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Mangroves of the Western Indian Ocean LC

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Abstract

'Mangroves of the Western Indian Ocean' is a regional ecosystem subgroup (level 4 unit of the IUCN Global Ecosystem Typology). This province spans 10 countries and includes the following marine ecoregions: Cargados Carajos/Tromelin Island, Delagoa, Mascarene Islands, Seychelles, Southeast Madagascar, East African Coral Coast, Northern Monsoon Current Coast, Bight of Sofala/Swamp Coast, Western and Northern and North-eastern Madagascar; however not every ecoregion has mangroves. The mangrove extent was 7,505 km^2 in 2020, representing 5% of the global mangrove area. This province has predominantly terrigenous sedimentary ecosystems but also carbonate-type mangroves on oceanic islands. There are 10 species of true mangroves and several associated species.

The ecosystem is threatened by catchment erosion and direct human pressures, including over-exploitation of mangrove-derived products, deforestation for conversion to other land use types (e.g., agriculture and aquaculture, or development infrastructure), pollution and climate-change. Oceanic islands with mangroves are threatened by sea-level rise and ocean surges, even where direct human impact is mostly absent.

Today the Western Indian Ocean mangroves cover is ≈18% less than our broad estimation for 1970. However, the mangrove net area change has been positive since 1996. If this trend continues a global change of -8.3% is projected over the next 50 years. Furthermore, the Western Indian Ocean mangrove province is expected to be relatively resilient to even extreme sea-level rise scenarios, due to high sediment supply and vertical accretion, except for the carbonate-category of oceanic island mangroves. We estimate that 2% of the Western Indian Ocean mangroves are undergoing degradation. This value could rise to +7.5% % over a 50-year period based on decay of vegetation indexes.

Overall, the Western Indian Ocean mangrove ecosystem is assessed as **Least Concern (LC).** However, for several sub-criteria, there is insufficient data. Therefore, it is recommended to update inputs to enhance the precision of the evaluation and to facilitate quantitative analysis of risks to the mangroves without precluding a potential change in status.

Citation:

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Key words: Mangroves; Red List of ecosystems; ecosystem collapse; threats.

Ecosystem classification:

MFT1.2 Intertidal forests and shrublands

Assessment's distribution:

The Western Indian Ocean province

Summary of the assessment:

Criterion	A	B	C	D	E	Overall
Sub-criterion 1	LC	LC	DD	DD	NE	
Sub-criterion 2	LC	LC	LC	LC	NE	LC
Sub-criterion 3	DD	LC	DD	DD	NE	

LC: Least Concern, DD Data Deficient, NE: Not Evaluated

Mangroves of the Western Indian Ocean

LC

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_20 Mangroves of the Western Indian Ocean

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

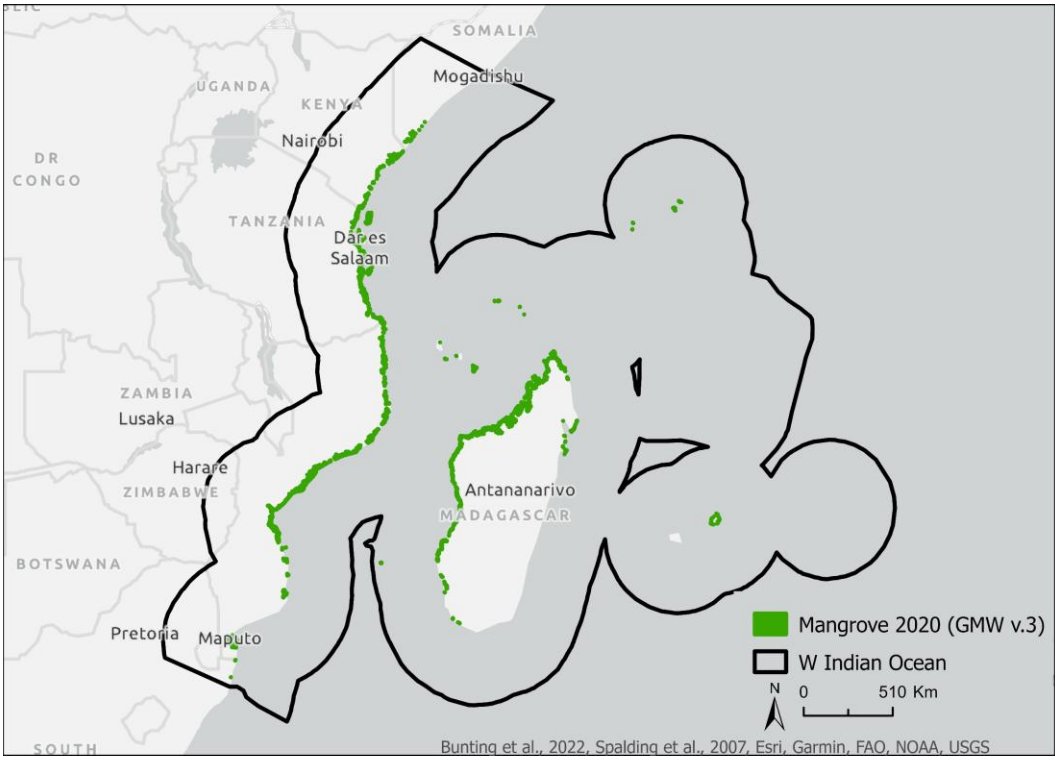

Figure 1. The distribution of mangroves in the Western Indian Ocean (shown in green). Source: Mangrove extent extracted from Bunting *et al.*, 2022. Province limits modified from Spalding *et al.*, 2007.

[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.

1. Ecosystem Description

Spatial distribution

The ‘Mangroves of the Western Indian Ocean’ province include the marine ecoregions of Cargados Carajos/Tromelin Island, Delagoa, Mascarene Islands, Seychelles, Southeast Madagascar, East African Coral Coast, Northern Monsoon Current Coast, Bight of Sofala/Swamp Coast, Western and Northern Madagascar. However, not every ecoregion has mangroves. The province extends over 10 countries: Comoros, France (Îles Éparses de l'océan Indien**,** Mayotte), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, southern part of Somalia, northern part of South Africa and Tanzania (Figure 1). The estimated extent of the mangroves of the Western Indian Ocean province was 7,505 km^2 in 2020, representing about 5% of the global mangrove area (Bunting *et al*, 2022). Fatoyinbo and Simard (2013) reported a mangrove cover of 6,200 km^2 in the Western Indian Ocean province representing 4.1% of the world's mangrove area, suggesting some slight increase to the current figures. On the other hand, Bhowmik *et al.* (2022) reported a mangrove cover of 9,290 km^2 in 1990, 9,050 km^2 in 2000, 9,020 km^2 in 2010 and 8,830 km^2 in 2020 in the eastern and southern Africa region, representing an annual loss rate of 0.07%, 0.13%, and 0.21% per year between 1990-2000, 2000-2010 and 2010-2020, respectively. The eastern and southern Africa regions indicated a higher decline rate of 0.21% per year in comparison to only 0.02% per year in the western and central Africa regions over the period 2010 to 2020.

Biotic components of the ecosystem (characteristic native biota)

The mangroves of the Western Indian Ocean province are biologically diverse with 10 recorded true mangrove plant species including *Pemphis acidula* which is often considered to be a mangrove species in its own right (Table 1). The herbaceous mangrove fern *Acrostichum aureum* also occurs in this province’s mangroves but is generally considered to be a mangrove associate rather than a true mangrove species. Other plant species listed among the mangrove associates in the region include the palm *Phoenix reclinata, Pandanus* spp. and woody trees and shrubs such as *Brexia madagascariensis, Cordia subcordata, Hibiscus tiliaceus, Terminalia catappa* and *Thespesia populnea*. Among the herbs and halophilous flora, *Salicornia* sp., *Suaeda monoica, Sesuvium portulacastrum,* and *Arthrocnemum* sp. are mangrove associates.

