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Ecological condition and conservation status of the critically endangered *Memecylon incisilobum* in the Maputaland Endemic Centre, southern Mozambique

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Executive Summary

This study provides an ecological and conservation assessment of *Memecylon incisilobum* , a critically endangered endemic species confined to the Maputaland Endemic Centre, southern Mozambique. The research focused on the Chihachu sacred forest, a 24 ha remnant coastal forest in Bilene, Gaza Province, recognized for its ecological and cultural significance. Floristic and phytosociological analyses revealed a structurally complex forest fragment supporting a diverse assemblage of native species characteristic of Maputaland coastal forests. Despite its small size, the forest maintains high ecological integrity, largely due to its sacred status, which has historically limited intensive resource exploitation. However, selective timber extraction, edge effects, and restricted forest extent indicate emerging threats to ecosystem stability. Population assessment confirmed that *M. incisilobum* is critically endangered, with a highly restricted distribution, small population size, and confinement to a single forest fragment. Socioecological and cultural assessments highlighted the role of traditional knowledge, sacred status, and local practices in conserving the forest. Interviews with community members, including the last descendant of King Massinga, revealed that the forest has historical and spiritual importance, though adherence to traditional protection rules is declining due to socioecological changes. Recommendations include strengthening community-based conservation initiatives, promoting environmental education, prohibiting tree cutting, supporting reforestation, establishing community rangers, and implementing long-term monitoring of both forest condition and *M. incisilobum* populations. This study demonstrates the critical interlinkage between ecological and cultural factors in conserving endemic species and provides a framework for integrated conservation actions in small, culturally significant forest remnants.

1. Introduction

Sacred forests represent some of the oldest forms of community-based conservation systems, playing a crucial role in the protection of biodiversity, cultural heritage, and ecosystem services, particularly in tropical regions. Across Africa, these forests have historically functioned as reservoirs of native flora and fauna, safeguarded through spiritual beliefs, customary laws, and traditional governance structures that regulated access and resource use (Berkes et al., 2000; Slocombe, 2000). In many cases, sacred forests have persisted as biodiversity refuges within increasingly fragmented landscapes, offering protection to endemic and threatened species that are absent or rare in surrounding areas (Gadgil et al., 1993; Sunderland et al., 2004).

In Mozambique, coastal forests are recognised as biodiversity hotspots characterised by high levels of endemism and ecological complexity, yet they are among the most threatened ecosystems in the country. Rapid population growth, agricultural expansion, selective logging, fire, and erosion of traditional management systems have led to widespread degradation and fragmentation of these habitats (CEAGRE, 2010; FAO, 2010). Sacred forests within coastal zones often remain the last relatively intact forest patches, maintained through cultural taboos and ritual restrictions rather than formal legal protection. However, socio-cultural transformations, shifts in belief systems, and increasing economic pressures have weakened traditional conservation mechanisms, placing these forests under growing threat (Pretty & Smith, 2004; Berkes, 2004).

Within this context, *Memecylon incisilobum* A. Fern. & R. Fern. (Melastomataceae) is a narrowly endemic tree species of significant conservation concern (IUCN, 2016). The species is restricted to a small number of forest fragments in southern Mozambique, primarily within coastal and sacred forest ecosystems. Due to its limited distribution, habitat specificity, and exposure to anthropogenic pressures, *M. incisilobum* has been classified as Critically Endangered (Matimele et al., 2018).

Understanding the conservation status of endemic species such as *M. incisilobum* requires an integrated approach that combines ecological assessment with socio-cultural analysis. Purely biological studies often overlook the role of local communities, whose livelihoods, perceptions, and traditional practices directly influence forest conditions and species persistence (Agrawal, 2001; Berkes, 2004). Conversely, social studies detached from ecological evidence may underestimate the vulnerability of species and ecosystems to subtle but cumulative forms of degradation. Integrated socio-ecological research is therefore essential for designing conservation strategies that are both ecologically sound and socially legitimate (Chazdon, 2014).

Phytosociological analysis is a widely used method for assessing forest structure, species composition, dominance patterns, and ecological stability. Parameters such as density, basal area, frequency, and Importance Value Index (IVI) provide insights into community organization and the relative ecological significance of species within a forest stand (Kent, 2012). When applied to sacred forests, such analyses can reveal whether traditional protection has effectively maintained ecological integrity or whether signs of degradation, such as reduced regeneration and altered species composition, are already evident (Gadgil et al., 1993; Chazdon, 2014).

Equally important is the evaluation of population structure and regeneration capacity of threatened species. Size-class distribution, abundance of juveniles and seedlings, and evidence of natural recruitment are key indicators of long-term population viability (Laurance et al., 2011). In parallel, understanding community perceptions, cultural values, and patterns of forest use provides critical context for interpreting ecological findings. Local ecological knowledge accumulated through long-term residence and intergenerational transmission often informs resource management decisions and compliance with traditional rules (Berkes et al., 2000). However, erosion of this knowledge, reduced participation in cultural practices, and declining awareness of threatened species may undermine the effectiveness of customary conservation systems. Assessing community awareness, attitudes towards conservation, and willingness to participate in management initiatives is therefore fundamental for developing participatory and adaptive conservation strategies (Pretty & Smith, 2004).

This study aimed to assess the ecological condition and conservation status of *Memecylon incisilobum* within a sacred forest in southern Mozambique through an integrated socio-ecological approach.

2. Objectives

2.1. General

- To assess the ecological condition and conservation status of the critically endangered *Memecylon incisilobum* in the Maputaland Endemic Centre, southern Mozambique

2.2. Specific Objectives

- To characterize the floristic composition and phytosociological structure of the sacred coastal forest in the Maputaland Endemic Centre;
- To analyse the ecological condition of the sacred forest;
- To evaluate the conservation status of *Memecylon incisilobum;*
- To analyse the socioecological conditions, patterns of resource use, local perceptions, cultural values, and traditional management practices of the local community.

