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ASSESSMENT OF BIODIVERSITY STATE, TRENDS AND THREATS IN MOZAMBIQUE

BIODEV 2030

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Abbreviations and Acronyms

ANAC	National Administration of Protected Areas
AOH	Area of Habitat
BER	Biodiversity Expenditure Review
BFP	Biodiversity Finance Plan
BIOFIN	Biodiversity Financing Initiative
BIOFUND	Foundation for Biodiversity Conservation
BDPES	Balance of the Economic and Social Plan
CA	Conservation Areas
CBD	Convention on Biological Diversity
CEAGRE	Center for Agricultural Studies and Natural Resource Management
CR	Critically endangered
DD	Deficient data
DPSRI	Driver-Pressure-State-Impact-Response
EBTAT	Expert-based Threat Assessment Tool
EIA	Environmental Impact Assessment
EN	Endangered species
EU	European Union
FNA	Financial Needs Assessment
GBIF	Global Biodiversity Information Facility portal
GIS	Geographic Information Systems
IBA	Important Bird Areas
IMMA	Important Marine Mammals Area
IUCN	International Union for Conservation of Nature
CMP	Conservation Measures Partnership

KBAs	Key Biodiversity Areas
Km^2	Kilometer
LC	Least concern
m	Meter
MASA	Ministry of Agriculture and Food Security
MEF	Ministry of Economy and Finance
MICOA	Ministry for Coordination of Environmental Affairs
MITADER	Ministry of Land, Environment and Rural Development
MMPATF	Marine Mammal Protected Areas Task Force
NBSAP	National Biodiversity Strategy and Action Plan
NE	Not Evaluated
NGOs	Non-governmental organization
NP's	National Parks
NR	National Reserve
NT	Near threatened
PIR	Policy and Institutional Review
PL	Of português Pequenos Libombos
POPs	Persistent organic pollutants
PPA	Private Protection Area
RLI	Red List Index
STAM	Simplified Threat Assessment Methodology
STAR	Species Threat Abatement and Recovery
USAID	United States Agency for International Development
VU	Vulnerable
WCS	Wildlife Conservation Society
WHO	World Health Organization

WIO	Western Indian Ocean
WWF	World Wildlife Fund

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Executive summary and recommendations

Background

I. Over the years, several national ecosystems (including those located within the boundaries of the Conservation areas) have suffered different levels of degradation that contribute to the reduction of biodiversity. In Mozambique, some species are already considered extinct and the number of vulnerable and threatened species has been increasing (MITADER, 2019a); this accelerated loss of biodiversity may have irreversible consequences for ecosystems and the national economy.

II. Mozambique has made efforts to ensure the conservation of its biological heritage. For this reason, through Resolution 2/94 of 24 August ratified the Convention on Biological Diversity (CBD) and developed a National Biodiversity Strategy and Action Plan (NBSAP). Through National Target 17 Mozambique has committed to engage sectors on biodiversity issues by 2020 and to develop, on the basis of the national targets, the sectorial targets, and integrate them into sectorial plans and effectively begin implementation (MITADER, 2015).

III. The BIODEV2030 initiative funded by the French Development Agency (AFD), coordinated by Expertise France, and implemented by International Union for Conservation of Nature (IUCN) and World Wildlife Fund (WWF)-France, aims to accelerate the mainstreaming of biodiversity into economic sectors which are key to biodiversity (BIO-) and development (-DEV), to 'bend the curve' of biodiversity decline and promote more sustainable and resilient economies. BIODEV2030 empowers 16[1] pilot countries, among which Mozambique, to reduce pressures on biodiversity over the next decade. The two-year project intends to foster ambitious commitments based on scientific assessments and clear accountability mechanisms that bring about change. It will strive to create the conditions for a national dialogue involving stakeholders of at least two economic sectors, identified by national representatives as strategic and relevant to each country's biodiversity and development. The multi-stakeholder dialogue shall catalyse concrete national and sectoral voluntary commitments over the next decade, as a

[1] 16 Pilot Countries include: Kenya, Burkina Faso, Benin, Senegal, Guinea Conakry, Mozambique, Ethiopia, Fiji, (under the mandate of IUCN) and Cameroon, Congo, Gabon, Guyana, Madagascar, Tunisia, Uganda, and Vietnam (under WWF).

complementary platform of the legislation, with the aim of halting biodiversity decline by 2030 and restoring biodiversity by 2050.

IV. In the context of BIODEV2030 project, the purpose of this study is to provide a scientific overview and assessment of sectoral threats to biodiversity at the national level in Mozambique, based on existing reports, scientific data and interviews of experts and national representatives. A new metric developed by IUCN, the Species Threat Abatement and Restoration (STAR) score is also used to quantify the potential reduction in the risk of extinction of species that could be achieved through good actions developed by different actors to address threats to species and restore habitats.

Methodology

V. The assessment of state, trends and threats to biodiversity is based on existing reports, scientific (including the STAR metrics), data and interviews of experts and national representatives, through the i) Expert-based Threat Assessment Tool (EBTAT) and ii) Simplified Threat Assessment Tool (STAT).

VI. Semi-structured interviews were conducted with 18 biodiversity experts in Mozambique by identifying threats and respective impacts to national biodiversity. To quantify and evaluate the threats to biodiversity in Mozambique, a list of potential pressures was submitted for expert assessment, which are organized into seven taxonomic groups: Freshwater fish; Plants; Mammals; Herpetofauna; Birds; Marine Biodiversity; Insects and Ecosystems.The group of ecosystem experts were asked to evaluate the items on the list of threats in relation to ecosystems (Terrestrial ecosystems, Coastal and marine ecosystems, Mangrove and Fresh water ecosystems) and ecoregions (Mosaic of Coastal Forest of Southern Zanzibar-Inhambane, Mosaic of coastal forest of Maputaland, ShrublandMopane of Zambeze, Southern ShrublandMiombo, Wooland-shrubland of Southern Africa, Flooded savannas of Zambezi coast, Flooded grasslands of Zambezi, Halophytes of Maksadgad, Forest and grassland mosaic of the Rift Austral mountains, East Africa Mangroves, Southern Africa Mangroves and Forest and grassland mosaic of the Rift Austral mountains).

VII. Semi-structured interviews were also conducted with 23 assessors representing government institutions, private sector, and NGOs. This assessment was based on freelisting threats (e.g. agriculture, infrastructure development, industry and mining, man-made disturbances, pollution, climate change, etc.) and the impact of threats to national biodiversity.

VIII. The potential to increase species survival through the reduction of threats and the restoration of natural habitat was quantified through the total STAR scores (Mair *et al*., 2021). STAR metrics calculation uses information on the species conservation status, its Area Of Habitat (AOH) and the threats that they face, as assessed in the global IUCN Red List of Threatened Species. A survey of the species corresponding to Amphibians, Birds and Terrestrial Mammals, was carried out by the global team only for those classified as Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR).

IX. The threat reduction scores and the habitat restoration scores for Reptiles and Plants were calculated for Mozambique by the country team using the data from the global Red List and same routines outlined above.

Results

X. From resided literature, the main threats to biodiversity in Mozambique are conversion, loss, degradation, and fragmentation of natural ecosystems; overexploitation of high-value species; introduction of invasive non-native species; pollution and climate change (MITADER, 2015). Experts from thematic groups identified a total of 9 level-one and 22 level-two threats as having an impact on at least one biological target. Biological resource use, agriculture and aquaculture as well as energy production & mining, were the top ranked threats domains for the nivel 1, while Commercial and industrial areas, Mining & quarrying, Housing & urban areas, Logging & wood harvesting, Habitat shifting & alteration, Oil & gas drilling were top-ranked level-two.Experts mentioned that urban and housing areas, commercial and industrial zones and level 2 tourism and recreation in the field of residential and commercial development have an impact on mammals, but plants and terrestrial ecosystems suffer much more from the first two. All three threats were classified by experts as continuous and with minor effects and severity on some populations, but very relevant for others. As an example, and according to the experts, residential and urban areas and commercial and industrial zones can impose serious threats to plants, marine biodiversity, coastal ecosystems such as mangroves and terrestrial ecosystems.

XI. Annual & perennial non-timber crops have been referred to by experts as having a significant impact on plants, herpetofauna and birds. In addition to plants the four threats in this domain have impact on hepetofauna and mammals. Thus, Annual & perennial non-timber crops were indicated as being a priority threat for conservation action for plants, herpetofauna, birds and mammals. Assessors reported that Shifting Agriculture, Small-holder Farming and Agro-industry Farming convert annually extensive areas of natural vegetation in areas of maize, rice, beans, cassava, sugar cane and banana monocultures, and constitute a main causes of habitat loss and land cover changes.

XII. The impact of Oil & gas drilling and Mining & quarrying was considered by experts to be very high for plants, mangroves and terrestrial ecosystems and high for herpetofauna, freshwater fish marine biodiversity and mammals. Both, although they have low STAR Threat Abatement Score, were also considered by government officials to be of significant impact, and are therefore Priority for Conservation Action.

XIII. Transportation & service corridor was considered by experts to be of very high impact on mammals and terrestrial ecosystems. Although this threat is not considered a priority for Conservation Action, Roads & railroads and Utility & service lines are top of the government agenda.

XIV. Activities associated with Biological Resource Use domain appear to have the greatest reported impact on plants, herpetofauna, marine biodiversity, birds, mammals, freshwater fish, mangrove and terrestrial ecosystems. Experts reported very high impact of Hunting & trapping terrestrial birds and mammals; Gathering terrestrial plants may pose high impact on plants; Logging & wood harvesting was reported to impact plants, herpetofauna, mammals, mangrove and terrestrial ecosystems and Fishing & harvesting aquatic resources has Very High impacts to Marine biodiversity and mangrove.

XV. Among the threats in this field, experts indicated that Fire & Fire Suppression had very high impact on plants, terrestrial ecosystems and on mammal's habitats. As also recognized by assessors representing government institutions, private sector, and NGOs, fires are one of the main factors in deforestation and forest degradation in Mozambique.

XVI. Climate change & severe weather was believed by experts to have very high impact to plants, herpetofauna, Marine biodiversity, mammals and mangrove.

XVII. Twenty three (23) assessors representing government institutions, private sector, and NGOs identified a total of 10 (level-one) and 16 (level-two) threats using the IUCN-CMP Threat Classification System through the Simplified Threat Assessment Methodology (STAM). Out of these, five were perceived by them to be top threats, and have the greatest impact on biodiversity in Mozambique. For instances, Annual & perennial non-timber crops, Logging & wood harvesting, Mining, Oil and gás, Fishing and harvesting and Fire & fire suppression, were reported by more than 80% of assessors as having the greatest impact on biodiversity in Mozambique.

XVIII. The STAR score for Mozambique (for amphibians, birds and terrestrial) is 3,153, where the threat abatement score is 2,730 (87% of the national STAR score) and the restoration score is 423 (13% of the national STAR score). Mozambique contributes 0.22% of the global STAR scores.

XIX. Biological resource use, Agriculture & aquaculture, Energy production & mining, Climate change & severe weather and Natural system modifications threats domains had top ranked scores at the national scale.

XX. STAR Metric threat abatement approach has identified areas with the highest potential for threat abatement and restoration in the country. Some of those areas are particularly rich in biodiversity and home of endemic species; endemic species tend to increase the STAR scores. For instance, the areas with the highest potential for threat abatement and restoration in Mozambique are coincidentally the same (Lioma and Gurue in the Zambezia province) and Chimanimani National Park (Manica province), Lichinga and Chimbonila (Niassa province) and Namanhumbir (Cabo Delgado province). In general, those areas from Zambezia province are threatened by agriculture, Mining & quarrying, Housing & urban áreas, Habitat shifting, Annual & perennial non-timber crops, Wood & pulp plantations, Roads & railroads, Logging & wood harvesting and Fire & fire suppression. Mining & quarrying is also a threat at Chimanimani National Park and Namanhumbir. Wood & pulp plantations and Housing & urban areas were identified as major threats at Lichinga and Chimbonila.

XXI. Annual & perennial non-timber crops had the highest STAR threat abatement score of 575, followed by Logging & wood harvesting with a score of 465; Fire & fire suppression scored 458; Habitat shifting & alteration scored 297 and Hunting & trapping terrestrial animals scored 178. Roads & railroads, Invasive non-native/alien species, Mining & quarrying, Livestock farming &

ranching had STAR threat abatement scores below 100, while threats as Fishing & harvesting aquatic resources, Gathering terrestrial plants, Oil & gas drilling scores below 10.

XXII. In addition to amphibia, mammals and birds, STAR scores were experimentally calculated for plants and reptiles to identify the highest potential to increase species survival through threat abatement. Near Threatened, endangered and vulnerable birds; critically and endangered mammals as well as endangered and vulnerable amphibians were the Taxonomic Group highly scored. Among amphibians, *Mertensophryne anotis* was highly scored, while *Paraxerus vincenti* (mammal), *Chelonia mydas*, *Rhampholeon gorongosae* and *Cycloderma frenatum* (reptiles) and *Warneckea cordiformis* and *Brachystegia oblonga* (plants) were also highly scored.

XXIII. Threats abatement scores at species level indicated that four species (*Paraxerus vincenti*, *Artisornis sousae*, *Rhinolophus mabuensis* and *Mertensophryne anotis* represent 40% of the country's Total Threats abatement scores. On the other hand, it allowed analyzing in detail the contribution of each threat to the risk of species extinction.

Discussion

XXIV. Biodiversity has been decreasing in Mozambique. A worrying decline has been observed in populations of plants, mammals, birds, amphibians, reptiles, fish and some terrestrial, aquatic and marine ecosystems. Although there is a vast descriptive and qualitative literature on threats to biodiversity in Mozambique, quantitative data on the severity of the impact of direct threats to biodiversity in Mozambique are lacking. Thus, STAR highlights which threats are particularly responsible of the loss of species already identified as threatened (from critically to nearly), and therefore which threats should be first tackled to reduce the risk of species extinction.The STAR approach is complemented by expert knowledge and insight from government officials, from private sector and civil society.

XXV. STAR threat abatement scores were highest for Annual & perennial non-timber crops, Logging & wood harvesting; Fire & fire suppression; Shifting & habitat, and Hunting & trapping terrestrial animals. In general, experts as well as advisors from the government, the private sector and civil society converge on the negative potential that these threats represent for biodiversity in Mozambique. Although this potential is recognized, the threats mentioned can collectively cascade; the effect of one threat may induce the occurrence of the other. This fact suggests that the potential impact of threats is also dependent on the respective context.

XXVI. The result suggests that the Annual & perennial non-timber crops, Logging & wood harvesting and Fire & fire suppression have the greatest impact on biodiversity. In Mozambique, Annual & perennial non-timber crops includes two subcategories responsible for deforestation: Itinerant (65%) and commercial (4%) agriculture. Yet Large-Scale Commercial Agriculture is the main threat in the country, but in localized areas. Mainly practiced by large companies, and oriented towards areas where the land is fertile, it has been implemented in areas that are not always coincident with shifting cultivation. In general, agriculture leads to loss of habitats due to farming and a reduction in species abundance due to land conversion. Although small-scale agriculture is the predominant form of agriculture in Mozambique, the use of inputs such as fertilizers, pesticides and agricultural machinery is less than in commercial agriculture. Even in the latter one, its use is weak and irregular throughout over the years, except in sugarcane, one of the few with high levels of mechanization and intensive use of inputs (MITADER, 2018a). This fact suggests its minor impact on biodiversity.