The cheniers or dunes developing behind, or sometimes in the mangroves, are fixed by the very wide-ranging creeper *Ipomoea pes-caprae* and other sand-fixing vegetation, thus paving the way for terrestrialisation. Mistletoes (*Agelanthus* spp.) are encountered in the mangrove canopy (amongst the mangrove species it particularly parasitises *Sonneratia alba*). Indeed, mangroves in this province are mostly adjacent to beach forest types with the above-mentioned wide-ranging woody species at the landward side and seagrass beds on contiguous seaward mudflats. The seagrass beds and mudflats interact dynamically with mangroves, which sometimes colonise such areas where a suitable inundation regime develops. All the true mangrove tree species are classified as Least Concern (LC) on the IUCN Red List of Threatened Species (IUCN, 2022).

Mangrove creek in Gazi Bay (Kenya) at low tide, with Avicennia marina*,* Sonneratia alba *and* Rhizophora mucronata *at the waterfront, and sandflats/mudflats with seagrass beds adjacent to mangroves in the creek (Photo credit: Diana Di Nitto)*

Gazi Bay (Kenya): natural dune (chenier) formation in a Sonneratia alba *assemblage being colonised by* Ipomoea pes-caprae*. The open bay mudflats and seagrass beds (submerged) are delimited by a mangrove zone (at rear). A palm-nut vulture (*Gypohierax angolensis*) is using these dying mangrove trees as a roosting site (photo credit: Nico Koedam)*

Sparse and low landward mangroves in Gazi Bay (Kenya) at incoming tide, with predominantly low Avicennia marina *and* Ceriops tagal *in front, and higher mangrove in the background, containing all the Western Indian Ocean true mangrove species (photo credit: Nico Koedam)*

Table 1. True mangrove species reported in the countries of the Western Indian Ocean province. Data from UNEP-Nairobi Convention/USAID/WIOMSA (2020), Jeanson *et al*. (2019), Plants of the World Online website and World Register of Marine Species.

True mangrove tree species	**Kenya**	**Tanzania**	**Mozambique**	**Madagascar**	**Mauritius**	**Seychelles**	**Somalia**	**South Africa**	**Comoros**	**France (Mayotte)**
Avicennia marina	+	+	+	+		+	+	+	+	+
Bruguiera gymnorhiza	+	+	+	+	+	+	+		+	+
Ceriops tagal	+	+	+	+		+	+	+	+	+
Heritiera littoralis	+	+	+	+					+	+
Lumnitzera racemosa	+	+	+	+		+			+	+
Rhizophora mucronata	+	+	+	+	+	+	+	+		+
Sonneratia alba	+	+	+	+		+	+		+	+
Xylocarpus granatum	+	+	+	+		+	+	+		+
X. moluccensis	+	+	+			+				+
*Pemphis acidula**	+	+	+	+	+	+	+		+	+
Total	**10**	**10**	**10**	**8**	**3**	**9**	**7**	**4**	**7**	**10**
Mangrove area (ha)	**61,000**	**181,000**	**390,500**	**314,000**	**145,000**	**1,900**	**3,000**	**1,921**	**91**	**694**
Mangrove Area 2020 GMW v.3 (ha)	54441	110740	302809	277591	432	383	3515	2644	97	676

* Pemphis acidula *is considered to be a true mangrove species in many regions, and it occurs in several countries of the Western Indian Ocean province.*

Appendix 1 includes a list of plant species considered true mangroves according to the Red List of Threatened Species (RLTS) spatial data. This list encompasses the class, order, family, scientific name and the Red List of Threatened Species (RLTS) category.

There are varying reports on the number of animal species associated with the mangrove habitat. At least 200 species within the taxa Actinopterygii (62), Arachnida (3), Aves (79), Chondrichthyes (10), Gastropoda (4), Insecta (2), Magnoliopsida (15), Mammalia (15), Polypodiopsida (1) and Reptilia (9) are associated with mangrove habitats in the IUCN Red List of Threatened Species (IUCN, 2022) that have natural history collection records, or observations, within the distribution of this province (GBIF, 2022). Among the latter species, nine species have been classified as Critically Endangered (CR), 12 species as Endangered (EN) (*e.g.* the Madagascar teal (*Anas bernieri*) and the Madagascar Sacred ibis (*Threskiornis bernieri*)), 18 as Vulnerable (VU), 11 species as Near Threatened (NT) and 144 as Least Concern (LC) according to the IUCN Red List of Threatened Species (IUCN, 2022). The dugong (*Dugong dugon*) has globally been classified as Vulnerable (VU), while dugong populations in East Africa have entered the IUCN Red List as Critically Endangered. The range of the dugong covers the Western Indian Ocean mangroves, where it is observed, but sightings are rare, and no accurate census is available. Adequate inventories of the invertebrate species (except brachyurans), and fungi, algae, and lichens, are lacking to date.

A crocodile resting among mangrove roots in Mwazaro, southern coast of Kenya; though part of the biodiversity of the Ramisi, Mwazaro mangrove complex, crocodiles pose a risk to fishermen (photo credit: Hussein Tirangoi)

Mangroves of the Western Indian Ocean region are diverse and do not host a single, homogenous crab community, with some species restricted to specific areas/countries. For example, *Neosarmatium africanum* is present from Somalia to South Africa plus West Madagascar, Mayotte and Comoros, while its sister species *N. meinerti* has a narrower distribution, occurring on only a few Western Indian Ocean islands (such as Seychelles, La Réunion and Mauritius) (Ragionieri *et al*., 2009). Other species show a southern-centred distribution, with *Parasesarma capensis*, according to current reports, present only in mangrove forests of southern Mozambique and South Africa, as well as *Parasesarma catenatum*.

The level of endemism of the Western Indian Ocean mangrove crab fauna is high, with two genera and 17 species present exclusively in this province (Appendix 3). Notable examples are the monotypic genus of fiddler crabs *Cranuca* and genus *Cristarma*, including only two species: *Christarma eulimene* and *C. ortmanni*, which are restricted to this mangrove province after their separation from the genus *Chiromantes* (Schubart and Ng, 2020).

Within the Sesarmidae family, *Leptarma gazi* has been reported only in mangroves of Kenya and Tanzania (Cannicci *et al*., 2017). *Metopograpsus cannicci* is another example of a recently described species that is endemic to the Western Indian Ocean region (Fratini *et al*., 2018).

Fiddler crabs such as this Paraleptuca chlorophthalmus *in Kenya are important to mangrove ecosystem processes; they provide bioturbation by turning over the soil surface layer, depositing countless feeding pellets which accelerate microbial activity (photo credit: Stefano Cannicci in Dahdouh-Guebas et al., 2020)*

In addition, Appendix 2 includes the list of taxa that are associated with mangrove habitats in the Red List of Threatened Species database and Appendix 3 encompasses the list of crab species described from the Western Indian Ocean province.

Abiotic Components of the Ecosystem

Regional mangrove distributions are influenced by interactions among landscape position, rainfall, hydrology, sea level, sediment dynamics, subsidence, storm-driven processes, and incidences of herbivores and parasites, sometimes affecting forest health and structure. 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. High rainfall reduces salinity and increases nutrient loading from adjacent catchments, while tidal flushing also regulates salinity.