3. Methodology

3.1. Study area

The Chihachu sacred forest, cover an area of 24 ha, it is located in the Macia District, Gaza Province, southern Mozambique, specifically in the Bilene region within the Maputaland coastal plain, between 25.189274°S and 33.208127°E. The area lies predominantly within the Limpopo Basin and includes wetlands recognised as RAMSAR sites, particularly coastal lagoons that provide habitats for endemic species (Couto et al., 2019). The regional climate is characterised by marked seasonality, with a wet season from November to April accounting for approximately 70% of the annual rainfall, and a dry season from May to October. January is the wettest month, with mean monthly precipitation of about 130 mm, whereas July and August are the driest months, with mean monthly rainfall averaging approximately 13 mm.

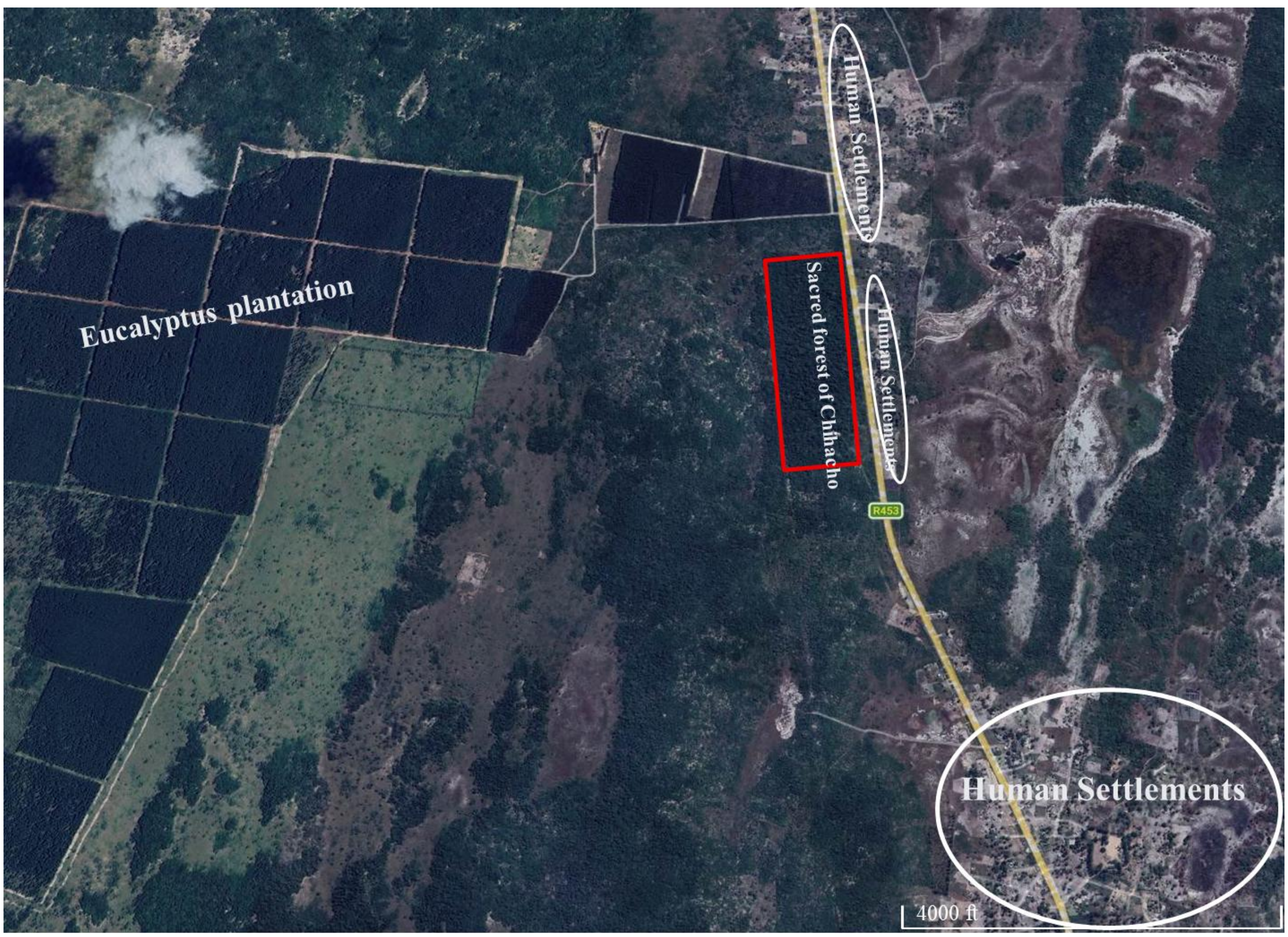

Figure 1: Study area

The Bilene region lies within the Tongoland–Pondoland Regional Mosaic, a core component of the Maputaland Endemic Centre, a globally significant biogeographical region characterized by high levels of plant endemism resulting from the convergence of Zambezian and southern African floristic elements. This context underpins the occurrence of narrowly endemic and threatened species, including *Memecylon incisilobum* (Impacto, 2012).

Vegetation in the district forms a heterogeneous mosaic structured along a coastal–inland gradient. Coastal dune systems are dominated by pioneer species such as *Sesuvium portulacastrum*, *Cyperus maritimus*, *Scaevola thunbergii*, and *Ipomoea pes-caprae*, which stabilize sandy substrates and facilitate the development of coastal thicket and forest communities. These formations commonly include woody species such as *Mimusops caffra*, *Brachylaena discolor*, *Ozoroa obovata*, *Ochna natalitia*, and *Vepris lanceolata*, with floristic composition strongly influenced by marine exposure (Impacto, 2012).