XXVII. Logging & Wood Harvesting had the second highest STAR threat reduction score. Experts are aware that this threat is the third most scoring, while government officials, the private sector and civil society have also considered the second threat to biodiversity. In fact, Logging & Wood Harvesting was responsible for deforestation in about 8% in the country between 2000 and 2012 (MITADER, 2016). Mozambique has a current total commercial volume of forests estimated at 123 million m^3 (MITADER, 2016). After a long period of illegal timber trade in the country, significant changes in the management of the forest sector have been introduced in the last five years (MITADER, 2018a). However, enormous challenges still persist. This is partly due to corruption (MITADER, 2018a), but also because the timber business is associated with the subsistence economy of rural communities as well as with Unsustainable Exploitation of High-Value Wildlife for International Trade (USAID, 2013).

XXVIII. Fires are a tool for cleaning cultivation areas and artisanal charcoal production (MITADER, 2018a). In the last 10 years, between 40 and 50 thousand hectares have been burned annually, with a slight reduction after 2010 (MITADER, 2018a). Despite the reduction in the number of uncontrolled fires and fires per year, the area affected by uncontrolled fires per year between

2010 and 2016 has increased. For example, around 2000, fires affected 35,000 ha (MITADER, 2018a), today this figure has risen to 45,000 ha / year (MITADER, 2016).

XXIX. Mining and oil and gas industry had a very low STAR Threat Abatement Score (56 for mining and only 1 for oil and gas). Contrary to this result, they were both most frequently reported as a threat by experts. It may probably be related to the insufficient data used to STAR scores, but the relatively in-depth knowledge of the two threats by experts. Although the extractive industry is seen as hope for the country's economy, it does represent an emerging threat to biodiversity, as suggested by experts. On the one hand, large operators explore extensive areas and can voluntarily and legally protect the environment (see Sonter *et al*., 2018), but on the other hand artisanal mining can pose a severe challenge and threat to the environment, without known adopting of good environmental practices (Mujere and Isidro, 2016).

XXX. Fishing & harvesting aquatic resources had a very low STAR Threat Abatement Score - only 9 - but it must be noted that STAR scores do not include marine and aquatic species yet. There were also few experts who participated in semi-structured interviews on this topic. Nevertheless Fishing & harvesting aquatic resources was frequently reported as a threat by government officials, NGOs and private sector representatives. The officers' recognition of this threat is also not surprising. The marine and aquatic environment has been suffering perceptible impacts by the majority of users, since they are dependent on their richness in biodiversity.

XXXI. High scores for STAR Threat Abatement and restoration are not necessarily related to key areas of biodiversity or to the distribution of mammals. On some KBAs (Njesi, Chimanimani, Serra Choa, Machipanda, Taratibu, Chiperone, Mabu, Namuli and Inago) there is an overlap with high STAR scores, while partially, the Gorongosa-Marromeu Complex faces high levels of threats and restoration. Apparently, these results may suggest that these areas are home of some critically endangered or Vulnerable (endemic) species, with small AOH, as reported in recent studies.

Conclusions

XXXII. The results obtained using the three methodological routines indicate strong convergency on those threats posing the greatest impact on biodiversity in Mozambique and included Annual & perennial non-timber crops, Logging & wood harvesting, Fire & fire suppression; Habitat shifting

& alteration and Hunting & trapping terrestrial animals. On the other hand, from STAR Threats abatement scores framework, Fishing & harvesting aquatic resources, Gathering terrestrial plants, Oil & gas drilling had a negligible impact. However, these threats received strong supports from experts and officials as with high impact. Agriculture, silviculture/forestry, mining and oil and gas, fishery and infrastructure are the economic sectors, which drive the threats.

XXXIII. Logging & wood harvesting as well as infrastructures are not addressed in the frame of voluntary commitments. Some voluntary commitments in the agriculture, mining and oil & gas sectors as well as fishery may help to lower the impact of logging & wood harvesting as well as infrastructures on biodiversity.

Recommendations

XXXIV. To effectively conserve terrestrial, marine, and freshwater biodiversity in Mozambique, it is recommended that the agriculture, mining, oil & gas and fisheries are prioritized for engagement when setting voluntary commitments through BIODEV2030. Therefore, the following recommendations have been made to help guide the process of establishing voluntary commitments.

XXXV. Establishing voluntary commitments focusing on promoting conservation-friendly agriculture inside and outside conservation areas may have a high potential to conserve biodiversity. The novel Agriculture and Natural Resource Landscape Management Project (SUSTENTA) approach on the Environmental safeguards for agriculture seems to be a good political will. SUSTENTA requires that projects to be financed must draw up Environmental and Social Management Plans (PGAS) so that (i) they avoid activities that may result in negative environmental and social impacts, as well as which fall on resources or areas considered sensitive; (ii) prevent the occurrence of negative environmental and social impacts; (iii) prevent any future actions that may adversely affect environmental and social resources; (iv) limit or reduce the degree, extent, magnitude and duration of adverse impacts through minimization, displacement, redesign of elements of the project; (v) repair or improvement of affected resources, such as natural habitats or water resources, especially when previous developments have resulted in significant degradation of those resources; (vi) restoration of resources allocated to the previous state (and possibly more stable and productive state), typically more natural, and (vii) create, improve or protect the same type of resources in another suitable and acceptable location, compensating for lost resources, including compensating individuals and other entities for any loss of assets and / or opportunities (MITADER, 2016).

XXXVI. If aggregators are linked to the Environmental and Social Management Framework (ESMF) under the SUSTENTA project, they can adhere to voluntary commitments for themselves as a company, but also, due to the spill over effect, will guarantee the implementation of voluntary commitments by the producers associated with the company. In this way, voluntary commitments will be implemented in specific places where agribusiness is being developed by specific company and respective network of producers.

XXXVII. Promoting woodfuel and charcoal management, intensive crop farming, uses of tree crops and agroforestry systems and on-farm woodlots and fuel-efficient stoves for cooking fuel may have a high potential to conserve biodiversity. Furthermore, integration of biodiversity conservation into its development portfolio, supporting Conservation-Friendly Sustainable Agriculture and Livelihoods, supporting and Empowering Coastal Communities to Manage and Benefit from Biodiversity and supporting Anti-Corruption Efforts and Law Enforcement to Reduce Illegal International Trade in Wildlife and Timber may also improve biodiversity conservation.

XXXVIII. Implementation of a massive program for the use of cooking gas in rural areas by the Ministry of Mineral Resources and Energy could also be to reduce pressure on the forestry sector and thus reduce the risk of species extinction.

XXXIX. Promoting woodfuel and charcoal management, intensive crop farming, uses of tree crops and agroforestry systems and on-farm woodlots and fuel-efficient stoves for cooking fuel may have a high potential to conserve biodiversity.

XL. Mining activity has grown a lot in the last ten years in Mozambique in almost all provinces. The oil & gas industry has also been established across the country. Although the analysis of STAR threats has not identified as a substantial threat, both experts and government officials, the private sector and civil society anticipated the growing impact of these threats in the future (while STAR takes stock of existing threats), which suggests some attention. Mining mainly affects the coast and terrestrial biodiversity and on the other hand oil & gas, mainly marine biodiversity. Establishing voluntary commitments concerning on biodiversity offsetting areas may have a high potential to conserve biodiversity.

XLI. Establishing voluntary commitments taking into account CCP (Community Fisheries Councils) concept may have a high potential to conserve biodiversity. CCPs are created with direct support from government, NGOs and other entities. These institutions identify and facilitate the organization of a small number of fishers into a CCP. Fishers that belong to a CCP are allocated a small marine area for them to control (decide how fishing can be done there, by who, with what gears, etc.) called Community Management Fishing Area. This means that rule setting and enforcement are ensured by fishers themselves (within their CCP allocated area). Thus, this may give them some power to determine fisheries rules within limited spatial areas and empowers fisheries and their communities to address their marine-related problems. By involving fishers in problem resolution, fisheries management gains automatically a focus on sustainable use, an important aspect in a context of biodiversity conservation.

XLII. To provide robustness and relevance in the implementation of the actions to be planned, countries should be encouraged to replicate STAR metric procedures based on their context, available data and the respective correction; there are gaps in biodiversity data that would need to be filled.

Part I – Introduction and Methodology

1.1. Introduction

The biodiversity of species contributes greatly to the development of a sustainable and resilient economy of a country, as it ensures the supply of vital ecosystem goods and services (MITADER, 2018a). Over the years, several national ecosystems (including those located within the boundaries of the Conservation areas) have suffered different levels of degradation that contribute to the reduction of biodiversity. In Mozambique, some species are already considered extinct and the number of vulnerable and threatened species has been increasing (MITADER, 2019a), this accelerated loss of biodiversity may have irreversible consequences for ecosystem and the national economy.

Mozambique has made efforts to ensure the conservation of its biological heritage. For this reason, through Resolution 2/94 of 24 August ratified the Convention on Biological Diversity (CBD). This was the first global agreement on the conservation and sustainable use of all components of biodiversity. Mozambique has committed to achieving a significant reduction in the rate of biodiversity loss at the national level (MICOA, 2003).

In 2010 the CBD established the 2011-2020 Biodiversity Strategic Plan, which included 20 Aichi biodiversity targets. Aichi goal 12 specifically refers to preventing the extinction of threatened species and maintaining and improving the conservation of species, especially those suffering the greatest decline. In light of this, Mozambique developed a National Biodiversity Strategy and Action Plan (NBSAP) and through its National Target 12 committed to "Rehabilitate at least 15% of degraded ecosystems/habitats by 2030, restore their biodiversity, and ensure their sustainability, with a view to mitigating the effects of climate change and combating desertification" (MITADER, 2015). So far, the measures taken over the years to reduce the levels of habitat and ecosystem degradation have not been fully effective, as ecosystem rehabilitation actions are implemented in few areas due to financial and technical limitations (MITADER, 2019a).

To ensure biodiversity conservation, all stakeholders need to be involved and voluntary sectorial commitments set to halt biodiversity loss. Through National Target 17 Mozambique has committed to engage sectors on biodiversity issues by 2020 and to develop, on the basis of the national targets, the sectorial targets, and integrate them into sectorial plans and effectively begin implementation (MITADER, 2015).

The BIODEV2030 initiative aims to accelerate the mainstreaming of biodiversity into economic sectors which are key to biodiversity (BIO-) and development (-DEV), to 'bend the curve' of biodiversity decline and promote more sustainable and resilient economies. BIODEV2030 empowers 16[2] pilot countries, among which Mozambique, with diverse ecological, economic, political and institutional contexts, to catalyse voluntary national and sectoral commitments for biodiversity to reduce pressures on biodiversity over the next decade. The project is funded by the French Development Agency (AFD), coordinated by Expertise France, and implemented by International Union for Conservation of Nature (IUCN) and World Wildlife Fund (WWF)-France in 8 countries each. The two-year project intends to foster ambitious commitments based on scientific assessments and clear accountability mechanisms that bring about change. It will strive to create the conditions for a national dialogue involving stakeholders of at least two economic sectors, identified by national representatives as strategic and relevant to each country's biodiversity and development. The multi-stakeholder dialogue shall catalyse concrete national and sectoral voluntary commitments over the next decade. The voluntary contributions will be a big step towards building ambitious common goals aimed at halting the decline in biodiversity by 2030 and restoring biodiversity by 2050. Besides, BIODEV2030 offers a platform to support the achievement of the Agenda 2025 and the National Development Strategy of Mozambique, which define agriculture, industry, mining, tourism and infrastructure and protection of natural resources as building blocks for the sustainable development of the country (see Box 1) and is aligned with African Agenda 2063 (Goal 7); Global biodiversity targets (Aichi targets 4 & 12); Mozambique biodiversity targets 12 & 17 and contributions to NDC (agriculture, forestry and fishery). Last, the voluntary commitments catalyzed with BIODEV2030 shall support the achievement of National Biodiversity Strategies and Action Plans (NBSAPs) – and possibly the Nationally Determined Contributions (NDCs)[3].

National legislation (Environment Law, Land Law, Fisheries Law, Forestry and Wildlife Law, Tourism Law, together with their respective regulations) has incorporated the principle of total compensation for damage caused by development projects for more than 20 years. Recently, and through the Regulations on Environmental Impact Assessment (Decree 54/2015 of 31 December) as well as the Regulation of the Conservation Law (Decree 89/2017 of 29 December) defined the concept of No Net Loss of Biodiversity,

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[2] 16 Pilot Countries include: Kenya, Burkina Faso, Benin, Senegal, Guinea Conakry, Mozambique, Ethiopia, Fiji, (under the mandate of IUCN) and Cameroon, Congo, Gabon, Guyana, Madagascar, Tunisia, Uganda, and Vietnam (under WWF).

[3] Nationally Determined Contributions, CO2 emission targets under UNFCCC

determining the criteria and conditions for restoration activities, inside and outside the Conservation Areas (AC) and for compensation, within the AC and their buffer zones. These facts demonstrate that there is a legal environment for enforcing the normative principles relating to Mitigation Hierarchy, No Net Loss and Biodiversity Offsets in Mozambique. In this way, the implementation of the voluntary commitments in the perspective of the BIODEV20230 project approach is a healthy complement to the fulfillment of the legislation in force.

In the context of BIODEV2030 project, the purpose of this study is to provide a scientific overview and assessment of sectoral threats to biodiversity at the national level in Mozambique, based on existing reports, scientific data and interviews of experts and national representatives. A new metric developed by IUCN, the Species Threat Abatement and Restoration (STAR) score - introduced in section 125 - is also used to quantify the potential reduction in the risk of extinction of species that could be achieved through good actions developed by different actors to address threats to species and restore habitats.

The results of this study identify the most important threats to biodiversity, the opportunities for threat reduction and restoration, and the economic sectors who drive these threats and opportunities. Therefore the study shall inform national authorities and key stakeholders to prioritise engagement of two economic sectors with the greatest impact on biodiversity in Mozambique, on which the project should focus its efforts in the multi-stakeholder dialogue phase, with the aim to reduce pressures by 2030.

Box 1: The Agenda 2025 and the National Development Strategy 2015-2035

In 2003, a Committee of Counselors developed a document entitled "Agenda 2025" that outlines Mozambique's vision and strategies – a reference for future governments and society – for national reconciliation and development. It revolves around 4 strategic lines: i) Human capital (health and education); ii) Social capital (social justice, access to land use and tenure, gender balance, national cohesion and youth): iii) Economy and development (prioritization of agriculture, industry, mining, tourism and infrastructure, macroeconomic stability, protection of natural resources); and vi) Governance (peace, social and political stability, democracy, legality and security). [4]

Resulting from the need to ensure the implementation of the development strategies set out in Agenda 2025, the National Development Strategy 2015-2035 (Estratégia Nacional de Desenvolvimiento)[5] presents an approach to development with emphasis on the structural transformation of the economy, for which industrialization is the key driver by boosting the development of the main sectors of activity, job creation and capitalization of Mozambicans.

Similar to the Agenda 2025, the National Development Strategy outlines 4 pillars:

i) Human capital development (market-oriented training; institution and expansion of vocational education and improvement of health and social protection standards).
ii) Development of productive-based infrastructures (infrastructure investment and planning: industrial parks; EEZs, thermal plants; roads, ports and railways; definition of housing areas and state reserves).
iii) Research, innovation, and technological development (creation of specialized research and development (R&D) centers in the following areas: agriculture, livestock and fisheries; energy; mineral resources; water resources management and ICTs).
iv) Articulation and institutional coordination (improvement of public institutions, improvement of coordination and intersectoral articulation, reform of legislation and creation of institutions that serve the industrialization strategy).

The implementation of the National Development Strategy is to be materialized through the economic and social management instruments comprising the National Planning System (SNP), namely the Government Five Year Plan (PQG), the Medium Term Fiscal Scenario (CFMP), the Economic and Social Plan (PES) and the State Budget (OE).