The above factors support various forms or assemblages depending on the specific conditions. These assemblages include various types of terrigenous mangroves (Worthington *et al.*, 2020): (i) fringing mangroves widespread and surrounding the perimeter of mostly gently sloping coastlines; (ii) riverine mangroves, bordering rivers; (iii) basin mangrove, widespread and occupying larger areas at the back of both fringing and riverine mangroves; (iv) dwarf or stunted mangroves, common in abnormal or equinoctial tidal reach, having tidal inundation only a few days in a month; (v) overwashed mangroves, also common, especially dominated by intertidal isolated stands, such as those by *S. alba* common in coral limestone areas of northern Mozambique, Tanzania and Kenya (Bosire *et al.*, 2006, 2008, 2015). The oceanic islands also feature mangroves on carbonate substrata.

Key processes and interactions

Mangroves act as structural environmental engineers (foundation species), with species possessing traits such as pneumatophores, salt excretion glands, vivipary, or propagule buoyancy, and combinations of such traits, that allow survival and recruitment in poorly aerated, saline, mobile, and tidally inundated substrata. They also exhibit high efficiency in water use, nitrogen use and nutrient resorption. Mangroves produce large amounts of detritus (*e.g.*, leaves, twigs, and bark), which is either buried in waterlogged sediments, or consumed by crabs and gastropods, then decomposed further by meiofauna, fungi and bacteria, thereby mobilising carbon and nutrients to other trophic levels, or mineralising organic compounds.

Further, mangrove forests host a distinctive associated fauna mainly composed of extremely specialised organisms of both marine and terrestrial origins. Among the most representative groups of such unique communities of species are the brachyuran (true) crabs, which are highly biodiverse and show peculiar evolutionary adaptations to terrestrial and, in some cases, arboreal life (Cannicci *et al.*, 2008; Lee *et al.*, 2008; Cannicci *et al*., 2021). They are the dominant resident invertebrate fauna in mangroves and, as such, play key roles in the ecological processes that modulate the structure and function of mangrove ecosystems (Cannicci *et al.*, 2008; Lee *et al*., 2008). For example, it is known that mangrove macrobenthic communities, mainly composed of crabs, act as ecosystem engineers and enhance the oxygenation and bioturbation of the soil, contributing to the viability of mangrove trees and other associated organisms. Their burrows also provide habitat for other invertebrates like molluscs and worms. Thus, it is recognised that there are no healthy mangroves without viable invertebrate assemblages (Cannicci *et al*., 2021).

Mangrove ecosystems can serve as major blue carbon sinks, incorporating organic matter into sediments and living biomass. In the Western Indian Ocean region, a ground-breaking project has been established, involving a community-driven carbon credit system centred around mangrove conservation to offset greenhouse gas emissions in the voluntary carbon market. This initiative, known as Mikoko Pamoja, was developed within the Gazi Bay community in Kenya in 2013. By preserving and restoring mangroves, the community generates revenue through the sale of carbon credits to compensate for emissions, which in turn funds various social and economic development projects. Furthermore, this model has been expanded to the Vanga community near the Tanzanian border, with the incorporation of adjacent seagrass ecosystems, a project known as the Vanga Blue Forest.

Mikoko Pamoja, the first mangrove carbon project in the world, was developed within the Gazi Bay community, Kenya in 2013; the community water project shown here was made possible by community revenues through the sale of carbon credits to offset CO_2 emissions (photo credit: Diana Di Nitto)

Specialised mangrove roots (pneumatophores) establish a complex biotope structure that shields juvenile fish and pelagic species from predators and offers a solid substratum for the attachment of sessile and mobile invertebrates (*e.g.*, oysters, mussels, and gastropods) and algae (zu Ermgassen *et al.*, 2021). In many cases the fish communities are the basis for a complex multi-seasonal dependency on fisheries (Ndarathi *et al.*, 2020). The pneumatophores also offer support to mudskippers.

Mangrove canopies harbour insect herbivores and other terrestrial taxa including invertebrates, reptiles, small mammals, and extensive bird communities. However, in general, the diversity of invertebrates and microorganisms is not well known; and within the province, the level of comprehensive understanding and inventories of diversity is not balanced. A diagram illustrating the key processes and interactions is shown in Figure 2.

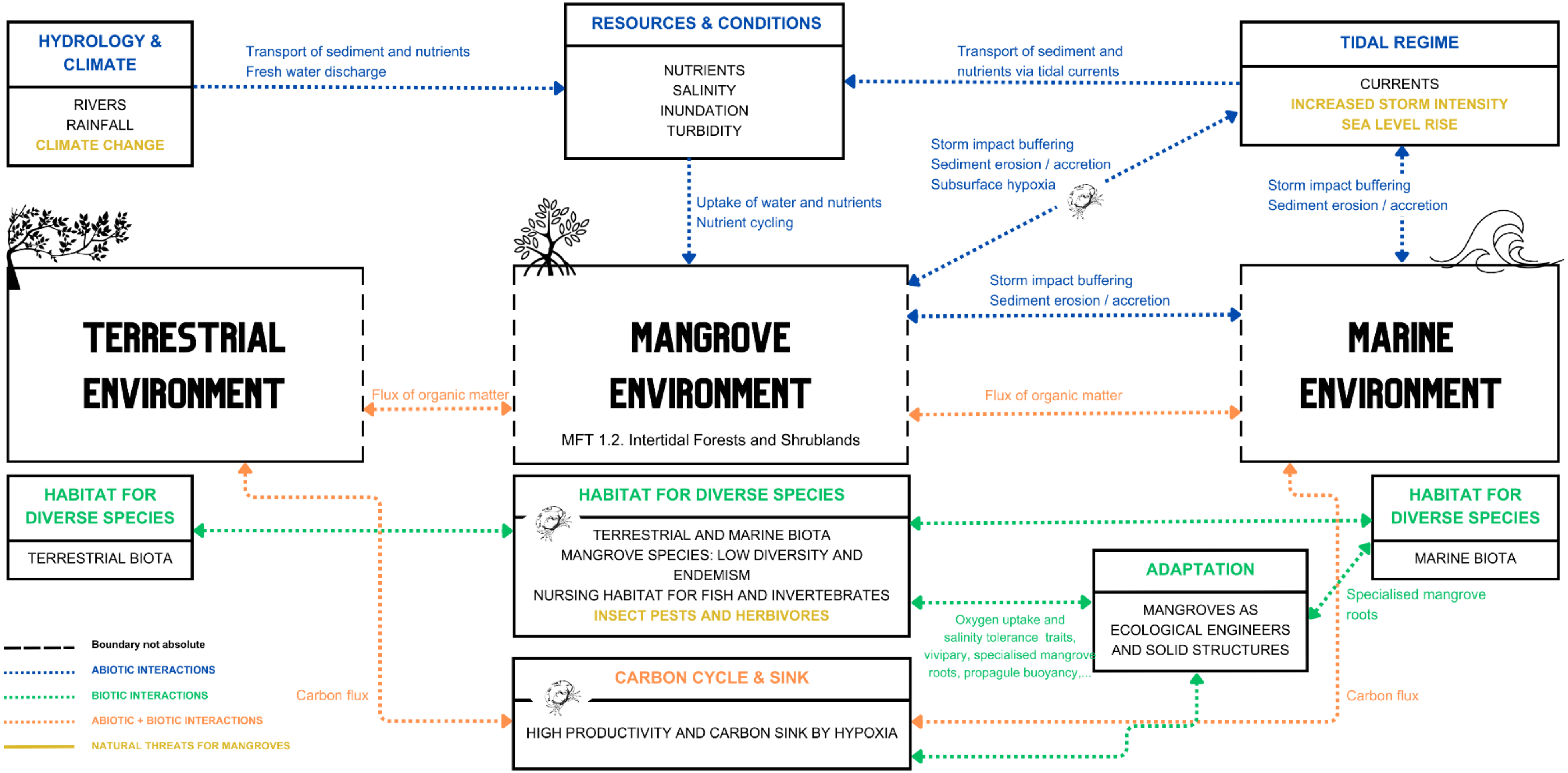

Figure 2: Diagram illustrating the fundamental key processes and interactions within mangrove ecosystems of Western Indian Ocean province. To clarify core ecological dynamics, this diagram does not include a comprehensive overview of all anthropogenic and natural threats.

