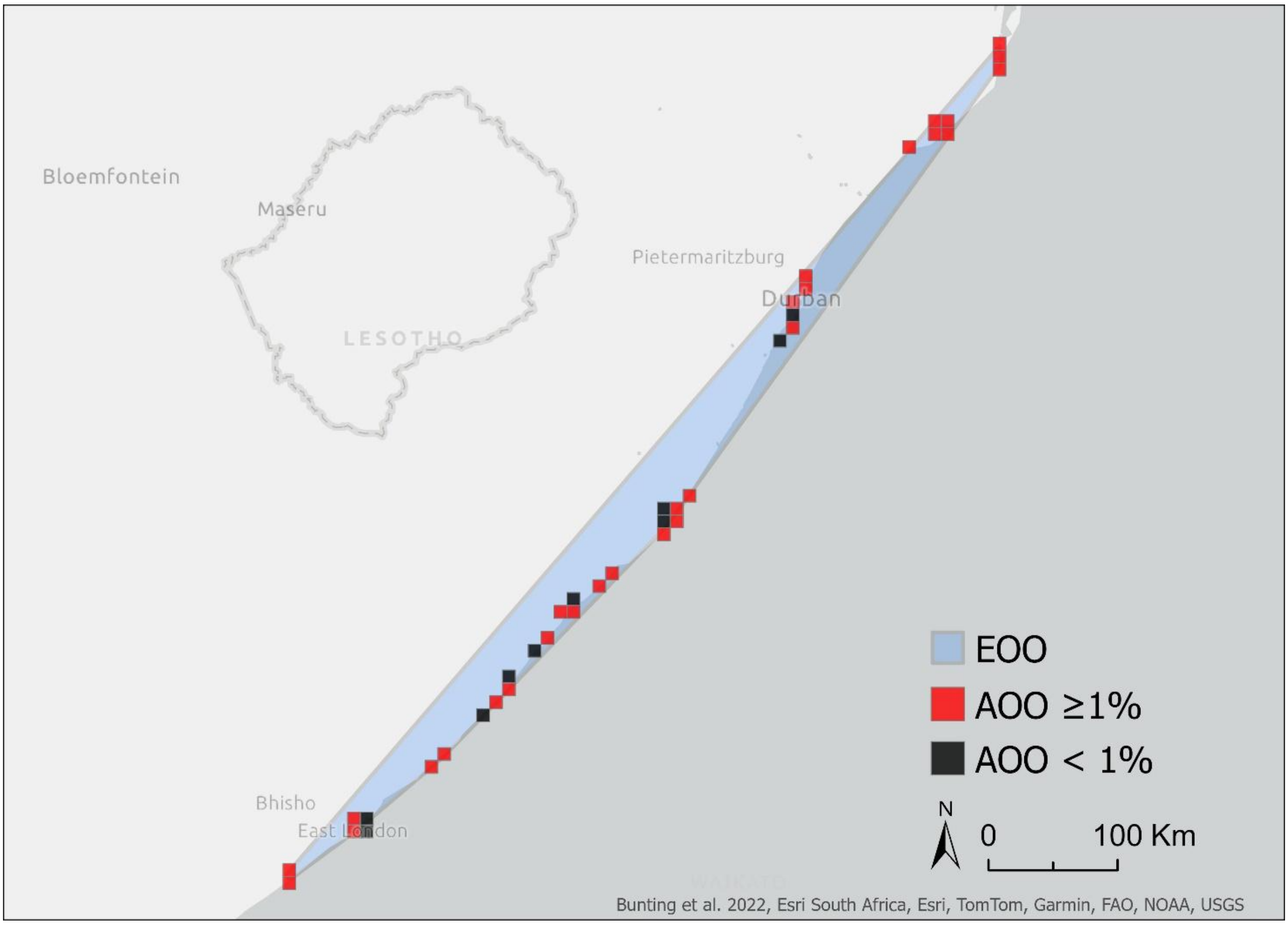

Figure S2. The Agulhas mangrove Extent of Occurrence (EOO) and Area Of Occupancy (AOO) in 2020. Estimates based on the GMW v3.0 2020 spatial layer (Bunting *et al.*, 2022). The red 10 x 10 km grids (n = 29) cover 99% of the ecosystem, and the black grids to <1% (n = 10).