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[4] Agenda 2025. The Nation's Vision and Strategies. Committee of Counsellors, November 2003. Maputo, Mozambique https://www.cartercenter.org/documents/nondatabase/Agenda%202025%20Final%20Integral%20English.pdf Accessed December 2019

[5] Estratégia Nacional de Desenvolvimento (2015-2035), 2014. Maputo, Mozambique: https://www.cabri-sbo.org/uploads/bia/mozambique_2015_planning_external_national_plan_author_region_portuguese_.pdf Accessed December 2019

For the report on State Assessment, Trends and Threats to Biodiversity in Mozambique, the model proposed by IUCN, which takes into account biodiversity in the national context, was adopted. Accordingly, the report is divided into four (4) sections:

Section I aims to present information on the methodology that was adopted in the assessment of the State, Trends and Threats to National Biodiversity. A review of the national biodiversity literature and a biodiversity assessment based on the DPSRI model was made. This was addressing an analytical structure of the pressure-response indicator matrix, which defines and relates the set of determinants of characteristics that influence the environment at any territorial scale. Methodological aspects is described regarding biodiversity assessment based on different experts scores on biodiversity, reduction and threats of species based on STAR metrics using the IUCN red list of threatened species.

Section II consists of specialized chapters that discuss the current environmental status in terms of theme/specific issues taking into account the main types of ecosystems in the country and their environmental indicators. This section provides an overview of Mozambique and its biodiversity and will indicate specific trends in environmental change using the IUCN red list of threatened species in the national context. This analysis is complemented by an assessment based on different experts from different national ecosystems (marine, terrestrial, aquatic and coastal ecosystems). An analysis of the status and threats of major biodiversity groups (mammals, birds, amphibians, fish and plants) using IUCN red list numbers was also done. Finally, important aspects related to the management of conservation areas and KBAs is discussed and the conservation measures adopted and their importance for the maintenance of national biodiversity will be analyzed.

Section III provides information on assessing threats to national biodiversity. An assessment made at the national level using the STAR metrics developed to quantifies the contributions that abating threats and restoring habitats in specific places offer towards reducing extinction risk. Scores on habitat restoration and threat reduction is presented through graphical illustrations and maps.

Section IV consists of a discussion on the main outcomes of major threats to biodiversity, their root causes, potential solutions and the economic sectors driving the greatest pressures. Some recommendations will be given on potential actions to reduce the threats in some economic activities in the country.

1.2. Methodology and data

The assessment of state, trends and threats to biodiversity developed in this report at the national level in Mozambique is based on existing reports, scientific data and interviews of experts and national representatives.

1.2.1. Conceptual framework and definitions

The Convention on Biological Diversity (CBD) defines Biological diversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (CBD, 2006).

To carry out a threat assessment, biological targets and stressors must first be identified (Salafsky *et al*., 2008). In recent decades the methodology adopted to report on biodiversity assessment is based on its analytical framework of Pressure-State-Response indicators, which define and relate the set of determinants of characteristics that influence the environment at any territorial scale. In this matrix, the causal link chain begins with the Driving Forces (economic and human activities), goes through Pressure (emissions, waste) to the State (physical, chemical and biological) ending with Impacts (on ecosystems, human health) that will culminate in government responses (policies and legal and institutional bases) (Maxim *et al*. 2009). This will not only illustrate the current state of biodiversity, but will also provide to policymakers and other stakeholders with information on how to improve biodiversity management and how economic sectors can voluntarily contribute to reducing threats to biodiversity in the country.

1.2.2. Literature review

The literature review was performed on information from various official government documents, reports from non-governmental organizations, websites and official biodiversity links. Qualitative and quantitative data was collected at this stage. In this report the national reports were used as a basis: National Biodiversity Outlook Report, CBD- 5th Country Biodiversity Report; CBD- Sixth National Biodiversity Convention Report; Second Country Environmental Status Report; NBSAP; Policy and Institutional Review (PIR); Expenditure Review (BER) and gains insights from Needs Assessment (FNA) and Finance Plan (BFP) discussions as part of BIOFIN report. A bibliographical review of the main existing documents governing the country was also made. This bibliography was include existing legislation, policies, sector strategies, national development strategy documents, including public budget allocation exercises as well as specialized reports from World Bank, United Nations Agencies, USAID, EU, IUCN, WWF, BioFund and WCS reports and others. Threats to biodiversity and the most important causes at national and local levels were identified using the STAR scores calculated based on IUCN-CMP classification of threats (https://www.iucnredlist.org/resources/classification-schemes).

After collecting and compiling information, the existing gaps were analyzed. To fill these information gaps, meetings were held with key informants based in ministries, universities, the private sector, conservation agencies and other specialized UN agencies; civil society organizations or NGOs to conduct a timely discussion of indicators to consolidate the text and fill the gaps on each topic.

1.2.3. Country Level Assessment

1.2.3.1. Expert-based Threat Assessment Tool (EBTAT)

To confirm the analyses and fill the identified gaps, semi-structured interviews were conducted with 18 biodiversity experts in Mozambique (taxonomic groups, KBAs, ecosystems and Ecoregions) (See Annex A, Table 1). This assessment was based on key expert assessments (EBTAT) by identifying threats to national biodiversity (agriculture, infrastructure development, industry and mining, man-made disturbances, pollution, climate change, etc.) and the impact of threats to national biodiversity.

To quantify and evaluate the threats to biodiversity in Mozambique, a list of potential pressures was submitted for expert assessment. Mozambican biodiversity experts are organized into seven thematic groups which were established for conducting the KBAs and global Red List assessments in the country in the period 2019-2020: Freshwater fish; Plants; Mammals; Herpetofauna; Birds; Marine Biodiversity; Insects and Ecosystems. The taxonomic groups included Mozambican and international experts.

Experts were asked to evaluate the items on the list (see Annex B) and add other items that are of importance to Mozambique.

They were then evaluating the relevance of the threats, expressing an opinion on a binary scale of **YES = 1** and **NO = 0** in three domains:

1. Time: past, continuing or future;
2. Scope: the proportion of the total population affected;
3. Severity: the general falls caused by the threat.

Each of the domains was have their respective subdomains, as described below:

Score the threats according to time (YES = 1; NO = 0)

1. Only in the past (it is unlikely to come back);
2. Only in the past (no direct effect, but limiting);
3. Now suspended (may return in the long run);
4. Now suspended (may return in the short term);
5. Continuing;
6. Only in the future (can happen in the short term);
7. Only in the future (can happen in the long term).

Score the threats in relation to the scope (YES = 1; NO = 0):

1. Affects a negligible proportion of the population;
2. Affects the minority (< 50%) of the population;
3. Affects the majority (50 to 90%) of the population;
4. Affects the entire population (> 90%).

Score threats against gravity (YES = 1; NO = 0):

1. Negligible declines;
2. Fluctuations;
3. Relatively slow but significant declines (< 20% over 3 generations);
4. Rapid declines (20 to 30% over 3 generations);
5. Very fast declines (> 30% over 3 generations);

At the end, for each subdomain the percentage of the assigned score and the respective ordering of the subdomains were calculated. The median of the percentage of the subdomains were determining the relevance of the threat.

Based on the results obtained, the threats were sorted and then classified as:

(1) Not relevant (scored in the last three positions);

(2) Moderately relevant (scored in the next three positions);

(3) Relevant (scored in the three positions following the previous category) and

(4) Very relevant (scored in the first three positions).

Analysis of subdomains may also provide information on:

a. Threats that have been most significant in the past, but which have now dissipated;

b. Continuous threats;

c. Emerging threats;

d. Future threats;

e. Severe threats (scope 4 + gravity 5).

The group of ecosystem experts were asked to evaluate the items on the threat list indicated in Annex B in relation to ecosystems (Terrestrial ecosystems, Coastal and marine ecosystems, Mangrove and Fresh water ecosystems) and ecoregions (Mosaic of Coastal Forest of Southern Zanzibar-Inhambane, Mosaic of coastal forest of Maputaland, ShrublandMopane of Zambeze, Southern ShrublandMiombo, Wooland-shrubland of Southern Africa, Flooded savannas of Zambezi coast, Flooded grasslands of Zambezi, Halophytes of Maksadgad, Forest and grassland mosaic of the Rift Austral mountains, East Africa Mangroves, Southern Africa Mangroves and Forest and grassland mosaic of the Rift Austral mountains). Ecosystem experts were rank in order of relevance the threats already identified for the 30 KBAs in Mozambique, as well as the other potential KBAs.

Experts from the groups mentioned above were independently assessing the threats to the taxon in question. At the end, there was a virtual meeting to present the results of their respective evaluation, discussion and consensus building with the team producing this report.

1.2.3.2. Simplified Threat Assessment Tool (STAT)

To confirm the analyses and fill the identified gaps, semi-structured interviews were also conducted with 23 assessors representing government institutions, private sector, and NGOs (See Annex A, table 2). This assessment was based on freelisting threats (agriculture, infrastructure development, industry and mining, man-made disturbances, pollution, climate change, etc.) and the impact of threats to national biodiversity.

During the meetings, best practices for conservation of biodiversity and the role of each institution on voluntary agreement to implement these practices were assessed.

1.2.3.3. Evaluation through STAR scores (Species Threat Abatement and Restoration)

STAR scores calculation requires information on the species conservation status, its Area Of Habitat (AOH) and the threats that their face (for details, please see Box 2). For this purpose, STAR scores used a set of global scores already calculated for Amphibians, Birds and terrestrial mammals provided by IUCN, was carried out by the global team only for those classified as Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR), with well documented spatial information (distribution ranges) and threats assessed. For each selected species, the current, historical and recoverable AOH was calculated. Species ranges (extracted from the IUCN Red List page), land use and land cover and the digital elevation model data were used for the calculation. The three variables were overlayed in a GIS environment (Geographic Information Systems), based on the data e xtracted from the IUCN Red List webpage on habitat preferences and species altitude range limits and the species distribution areas. Only the preferred habitat types and elevation ranges were considered for the AOH species estimation.

The type of habitat was decisive for the current and historical AOH estimation. The current AOH estimate, the 2015 land use and land cover map was used (Adopted by IUCN as the most recent map). For the estimation of historical (past) AOH, the 1992 land use and land cover map was used (Adopted by CBD as the oldest comparable land cover map). The recoverable AOH was then the difference between the historic AOH and the current AOH. Current and historical AOH was overlaid in order to deduct species current proportion of habitats (PCsp) and its recoveral proportion (PRsp).

All threats rasters affecting the species were extracted from the IUCN Red Species List page. These threats are classified according to the Conservation Measures Partnership. Those are divided into 12 groups, subdivided into several subgroups, that were then overlaped in GIS, the area of distribution of each species to each of the threats in order to calculate the relative contribution of each threat to the risk of extinction of the species concerned.

Box 2: The STAR Metric concept (as from CBD, 2019 and Mair *et al*., 2021).

The STAR Metric measures the action taken by actors to reducing species extinction risk. As site based, allows countries to measure their relative contribution to species conservation at the global scale by exploring potential opportunities for improving the state of species by reducing threats and restoring habitat, through conservation actions that could be taken across multiple scales and over timeframes of value to decision-making. Currently, STAR uses global species range and threat data for mammal, bird, and amphibian taxonomic groups from the IUCN Red List of Threatened Species to calculate STAR scores due to good data availability. The possibility of including plant groups and other animal taxa (e.g. reptiles) in near future is being explored in order to expand the taxonomic scope. The core team intents to use all globally assessed taxa (those for which all species have been assessed) in the metric calculation in the future, since these species are Near Threatened and threatened (Vulnerable, Endangered, and Critically Endangered).

STAR operates on the principle that any change in threats, positive or negative, will lead to changes in the risk of species extinction. STAR measures the potential 'conservation gain' for species that could be achieved through action taken within a geographical area.

The metric considers two complementary site-based actions for species conservation:

1. The abatement of threats in order to prevent further deterioration in species survival probability (i.e. to prevent further decline in Red List Index).

2. The restoration of habitat in order to contribute to improving species survival probability (i.e. to increase Red List Index).

Both threat abatement and restoration of habitat components of the metric for amphibians, birds and mammals have already been developed by core team. STAR threat abatement scores indicate which threats have a high impact on species groups and thereby reveal which threats have the highest potential to make significant contributions to improving species survival if abated. They also only demonstrate the current impact of a threat on biodiversity (mammals, birds, and amphibians) and cannot predict the future impact. The restoration score indicates the potential contribution from site-based restoration of a habitat could make to improving species survival. An important condition of the restoration component is that for restoration scores to be realised, relevant threats must first be abated at the site. This is to ensure that the restored habitat can viably support the species for which it is being restored.

The results obtained from the calculation of each of the considered variables were used in the formula below, in order to determine the threat reduction and the habitat restoration score for each species.

Threat Abatement score + Habitat Restoration score

$$\Sigma(\mathit{Pc}\mathrm{Sp} \times \mathit{W}\mathrm{Sp} \times \mathit{R}\mathrm{SpT})+\Sigma(\mathit{Pr}\mathrm{Sp} \times \mathit{W}\mathrm{Sp} \times \mathit{R}\mathrm{SpT} \times \mathrm{MSp})$$

Where:

- ***Pc*****Sp:** is the current extent of Area of Habitat (AOH) for species, *Sp* at the site, expressed as a percentage of the total global AOH that was historically available for the species.
- ***W*****Sp:** is the Red List category weighting of species *Sp* (NT=1,VU=2,EN=3,CR=4).
- ***R*****SpT:** is the relative contribution of threat to the extinction risk of species *Sp*;
- ***Pr*****Sp:** is the extent of restorable AOH (i.e. AOH that has been lost) for species *Sp*at the site, expressed as a percentage of the total global AOH that was historically available for the species.
- **MSp:** is a multiplier appropriates to the habitat at location i to discount restoration scores. Will be used a global multiplier of 0.29 based on the median rate of recovery from a global meta-analysis

The threat abatement scores and the habitat restoration scores for all species by taxonomic group were summed. Finally, the threat abatement scores and the habitat restoration scores of the 3 taxonomic groups were summed in order to obtain the total STAR metric score for the country.

Using the same routines outlined above, STAR metric scores for Reptilians and Plants were calculated for Mozambique by the country team.

1.2.4. Local Level Assessment

The local level assessment aims to illustrate, through two case studies, how sectors can voluntarily adopt good practices for biodiversity conservation in the implementation of their economic activities. Mining and oil & gas activities may pose threats to biodiversity and, as such, in addition to the legislation in force on this matter, the voluntary commitments by private actorsmay Support the enforcement in Mozambique. This alignment forms the basis for the objectives to be achieved in the BIODEV2030 project.

Oil and gas as well as mining exploration and production activities can lead to adverse environmental and social impacts that can harm local biodiversity. Gas and mining development in the Rovuma landscape basin in Cabo Delgado province as well as mining in Tete province could be the greatest threats to terrestrial and marine biodiversity at this sub-national site. Therefore, an assessment was made in the Rovuma basin and Moatize district based on literature review and meetings with officials from Total Mozambique and Vale Mozambique. This exercise was resulted in two case studies of assessments of threats to biodiversity at the local level.

Part II – Biodiversity Status and Trends

2.1. The scope of the assessment

Mozambique (Fig. 1) is located in the southern Africa region between the parallels 10°27' and 26° 56' South latitude and the meridians 30°12' and 40°51' East longitude (Fig. 1), occupying an area of about 799,380 km^2 and borders Tanzania, Malawi, Zambia, Zimbabwe, South Africa and Eswatini. The country has a population of about 29 million inhabitants, according to the 2017 census.

The 2,700 km long coastline is characterized by plains, with an altitude ranging from 100 to 200 meters above sea level. The interior, characterized by mountains, has an average altitude of about 800 meters, with Monte Binga in Chimanimani, Manica Province, with its 2436 meters, the highest point in the national territory (Fig. 2).