2. Ecosystem Threats and Vulnerabilities

Main threatening processes and pathways to degradation

Mangrove loss and degradation arise from various factors, including conversion for other land uses, coastal infrastructure development (*e.g.* Kenya; harbour and road infrastructures in Mombasa and Lamu); urbanisation and associated coastal development; over-harvesting; browsing by cattle; diversion of freshwater flow; bait harvesting/digging; siltation or deposition of sediment and mangrove smothering; and insect infestations that kill branches, whole trees or stands (Dahdouh-Guebas *et al*., 2004; Jenoh *et al*., 2016; Yando *et al*., 2021). Although research has shown some degree of resilience and ability for rapid adaptation following instantaneous sediment burial in mangroves (Okello *et al.*, 2014; Okello *et al.*, 2020), continuous/repeated sedimentation events may result in physiological fatigue and consequent death of affected trees (Ellison, 1998).

Other agents of degradation are pollution stemming from both domestic and industrial sources; oil spills, as well as poor agricultural land use and the resultant consequences of siltation downstream, which are normally associated with heavy downpours. The increasing shipping and harbour activities in the Western Indian Ocean region, and the associated oil spill risks, must be matched by planning to mitigate the impacts of such events. There is no centralised early warning system for oil spills in the region. The Nairobi Convention has highlighted that Member States want to prioritise a regional centre or mechanism for oil spill preparedness and response. Furthermore, organisations such as the International Maritime Organization (IMO) and Oil Spill Mutual Aid Group Society (OSMAG) are advocating for the establishment of National Oil Spill Contingency Plans (NOSCPs) and regional cooperation frameworks to enhance coordinated responses to maritime pollution incidents, including oil spills.

There is a need to re-evaluate emerging threats targeting specific species: for instance, insect infestation in *Sonneratia alba.* The wood boring coleopteran *Bottegia rubra* and a metarbelid lepidopteran (sp. nov.) are native and part of the mangrove ecosystem's species richness, but they may expand and affect the water-fringing *S. alba* stands (Jenoh *et al.*, 2016).

Selective over-harvesting of certain size categories of mostly *Rhizophora mucronata* trees, which are highly prized for construction wood in much of the region, has led and may further lead to over-exploitation (Dahdouh-Guebas *et al.*, 2000), if not countered by provision of similar alternatives (*e.g. Casuarina equisetifolia* poles; this is a coastal-terrestrial species and non-native, but planted and naturalising).

Lack of tidal access affects system health and exchange of genetic material through limited propagule dispersal and altered salinity or hypoxia conditions (South Africa). Mangroves increasingly suffer from plastic waste, both seaborne and originating from land. Throughout the entire province, massive amounts of plastic and other wastes are trapped in mangroves by their complex root structures, and mechanically reduced to microplastics.

The location of mangrove forests within intertidal areas renders them vulnerable to forecasted sea-level rise as a result of climate change (Di Nitto *et al.*, 2008, 2014). Some of the low island systems are likely to disappear altogether. Human coastal development, infrastructure may restrict landward migration of mangroves via 'coastal squeeze'. Further, tropical storms can damage mangrove forests through direct defoliation and destruction of trees, as well as through mortality of animal communities within the ecosystems. Weather patterns associated with ENSO processes, such as heavy rains and freshwater input, have already led to floristic shifts in the mangroves (*e.g.* Kenya and Mozambique (Limpopo Estuary and Save Delta), 1997-98 and 2015-2016 (Bandeira and Balidy, 2016; Macamo *et al.*, 2016; Fortnam *et al*., 2021)). Although ENSO-related events are part of natural processes, their frequency and intensity may change. These extreme events have all been identified as future research priorities (Dahdouh-Guebas *et al.*, 2022) and most sites in the WIO Region have been identified as priority areas to protect mangroves and maximise ecosystem services (Dabalà *et al.*, 2023).

Drivers of mangrove degradation include poverty, inappropriate management in catchments including poor agricultural land use practises in the hinterland, lack of waste management strategies or insufficient enforcement of existing legislations. Further, extreme weather events and ocean processes are also increasingly becoming important drivers of mangrove loss globally and in the region (Charrua *et al*., 2020; Goldberg *et al.*, 2020).

Over-exploitation of mangroves in the 1990's in Bwajumwali, Pate Island (Kenya), leaving this vast area devoid of trees without natural regeneration (photo credit: Judith Okello, 2023)

Digging for bait can disturb the mangrove habitat, particularly the root systems; and on a large scale can increase erosion and the overall health of the mangrove ecosystem (photo credit: Nico Koedam)

Mangrove creek in Gazi Bay (Kenya) at high tide. White branches indicate mortality in Sonneratia alba due to mistletoe (Agelanthus sp.)*, a wood-boring coleopteran, or lepidopteran, or all of these (photo credit: Nico Koedam)*

Rusty brown frass formed by moth larvae on the bark of Sonneratia alba*;*
this moth is a new species and genus of lepidopteran (photo credit: Nico Koedam)

A tremendous amount of waste and plastic is disposed of and trapped within the complex root structures of the Kawéni mangroves in Mayotte (photo credit: Rémi Brosse, 2021)

Drone image of the Dembéni mangroves in Mayotte illustrating coastal squeeze of mangroves; in this case due to rural encroachment (photo credit: Yann Mercky, 2023)

Definition of the collapsed state of the ecosystem

Mangroves, acting as structural engineers, possess specialised traits that facilitate high water and nutrient use efficiency and resorption, influencing critical processes and functions within their ecosystem. Ecosystem collapse is recognised when the tree cover of diagnostic true mangrove species dwindles to zero, indicating complete loss (100% mortality).

Mangrove ecosystems exhibit remarkable dynamism, with species distributions adapting to local shifts in sediment distribution, tidal patterns, and variations in local inundation and salinity gradients. Disruptive processes can trigger shifts in this dynamism, potentially leading to ecosystem collapse. Ecosystem collapse may manifest through the following mechanisms: (i) restricted recruitment and survival of diagnostic true mangroves due to adverse climatic conditions (*e.g*., low or high temperatures), fragmentation of forests and reduced tidal access; (ii) alterations in rainfall, river inputs, waves, and tidal currents that destabilise and erode soft substrata, increased sediment input, hindering recruitment and growth; (ii) shifts in rainfall patterns and tidal flushing altering salinity stress and nutrient loadings, impacting overall survival.