Landward, sublittoral semi-deciduous forests form mosaics dominated by *Sideroxylon*, *Afzelia*, *Ficus*, and *Balanites*. These forests constitute important refugial habitats within the Maputaland Endemic Centre and support structurally complex environments essential for forest-dependent endemic species. The sacred coastal forest examined in this study represents an elevated remnant of this vegetation type and provides the only known habitat for *Memecylon incisilobum* , a shade-tolerant understory species highly sensitive to habitat disturbance and fragmentation (Impacto, 2012). Transitional savanna grasslands dominated by *Urelytrum*, *Triraphis*, and *Eragrostis* occur between forest and coastal vegetation, while inland areas near water bodies support woodlands dominated by *Acacia xanthophloea* and associated species (Impacto, 2009; Impacto, 2012).

3.2. Data Collection

Prior to the fieldwork, a preliminary visit to the study area was conducted. A team, composed of the project coordinator, a botanist, and researchers, travelled to the field to perform a reconnaissance of the study area, establish contact with local leadership, and organize the logistical aspects of the fieldwork. The fieldwork was conducted over five field missions and involved a team comprising a team leader (ecologist), two undergraduate students in ecology, one botanist, two researchers in plant ecophysiology, and a local community guide. The guide was selected based on his knowledge of the area and the local plant diversity. Field access was facilitated by a four-wheel-drive vehicle (4 × 4).

Figure 2: Reconnaissance survey of *Memecylon incisilobum* within the sacred forest, conducted with the assistance of a local guide.

The team conducted vegetation surveys at 1 to 4 plots per day, depending on the distance to the plot, accessibility, and the number of tree and shrub individuals within the plot. Surveys were carried out between 07:00 and 17:00.

To assess the species composition, as well as the structural characteristics of the vegetation in the ecosystem, were dimensioned plots of 300 × 50 m. Were identified all individuals within the plot with a diameter at breast height (DBH) ≥ 5 cm. These were counted and their DBH measured at a height of 1.3 m above the ground using a tree caliper. Individuals with bifurcations below 1.3 m had each trunk measured separately, and were estimated the total heights of all individuals.

Species identification was carried out in the field using field guides (van Wyk & van Wyk, 2013; Palgrave, 2003; Burrowns et al., 2018). For any specimens not identifiable in the field, samples were collected for subsequent identification and confirmation using reference collections at the National Herbarium of Mozambique (Herbário Nacional de Moçambique – LMA) and the Eduardo Mondlane University Herbarium (LMU).

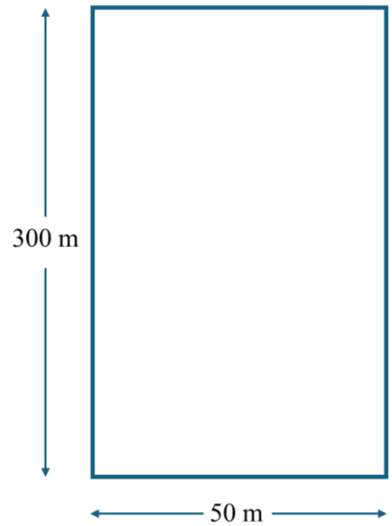

Figure 1: Layout of the plot

3.3. Assessment of the Ecological Condition of the Chihachu Sacred Forest Region

The relevant phytosociological parameters for analysing the horizontal and vertical structure were calculated using the following formulas:

Absolute and Relative Frequency

$$FA_i = \frac{p_i}{P} \times 100; FR_i = \left(\frac{FA_i}{\sum_{i=1}^{n} FA_i}\right) \times 100$$

Where:

FA_i= absolute frequency of the i-th species in the plant community.

FR_i= relative frequency of the i-th species in the plant community.

p_i= number of sampling units in which the i-th species occurs.

P= total number of sampling units.

Absolute and Relative Density

$$DA_i = \frac{n_i}{A}; DR_i = \frac{DA_i}{DT} \times 100$$

Where:

DA_i= absolute density of the i-th species, in number of individuals per hectare.

n_i= number of individuals of the i-th species in the sample.

A= total area sampled, in hectares.

DR_i= relative density (%) of the i-th species.

Absolute and Relative Dominance

$$DoA_i = \frac{DoA_i}{DoT}; g = \frac{\pi(DAP)^2}{4}; DoA_i = g_i A$$

Where:

DoA_i= absolute dominance of the i-th species, in m²/ha.

g= basal area of the i-th species in the sampled area, in m².

A= sampled area, in hectares.

DAP= diameter at breast height (measured at 1.3 m from the ground).

Importance Value Index (IVI)

$$IVI_i = DR_i + DoR_i + FR_i; IVI(\%) = \frac{IVI_i}{3}$$

Where:

IVI_i= Importance Value Index of the i-th species.

Coverage Value Index (CVI)

$$CVI_i = DR_i + DoR_i; CVI(\%) = \frac{CVI_i}{2}$$

Where:

CVI_i= Coverage Value Index of the i-th species.

Due to the absence of established metrics for the ecosystem in the study area, an exploratory assessment of the ecological condition of the ecosystem in which *Memecylon incisilobum* occurs was conducted by adapting the methodology developed by Nazerali (2020) for Miombo forests and further adapted by CEAGRE (2022) for the coastal forests of Licuáti.

For this purpose, two groups of indicators were combined in a three-step approach:

Step 1: Measurement of the ecological condition of the habitat - This step consisted of aggregating three indicators of structure and composition, namely: (i) individual density (N/ha), (ii) basal area (m^2/ha), and (iii) mean tree height (m). As reference values for each indicator were not available for the study area or ecosystem, the highest values recorded within the plots were considered as the reference for the area, since all plots were in a similar (and relatively good) state of conservation. The mean values of the quantitative indicators across the plots were calculated and expressed as a percentage relative to the reference values.

Table 1: Indicators of the ecological condition of the Chihachu sacred forest ecosystem

Indicator	Reference Value
Individual density (N/ha)	20.88
Basal area (m^2/ha)	4.94
Mean height (m)	40

Step 2: Analysis of the presence of anthropogenic activity- The anthropogenic activity was considered a secondary indicator, with tree felling, deforestation, and fires being used as the main variables. These data were collected through field observations of evidence of anthropogenic disturbances in the area, following the established criteria in Table 2.