The country's economy is predominantly based on agriculture, with few alternatives that can reduce the pressure on natural resources. Agriculture employs 70% of the population (INE, 2016). Thus, the greatest environmental challenges are the search for environmentally sustainable solutions to the impacts resulting from anthropogenic actions, which include land degradation, soil erosion, soil fertility reduction, deforestation, wetland degradation, biodiversity loss and pollution.

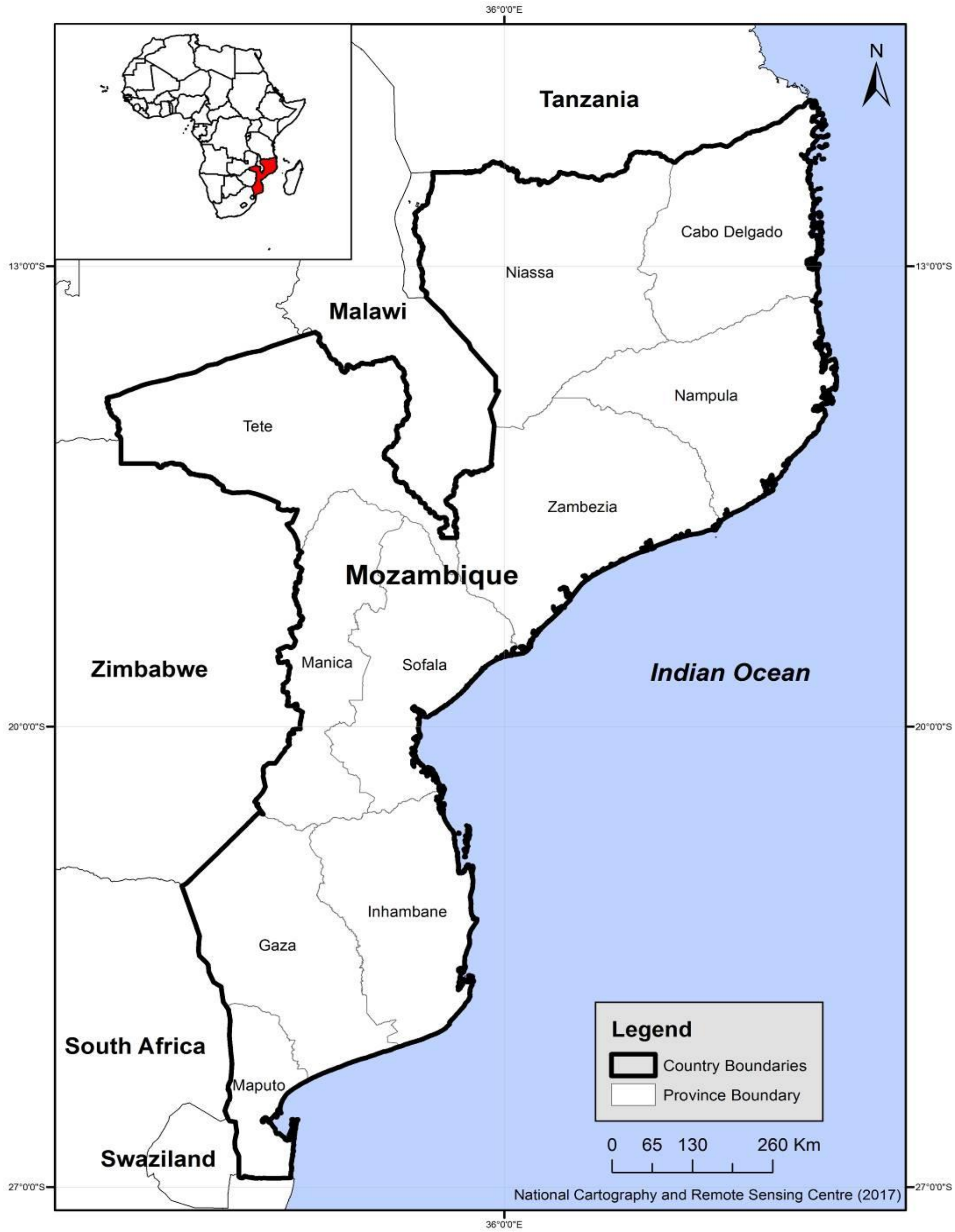

Figure 1: Map of Mozambique (Source: National Cartography and Remote Sensing Centre, 2017).

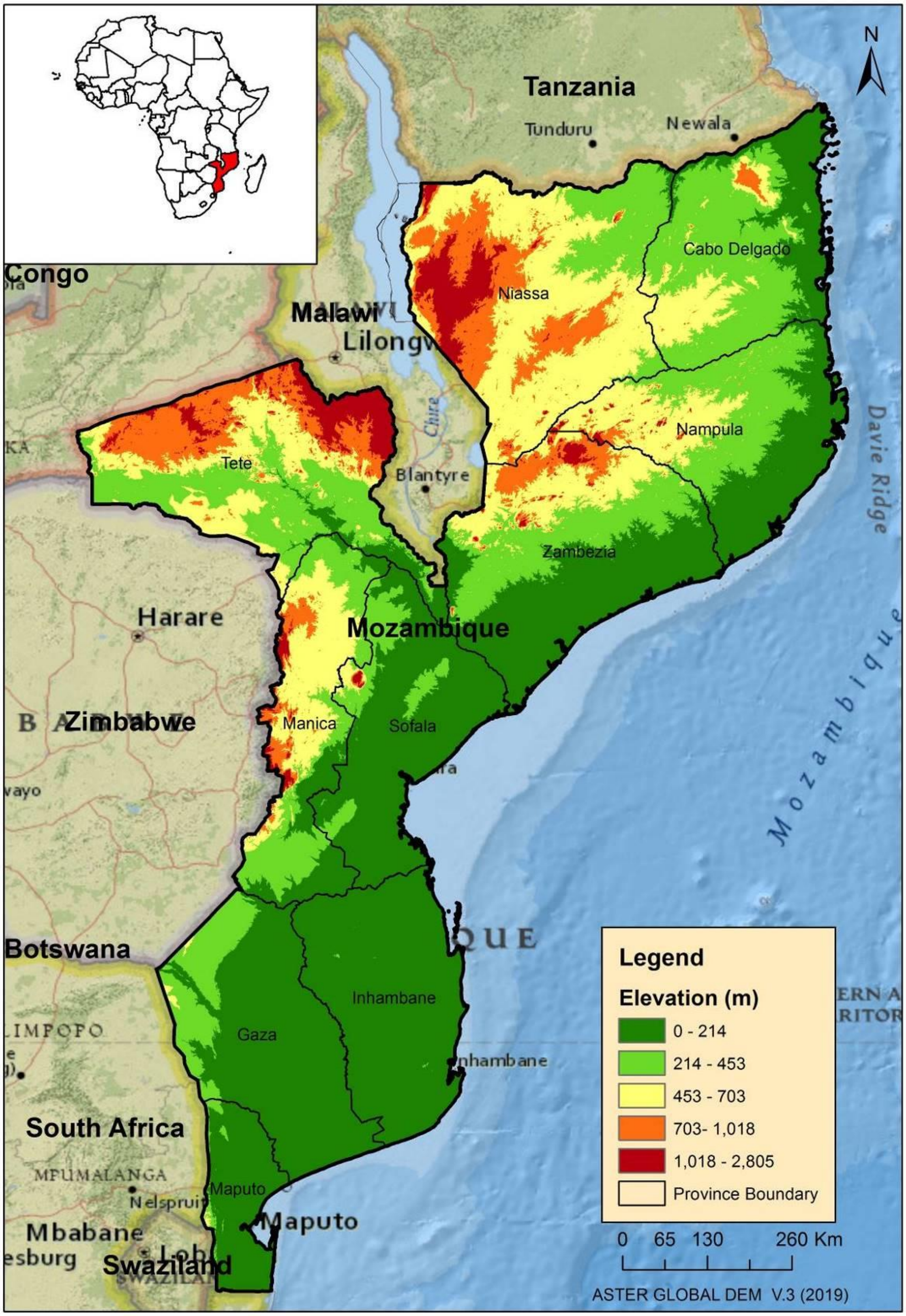

Figure 2: Biophysical environment of Mozambique (Source: Aster Global DEM V.3, 2019).

2.2. **Biodiversity status and trend - Ecosystem approach**

2.2.1. Ecoregions and Ecosystems

About 74.2% of the national area is "natural" areas, while 7.8% is "modified", and 18% mixed. The modified areas are strictly associated with the concentration of the human population (CEAGRE, 2015).

Four phytogeographic regions are recognized in Mozambique: (I) Swahili Regional Endemism Center, (II) Maputaland-Tongoland Endemism Center, (III) Zambezi Regional Endemism Center, and (IV) Swahili-Maputaland Regional Transition Zone (MICOA , 2014), which are subdivided into 14 ecoregions which include: Eastern Zimbabwe Mountain and Prairie Mountain Mosaic , Flooded Savannahs of the Zambezi Coast, Southern Shrub Miombo, Southern and Eastern African Mangroves, Lake Niassa, Mosaic Maputaland Coastal Forest, Southern African Shrub, Southern African Mangrove, Miombo Eastern and Southern Forests , Southern Rift Mountain Forest and Prairie Mosaic, Southern Zanzibar-Inhambane Coastal Forest Mosaic, Zambezi Shrub Mopane, Flooded prairies of the Zambezi, and Halophytes of Maksadgad. Seven of these are of global importance (CEAGRE, 2015) (Fig. 3). These regions host a diversity of fauna and flora species, including endemic and almost endemic.

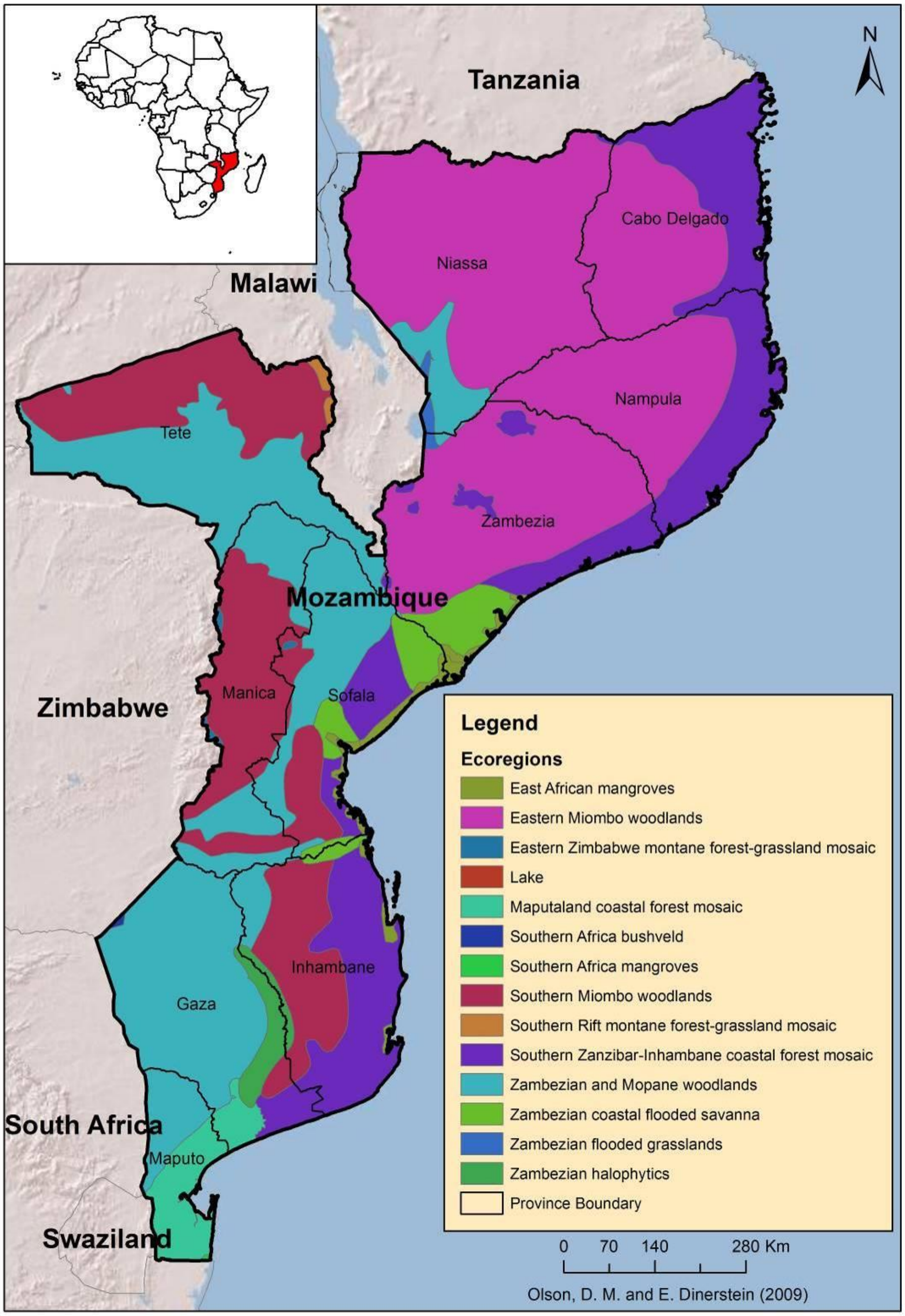

Figure 3: Ecoregions of Mozambique (Source: Olson & Dinerstein, 2009).

2.2.2. Realms, Biomes, and Ecosystems

Mozambique's ecosystems are grouped into 30 natural habitats (CEAGRE, 2015), which encompass a variety of flora and fauna species, many of which are endemic to the region (MICOA, 2014). The state of conservation of ecosystems is critical; most of them need additional efforts to move to the well protected category. However, the Mozambican territory has a protected area network covering 26% of the entire territory, including Parks, Reserves, Coutadas, Game Farms, Hunting Community Areas (MITADER, 2015; ANAC, 2016).

According to geographic distribution maps and zone descriptions provided in the IUCN Global Ecosystem Typology V1.01 (Keith *et al*., 2020), Mozambique can be classified into nine realms, 19 biomes, and 46 ecosystem functional groups (Annex C).

2.2.2.1. Terrestrial Realm

Wild & Barbosa (1967) classified the vegetation of Mozambique into 54 classes; the miombo is the most dominant vegetation type, followed by mopane (Wild & Barbosa 1968; Bandeira *et al.,* 2007) and Mecrusse (MITADER, 2018a).

Based on varieties of the ecological characteristics, Marzoli (2007) grouped vegetation in nine classes. According to Marzoli (2007) around 70% (58.8 M ha) of Mozambique terrestrial landscape are occupied by forest and other vegetation formation.

Currently, forest covers 58.2% (47.9 M ha) of the country area, and followed by grassland/savannah (20.6 %) and cropland (17.5%). Shrubs and shifting forests cover 19% (MITADER, 2018a). Of the total forest cover 22.5 million hectares are dense forests, 16.4 million hectares open forests, 802 thousand hectares open forests in wetlands and 357 thousand hectares mangrove forests (MITADER, 2018a). Wetlands, settlements and other lands are much less widespread, covering 1.9%, 1.2% and 0.6% respectively (Malatesta *et al*., 2019).

Forest resources in Mozambique have contributed to socioeconomic development and poverty alleviation. However, its exploitation has faced major challenges to maintain its long-term sustainability with high demand driven by the international market. The levels of exploitation of timber species from natural forests have exceeded the permitted annual cut volumes, which range from 515,700 to 640,500 m^3, due to a variety of unsustainable forest management practices. If current levels of over-exploitation are maintained, this may contribute to the extinction of timber species in the long run, which will jeopardize the future of forests in Mozambique. The volume of sawn timber production has increased significantly in recent years, from 192,271 m^3 in 2010 to 301,338 m^3 in 2016. From 2013 to 2017 there was also an increase in the volume of licensed wood from 212,711 m^3 in 2013 to 255,492 m^3 in 2017 corresponding to 20%. The levels of wood harvested have been dominated by the timber obtained illegally. By 2013, 93% of all commercial timber harvesting was illegal, against an average of 81% between 2007 and 2012 (MITADER, 2018).