Although simulated seaborne dispersal of mangrove propagules suggests good connectivity within the extensive Western Indian Ocean province, population genetic studies show genetic breaks in major mangrove tree species reflecting actual or past barriers to gene flow, regardless of geographic distance. Connectivity and gene flow may relate to each species' resilience to change. On the other hand, forecasted changes in sea surface salinity, temperature and hence water density, with the capacity to affect seaborne dispersal, are much less pronounced in the Western Indian Ocean province than in other mangrove regions worldwide (Van der Stocken *et al.*, 2019, Triest *et al.*, 2021, Van der Stocken *et al.*, 2022)

Threat Classification

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

1. **Residential & Commercial Development**
    - Housing & Urban Areas
    - Commercial & Industrial Areas
    - Tourism & Recreation Areas
2. **Agriculture & Aquaculture**
    - 2.3 Livestock farming & ranching
        - 2.3.2 Small-holder grazing, ranching or farming
    - 2.4 Marine & Freshwater Aquaculture
        - 2.4.1 Subsistence/Artisanal Aquaculture
        - 2.4.2 Industrial Aquaculture
5. **Biological Resource Use**
    - 5.1 Hunting & Collecting Terrestrial Animals
    - 5.3 Logging & Wood Harvesting
    - 5.4 Fishing & Harvesting Aquatic Resources
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 Wastewater
        - 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
10. **Geological events**
    - 10.2 Earthquakes/Tsunamis
11. **Climate change & Severe Weather**
    - 11.1 Habitat Shifting & Alteration
    - 11.4 Storms & Flooding

3. Ecosystem Assessment

Criterion A: Reduction in Geographic Distribution

Sub-criterion A1 measures the trend in ecosystem extent during the last 50-year period. Unfortunately, there is currently no common regional dataset that provides information for the entire target area in 1970. However, country-level estimates of mangrove extent can be used to extrapolate the trend between 1970 and 2020. Accordingly, we compiled reliable published sources (see Appendix 4) that contain information on mangrove area estimates close to 1970 (both before and after) for each country within the province. These estimates were then used to interpolate the mangrove area in 1970 in each country. By summing up these estimates, we calculated the total mangrove area in the province in 1970. We only considered the percentage of each country's total mangrove area located within the province. However, the estimated figures for 1970 should be considered only indicative (see Appendix 4 for further details of the methods and limitations).

To estimate the Western Indian Ocean mangrove area from 1996 to 2020, we used the most recent version of Global Mangrove Watch Version 3 (GMW v3.0) spatial dataset. The mangrove area in the province (and in the corresponding countries) was corrected for both omission and commission errors, utilising the equations in Bunting *et al.* (2022).

Results from the analysis of sub-criterion A1 (Appendix 4) show that the Western Indian Ocean mangrove province has lost approximately 18.7% of its mangrove area over the last 50 years (1970-2020). Based on the information collected, the rate of change in mangrove area was greater in Mauritius (-1.8 %/year) and Seychelles (-1.7 %/year) and Mozambique (-0.5 %/year) which together account for the 40.5% of the mangrove extent in this province (Appendix 4). Overall, the net change in geographic distribution is below the 30% risk threshold, thus the ecosystem is assessed as **Least Concern (LC)** under sub-criterion A1.

Western Indian Ocean	2020*	1970*	Net area Change (km^2)	% Net Area Change	Rate of change (%/year)
	7,505	9,226	-1,721	-18.7	-0.4

**Units in km^2 Details on the methods and references used to estimate the mangrove area in 1970 are listed in Appendix 4. Total mangrove area in 2020 is based on the Global Mangrove Watch Version 3 (GMW v3.0) dataset.*

Sub-criterion A2 measures the change in ecosystem extent in any 50-year period, including from the present to the future: The Western Indian Ocean mangrove province shows a net area loss of -3% (1996-2020) based on the Global Mangrove Watch time series (Bunting *et al.,* 2022). This value reflects the offset between areas gained (+0.10 %/year) and lost (-0.23 %/year). The largest decline in mangrove area occurred between 1996 and 2010; but since then, there has been a deceleration in net area loss. Applying a linear regression to the area estimations between 1996 and 2020 we obtained a rate of change of -0.11 %/year (Figure 3). Assuming this trend continues in the future, it is predicted that the extent of mangroves in the Western Indian Ocean province will decrease by -5.7% from 1996 to 2046, and by -8.3% from 1996 to 2070; Given that these predicted changes in mangrove extent are much less than the 30% risk threshold, the Western Indian Ocean mangrove province is assessed as **Least Concern (LC)** under sub-criterion A2.

Rate of change: -0.1 % / Year **R^2=0.9**

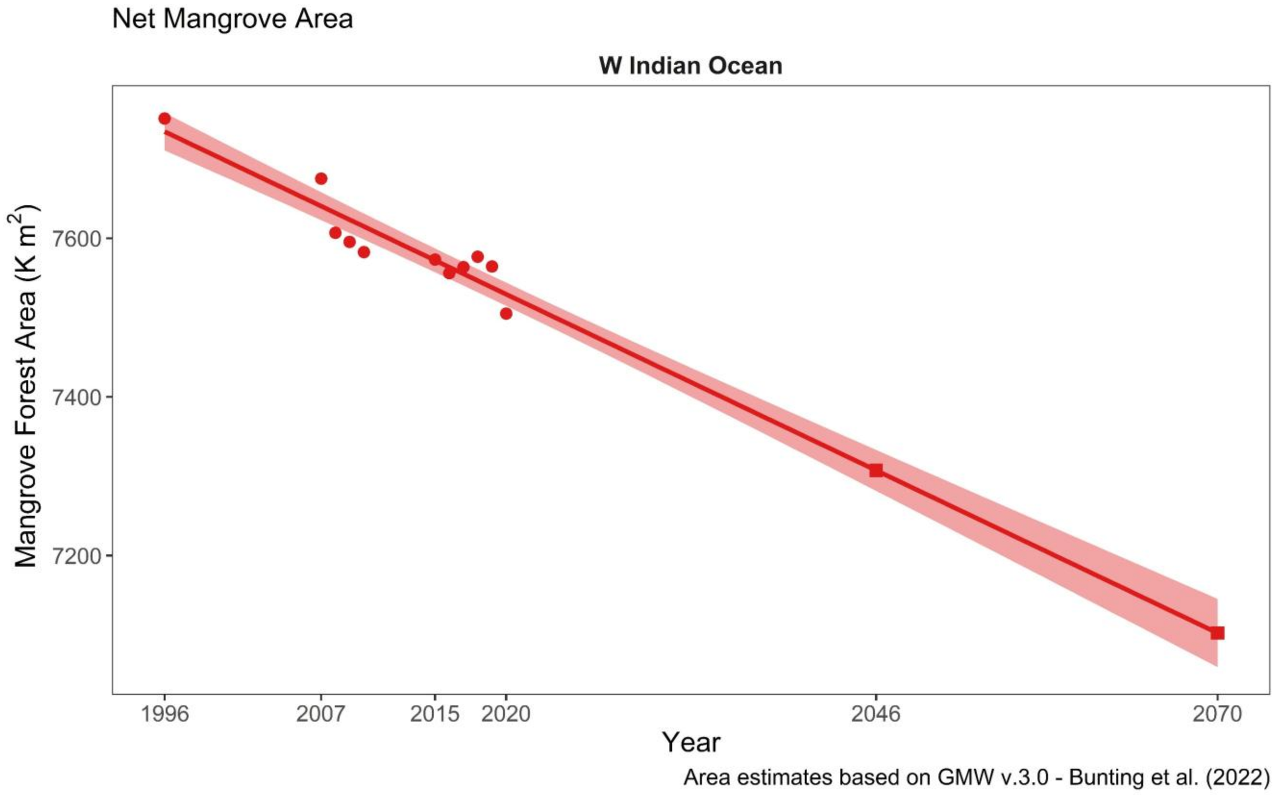

Figure 3. Historical and potential future change in mangrove area within the Western Indian Ocean province mangrove extent. Dots show historical estimates based on the GMW v3.0 dataset and equations in Bunting et al. (2022), while the squares show projected changes to the years 2046 and 2070, based on linear regression with an assumption that no efforts are put in future to halt losses. The solid line and shaded area are the linear regression and 95% confidence intervals.

Sub-criterion A3 measures changes in mangrove area since 1750. Unfortunately, there is no reliable data on the mangrove extent for the entire province during this period, and therefore the Western Indian Ocean mangrove ecosystem is classified as **Data Deficient (DD)** for Sub-criterion A3.

Overall, the ecosystem is assessed as **Least Concern (LC)** under criterion A.