Table 2: Anthropogenic activity indicator (adapted from Ribeiro et al., 2020)

Human activities	Score
No evidence of anthropogenic activities	1 (100%)
Anthropogenic activity in 25% of the area	2 (75%)
Anthropogenic activity in 50% of the area	3 (50%)
Anthropogenic activity in 75% of the area	4 (25%)

Step 3: Final assessment- This is the step, which consists of determining the average score of the plots by combining qualitative and quantitative indicators. The final classification of the ecological condition of the habitat was performed based on Table 3 (Nazerali, 2020).

Table 3: Final decision table for ecological condition (adapted from Ribeiro et al., 2020)

Condition	Description	Overall mean (%)
Good	The tree component is in good condition and anthropogenic damage is minimal compared with reference values for the vegetation type.	60-100
Moderate	The tree component is in fair condition and anthropogenic damage is moderate compared with reference values for the vegetation type.	30-59
Poor	The tree component is in poor condition and anthropogenic damage is high compared with reference values for the vegetation type.	<30

3.4. Socioecological Assessment, Threats, and Community Use

Data on socioecological aspects, threats, and community use were collected from communities adjacent to the forest where *Memecylon incisilobum* occurs. This approach aims to understand the interaction dynamics between local communities and the forest, including challenges associated with natural resource management. The socioecological characterization was based on a mixed-methods approach, combining quantitative and qualitative methods to capture both general patterns at the household level and local perceptions, knowledge, and resource-use practices. The quantitative survey was conducted at the household level, while the qualitative component relied on a Participatory Rapid Appraisal (PRA), widely used in socio-environmental studies for integrating local knowledge into analyses of natural resource management (Chambers, 1994; Pretty et al., 1995).

For the quantitative component, was administered a structured questionnaire to 70 households, proportionally selected within the studied community. The questionnaire included variables related to socioecological characteristics, dependence on forest resources, uses of the sacred forest, perception of threats, and conservation practices. Was also conducted the qualitative component through semi-structured interviews with community leaders, elders, and other key informants, following the approach proposed by Chaigneau et al. (2019). This method allowed an in-depth exploration of aspects related to traditional forest use, perceived threats, associated cultural practices, and local mechanisms for knowledge management and transmission.

The total sample size for the study was determined using the following formula:

$$n = \frac{N \cdot p \cdot q \cdot z_{\alpha/2}^2}{p \cdot q \cdot z_{\alpha/2}^2 + (N-1) \cdot e^2}$$

where: n = sample size; N = population size; p = success proportion; q = failure proportion; $z_{\alpha/2}^2$= confidence interval (in this case 95%, equivalent to 1.96); e^2 = sampling error (10% or 0.1 of the confidence interval). Since the success proportion (p) was unknown, a 50% probability of the phenomenon occurring was assumed (Gil, 2007).

For the selection of the interviewed households, a non-discriminatory exponential snowball sampling technique was used (Naderifar et al., 2017). For this type of sampling, the first subject was recruited and then provided multiple referrals that guided the selection of the next interview. Each subsequent referral generated additional contact until the required sample size was achieved. Following Chaigneau et al. (2019), heads of households, both men and women, were interviewed depending on availability.

A descriptive statistical analysis of socioecological data was carried out in relation to: (i) respondent profile; (ii) use and access to the sacred forest; (iii) cultural and spiritual importance; (iv) environmental perceptions and changes; (v) management, conservation, and tradition; (vi) traditional knowledge and transmission; and (vii) sustainability and community participation. Local knowledge concerning the consequences of certain daily activities practiced by communities on the ecosystem was also explored. The data were organized in an electronic spreadsheet using Microsoft Excel and subsequently imported into SPSS software, where simple frequency analyses were performed to identify the highest scoring items and their relation to the overall score (Sabino et al., 2014).

4. Data Analysis

The relevant phytosociological parameters for analysing the horizontal and vertical structure of the forest plant community included frequency, density, dominance, and natural regeneration. Plant species were classified according to their conservation status and endemism, following the criteria of the IUCN (2021), Darbyshire et al. (2019), and Odorico et al. (2022). The scientific names of plant species and their categorisation as endemic, native, or exotic were verified and standardised using authoritative databases, including *Plants of the World Online* (http://www.plantsoftheworldonline.org), *The World Flora Online* (http://www.worldfloraonline.org/), Flora of Mozambique (https://www.mozambiqueflora.com/), and the CABI Invasive Species Compendium (https://www.cabi.org/isc).

5. Results and discussion

5.1. Phytosociological Analyse

The floristic survey of the coastal forest patch reveals a species-rich but structurally uneven community. The total of 43 species across 26 families indicates moderate floristic diversity for a coastal forest of this size, with a clear dominance of native species and very limited introduction of exotics (only *Anacardium occidentale*). This aligns with other studies in southern African coastal forests, where native species often dominate but critically endangered endemics occur in highly restricted patches (White, 1983; Timberlake et al., 2021).

Family representation shows a predominance of Anacardiaceae and Fabaceae, which is typical in tropical and subtropical forests where these families provide structural and functional support, such as nitrogen fixation (Fabaceae) and fruit production (Anacardiaceae). Most species are listed as Least Concern (LC) on the IUCN Red List. Exceptions include *Lannea schweinfurthii*, which is classified as Near Threatened (NT), and the endemic and critically endangered species *Memecylon incisilobum* (CR) (https://www.iucnredlist.org/, 2026).