The rate of forest degradation is poorly known (MITADER, 2018a), but estimated around 0.58% (219 000 ha) per year by Marzoli (2007), which tends to increase currently (MITADER, 2018a). However, forest degradation has different origins in productive activities: expansion of agricultural (65% per year); the expansion of residential areas and infrastructures (12%); logging covering (8%); firewood and coal production (7%) (MITADER, 2016). For instances, from 2007 to 2018 there was a decrease of 21% of the total forest area and 36% of the productive forest area (MITADER, 2018a). The country is one of the richest in plants diversity in the region. For instances, four phytocorian of those defined accordingto White (1983) occur in Mozambique (i) Zambezian Regional Centre of Endemism; (ii) Zanzibar–Inhambane regional mosaic later divided by two region (Swalihillian regional centre of endemism; Swahillian-Maputaland regional transitional zone, by Clarke 1998); (iii) Maputaland-Tongoland regional mosaics and (iv) Afromontane Archipelago-like Centre of Endemism.

According to Keith *et al*. (2020) terrestrial biomes (Tropical-subtropical forests; Savannas & grasslands; Intensive anthropogenic terrestrial ecosystems), Mozambique has ten Ecosystem Functional Groups (See Annex C).

Mozambique's mountainous areas are known to have high levels of endemic species. For instances, the Chimanimani Mountains have an estimated 100 endemic plant species (MITADER, 2015a; van Wyk and Smith, 2001), 60 species of the Tettigoniidae (Orthoptera) were recorded from Gorongosa area and around, of which two appear to be endemic to Mt. Gorongosa (Naskrecki and Guta, 2019); Mamuli has 420 plant species, 155 bird species and 42 mammals (Timberlake *et al*., 2009) and 10 new species (plants, mammals, reptiles and butterflies) have been confirmed from Mt Mabu forests (Bayliss et at., 2014).

2.2.2.2. Freshwater Realm

Mozambique has an extensive drainage network that includes about 100 principal river basins. The most important national rivers systems are the Lúrio, Licungo, and Messalo Rivers. The international rivers are Zambezi (shared with Angola, Botswana, Namibia, Zambia, and Zimbabwe), Limpopo (shared with Botswana, South Africa, and Zimbabwe), Rovuma (shared with Tanzania), Olifants (shared with South Africa), Incomati (shared with South Africa and Swaziland), Shire (shared with Zimbabwe), Shire (Shared with Malawi), Save (shared with Zimbabwe) Umleluzi (shared with Eswatini) and Sabie (shared with South Africa).

The most important lakes in Mozambique are the Niassa, Chirua, Chiúta and Amaramba. Lake Malawi/Nyassa in the Rift Valley bordered by the countries of Malawi, Mozambique and Tanzania is one of the most studied lakes in Africa.

Lake Malawi/Nyassa and its influents, Lake Malombe, and the Shire River in between the two lakes form the globally distinctive ecoregion. In this ecoregion, lake richness of taxa is high with about 800 species of cichlid fishes of which over 99% are endemic and 909 species of freshwater decapods (Sayer *et al*., 2019). Specifically, the Lake Malawi/Nyasa/Niassa Catchment, supports 459 taxonomically described native freshwater fish species; 38 native freshwater mollusc species; 155 native odonate species and 247 species of freshwater plants (Sayer *et al*., 2019).

Some coastal lakes, swamps and wetlands that are temporarily flooded by the rains are located behind the coastal dune systems in southern Mozambique, the most important being the Bilene, Nhambavale, Quissico, Inharrime and Piti lakes.

The other important place is the lower Zambezi, where Cabora Bassa Dam is located, that flows southeasterly for 593 Km through Mozambique and to Indian Ocean, an area of major wetland biodiversity, where a distinctive biodiversity feature is found and is, with an extensive area of papyrus, aquatic grasslands and mangroves. The Marromeu complex and the delta of the Zambezi are important wetland areas, recently designated as the Ramsar sites, support the largest population of waterfowl in Mozambique that includes species of pelicans, ibis, ducks and storks. Thousands of migratory species including flamingos depend on these habitats are used as breeding, refuge and feeding areas.

By damming rivers Mozambique has artificial lakes called reservoirs, such as Cabora Bassa Reservoir (Zambeze River), Pequenos Limbos (Umbeluzi River), Corumana (Sabié River), Massingir (Olifants River) and others. These rivers, lakes, reservoirs wetlands are the major types of ecosystems and habitat and contribute significantly to host many freshwater biodiversity and also has great influence marine and terrestrial ecosystems.

Over 50% of the Mozambican territory is occupied by aquatic ecosystems, including wetlands that are distributed throughout Mozambique specifically in watersheds (MITADER, 2019). There are currently two regions in the country declared wetlands by the RAMSAR Convention: Marromeu National Reserve in Sofala Province (1,500 km^2), and the Niassa Lake Reserve in Niassa Province (478 km^2), both of which cover an area of 1,978 km2 (MITADER, 2018).

According to the recent report on the national inventory of wetlands and potential RAMSAR sites (Couto *et al*., 2019), taking into account the RAMSAR classification system, there are three categories of wetlands in the country, which include: i) **Artificial inland wetlands** which occupy an area of 316,033 ha, corresponding to 4%, which include designated areas for aquaculture, salt flats, dams, water treatment plants as well as irrigated areas for agriculture; (ii) **Marine or coastal wetlands**, which cover an area of 1,603,590 ha, corresponding to 28.3%, including areas of marine waters, estuarine waters, coastal freshwater or saline lakes as well as coral reefs; and finally iii) **Inland wetlands** with an area of 1,669,681 ha corresponding to 67.7%, which include marshes, waterways, flood areas, inland deltas, freshwater or saltwater lagoons. The recent report listed 114 wetlands, from which 8 are of highest priority due to their ecological, biological or hydrological relevance, need conservation. They are the wetlands of Districts of Nangade, Palma and Mocimboa; the coral reefs of the Primeiras and Segundas Islands Environmental Protected Area; Lake Urema; Buzi and Púngoè Rivers Estuary; Banamana Lagoon; Changane River; Chuáli Lagoon; and the wetlands of Maputo Special Reserve.

At coastal side, the IBA are the wetland areas, particularly Quirimbas and Bazaruto NP's, Maputo bay and Zambezi delta, which consists of most of the flood-plain of the Zambezi river (including the Marromeu Reserve), as well as the adjoining hunting concessions (coutadas 10, 11 and 12) whose habitats are open water (fresh and estuarine), sandbanks, isolated pools, marshland, grassland and Acacia savanna in the delta and flood-plain, extensive lowland forest and deciduous woodland in the hunting concessions, and *Brachystegia* woodland on the western fringes of the site.

2.2.2.3. Coastal Realm

The critical ecosystems that occur along the 2700 km of the Mozambican coastline are mangrove forests, seagrass beds, coral reefs, salt marshes, rocky shores and sandy beaches (Hoguane, 2007). The area occupied by mangroves is estimated at 3050 km^2 in Mozambique, which represents 13% of the global area (Spalding *et al*., 2010; Fatoyinbo and Simard, 2013). Mangroves grow profusely between the

Save river and Angoche, while being scant in southern Mozambique. In the north they colonise the mouths of the major rivers such as Lurio and Rovuma, protected bays and some Islands such as Ibo (Barbosa *et al*., 2001).

Coral reefs occupy an estimated area of 1 860 km^2, which represents 14% of the regional cover for this ecosystem (Motta *et al*., 2002 a, b; Spalding *et al*., 2001). The most important coral sites in Mozambique are located in the provinces of Nampula and Cabo Delgado (Mozambique Island, Quirimbas Archipelago, Pemba Bay). Some other smaller formations can be found in southern Mozambique (Bazaruto, Tofo, Maputo Bay), while they are uncommon in central Mozambique due to the predominantly muddy and low salinity coast (Motta *et al*., 2002; Spalding *et al*., 2001).

Seagrass beds occur along the coast of Mozambique occupying an estimated area of 439 km^2.The most important known sites of occurrence of seagrass beds are the region between Inhassoro and Bazaruto, the Mecúfi-Pemba region, Quirimbas Archipelago, Mozambique Island, Fernão Veloso and from Maputo Bay to Ponta do Ouro (Bandeira and Gell, 2003; Bandeira *et al*., 2014).

Rocky shores and sandy beaches and common feature along the Mozambican coast and dominate the shores in northern and southern Mozambique. In central Mozambique the substratum is predominantly muddy and both features are uncommon. Seaweed and seagrass communities form mosaics that colonize the rocky limestone sediments and extensive intertidal sandy areas in the northern coast (e.g.: Mozambique Island, Fernão Veloso).

Saltmarshes are barely studied in Mozambique. They occur associated to mangrove forests, growing in the transition between mangroves and the terrestrial vegetation.

2.2.2.4. Marine Realm

The country's offshore territorial waters cover an area of about 100.000km^2. Mozambique presents important areas of marine biodiversity of global and ecorregional level such as Maputo Bay-Machangulo complex and Bazaruto Archipelago (EAME, 2004) as well as ecologically and biologically significant marine areas (Secretariat of the Convention on Biological Diversity, 2016), such as Delagoa shelf edge canyons and slope and BaixoPinda-Pebane (Primeiras e SegundasArquipelago) where different marine habitats and particular groups of marine organisms, have been described to occur.

Down to the 200m depth contour, Mozambique has an estimated continental shelf area of 79451 km^2 (UNEP-Nairobi Convention and WIOMSA, 2015). The continental shelf is divided into two regions, the north, which is very narrow with submarine canyons and bordered by true coral reefs (from Rovuma River to Ponta Namalunga), and the south, which is wider (Ponta Namalunga to Ponta do Ouro. The southern region, besides being wider, presents a more diverse profile, extending more than 100 km seaward on its widest point (Sofala Bank, Beira), narrowing to 2 km around Bazaruto, extending again around Delagoa and Maputo Bay's latitude (Pereira *et al*. 2014). In this region, corals have been reported as deep as 40 to 100 m, between Quelimane and the Zambezi delta (steep continental shelf can be observed in this area). Coral reefs are also reported to occur, here and there, between the Bazaruto Island and Ponta Zavora, and down to 100 m between the Inhaca Island and Ponta do Ouro (Pereira *et al*. 2014).

Rocky outcrops and canyons are present in deeper waters off the shelf, from Bazaruto to Ponta do Ouro, and the huge amount of sediment from the Zambezi Delta and Save River are responsible for the deposition of sand and silt particles on the continental shelf, making the seafloor sandy-muddy. Muddier substrate can also be found beyond the shelf break between Bazaruto and Cabo das Correntes (Saetre and da Silva 1979 and Fischer *et al*., 1990, cited by Pereira *et al*., 2014).

2.3. Biodiversity status and trend - Species approach: Flora and Fauna

Mozambique has valuable ecological attributes, geographical areas with unique and exceptional richness, which share a biological diversity that contributes to food security and the economy of the country. Despite additional efforts, the level of knowledge of species diversity in the country still remains weak. The most comprehensive collection of information on Mozambique's biodiversity to date is from de Koning (1993); Parker (1999, 2005); Smithers & Tello (1976); Smith *et al*. (2008). More accurate and up-to-date information on biodiversity data are provided by specific and individual checklists for selected taxa (de Koning, 1993; Burrows *et al*., 2018; Schneider *et al*., 2005; IUCN, 2021).

However, the diversity of species in Mozambique is estimated to be 6,145 plant species, 35 of which are new taxa and new 105 records; of these, more than 300 species of plants are in the IUCN Red List, of which 22% are endemic (MITADER, 2019a). The country has about 4,271 species of fauna, of which insects are the most abundant group (72%), birds (17%), mammals 5% and the least abundant amphibians with 2% (MICOA, 2014; MITADER, 2018a).

The conservation status of these species is neither ecologically healthy nor satisfactory. Threatened species in Mozambique by taxonomic group include 18 mammalian species, 30 birds, 14 reptiles, 8 amphibians, 83 fishes, 208 plants and 65 other invertebrates (IUCN, 2020).

More than these, there are 55 Marine Species including sharks and rays (38); mammals (4); bony fish (8) and 5 Species of sea turtles that are seriously threatened (Warnell *et al*., 2013). For instance, the 4 mammalian species are Vulnerable, and while one species of turtle is Vulnerable, two are endangered and others two critically endangered (Warnell *et al*., 2013). Ten species of bony fishes are vulnerable, 3 endangered and one critically endangered. Finally, 78.9% of the 38 species of sharks and rays are vulnerable, while six are endangered and two are critically endangered (Warnell *et al*., 2013).

Vascular plants, Birds, mammals, fish and insects are some of the most well studied vertebrate groups in Mozambique. The IUCN Red List Index (RLI), provide the survival probability for birds, mammals, amphibians, corals, and cycads. The RLI for Mozambique demonstrates an overall downward trend or decrease in survival probability from 1990s to 2020 for these five species groups (Fig. 4, http://www.iucnredlist.org/about/publication/red-list-index). This report will not includes cycads and corals as biological targets, but birds, mammals, amphibians, reptiles, fish and plants. Thus these classes are assessed further.

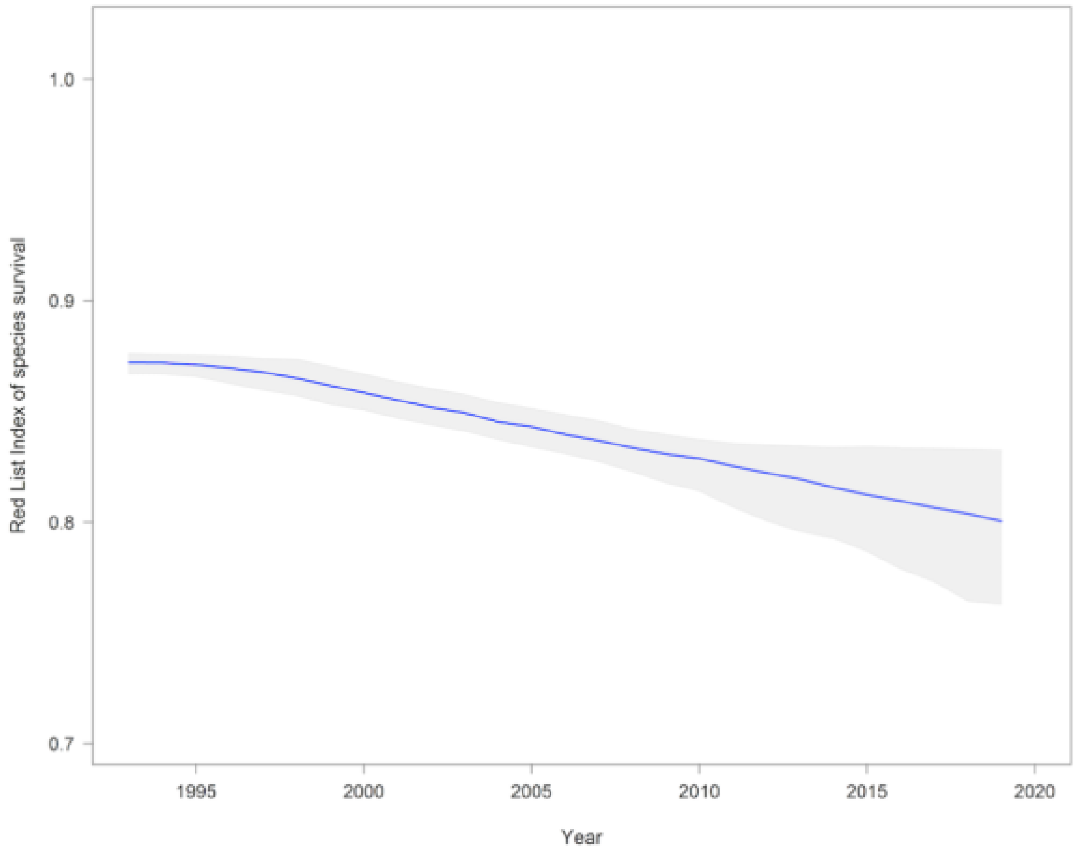

Figure 4: Red List Index of species survival (Fonte: http://www.iucnredlist.org/about/publication/red-list-index).