Criterion B: Restricted Geographic Distribution

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). These parameters were calculated based on the 2020 Western Indian Ocean province mangrove extent (GMW v.3).

For 2020, the Western Indian Ocean province AOO and EOO were measured as 771 grid cells 10 km x 10 km and 5,446,815 km^2, respectively (Figure 4). Excluding from the total of 1167 those grid cells that contain patches of mangrove forest that account for less than 1% of the grid cell area, (< 1 km^2), the AOO is measured as **771, 10 x 10 km grid cells** (Figure 4, red grids).

Province	Extent of Occurrence EOO (km^2)	Area of Occupancy (AOO) ≥1	Criterion B
The Western Indian Ocean	5,446,815	771	**LC**

Considering the very high number of threat-defined-locations, there is no evidence of plausible catastrophic threats leading to potential disappearance of mangroves across their extent. As a result, the Western Indian Ocean mangrove ecosystem is assessed as **Least Concern (LC)** under criterion B.

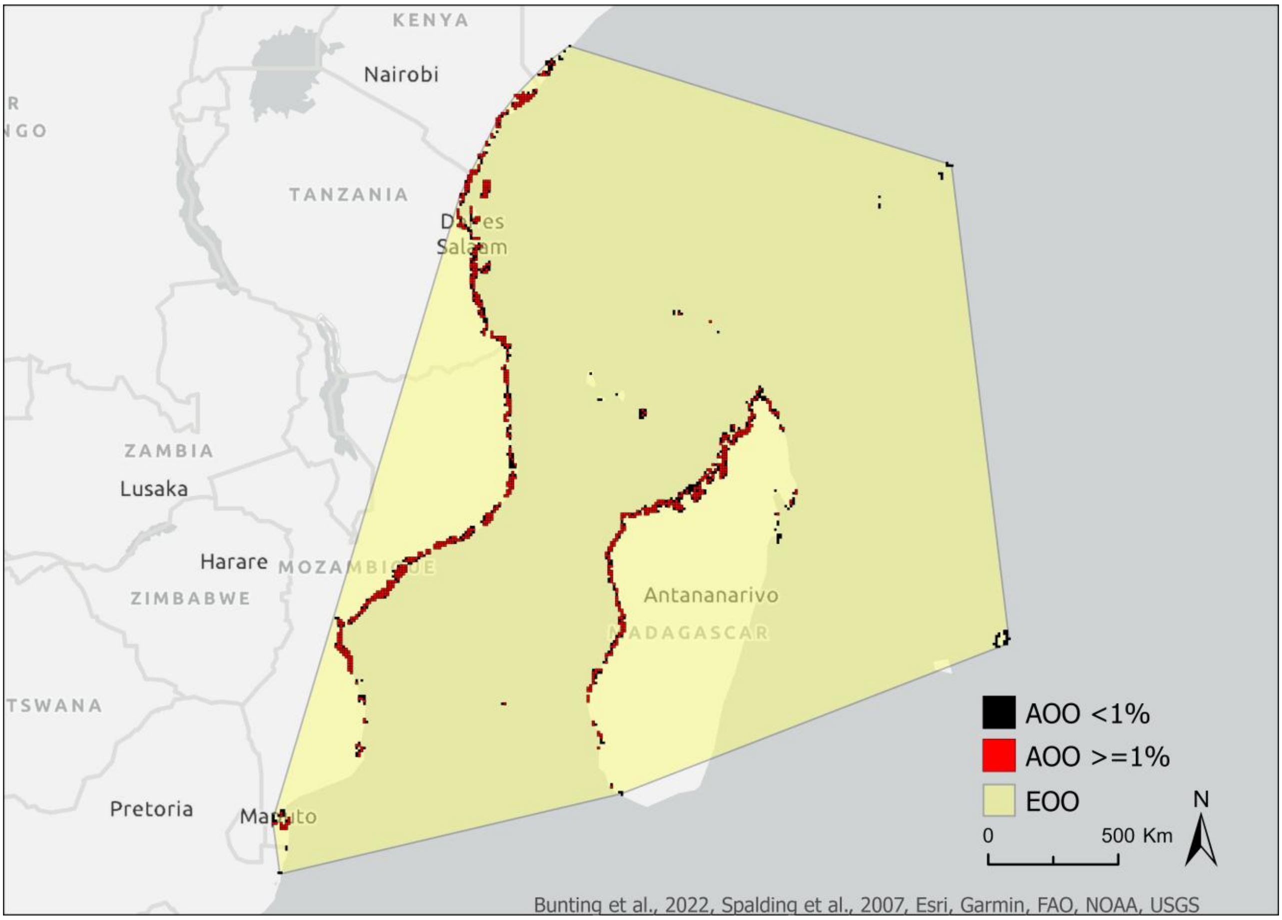

Figure 4. The Western Indian Ocean mangrove Extent of Occurrence (EOO) and Area of Occupancy (AOO) in 2020. Estimates based on 2020 GMW v3.0 spatial layer (Bunting *et al.*, 2022). The red 10 km x 10 km grids (n=771) represent more than 1% covered by the ecosystem, and the black grids less than 1% (n=396).

Criterion C: Environmental Degradation

Criterion C measures the environmental degradation of abiotic variables necessary to support the ecosystem. Sub-criterion C1 measures environmental degradation over the past 50 years: There are no reliable data to evaluate this sub-criterion for the entire province, and therefore the Western Indian Ocean mangrove ecosystem is classified as **Data Deficient (DD)** for sub-criterion C1.

Sub-criterion C2 measures environmental degradation in the future, or over any 50-year period, including from the present. In this context, the impact of future sea level rise (SLR) on mangrove ecosystems was 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, the 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.

According to the results, even under an extreme SLR scenario of a 1.1-meter rise by 2100, the projected submerged area is ~5% by 2070, which remains below the 30% threshold of decline. Therefore, considering that no mangrove recruitment can occur in a submerged system (100% relative severity), but that less than 30% of the ecosystem extent will be affected by SLR, the Western Indian Ocean mangrove ecosystem is assessed **as Least Concern (LC)** for sub-criterion C2.

Sub-criterion C3 measures change in abiotic variables since 1750. There is a lack of reliable historic data on environmental degradation covering the entire province, and therefore the Western Indian Ocean province is classified as **Data Deficient (DD)** for this sub-criterion.

Overall, the ecosystem is assessed as **Least Concern (LC)** 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 Western Indian Ocean 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 *et al*, 2018; Otero *et al.*, 2018, 2019; Murray *et al.*, 2020; Lucas *et al.*, 2020; Aljahdali *et al.*, 2021; Lee *et al.*, 2021; Lucas *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 16 years (~2000 to 2016), 2% of the Western Indian Ocean mangrove area is classified as degraded, resulting in an average annual rate of degradation of 0.11%. Assuming this trend remains constant, +7.5% of the Western Indian Ocean 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 Western Indian Ocean mangrove province is assessed as **Least Concern (LC)** under sub-criterion D2b.