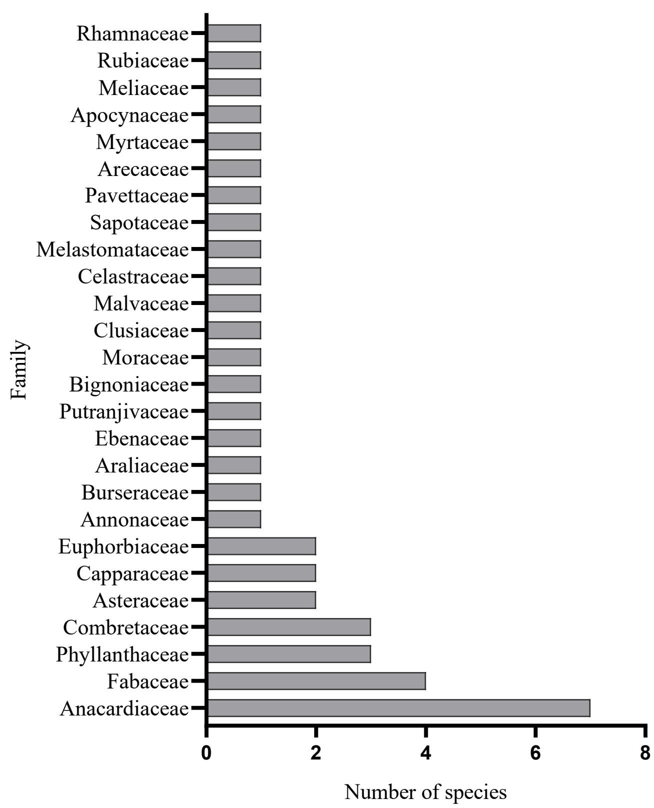

Figure 3: Floristic specific composition of the sacred forest of Chihachu.

The phytosociological indices reveal interesting dynamics:

- **Abundance and frequency:** *Memecylon incisilobum* has the highest absolute abundance (87 individuals) and frequency (202.3). Its relative abundance (17.37%) indicates it plays a disproportionately important role in forest structure and function relative to its population size.
- **Density:** *Dialium schlechteri* and *Mimusops caffra* dominate in absolute density.
- **Dominance and importance indices:** Absolute and relative dominance show that *Dialium schlechteri* and *Ficus lutea* are structurally important, likely forming the main canopy strata, while the importance value index (IVI) emphasizes the ecological significance of *Memecylon incisilobum* , *Dialium schlechteri*, and *Mimusops caffra*. This combination of dominance and high IVI for *M. incisilobum* suggests that, despite its low total population, it has a strong functional impact on the forest ecosystem (Table 4).

Overall, these results indicate a forest patch with a mixture of structural dominance by a few canopy species and a high ecological significance of a single critically endangered endemic, which is unusual and highlights conservation priority. The presence of *Memecylon incisilobum* as both ecologically dominant and threatened underscores its potential role as a functionally important species, with potential implications for forest regeneration, local biodiversity, and ecosystem services (Chazdon, 2014; Poorter et al., 2015).

The data also suggest that regeneration may be uneven, since highly dominant species like *Dialium schlechteri* have high density but *M. incisilobum*, despite high abundance, is limited in distribution and regeneration, consistent with field observations of low juvenile numbers. This demographic pattern is typical in species under pressure from selective logging or restricted habitat availability and indicates potential long-term vulnerability (Franklin et al., 2002; Laurance et al., 2011).

Table 4: Phytosociological parameters of the vegetation

Species	Family	Status	RedList	AA	AR	FA	FR	DA	DR	DoA	DoR	IVI	IVC
Afzelia quanzensis	Fabaceae	Native	LC	37	7.39	86.0	7.39	1.54	7.38	9.88	8.60	7.79	7.99
Albizia adiantifolia	Fabaceae	Native	LC	34	6.79	79.1	6.79	1.42	6.78	6.93	6.03	6.53	6.41
Albizia versicolor	Fabaceae	Native	LC	6	1.20	14.0	1.20	0.25	1.20	1.75	1.52	1.31	1.36
Anacardium occidentale	Anacardiaceae	Introduced	LC	6	1.20	14.0	1.20	0.25	1.20	1.54	1.34	1.25	1.27
Antidesma venosum	Phyllanthaceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.14	0.12	0.17	0.16
Artabotrys brachypetalus	Annonaceae	Native	LC	2	0.40	4.7	0.40	0.08	0.40	0.03	0.03	0.27	0.21
Brachylaena discolor	Asteraceae	Native	LC	7	1.40	16.3	1.40	0.29	1.40	0.91	0.79	1.20	1.09
Bridelia cathartica	Phyllanthaceae	Native	LC	16	3.19	37.2	3.19	0.67	3.19	1.87	1.63	2.67	2.41
Cadaba natalensis	Capparaceae	Native	LC	5	1.00	11.6	1.00	0.21	1.00	0.18	0.16	0.72	0.58
Capparis sepiaria	Capparaceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.03	0.03	0.14	0.11
Combretum apiculatum	Combretaceae	Native	LC	15	2.99	34.9	2.99	0.63	2.99	1.49	1.30	2.43	2.15
Commiphora mollis	Burseraceae	Native	LC	5	1.00	11.6	1.00	0.21	1.00	4.2	3.66	1.88	2.33
Cussonia arborea	Araliaceae	Native	LC	8	1.60	18.6	1.60	0.33	1.60	6.01	5.23	2.81	3.41
Dialium schlechteri	Fabaceae	Native	LC	41	8.18	95.3	8.18	1.71	8.18	20.29	17.66	11.34	12.92
Diospyros sp	Ebenaceae	Native	LC	17	3.39	39.5	3.39	0.71	3.39	5.18	4.51	3.76	3.95
Drypetes natalensis	Putranjivaceae	Native	LC	2	0.40	4.7	0.40	0.08	0.40	0.1	0.09	0.30	0.24
Fernandoa magnifica	Bignoniaceae	Native	LC	3	0.60	7.0	0.60	0.13	0.60	0.74	0.64	0.61	0.62
Ficus lutea	Moraceae	Native	LC	7	1.40	16.3	1.40	0.29	1.40	13.29	11.57	4.79	6.48
Garcinia livingstonei	Clusiaceae	Native	LC	3	0.60	7.0	0.60	0.13	0.60	0.22	0.19	0.46	0.40
Grewia sp	Malvaceae.	Native	LC	5	1.00	11.6	1.00	0.21	1.00	0.35	0.30	0.77	0.65
Hymenocardia ulmoides	Phyllanthaceae	Native	LC	34	6.79	79.1	6.79	1.42	6.78	4.76	4.14	5.90	5.46
Lannea schweinfurthii	Anacardiaceae	Native	NT	23	4.59	53.5	4.59	0.96	4.59	3.19	2.78	3.99	3.68
Maytenus undata	Celastraceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.04	0.03	0.14	0.12
Memecylon incisilobu	Melastomataceae	Native	CR	87	17.37	202.3	17.37	3.63	17.36	1.23	1.07	11.93	9.22
Mimusops caffra	Sapotaceae	Native	LC	37	7.39	86.0	7.39	1.54	7.38	13.5	11.75	8.84	9.57
Pavetta sp	Pavetta	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.04	0.03	0.14	0.12
Pericopsis angolensis	Fabaceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.57	0.50	0.30	0.35
Phoenix reclinata	Arecaceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.002	0.00	0.13	0.10
Rhus chirindensis	Anacardiaceae	Native	LC	5	1.00	11.6	1.00	0.21	1.00	0.36	0.31	0.77	0.66
Sapium ellipticum	Euphorbiaceae	Native	LC	3	0.60	7.0	0.60	0.13	0.60	0.08	0.07	0.42	0.33