2.3.1. Terrestrial Diversity

2.3.1.1. Plants

According to Darbyshire *et al*. (2019), there are about 6 157 from "Flora of Mozambique" website (Hyde *et al*. 2019a) and associated database of species records. Actually, 271 strict-endemic taxa (235 species) and 387 near-endemic taxa (337 species) of vascular plants in Mozambique is provided. Together, these taxa constitute 9.3% of the total currently known flora of Mozambique and include five strict-endemic genera (Baptorhachis, Emicocarpus, Gyrodoma, Icuria and Micklethwaitia) and two near-endemic genera (Triceratella and Oligophyton) (Darbyshire *et al*. 2019).

Mozambique supports a variety of ecosystems/habitat types: areas of miombo (dry or wet miombo), mopane woodland, coastal vegetation (forest and woodland), savannah, riverine wetland vegetation, upland grassland and moist forest are all potentially interesting in their biodiversity (CEAGRE, 2015). Also, despite to the high diversity in the country six centre of plant Endemism (Fig. 5) in Mozambique were identified namely: Rovuma- this centre lies in coastal zone of Cabo-Delgado, Nampula and Zambézia Provinces; Maputaland-lies from Gaza coastal zone, Maputo and down to South Africa; Lebombo-mountains within Maputo province, including Eswatini and South Africa; Inhambane – lies from coastal zone of Save river to Gaza Province; Chymanimani-Nyanga- that include most of the mountains in Manica and mount Gorogonsa and Mulanji-Namuli-Ribaue in Zambezia and Nampula inland provinces this centre goes to Malawi (Darbyshire *et al*., 2019).

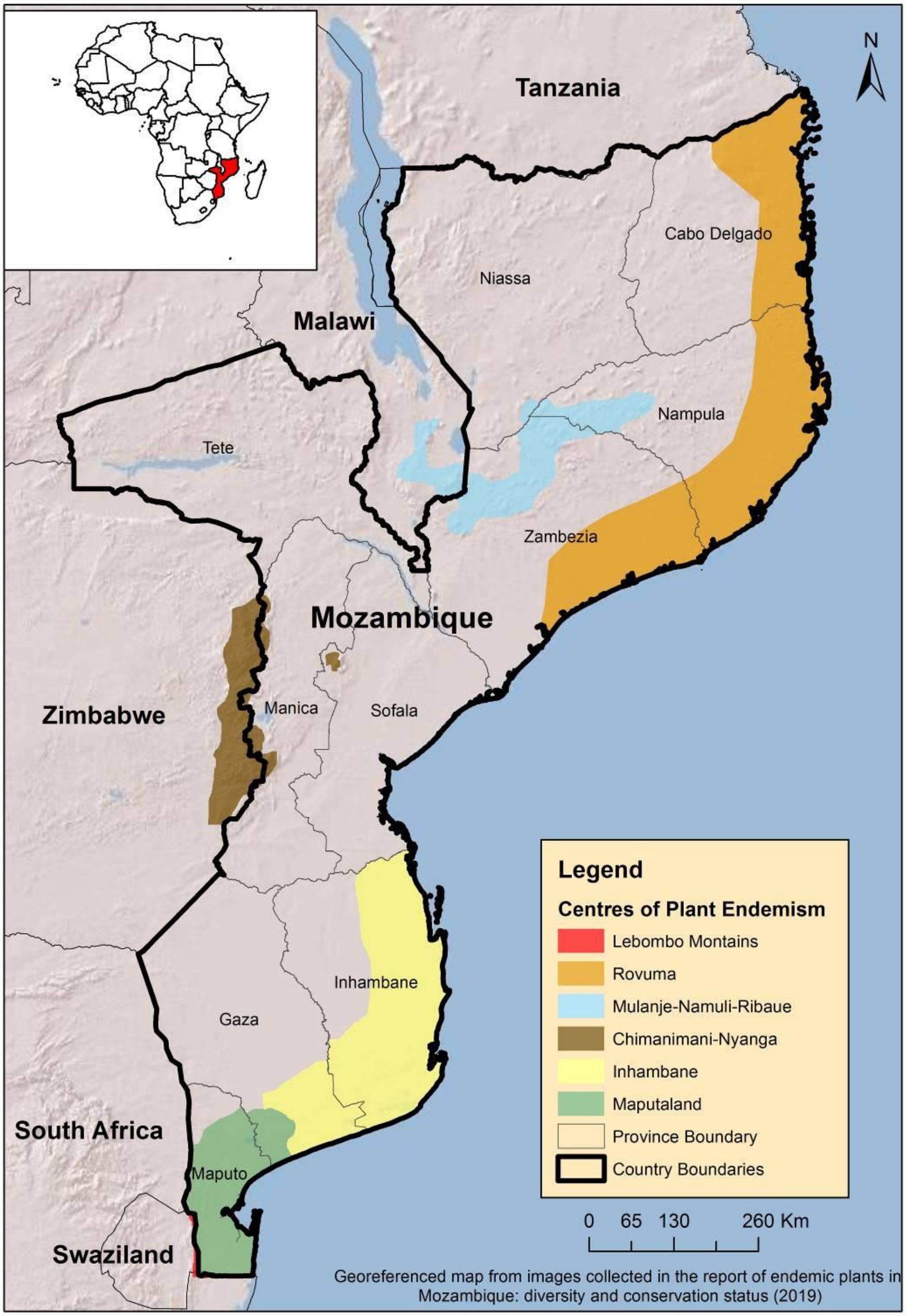

Figure 5: Centres of plant endemism in Mozambique (Source: Darbyshire *et al*., 2019).

About 5 genera of strict-endemic plants are known in Mozambique, namely: *Baptorhachis*, *Emicocarpus*, *Gyrodoma*, *Icuria* and Micklethwaitia, whith 235 species of plants; and two near-endemic genera, namely: *Triceratella* and *Oligophyton*, with 337 species of plants. A Table 1 representing important plant families of both strict-endemic and near-endemic genera is presented below. With regard the conservation status of strict-endemic and near-endemic plants, 53.9% (n = 477) are threatened, of which 45.9% (n = 257) are vulnerable, 39.3% are endangered and 14.8% are critically endangered (Darbyshire *et al*. 2019).

The main threats to plant biodiversity in Mozambique are Slash and burn agriculture, shifting agriculture, Charcoal production, firewood harvesting, tourism activities, urbanization, Settlements, logging, and the impacts of domestic livestock and uncontrolled fires. These threats are almost shared to all terrestrial ecosystems and habitats, but in some places with particular threats, such as Artisanal Mining and some Alien species (*Vernonanthura* spp.) seen in Chimanimani (see, Timberlake *et al*. 2020; Darbyshire *et al*., 2019; Massingue, 2018; Clark *et al*., 2017; Timberlake *et al*., 2016a; Timberlake *et al*., 2016b).

The actions such as habitat protection, restoration, introduction to the local level government the conservation policies, awareness, and communications to indigenous communities are urgently needed to guarantee the reversion of the future habitat loss trends and reduce the risk of species extinction. Additionally, more field surveys are needed to assess species and Population size & trends; Life history & ecology.

Table 1: First 10 Important plant families for published endemic taxa in Mozambique (source: Darbyshire *et al*., 2019).

Strict-endemic	Number os species	Near-endemic	Number of species
Fabacea	40	Fabacea	84
Euphorbiaceae	26	Rubiaceae	71
Rubiaceae	23	Euphorbiaceae	42
Malvaceae	12	Lamiaceae	30
Apocynaceae	11	Apocynaceae	27
Acanthaceae	10	Asteraceae	27
Lamiaceae	10	Acanthaceae	26
Lythraceae	9	Malvaceae	21
Asphodelaceae	8	Orchidaceae	21
Melatomastaceae	8	Asphodelaceae	20

2.3.1.2. Mammals

The number of mammals' species in Mozambique is estimated at about 260 (IUCN, 2021). A list of 20 protected species, including African elephant (*Loxodonta africana*), lion (*Panthera leo*), leopard (*Panthera pardus*), wild dog (*Lycaon pyctus*) as well as all mongoose species is provided through the national law of forest and wildlife (Govern of Mozambique, 2002). Based on IUCN red list classification (IUCN, 2021 accessed in March 2021), 19 mammal's species existing in the country are globally threatened: 57.9% are VU, 36.8% are EN and 5.3% are CR (see Table 2).

The trend of some species whose data are available, suggests reduction across the country. For instances, the current population of elephant is estimated to 9 114, with a stable population almost at entire conservation areas after an alarming reduction of 71.4% (n = 21 400) in Niassa special Reserve, an area with the highest concentration of elephant population in Mozambique, between 2011 and 2014 (Grossmman *et al*., 2014). The giraffe (*Giraffa camelopardalis*) population has a slight increasing, with a population estimated in 437 individuals (Gibson and Craig, 2018). The lion population of 2 700 individuals was estimated in 2009, with 71% of lions occurring out of the conservation areas (Chardonnet *et al*., 2009).

The trends of overall felines and canids populations are unknown. However, lion population has increased from a mean of 35 individuals, in 2012, to 146 individuals in 2019 in Gorongosa National Park, and wild dog and leopard were reintroduced as part of future Complex Gorongosa - Marromeu since 2010 (Beifuss *et al*., 2010; Bouley *et al*., 2018). In the Niassa Special Reserve, lion and wild dog population were estimated between 1 000 – 1 200 and 350, respectively (NCP, 2015). Hippo occurs along the main river of the country, with 80% occurring in Zambezi and Lugenda rivers and Cahora Bassa lake. Its population is estimated to range between 6497 to 6742, a double of its population in 2010 (BassAir, 2017).

The main threats to the terrestrial mammals in Mozambique are habitat loss due to agriculture and logging, frequentsfires set by humans, human settlements inside conservation areas and along the coastal side, mining, poaching, charcoal production and fuelwood collection (Lindsey and Bento, 2012; Grossmman *et al*., 2014; Everatt, 2015; Lindsey *et al*., 2015; NCP, 2015; Prin *et al*., 2014; Campira, 2018; Allan *et al*., 2017; Bouley *et al*., 2018). At the Niassa SR, poisoning still concerns for the conservation of felines, particularly lion (NCP, 2015). Cattle presence inside the conservation was also reported during the national terrestrial mammals' survey (Gibson and Craig, 2018). The main threat to hippo is drought

(Hanekom, 2019); but also, agriculture, human presence, water turbidity and drought (Beilfuss *et al*., 2010; BassAir, 2017; Ntumi, 2020; Ntumi *et al*., 2020).

Mozambique has two endemic species, namely: Vincent's Bush Squirrel (*Paraxerus vincenti*), a rodent found at mount Namuli, and Mt. Mabu horseshoe bat (*Rhinolophus mabuensis*), both found in Afromontane areas of north of Zambezi River central of Mozambique, and listed by IUCN as Endangered species. Only population of *Paraxerus vincenti* is decreasing while the other species has unknown population trend. However, decreasing trends due to the habitat loss as result of forest clearing for agriculture, logging, wood harvesting as well as the frequent wild fires, which negatively affect Afromontane forest regeneration (Kennerley and Peterhans, 2016; Taylor, 2019) are observed.

Table 2: Conservation status of the global threatened species of terrestrial, freshwater and marine mammals occurring in Mozambique (IUCN, 2021).

Species	**Status**
Diceros bicornis	CR
Paraxerus vincenti	EN
Balaenoptera musculus	EN
Redunca fulvorufula	EN
Lycaon pictus	EN
Sousa plumbea	EN
Rhinolophus mabuensis	EN
Carpitalpa arendsi	VU
Smutsia temminckii	VU
Panthera leo	VU
Giraffa camelopardalis	VU
Loxodonta africana	VU
Hippopotamus amphibius	VU
Colobus angolensis	VU
Dugong dugon	VU
Physeter macrocephalus	VU
Panthera pardus	VU
Balaenoptera physalus	VU

2.3.1.3. Birds (Avifauna)

According to BLI, Mozambique has 675 species of birds, grouped 345 genders and 102 families. About 518 species are landbirds, 137 are waterbirds, 36 are seabirds, 208 are migratory and 2 are breeding endemic. Accipitridae (Hawks and Eagles) is the most diversified family, with 6.4% of the overall species of bird grouped into 26 genera, followed by the families Cisticolidae (Cisticolas and allies) and Muscicapidae (Chats and Old-world flycatchers), with 4.7% and 4.6%, respectively. About 35.6% of the families have less than 10 species (BLI, 2021) (see Table 3).

Table 3: Top 10 most abundant families of bird species (source: BLI, 2021).

Family	**Genera**	**Species (sp)**	**Sp (%)**
Accipitridae (Hawks and Eagles)	26	43	6,4
Cisticolidae (Cisticolas and allies)	8	32	4,7
Muscicapidae (Chats and Old-world flycatchers)	20	31	4,6
Ploceidae (Weavers and allies)	7	25	3,7
Estrildidae (Waxbills, grass finches, munias and allies)	15	22	3,3
Ardeidae (Herons)	9	20	3,0
Nectariniidae (Sunbirds)	6	20	3,0
Scolopacidae (Sandpipers, Snipes, Phalaropes)	9	19	2,8
Cuculidae (Cuckoos)	7	18	2,7
Hirundinidae (Swallows and martins)	9	17	2,5

Most of the species (91.7%, n = 782) are globally not threatened. About 32 species of bird are classified as being globally threatened, of which 3 species are critically endangered, 16 species are endangered and 13 species are vulnerable. Furthermore, about 24 species are near threatened.

In regard to the conservation issues, they are analysed considering two situations of the habitats: inland habitats and coastal habitats. The first areas include most of the conservation areas (CA's) as well as Afromontane areas, where woodland and moist forest occurs (Parker, 2001; Stalman *et al.*, 2014; Bernardo, 2018; Briggs, 2020). In regard to conservation areas, the Niassa National Reserve has 370 (Briggs, 2020), whereas the national parks of Banhine, Zinave and Limpopo each has 24, 123 and 141 species each, respectively (Lepage, 2020). This last CA, almost half (47%) of the bird species are concentrated in rivers Shingwedzi and Águia Pesquira (Bernardo, 2018).

Other inland habitats considered as Important Bird Areas (IBA) are Afromontane areas – Namuli and Chiperone (province of Zambézia), Njesi plateau (Niassa province), Gorongosa and Chimanimani (Manica province) massifies (Parker, 2001). However, most of Afromontane habitats, with exception of Gorongosa and Chimanimani areas (Müller *et al.*, 2012; BIOFUND, 2020), are not protected and local communities practice agriculture and frequent wild fires, which result in habitat loss (Timberlake *et al*., 2007, 2009; Jones *et al*., 2016). The Maputo bay (Matola – Língamo saltmarsh) itself is used by 4 500 water birds during the low tide feed (Bento, 2014) while Rift valley in Gorongosa NP hosted 3 791 nests of bird after Idai cyclone on the flooded land, an increase of its importance when compared during the same period in 2014 (Denlinger *et al*., 2019).