No data were found to assess the disruption of biotic processes and degradation over the past 50 years (sub-criterion D1) or since 1750 (sub-criterion D3). Thus, both sub-criteria are classified as **Data Deficient (DD).**

Overall, the Western Indian Ocean mangrove 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 50years period	**A3** Historical (1750)
	LC	LC	DD
B. Restricted Geo. Distribution	**B1** Extent of Occurrence	**B2** Area of Occupancy	**B3** # Threat-defined Locations < 5?
	LC	LC	LC
C. Environmental Degradation	**C1** Past 50 years (1970)	**C2** Future or any 50 years period	**C3** Historical (1750)
	DD	LC	DD
D. Disruption of biotic processes	**D1** Past 50 years (1970)	**D2** Future or Any 50 years period	**D3** Historical (1750)
	DD	LC	DD
E. Quantitative Risk analysis	NE		
OVERALL RISK CATEGORY	LC		

DD = Data Deficient; LC = Least Concern; NE = Not Evaluated

Overall, the status of the Western Indian Ocean mangrove ecosystem is assessed as **Least concern (LC).**

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7. Appendices

1. List of Key Mangrove Species

List of plant species considered true mangroves according to the 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
Polypodiopsida	Polypodiales	Pteridaceae	*Acrostichum aureum**	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera gymnorrhiza*	LC
Magnoliopsida	Myrtales	Lythraceae	*Sonneratia alba*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Ceriops tagal*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora mucronata*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia marina*	LC
Magnoliopsida	Myrtales	Lythraceae	*Pemphis acidula*	LC
Magnoliopsida	Sapindales	Meliaceae	*Xylocarpus granatum*	LC
Magnoliopsida	Sapindales	Meliaceae	*Xylocarpus moluccensis*	LC
Magnoliopsida	Myrtales	Combretaceae	*Lumnitzera racemosa*	LC
Magnoliopsida	Malvales	Malvaceae	*Heritiera littoralis*	LC

**Acrostichum aureum: this herbaceous fern is usually not considered a true mangrove species.*

2. List of Associated Species

List of taxa that are associated with mangrove habitats in the Red List of Threatened Species database. We included only species with entries for Habitat 1.7: "Forest - Subtropical/Tropical Mangrove Vegetation Above High Tide Level" or for Habitat 12.7 "Marine Intertidal - Mangrove Submerged Roots"; and with suitability recorded as "Suitable"; with "Major Importance" recorded as "Yes"; 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).

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	Hydrocharitaceae	*Enhalus acoroides*	LC	Species Code: Ea
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
Magnoliopsida	Malpighiales	Phyllanthaceae	*Phyllanthus casticum*	LC	
Magnoliopsida	Caryophyllales	Amaranthaceae	*Sarcocornia mossambicensis*	DD	
Magnoliopsida	Myrtales	Melastomataceae	*Memecylon torrei*	EN	
Actinopterygii	Perciformes	Ephippidae	*Platax orbicularis*	LC	Orbiculate Batfish
Actinopterygii	Gobiiformes	Gobiidae	*Mahidolia mystacina*	LC	Flagfin Prawn Goby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys takagi*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys lonchotus*	LC	SpeartailMudgoby
Actinopterygii	Gobiiformes	Gobiidae	*Feia nympha*	LC	Nymph Goby
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Chelonodontops laticeps*	LC	BluespottedBlaasop
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulviflamma*	LC	Dory Snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulvus*	LC	Blacktail Snapper
Actinopterygii	Anguilliformes	Muraenidae	*Uropterygius concolor*	LC	Brown Moray Eel
Actinopterygii	Perciformes	Blenniidae	*Omobranchus ferox*	LC	Gossamer Blenny
Actinopterygii	Gobiiformes	Gobiidae	*Redigobius balteatus*	LC	Girdled Goby

Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus gibbosus*	LC	Brown Sweetlips
Actinopterygii	Perciformes	Leiognathidae	*Leiognathus equulus*	LC	Common Ponyfish
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus harak*	LC	Thumbprint Emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus nebulosus*	LC	Spangled Emperor
Actinopterygii	Perciformes	Carangidae	*Atule mate*	LC	Yellowtail Scad
Actinopterygii	Gobiiformes	Gobiidae	*Parachaeturichthys polynema*	LC	Lancet-Tail Goby
Actinopterygii	Gobiiformes	Gobiidae	*Paratrypauchen microcephalus*	LC	Comb Goby
Actinopterygii	Tetraodontiformes	Monacanthidae	*Paramonacanthus frenatus*	LC	Wedgetail Filefish
Actinopterygii	Clupeiformes	Clupeidae	*Sardinella melanura*	LC	Blacktip Sardinella
Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus paulayi*	LC	Zebra Sweetlip
Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus plagiodesmus*	LC	Barred Rubberlip
Aves	Anseriformes	Anatidae	*Anas bernieri*	EN	Madagascar Teal
Aves	Coraciiformes	Alcedinidae	*Halcyon senegaloides*	LC	Mangrove Kingfisher
Aves	Passeriformes	Dicruridae	*Dicrurus aldabranus*	NT	Aldabra Drongo
Aves	Passeriformes	Zosteropidae	*Zosterops vaughani*	LC	Pemba White-Eye
Aves	Pelecaniformes	Threskiornithidae	*Threskiornis bernieri*	EN	Madagascar Sacred Ibis
Gastropoda	Sorbeoconcha	Potamididae	*Cerithidea decollata*	LC	
Gastropoda	Littorinimorpha	Littorinidae	*Littoraria undulata*	LC	
Gastropoda	Neogastropoda	Conidae	*Conus varius*	LC	
Mammalia	Sirenia	Dugongidae	*Dugong dugon*	VU	
Reptilia	Crocodylia	Crocodylidae	*Crocodylusniloticus*	LC	Nile Crocodile

3. List of crab species described from the Western Indian Ocean province.

The asterisks indicate the genera/species endemic to this province.

Family	Genus	Species
Dotillidae	*Dotilla*	*D. fenestrate* (Hilgendorf, 1869)
Gecarcinidae	*Cardisoma*	*C. carnifex* (Herbst, 1796)
Grapsidae	*Metopograpsus*	*M. cannicci** (Innocenti, Schubart& Fratini, 2020)
		M. messor (Forskål, 1775)
		M. oceanicus (Hombron & Jacquinot, 1846)
Macrophthalmidae	*Macrophthalmus*	*M. depressus* (Rüppell, 1830)
		M. grandidierii (A. Milne-Edwards, 1867)
		M. parvimanus (Guérin, 1832)
Ocypodidae	*Austruca*	*A. occidentalis** (Naderloo, Schubart & Shih, 2016)
	*Cranuca**	*C. inversa** (Hoffmann, 1874)
	Gelasimus	*G. hesperiae** (Crane, 1975)
	Ocypode	*O. ceratophthalmus* (Pallas, 1772)
	Paraleptuca	*P. chlorophthalmus** (H. Milne Edwards, 1837)
	Tubuca	*T. urvillei* (H. Milne Edwards, 1852)
Oziidae	*Epixanthus*	*E. dentatus* (White, 1848)
Pilumnidae	*Eurycarcinus*	*E. natalensis* (Krauss, 1843)
Portunidae	*Scylla*	*S. serrata* (Forskål, 1775)
	Thalamita	*T. crenata* Rüppell, 1830
Sesarmidae	*Clistocoeloma*	*C. villosum* (A. Milne-Edwards, 1869)
	*Cristarma**	*C. eulimene** (De Man, 1895)
		*C. ortmanni** (Crosnier, 1965)
	Leptarma	*L. gazi** (Cannicci, Innocenti & Fratini, 2017)
		*L. leptosoma** (Hilgendorf, 1869)
	Neosarmatium	*N. africanum** (Ragionieri, Fratini &Schubart, 2012)
		*N. meinerti** (De Man, 1887)
		N. smithi (H. Milne Edwards, 1853)
	Parasesarma	*P. bengalense* (Davie, 2003)

		*P. capensis** (Fratini, Cannicci & Innocenti, 2019)
		*P. catenatum** (Ortmann, 1897)
		P. guttatum (A. Milne-Edwards, 1869)
		*P. samawati** (Gillikin & Schubart, 2004)
	Sarmatium	*S. crassum* (Dana, 1851)
	Selatium	*S. brockii* (De Man, 1887)
		*S. elongatum** (A. Milne-Edwards, 1869)
	Sesarmoides	*S. longipes* (Krauss, 1843)
	Sesarmops	*S. impressus** (H. Milne Edwards, 1837)
Varunidae	*Pseudohelice*	*P. latreilli** (H. Milne Edwards, 1837)

4. National Estimates for sub-criterion A1

To estimate the Western Indian Ocean mangrove ecosystem extent in 1970, we gathered reliable information on the mangrove area for each country within the province around this period (Table b). We then estimated the mangrove area in 1970 for each country, assuming a linear relationship between mangrove extent and time. Finally, we summed up the country estimates to determine the total mangrove area in the Western Indian Ocean province (Table a). We assumed that the percentage of mangrove extent by country within the province remained constant over time, as the percentages did not change between 1996 and 2020 (GMW v3.0 dataset). However, using mangrove area estimates from different sources can lead to uncertainty (Friess and Webb, 2014)[2] and there were no regional statistics or global studies available for this time period. Thus, the estimates for 1970 should be considered only indicative.