Sclerocarya birrea	Anacardiaceae	Native	LC	3	0.60	7.0	0.60	0.13	0.60	0.49	0.43	0.54	0.51
Sclerocroton integerrimus	Euphorbiaceae	Native	LC	2	0.40	4.7	0.40	0.08	0.40	0.18	0.16	0.32	0.28
Stricnos madagascariensis	Anacardiaceae	Native	LC	2	0.40	4.7	0.40	0.08	0.40	0.16	0.14	0.31	0.27
Stricnos spinosa	Anacardiaceae	Native	LC	11	2.20	25.6	2.20	0.46	2.20	2.92	2.54	2.31	2.37
Strychnos decussata	Anacardiaceae	Native	LC	29	5.79	67.4	5.79	1.21	5.79	6.02	5.24	5.60	5.51
Syzygium cordatum	Myrtaceae	Native	LC	3	0.60	7.0	0.60	0.13	0.60	0.85	0.74	0.65	0.67
Tabernaemontana elegans	Apocynaceae	Native	LC	20	3.99	46.5	3.99	0.83	3.99	1.78	1.55	3.18	2.77
Terminalia myrtifolia	Combretaceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	1.57	1.37	0.59	0.78
Terminalia sericea	Combretaceae	Native	LC	3	0.60	7.0	0.60	0.13	0.60	0.04	0.03	0.41	0.32
Trichilia emetica	Meliaceae	Native	LC	8	1.60	18.6	1.60	0.33	1.60	1.26	1.10	1.43	1.35
Vangueria infausta	Rubiaceae	Native	LC	2	0.40	4.7	0.40	0.08	0.40	0.53	0.46	0.42	0.43
Vernona colorata	Asteraceae	Native	LC	1	0.20	2.3	0.20	0.04	0.20	0.01	0.01	0.14	0.10
Ziziphus mocucrunata	Rhamnaceae	Native	LC	2	0.40	4.7	0.40	0.08	0.40	0.19	0.17	0.32	0.28

Tree species and their phytosociological parameters, including absolute abundance **(AA),** relative abundance **(AR),** absolute frequency **(FA),** relative frequency **(FR),** absolute density **(DA),** relative density **(DR),** absolute dominance **(DoA),** relative dominance **(DoR),** cover value index **(IVC)** and importance value index **(IVI).**

5.2. Ecological Condition Assessment

Considering the absence of specific reference values for this ecosystem, the maximum values observed in the sampled plots were adopted as reference: 20.88 N/ha for density, 4.94 m²/ha for basal area, and 40 m for mean height, indicators reported in similar forest inventory studies (Mueller-Dombois & Ellenberg, 1974; Kent & Coker, 1992). Approximately 25% of the area showed evidence of anthropogenic impacts, including tree felling for timber, firewood, and charcoal production (figure 3), corresponding to a score of 2 on the scale adapted from Ribeiro et al. (2020), where 1 indicates no impact and 4 indicates maximum impact. Similar pressures have been documented in other tropical ecosystems subject to community use, where forest resource exploitation can gradually lead to the decline of tree structure and natural regeneration if sustainable management practices are not implemented (Foley et al., 2007; Chazdon, 2014).

Figure 4: Tree felling for timber at Chihachu sacred forest.

The good ecological condition observed in Chihachu secret forest, a habitat of *Memecylon incisilobum,* has been associated, in other contexts, with the reduction of recurrent impacts and the maintenance of a complex forest structure (Chazdon et al., 2009). The maintenance of high density and basal area suggests that the forest still possesses the structural capacity to support biodiversity, provide ecosystem services, and fulfil habitat functions, essential elements for ecological resilience in tropical systems (Laurance et al., 2011). However, the methodology adapted from Nazerali (2020), combined with the adaptations proposed by CEAGRE (2022), allowed the assessment of ecological condition without historical reference metrics. While this ensures a consistent internal analysis, the absence of external references limits the ability to identify cumulative changes over time (Gardner et al., 2009). Longitudinal studies are essential to capture trends of loss, gain, or structural stability over decades (Laurance et al., 2014). Additionally, socially significant ecosystems, such as sacred forests, tend to exhibit lower levels of degradation compared with areas of open access, as documented in African and Asian contexts (Berkes et al., 2000; Slocombe, 2000). Sociocultural norms and traditional practices frequently function as regulatory mechanisms analogous to protected areas, limiting predatory exploitation and preserving microhabitats and species of cultural or spiritual value (Zannini et al., 2021; Sunderland et al., 2004).