2.3.1.4. Reptiles

According to IUCN (2021), the country has a record of approximately 126 species. Reptiles have a wide distribution within the country, occurring in mopane and miombo forest, inselbergs (afromontane areas) as well as the coastal vegetation and within national conservation areas. A survey carried out in 2005 in Niassa SR reported an occurrence of 57 species, representing more than 50% of the total species of all known reptiles at north region (n = ~100) (Branch *et al*., 2005). In Gorongosa NP, Francisco (2016) reported 42 species of reptiles grouped into 32 genera and 19 families whereas in Chimanimani, an important and protected afromontane site, the number of reptile species is estimated to be 45 (Biofund, 2020). The Bazaruto archipelago is believed to have about 39 species of reptiles (Jacobsen *et al*., 2010).

Based on IUCN red list classification, 14 reptilian species existing in the country are globally threatened: 50% are VU, 35.7% are EN and 14.3% are CR (see Table 4).

The main threat to reptiles in Mozambique is habitat loss, particularly at Afromontane areas located at north of Zambezi River where legal protection is lacking. Habitat loss is due to forest clearing for agriculture (including potatoes culture) and timber harvesting. Uncontrolled fires with serious negative effect on forest regeneration as result of farm clearing for agriculture as well as illegal hunting is also a concern for conservation of the endemic species of reptiles in unprotected Afromontane areas such as Njesi plateau, and Chiperone (http://lntreasures.com/mozambiquer.html; Timberlake et al., 2007; Branch and Bayliss, 2009; Jones et al., 200; BLI, 2020b; WCS et al., 2021). Other threats to reptiles are collection for food, skin and medicinal purposes, pet trades, although quantitative data is unknown, as well as retaliation by human mainly in some rivers such as Búzi and Zambezi as result of human conflict with Nile crocodile (MICOA, 2009; Ntumi *et al.,* 2020 not published).

Mozambique has 23 endemic species of reptiles, of which 30% are listed as LC, 26.1% are DD, 21.7% are NT, 13% are EN and 4% (1 species) are VU and CR, respectively (see table 4). The populations of the CR species *Rhampholeon bruessoworum* and the endangered species *Atheris mabuensis* and *Rhampholeon* *tilburyi* are in decline and fragmented. They occur at non-protected Afromontane habitat in north of Zambezi river. Management plan to protect these habitats are crucial for the conservation of these species.

Table 4: Endemic reptilian species in Mozambique and the global conservation status (IUCN, 2021).

Species	Status
Acontias aurantiacus	LC
Afroedura gorongosa	LC
Aparallactus nigriceps	DD
Atheris mabuensis	EN
Cordylus maculae	LC
Dipsadoboa montisilva	NT
Leptotyphlops pungwensis	DD
Lycophidion semiannule	DD
Lygodactylus regulus	NT
Mochlus lanceolatus	LC
Nadzikambia baylissi	NT
Proscelotes aenea	DD
Rhampholeon bruessoworum	CR
Rhampholeon gorongosae	EN
Rhampholeon maspictus	NT
Rhampholeon nebulauctor	VU
Rhampholeon tilburyi	EN
Scelotes duttoni	LC
Scelotes insularis	LC
Scolecoseps boulengeri	DD
Scolecoseps broadleyi	NT
Zygaspis maraisi	DD
Zygaspis violacea	LC

2.3.1.5. Amphibians

The amphibian's species richness in Mozambique is estimated in 97 species (IUCN, 2021). The distribution of the species within the country is related to the presence of wetlands (river, lakes, seasonal flooded grassland) grassland, and Afromontane areas, including forest and rocky areas, such as cliffs and mountain peaks (Conradie *et al.*, 2016; 2018; Francisco, 2016). Based on IUCN red list classification, 11 amphibian species exiting in the country are globally threatened: 45.5% are EN, 36.4% are VU and 18.2% are CR (see Table 5).

Mozambique has 5 endemic species: one Critically Endangered species (*Nothophryne unilurio*), 3 Endangered species (*Nothophryne baylissi*, *Nothophryne inagoensis* and *Nothophryne ribauensis*), and one Data Deficient species (*Ptychadena boettgeri*) (IUCN, 2021). All threatened endemic species (Critically Endangered and Endangered species) are found across dispersed inselbergs of upper Zambezi River where habitat loss - due to agriculture, logging, wood harvesting livestock farming, human settlement, frequent wild fires, habitat shifting and alteration and droughts are responsible for the decreasing trends of the respective populations. Nevertheless, the persistence of these species is a matter of concern since the respective range areas are not protected (Conradie *et al*., 2016; 2018).

Very little research has been published on the amphibian fauna, with only a handful of papers investigating specific regions, mainly the Afromontane areas, namely: Chimanimani and Gorongosa national parks (only at mountain side); Namuli, Chiperone, Mabu, Inago, Njesi plateau, where most of the endemic species of the country occur (Timberlake *et al*., 2007; 2009; Conradie *et al.,* 2016; 2018; Jones *et al.,* 2016; BIOFUND, 2020; GNP, not published). According to Francisco (2016), low Gorongosa NP hosts almost 34% of the national amphibian's species belonging to 11 families and 16 genera.

Table 5: Endemic amphibian species in Mozambique and the global conservation status (IUCN, 2021).

Species	**Status**
Nothophryne unilurio	CR
Arthroleptis troglodytes	CR
Probreviceps rhodesianus	EN
Nothophryne baylissi	EN
Amietia inyangae	EN
Nothophryne inagoensis	EN
Nothophryne ribauensis	EN
Hyperolius inyangae	VU
Arthroleptis francei	VU
Strongylopus rhodesianus	VU
Hyperolius spinigularis	VU

2.3.2. Freshwater Diversity

Around 366 species of fishes are currently reported in the country mainly represented by 19 orders (See Table 6 for details; https://www.fishbase.se/Country/CountryChecklist.php?resultPage=8&c_code=508&vhabitat=fresh&cpresence=present).

Table 6: Diversity and richness of Freshwater fish of Mozambique (source: https://www.fishbase.se/Country/CountryChecklist.php?resultPage=8&c_code=508&vhabitat=fresh&cpresence=present).

Order	Family	Genera	Species
Anguilliformes	4	4	7
Beloniformes	1	1	1
Carcharhiniformes	1	1	1
Characiformes	2	5	10
Clupeiformes	2	3	3
Cypriniformes	1	6	42
Cyprinodontiformes	2	3	13
Elopiformes	1	1	1
Gonorynchiformes	1	2	2
Lepidosireniformes	1	1	2
Mugiliformes	1	4	6
Osteoglossiformes	1	6	11
Perciformes	13	77	220
Pleuronectiformes	1	1	1
Rhinopristiformes	1	1	2
Salmoniformes	1	1	1
Siluriformes	8	15	38
Synbranchiformes	1	1	1
Syngnathiformes	1	2	4
Total	**44**	**135**	**366**

Around 94 fish species have been recorded in the lower Zambezi. The Zambezi Delta hosts 73 waterbirds species, including species with global concern such as Paleartic and intra-African migrants and thousands of pairs of white pelicans breed in the delta, and 19 amphibian species was found in the delta. Aquatic reptiles such as Nile monitor (*Varanus niloticus*), Nile crocodile (*Crocodylus niloticus*) and various snakes also use the delta (Thiene *et al*., 2005). The Marromeu complex and the delta of the Zambezi are important wetland areas, recently designated as the Ramsar sites, support the largest population of waterfowl in Mozambique that includes species of pelicans, ibis, ducks and storks. Thousands of migratory species including flamingos depend on these habitats are used as breeding, refuge and feeding areas.

The main threats to freshwater biodiversity had been linked to human activities in freshwater environments in which has pushed freshwater systems more away from their natural conditions with severe consequences in species diversity and also disrupting their ecological functioning.

Population growth and overexploitation of resources, habitat change and degradation, pollution, invasive species (such as the Redclaw crayfish (*Cherax quadricarinatus*)) and climate change are other threats to freshwater biodiversity. The growth of the Mozambica population (estimated at 30 million people in 2020), together with the needed economic development and industrialization, will have some effects on transformations of freshwater ecosystems and resulting in a loss of biodiversity. With regard to *pollution* there are no real figures for Mozambique, however, clear signs of pollution such as eutrophication in some reservoirs such as Pequenos Libombos, Corumana, Massingir and Cabora Bassa are apparent (Mussagy *et al*., 2017).

River damming is one of the main threats to freshwater biodiversity. As in other countries of Africa large and small dams such as Cabora Bassa in Zambeze River, Massingir in Olifants River, Pequenos Libombos in Umbeluzi River and Corumana in Sabie River have been constructed in Mozambique. Damming creates fragmentation of the river whose consequence is alterations of river natural flow from upstream to downstream at the same time affecting lateral connections of the river flow with drainage basin. Based on the global IUCN Red List classification, 24 of the national freshwater species are threatened, 46% of the species are VU, 38% are CR and 17% are EN.

<u>Focus on Endemic species</u>

The number of endemic species is estimated in 30 divided into 8 families and 16 genera (See Table 7). About 6 (18.8%) of the endemic species are classified as threatened (*Pseudotropheus saulosi*, CR; *Nothobranchius hengstleri*, EN; and *Cynotilapia chilundu*, *Nothobranchius krammeri*, *Nothobranchius krysanovi* and *Nothobranchius niassa*, VU) and 35.6% area classified as NT. About 15.6% of the endemic species (*Chrysichthys hildae*, *Placidochromis chilolae*, *P. orthognathus*, *P. pallidus* and *Trematocranus* *pachychilus*) are Data Deficient (DD) and 18.8% are not evaluated. This group of species also needs a deep and systematic study (IUCN, 2020; http://lntreasures.com/mozambiquer.html).

Table 7: Endemic freshwater fish species of Mozambique and the global conservation status (IUCN, 2020; http://lntreasures.com/mozambiquer.html).

Family	Species	Conservation status
Amphiliidae	*Amphilius laticaudatus*	LC
Cichlidae	*Chetia brevicauda*	LC
	Copadichromis cyanocephalus	NT
	Copadichromis parvus	LC
	Cynotilapia chilundu	VU
	Metriacina glaucos	NT
	Metriacina mossambicum	LC
	Metriacina nigrodorsalis	LC
	Metriacina nkhunguensis	LC
	Metriacina phaeos	LC
	Metriacina xanthos	LC
	Melanochromis mossambiquensis	NT
	Melanochromis wochepa	NT
	Placidochromis chilolae	DD
	Placidochromis orthognathus	DD
	Placidochromis pallidus	DD
	Pseudotropheus saulosi	CR
	Trematocranus pachychilus	DD
Claroteidae	*Chrysichthys hildae*	DD
Cyprinidae	*Labeo baldasseronii*	Uknown?
	Enteromius manicensis	
	Labeobarbus pungweensis	
Eleotridae	*Eleotris soaresi*	Uknown?
Kneriidae	*Parakneria mossambica*	LC
Mormyridae	*Marcusenius lucombesi*	Uknown?
	Petrocephalus petersi	Uknown?
Nothobranchiidae	*Nothobranchius hengstleri*	EN
	Nothobranchius kadleci	NT
	Nothobranchius krammeri	VU
	Nothobranchius krysanovi	VU
	Nothobranchius orthonotus	LC
	Nothobranchius niassa	VU

2.3.3. Coastal Diversity

2.3.3.1. Mangrove

There are nine true mangrove species in the country. *Avicennia marina*, *Ceriops tagal* and *Rhizophora mucronata* are the commonest species. Others are *Bruguiera gymnhoriza*, *Sonneratia alba*, *Xylocarpus granatum*, *Lumnitzera racemosa* and *Heritiera littoralis*. *Xylocarpus moluccensis* has been recorded only in two sites (the Zambezi delta and Memba), but it is believed to occur in other sites (Trettin *et al.*, 2016; Bandeira, personal communication). Mangrove associated plant species can be found inside or in the margins of the forest (Bentjee and Bandeira, 2007). The mangrove fauna is very rich, and includes several species of crabs, fish, molluscs, birds, insects, etc., including many of economic importance, such as portunid crabs (*Scylla serrata*) and penaeid shrimps (Paula *et al.*, 2014).

Mangroves contribute to the reproduction of at least 30% of commercial marine species; protect communities from erosion and extreme events (60% of country population lives in the coastal zone). The overall conservation status of Mozambique's mangrove species is illustrated in the table below (Table 8).

Table 8: Global conservation status of mangrove species of Mozambique (IUCN, 2021).

Family	Species	Conservation status
Acanthacea	*Avicennia marina*	LC
Combretaceae	*Lumnitzera racemosa*	LC
Lythraceae	*Sonneratia alba*	LC
Malvaceae	*Heritiera littoralis*	LC
Meliaceae	*Xylocarpus granatum*	LC
Meliaceae	*Xylocarpus moluccensis*	LC
Rhizophoraceae	*Bruguiera gymnorhiza*	LC
	Ceriops tagal	LC
	Rhizophora mucronata	LC

2.3.3.2. Coral reefs

The species diversity of coral reefs in Mozambique is highly underestimated, with more than 300 species recorded so far (Obura, 2012). Coral associated species have also not been described in detail. In Maputo Bay, such species include echinoderms (starfish, brittle stars, sea urchins, holothurians), reef bivalves (e.g.: *Tridacna* spp.), octopus and several crustacean (lobster *Thenus orientais*, *Panulirus* spp.;

crabs *Liomera* sp., shrimp *Stenopus hispidus*), etc. (Schleyer and Pereira, 2014). Schleyer and Pereira (2014) reported 327 reef species of fish occurring in this area, from 58 families. The dominant families are Pomacentridae, Labridae, Chaetodontidae, Serranidae, Sparidade and others. Many of reef fish species have economic importance.

2.3.3.3. Seagrass beds

There are 12 species in the country, representing about 1/5 of the total number of species that occur globally: *Zostera capensis*, *Thalassia hepmrichii*, *Halophila ovalis*, *H. minor, H. stipulacea*, *Enhalus acoroides*, *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, *H. wrightii*, *Syringodium isoetifolium, Thalassodendron leptocaule* and *Thalassodendron ciliatum* (Bandeira and Paula (2014). The overall conservation status of Mozambique's Seagrasses species is illustrated in the table below (Table 9).

Table 9: Global conservation status of Seagrasses of Mozambique (Bandeira and Paula, 2014; IUCN, 2021).

Family	Species	Conservation status
Cymodoceaceae	*Cymodocea rotundata*	LC
	Cymodocea serrulata	LC
	Halodule uninervis	LC
	Halodule wrightii	LC
	Syringodium isoetifolium	LC
	Thalassodendron ciliatum	LC
	Thalassodendron leptocaule	NT
Hydrocharitaceae	*Enhalus acoroides*	LC
	Halophila minor	LC
	Halophila ovalis	LC
	Halophila stipulacea	LC
	Thalassia hemprichii	LC
Zosteraceae	*Zostera capensis*	VU

2.3.3.4. Seaweed macroalgae

Common seaweed macroalgae species in rocky shores and sandy beaches include *Jania adherens, Padina biryana* in the upper zones, *Saragum* sp. and *Laurencia* sp. in the middle and *Gracilaria* sp. and *Sargassum* sp. in subtidal areas (Bandeira, 2000). In the south, exposed and sheltered rocky shores can be found in Maputo Bay (Inhaca Island), Ponta do Ouro, Bazaruto Archipelago, Xai-xai-Zongoene beach, etc. However, the southern coast is predominantely sandy, with dunes that can grow as high as 120 m (Perreira *et al.,* 2014).

2.3.3.5. Saltmarshes

The species composition of Saltmarshes is not well documented, but known species include *Sporoboulos virginicus* and suculents such as *Sesuvium portulacatrum* and *Salicornia* sp.