Table a: Estimated mangrove area (km^2) by country in 1970 and 2020. Estimates for 2020* mangrove area are based on the Global Mangrove Watch Version 3 (GMW v3.0) dataset. The references used to calculate mangrove area for each country in 1970 are listed below in Table b.**

Year	Country total 2020*	Within province 2020*	Country total 1970**	Within province 1970**
Comoros	1	1	1.3	1.3
France:				
Îles Éparses de l'océan Indien	6.7	6.7		
Mayotte	6.8	6.8	6.5	6.5
Kenya	544.4	544.3	553.8	553.8
Madagascar	2775.9	2775.9	3353.5	3353.5
Mauritius	4.3	4.3	34.6	34.6
Mozambique	3028.1	3028.1	4091.1	4091.1
Seychelles	3.8	3.8	26.5	26.5
Somalia	35.2	26.1	120.5	89.3
South Africa	26.4	0.7	17.8	0.5
Tanzania	1107.4	1107.4	1068.2	1068.2
Western Indian Ocean		**7505.1**		**9225.6**

[2] Friess, D. A., & Webb, E. L. (2014). Variability in mangrove change estimates and implications for the assessment of ecosystem service provision: Variability in mangrove ecosystem loss. *Global Ecology and Biogeography*, *23*(7), 715–725. https://doi.org/10.1111/geb.12140

Table b: List of selected studies considered to have reliable information on mangrove area for the period around 1970 in each country of the Western Indian Ocean province.

Country	Year	Mangrove Area (ha)	Reference
Comoros	1980	125	FAO (2007) The World's Mangroves 1980-2005. Africa. https://www.fao.org/3/a1427e/a1427e05.pdf
Comoros	1990	120	FAO (2007) The World's Mangroves 1980-2005. Africa. https://www.fao.org/3/a1427e/a1427e05.pdf
Comoros	2002	117	FAO (2007) The World's Mangroves 1980-2005. Africa. https://www.fao.org/3/a1427e/a1427e05.pdf
Comoros	2005	115	FAO (2007) The World's Mangroves 1980-2005. Africa. https://www.fao.org/3/a1427e/a1427e05.pdf
France (Mayotte)	1969	645.75	Jeanson, M. *et al*. (2014) 'Mangrove Evolution in Mayotte Island, Indian Ocean: A 60-year Synopsis Based on Aerial Photographs', Wetlands, 34(3), pp. 459–468. https://doi.org/10.1007/s13157-014-0512-7.
Kenya	1981	54325	Doute, R.N. Ochanda and H. Epp. 1981. A forest Inventory of Kenya Using Remote Sensing Techniques. KREMU, Technical report series N 30, Nairobi: Kenya Rangeland Ecological Monitoring Unit.
Kenya	1995	52980	Gang, P.O. 1995. Application of Remote Sensing to Determine the Status of Mangrove Forest along the Kenyan Coast. In: Proceedings of the conference Caring for the Forest: Research in a Changing World IUFRO-95, 6-12 August 1995, Tampere, Finland. http://www.metla.fi/iufro/iufro95abs/d4pos18.htm
Madagascar	1921	400000	Perrier de la Bathie. 1921. La végétation malgache. Ann. Mus. Colon. Marseille, 3e sér., 9: 1-268.
Madagascar	1955	350000	Humbert, H. 1965. Notice de la carte internationale du tapis vegétal: Madagascar. Etat des travaux de la section scientifique et technique de l'institut francais de Pondichery - Hors serie No. 6 Toulouse - France
Madagascar	1966	327000	Kiener. 1966. Contribution à l'étude écologique et biologique des eaux saumâtres malgaches. Vie et milieu, pp 1013-1149
Madagascar	1987	325560	Commission of the European Communities. 1987. Mangroves of Africa and Madagascar. Conservation and reclamation: The Mangroves of Madagascar. CML, Centre for Environmental Studies, University of Leyden, 24 pp.
Mauritius	1987	2000	Ministry of Environmental and National Development Unit. Third National Report for the republic of Mauritius. P.29. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.cbd.int%2Fdoc%2Fworld%2Fmu%2Fmu-nr-03-en.doc&wdOrigin=BROWSELINK
Mauritius	1994	1400	Ministry of Environmental and National Development Unit. Third National Report for the republic of Mauritius. P.29. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.cbd.int%2Fdoc%2Fworld%2Fmu%2Fmu-nr-03-en.doc&wdOrigin=BROWSELINK
Mozambique	1972	408079	FAO. 1994. Study for the determination of the rate of deforestation of the mangrove vegetation in Mozambique. By Saket, M., Matusse, R. V. Field document MOZ/92/013. FAO, Rome, Italy. 9 pp.

Country	Year	Mangrove Area (ha)	Reference
Mozambique	1990	396080	FAO. 1994. Study for the determination of the rate of deforestation of the mangrove vegetation in Mozambique. By Saket, M., Matusse, R. V. Field document MOZ/92/013. FAO, Rome, Italy. 9 pp.
Mozambique	1997	392749	FAO. 1994. Study for the determination of the rate of deforestation of the mangrove vegetation in Mozambique. By Saket, M., Matusse, R. V. Field document MOZ/92/013. FAO, Rome, Italy. 9 pp.
Seychelles	1960	2900	Spalding, M.D., Blasco, F. d Field, C.D., eds. 1997. World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan. 178 pp.
Seychelles	1995	2000	Seychelles Island Foundation. 1995. Personal communication in: FAO (2007) The World's Mangroves 1980-2005. Asia. https://www.fao.org/3/a1427e/a1427e06.pdf
Somalia	1975	10000	FAO (2007) The World's Mangroves 1980-2005. Asia. https://www.fao.org/3/a1427e/a1427e06.pdf
Somalia	1980	9500	FAO (2007) The World's Mangroves 1980-2005. Asia. https://www.fao.org/3/a1427e/a1427e06.pdf
Somalia	1996	3679	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
South Africa	1983	1100	Saenger, P., Hegerl E.J. and J.D.S., Davie. 1983. Global status of mangrove ecosystems. Commission on Ecology Papers No.3. IUCN. Gland, Switzerland. 88 pp.
South Africa	1991	673	Snedaker, S.C. 1991. Personal communication.
Tanzania	1965	96000	Tanzania mainland: Forest Division. 1966. Forestry Annual Report. Dar-es-Salaam.;Zanzibar Island: FAO. 1979. Forestry programming and Formulation Mission to Zanzibar and Mainland Tanzania. Consultant’s report based on the work of S.C. Tamajong –Rome
Tanzania	1987	143284	Tanga, Pwani, Lindi, Mtwara, Dar Es Salaam, and Mafia Island: Semesi, A.K. 1993; Hunting. 1997; FAO, UNEP. 1981