5.3. Assessment of the Conservation Status of *Memecylon incisilobum*

The field data reveal that *Memecylon incisilobum* occupies a highly restricted coastal forest patch of approximately 2 km², with the total sampled area covering 24 ha. A total of 448 individuals were recorded, of which only 140 are mature. This number falls well below the commonly recognised IUCN threshold of 250 mature individuals for Critically Endangered species (IUCN, 2022). The mean density of 3.63 individuals per hectare highlights a sparse population distribution, which is further constrained by the species' highly limited spatial range. The area of occupancy (AOO) is 4 km², calculated using the standard 2 × 2 km grid recommended by IUCN, and the extent of occurrence (EOO) is similarly restricted.

Figure 5: *Memecylon incisilobum* at the Chihachu sacred forest.

The population structure indicates a severe demographic imbalance, with 277 juveniles and 31 sprouts recorded, but no seedlings or successful recruitment stages were observed. This absence of seedlings or new sprouts is a major concern, suggesting recruitment failure that could lead to local extinction if the current pressures persist. In forest ecosystems, such gaps in regeneration often result from habitat disturbance, overharvesting of seeds or young individuals, changes in microhabitat conditions, or competition from invasive species (Bond, 1994; Chazdon, 2008).

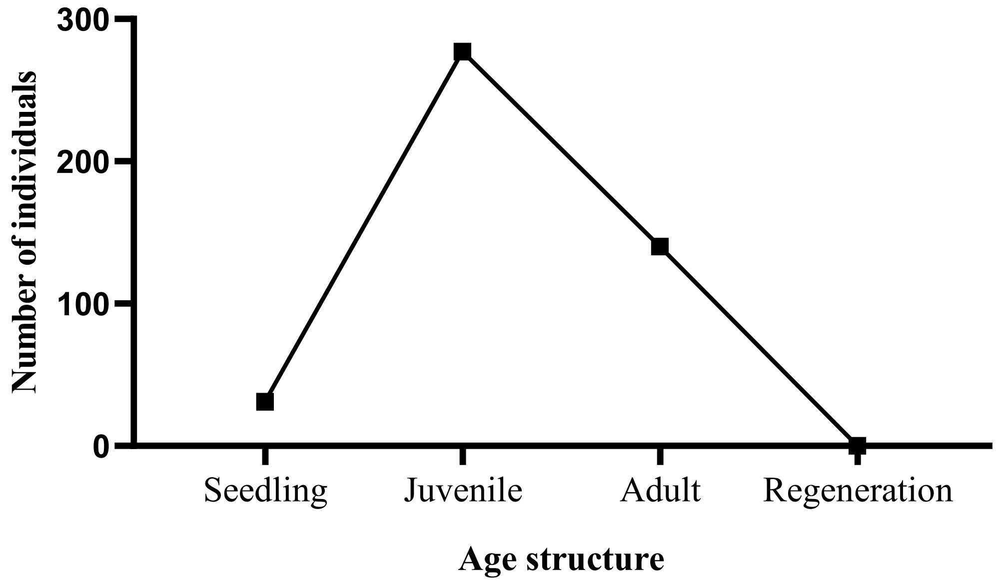

Figura 2: Age structure of the *Memecylon incisilobum* population

Although the core forest patch still maintains relatively good habitat quality, the marginal areas show signs of degradation caused by selective logging and the removal of commercially valuable trees. Such anthropogenic impacts, even when selective, can reduce canopy cover, disrupt ecological interactions, and affect the microclimatic conditions necessary for seed germination and seedling establishment (Foster et al., 1998; Gibson et al., 2011). The combination of a small, spatially restricted population and ongoing habitat decline magnifies the species' vulnerability to stochastic events, including fires, cyclones, or disease outbreaks, which are common threats in tropical coastal forests.

Based on the combination of extremely limited distribution, occurrence at a single location, low number of mature individuals, absence of natural regeneration, and inferred continuous decline in habitat quality, *Memecylon incisilobum* meets the IUCN Red List criteria B2ab(iii), C2a(i), and D. Therefore, its classification as Critically Endangered (CR) is proposed to be maintained.

Tabela 1: Summary table of the conservation status assessment according to the IUCN.

Variable Assessed	Data Obtained	IUCN Criterion Supported
Area of Occupancy (AOO)	4 km²	B2
Extent of Occurrence (EOO)	4 km²	B1
Number of Locations	1	B2a
Habitat Quality	Continuing decline inferred	B2b(iii)
Number of Mature Individuals	140	C
Age Structure	No natural regeneration	C2a(i)
Population Trend	Decline inferred	C2
Population Distribution	Single subpopulation	C2a(i)
Vulnerability to Stochastic Events	High	D
Proposed Category	Critically Endangered (CR)	B2ab(iii), C2a(i)

5.5. Socioecological and threat assessment and community use.

The study sample was predominantly composed of adults, with a mean age of 45 years and a predominance of females (72.9%). The long average residence in the community (≈29 years) indicates extensive local ecological knowledge and intergenerational connection to the forest resources. These findings align with studies in rural African contexts, where accumulated experience and proximity to the territory are positively correlated with local ecological knowledge (Berkes, 2004; Agrawal, 2001). The strong dependence on activities linked to direct resource use, particularly agriculture (70%), highlights the forest's role as a key subsistence support. Such patterns are typical of communities interacting with tropical ecosystems, where traditional management practices directly influence habitat dynamics and the availability of native species (Gadgil et al., 1993).

Figure 6: Chihachu community members practicing agriculture adjacent to the forest.

Regarding the use and access to the sacred forest, almost all respondents (97.1%) acknowledged its existence, yet 72.9% reported visiting rarely or never. This suggests that, although cultural knowledge of the forest is widespread, direct utilization is limited, likely due to traditional access norms, distance, or shifts in livelihoods. Medicinal plant collection (22.9%) and spiritual ceremonies (18.6%) remain the main activities, reflecting both cultural significance and selective resource exploitation, which may impact certain species if not managed (Chazdon, 2014; FAO, 2010). Even when access restrictions persist, as primarily through ritual requirements before entry (45.7%), yet one-third of respondents lacked clarity about these rules (41.4%), indicating a decline in traditional knowledge (Slocombe, 2000; Sunderland et al., 2004).

The forest is recognized as sacred by 57.1% of respondents, but 42.9% attributed no cultural or spiritual value, possibly reflecting generational and sociocultural changes (Zannini et al., 2021). Symbolic narratives, such as the need to leave offerings or the risk of getting lost when entering without permission, function as traditional social mechanisms that historically preserved microhabitats and vulnerable species (Berkes et al., 2000). However, ritual practices are now sporadic, suggesting a weakening of these protective functions and highlighting the need for complementary community-based management and cultural education (Pretty & Smith, 2004).

Figure 7: Interview moment with the last descendant of King Massinga.

Note: According to local tradition, the Chihachu sacred forest was formerly the king's residence, and it is believed that he was buried there upon his death. King Massinga lived prior to the colonial period in Mozambique, and the forest continues to hold important cultural and spiritual value for the community.

Environmental perception data reveal heterogeneity: half of respondents did not perceive significant changes in the forest, while 44.3% noted alterations, mainly decreased vegetation density (45.7%). This indicates partial degradation, likely linked to selective harvesting of economically valuable species such as *Dialium schlechteri*, *Afzelia quanzensis*, and *Mimusops caffra*. Such patterns are consistent with coastal forest studies in Africa, where unregulated community use can lead to biomass decline and hinder natural regeneration (FAO, 2010; Laurance et al., 2011). Variability in perceptions also suggests limitations in ecological knowledge, particularly among those less directly involved with the forest.

Concerning management, conservation, and tradition, the fact that 84.3% of respondents were unaware of *Memecylon incisilobum* is concerning, given its critical conservation status. Tree cutting was identified as the main threat (51.4%), with fires and other disturbances less frequently reported. While 67.1% acknowledged traditional rules, adherence is partial, and responsibility for forest protection is perceived as fragmented. This reflects both community governance fragility and erosion of traditional norms, a challenge common to African sacred forests (Slocombe, 200; Sunderland et al., 2004). Low participation in protection activities (61.4% not involved) indicates that community-based conservation requires reinforcement through training, local ranger programmers, and integration with traditional leaders (Pretty & Smith, 2004; Berkes, 2004).

Regarding traditional knowledge, only 31.4% reported formal transmission activities, while 50% perceived loss of this knowledge. Oral storytelling and community meetings remain the primary mechanisms. Loss of traditional knowledge compromises the community's capacity for sustainable management and protection of endemic species (Berkes et al., 2000; Agrawal, 2001). Education and youth engagement (61.4% suggested awareness programmes for younger generations) are crucial for maintaining practices and traditional rules.

Despite these challenges, most respondents (68.5%) expressed willingness to participate in conservation projects, particularly in reforestation (40%) and dissemination of cultural knowledge (14.3%). This highlights potential for integrating participatory conservation strategies aligned with local ecological and cultural norms (Chazdon et al., 2009; FAO, 2010). Recommended actions include maintaining the forest’s sacred character, prohibiting tree cutting, controlling fires, reforestation, establishing community rangers, and active monitoring. These measures are consistent with adaptive co-management approaches, proven effective in sacred forests and small protected areas (Berkes, 2004; Pretty & Smith, 2004).

6. Conclusion

This study provides an integrated ecological and conservation assessment of *Memecylon incisilobum* in a sacred coastal forest of the Maputaland Center for Endemic Species. Floristic and phytosociological analyses showed that, despite its small size (24 ha), the forest fragment maintains a relatively complex structural organization and harbors a diverse set of native species typical of Maputaland coastal forests, including timber species of high economic value.

The ecological condition assessment indicates that the forest remains, in general, well preserved, largely due to its cultural and spiritual importance, which historically limited intensive exploitation. However, evidence of selective logging, edge effects, and the forest's restricted spatial extent point to increasing vulnerability to degradation.

The conservation status assessment confirms that *Memecylon incisilobum* remains Critically Endangered, as a result of its extremely restricted distribution, small population size, and confinement to a single forest fragment. Its strong dependence on shaded, undisturbed forest conditions renders the species highly sensitive to habitat alteration, underscoring the urgency of targeted conservation measures, including habitat protection, population monitoring, and the development of *ex situ* conservation and propagation strategies.

Socioecological and community analyses have further highlighted that local perceptions, cultural values, and traditional management practices play a central role in maintaining forest integrity. The sacred status of the site functions as an informal governance mechanism that has contributed positively to conservation outcomes. However, changing socioecological dynamics and increasing pressure on forest resources represent emerging threats, emphasizing the need to strengthen community-based conservation approaches that effectively reconcile cultural practices with biodiversity conservation.

6.1. Recommendations

Based on these findings, we recommend:

i. The formal recognition of the Chihachu sacred forest as a locally protected conservation area;
ii. The implementation of long-term ecological and population monitoring programmes for *M. incisilobum*;
iii. The development of *ex situ* conservation and restoration initiatives, including propagation and reinforcement of existing populations; and
iv. The strengthening of community engagement through awareness programmes that integrate traditional knowledge with scientific conservation planning.

6.2. Limitations

This study was limited by its spatial focus on a single forest fragment and by the absence of long-term ecological and demographic data. Seasonal constraints may also have influenced the detection of regeneration patterns and floristic composition. Future research should expand spatial coverage to comparable coastal forests within the Maputaland Endemic Centre and incorporate long-term monitoring to better assess population dynamics, ecological resilience, and climate-related impacts.

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8. Attachment

Figure 8: Work team

Figure 9: *Memecylon* catted

Figure 10: Threat: Eucalyptus production company at the edge of the sacred forest.

Figure 11: Collection of wood for firewood production.

Figure 12: Moment of interview with one of the residents.

Figure 13: Lunch time