2.3.3.6. Ecosystem threats

Some species have been exploited to almost extinction (ex.: holothurians and sea horses), others are threatened by accidental catch and habitat destruction. Curio trade is intensive in northern Mozambique (Cabo Delgado, Nampula), despite being illegal. Coastal development and offshore exploitation of mineral resources are potential new threats that can impact on marine mammals and reptiles, but also other species.

Such root causes lead to more direct causes of ecosystems degradation, such as pollution by sewage discharge, poor agricultural practices that lead to increased sediment load in downstream ecosystems (coral reefs, mangroves and seagrass beds); unplanned coastal development, overfishing and excessive exploitation of natural resources, unsustainable tourism, river diversion, etc., all causing degradation and loss of mangrove forests, coral reefs, seagrass beds and sand dunes (UNEP, 2009). Degraded ecosystems fail to provide key ecosystem services, thus increasing community vulnerability to climate change impacts, poverty, diseases, food shortage and others. Direct relationships between the loss of habitats and negative impacts in the communities have been recorded at the Limpopo estuary, for instance, were the communities reported shortage of wood resources and fish, and increased vulnerability to heavy winds and erosion, after more than 400 ha of mangrove forest were lost to the 2000 floods (Bandeira and Balidy, 2016). Also, the communities of the Quirimbas National Park reported significant changes in local community well-being after significant loss in coral reefs habitat quality. With the implementation of closure periods, the corals were able to recover, with direct impact in local octopus fishery and tourism, and consequently, community well-being (Muaves, personal communication).

Many coastal species are used in traditional medicine in Mozambique, however such knowledge lacks documentation. Coral reef, salt marsh and rocky shore species have high potential for cosmetic and pharmaceutical industry in Mozambique. Meanwhile, healing and cultural ceremonies are conducted in mangrove forests all across the county and in central Mozambique. For instance, communities claim that the fruit of *X. granatum* is used to cure stomach ailments as reported elsewhere by Bibi *et al.* (2018).

Human impact, such as agriculture and fishing, is minimum at Zambezi delta due to the inaccessibility of the area, but negative effect of water flow interruption due to the dam at upper Zambezi (Kariba and Cahora Bassa) on bird's diversity needs to be investigated (Beilfuss *et al*., 2010; BirdLife, 2000c), whereas in Maputo city, mangrove deforestation due to urban extension, hunting and high voltage power line along Espírito Santo estuary and Infulene valley are the main threat for birds (Bento, 2014; Malatesta *et al*., 2019; BirdLife International, 2000c).

Other threats for birds at coastal habitats are extensive conversion of mangrove into salt production pans or aquaculture facilities, infrastructure construction, human pressure on alluvial riparian habitats, as well as the use of destructive fishing methods (using prohibited fishing gear) and overexploitation of fish, associated with illegal fishing, mining of coastal heavy mineral in Zambezi delta (MICOA, unpublished[6]).

2.3.4. Marine Diversity

2.3.4.1. Marine mammals

Mozambique's coast encompasses several ecological areas of regional and global importance, meeting all requests of Important Marine Mammals Area – IMMA – criteria (MMPATF, 2019). Of the 32 species of cetaceans (whales and dolphins) occurring on the East African Coast (Kiszka, 2015), 26 have been reported in Mozambican and/or Mozambique Channel waters (Pereira *et al*., 2014). Published data on the occurrence, abundance and distribution of cetaceans in Mozambican waters is still limited (Pereira *et al*., 2014; Kiszka, 2015), with little work performed on distinguishing species found in coastal water from the offshore/open ocean species (UNEP-Nairobi Convention and WIOMSA, 2015).

Seven species of whales have been reported to occur within Mozambican waters: *Balaenoptera acutorostrata, B. musculus, Eubalaena australis, Kogia breviceps, Megaptera novaeangliae e Mesoplodon mirus, and Physeter macrocephalus* (Cooke, 2018) as well as 12 delphinid species: *Sousa chinensis, S. plumbea, Tursiops truncatus, T. aduncus, Stenella longirostris, S. attenuata, Dolphinus delphis, Steno bredanensis, Pseudorca crassidens, Orcinus orca, Globicephala melas* and *Feresa attenuate* (Banks *et al.,* (n.d.); MICOA, 2009*;* ASCLME, 2012; Pereira *et al*., 2014; Guissamulo, 2014; Kiszka, 2015; Bachara and Gullan, 2016; Allport *et al*., 2017; Cooke, 2018; MMPATF, 2019).

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[6] Despite that the data is unknown, this article published during 2012 and 2014.

Megaptera novaeangliae is the most common baleen whale species in Mozambican waters, particularly during austral winter, with the total population abundance often reaching nearly 6,000 animals (Pereira *et al*., 2014; Kiszka, 2015). This whale species can be found in open waters from Ponta do Ouro to Inhambane (ASCLME, 2012). Within the Bazaruto Island Bay there have been reports of both mothers and young (IMPACTO and ERM, 2011). The offshore areas are also considered to be important breading grounds for Pygmy Sperm whale and Sperm whale (IMPACTO and ERM, 2011).

Bazaruto Archipelago (national park) and its adjacent areas are the most notable areas in the country, supporting a population of Dugongo (*Dugong dugon*) estimated at between 250 and 350 individuals (SMM, 2020). Other important marine mammal's species occur between Bazaruto Archipelago and Maputo bay, namely: Ocean humpback dolphin and Humpback whale. The population of the first Humpback dolphin is estimated between 100 to 1,400, whereas, the Humpback whale population was estimated at about 30 individuals in 2018 (Findlay *et al*., 2011; IUCN – MMPATF, 2019).

With inverse seasonal trends, *Tursiops aduncus* (common in winter) and *Sousa plumbea* (common in summer) are the most common dolphins in coastal waters, with average numbers above 100 animals respectively, in Maputo Bay and Bazaruto Archipelago (Kiszka, 2015). The Long-finned Pilot whale and False killer whale can be observed in deep waters offshore Mozambique (IMPACTO and ERM, 2011). And, two species of seals, the Crab eater seal (*Lobodon carcinophagus*) and the Sub-antarctic fur seal (*Arctocephalus tropicalis*), have been reported in Mozambican waters, however the coastal waters of Mozambique are considered to be outside the Sub-antarctic fur seal's regular global distribution, suggesting that this was a nomadic or vagrant individual (ASCLME, 2012).

The population of the Indian Ocean Humpback Dolphin (*Sousa plumbea*) has been decreasing for the Indian Ocean and this specie deserves special attention due to being gobally classified by IUCN as Endangered. The Indo-Pacific Humpback dolphin (*Sousa chinensis*) (decreasing population), Sperm whale (*Physeter macrocephalus*) and Dugongo (*Dugong dugon*) are globally classified by IUCN as Vulnerable, and the False killer whale (*Pseudorca crassidens*) and *Tursiops aduncus* are Near Threatened (IUCN, 2020).

Marine mammals are generally depleted by means of intentional catches, destructive and non-selective fishing gears that lead to accidental catches, by destruction of their habitat and pollution. Little is known about the extent of marine mammal by-catch, but it is known that Humpback dolphins are also caught in the drift gillnet fishery and that intentional captures also contribute to the decline of humpback dolphins

(ASCLME, 2012). Also, tourism and vessel traffic, or environmental stochasticity, such as tropical cyclones and floods are considered as threats for marine mammals (IUCN – MMPATF, 2019). The following table shows some threatened marine species that occur in the country.

Table 10: A short list of global threatened marine mammal's species occurring in Mozambique (source: IUCN, 2020).

Scientific Name	Conservation status
Dugong dugon	Vulnerable
Physeter macrocephalus	Vulnerable
Pseudorca crassidens	Near threatened
Sousa chinensis	Vulnerable
Sousa plumbea	Endangered
Tursiops aduncus	Near threatened

2.3.4.2. Marine turtles

There are five species of marine turtles in Mozambican waters, the loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and olive ridley turtle (*Lepidochelys olivacea*) (Pilcher and Williams, 2018). The last species is the only one confined to the northern region, while the others are seen along the entire coast. The green turtle is the most widespread, but nests mainly from Bazaruto Archipelago northwards. The hawksbill turtle follows the same nesting geographical area as the green turtle. The logger head and the leather back turtle are more common in the south, nesting from Ponta do Ouro to Bazaruto Archipelago, while olive ridley only nests in the north (ASCLME, 2012; Pereira *et al*., 2014; Bourjea, 2015).

Recently the coastal area of Sofala Bank was identified as a foraging area for Leatherback turtles (Robinson *et al*. 2016), this is extremely interesting considering that this species is considered an open-ocean specialist.

All five species of sea turtle populations are decreasing and are considered globally threatened (IUCN, 2020) (Table 11). Threats to marine turtles in Mozambique are related to fishing activities (trawling, beach seining, long lining, among other), mainly bycatch in semi-industrial, commercial and artisanal fishing, as well as coastal development, interference with nesting sites, and habitat degradation.

Estimates suggest that thousands of turtles are bycatch in the commercial shrimp fishery in Sofala Bank (Mellet, 2015; Pilcher and Williams, 2018; Williams et al., 2019). Direct exploitation of eggs and meat (both serve as food to coastal population) and harvesting of shells (artisanal use) of sea turtles is still an issue in the country (Bourjea, 2015). The scale of these threats and their impacts are largely data deficient (Pilcher and Williams, 2018). The recent discovery of petroleum and gas fields in the Mozambique Channel is no doubt a potential major concern for the conservation of turtles since it precipitate the moving of the inland population to the coast areas were artisanal fishing is one of the main economic activity (Williams *et al*., 2019).

Table 11: Sea turtle species global conservation status (source: IUCN, 2020).

Scientific Name	**Conservation status**
Caretta caretta	Vulnerable
Dermochelys coriacea	Vulnerable
Chelonia mydas	Endangered
Eretmochelys imbricate	Critically Endangered
Lepidochelys olivacea)	Vulnerable

2.3.4.3. Shore and Sea Birds

Information regarded to coastal bird's needs deep research and assessment, however, 36 species of seabirds, grouped into 26 genera and 12 families are reported to occur within Mozambican channel (BLI, 2020). The most representative families among the sea bird species are Laridae (12 species and 6 genera) and Procellariidae (8 species and 7 genera). About 13.9% of de families have single species (see Table 12).

Using Global IUCN Red List Category, 7 species are threatened: 5 endangered species (*Morus capensis*, *Phalacrocorax capensis*, *Spheniscus demersus*, *Thalassarche carteri* and *T. chlororhynchos*) and 2 vulnerable species (*Diomedea exulans* and *Procellaria aequinoctialis*) (BLI, 2021).

Table 12: Seabirds species of Mozambique and its global IUCN Red List Category status (source: BLI, 2021).

Family	Species	Global IUCN Red List Category
Diomedeidae	*Diomedea exulans*	VU
	Thalassarche carteri	EN
	Thalassarche chlororhynchos	EN
Fregatidae	*Fregata minor*	LC

Laridae	*Hydroprogne cáspia*	LC
	Larus cirrocephalus	LC
	Larus dominicanus	LC
	Larus fuscus	LC
	Larus hemprichii	LC
	Onychoprion anaethetus	LC
	Onychoprion fuscatus	LC
	Sterna hirundo	LC
	Sternula albifrons	LC
	Thalasseus bengalensis	LC
	Thalasseus bergii	LC
	Thalasseus sandvicensis	LC
Oceanitidae	*Fregetta trópica*	LC
	Oceanites oceanicus	LC
Phaethontidae	*Phaethon lepturus*	LC
	Phaethon rubricauda	LC
Phalacrocoracidae	*Phalacrocorax capensis*	EN
	Phalacrocorax carbo	LC
Podicipedidae	*Podiceps cristatus*	LC
Procellariidae	*Procellaria aequinoctialis*	VU
	Ardenna pacifica	LC
	Calonectris borealis	LC
	Daption capense	LC
	Macronectes giganteus	LC
	Pachyptila desolata	LC
	Pachyptila vittata	LC
	Pterodroma macroptera	LC
Scolopacidae	*Phalaropus fulicarius*	LC
Spheniscidae	*Spheniscus demersus*	EN
Stercorariidae	*Catharacta maccormicki*	LC
	Stercorarius parasiticus	LC
Sulidae	*Morus capensis*	EN

There are five Important Bird Areas (IBAs) along the country's coastline, the Maputo Special Reserve, Pomene, Bazaruto Archipelago, in the south; the Zambezi River Delta, in the centre; and the Moebase region (Zambézia province) in the north (Parker, 2001). Most of these IBAs are of special importance for migratory Palearctic shorebirds/seabirds. According to Parker (2001) some of these species are: Grey plover (*Pluvialis squatarola*), Lesser sandplover (*Charadrius mongolus*), Sanderling (*Calidris alba*), Common tern (*Sterna hirundo*), Lesser crested tern (*Sterna bengalensis*), Little tern (*Sterna albifrons*), African openbil (*Anastomus lamelligerus*) and Wattled crane (*Bugeranus carunculatus*).

A diversity of seabirds with decreasing populations and of special concern for conservation, occurs in Mozambican waters (here the shore birds are excluded). The Endangered (IUCN, 2020) Madagascar Pond-Heron (*Ardeola idae*) has been reported as a nonbreeding winter visitor in the Moebase region (Parker, 2001). Bar-tailed godwit (*Limosa lapponica*) is classified as Near threatened, deserving special attention as its biggest congregations recorded in Southern Africa were seen in the Bazaruto Archipelago. The African Penguin (*Spheniscus demersus*) is Endangered (IUCN, 2020), occurring mainly in the colder waters of southern Africa, although occasionally rare vagrants have been reported from the Mozambique coast.

The main threats to seabirds in the country are the fishing activities, the coastal habitats loss such as the land conversion for aquaculture, port/harbour expansion and urban development, invasive species, in the near future oil pollution (BirdLife International, 2020a). Egg collection and adult birds capture is also an issue for the species that nest in country waters.

2.3.4.4. Fish

There are 2200 species of fish found in the western Indian Ocean (WIO) (represent 14% of all marine fishes) with over one and a half thousand marine fish species in Mozambique waters (Table 13), with representatives ranging from the living fossil fish coelacanth (*Latimeria chalumnae*), to the largest fish in the world, the whale shark (*Rhincodon typus*) (ASCLME/SWIOFP 2012a). Most of the information regarding Mozambican fish diversity was mainly compiled from Sofala Bank (the most important fishery ground in the country) and comes from survey cruises carried out by the Norwegian research vessel Dr. Fridtjof Nansen along the years (Sætre and Silva, 1979). The physical and ecological conditions of the environment, determine the type of species present: on the coastal islands the fish fauna is represented by demersal and some pelagic species; the coastal rocky seabeds support demersal fish, small pelagic fish and tuna species. On the banks and oceanic peaks, there are concentrations of tuna and small amounts of demersal species of high commercial value; Sofala Bank, has the largest proportion of the country's marine resources, both small demersal and pelagic fish.

Pelagic species such as carangids, barracudas, hairtails and scombrids are found offshore on the Mozambique continental shelf from Ponta do Ouro, up to Angoche, and south of Pemba. The dominant family on the inner shelf of the northern region is Carangidae, mainly *Decapterus russeli*. Clupeidsand barracudas are also present. The narrow-barred Spanish mackerel (*Scomberomorus commerson*), caught along the continental shelf of Mozambique is one of the priorities for management (ASCLME, 2012)

From the 222 species elasmobranchs reported in the Southwest Indian Ocean region (SWIO), In Mozambique, approximately 145 different chondrichthyan (shark, batoid and chimaera) species have been documented to date, with southern Mozambique being recognized as a global hotspot for shark and ray species richness, endemism and evolutionary distinctiveness (Lucifora *et al*. 2011; Dulvy *et al*. 2014; Stein *et al*. 2018; Derrick *et al*. 2020). The Whale shark (*Rhincodon typus*), Giant manta (*Manta birostris*) and Reef manta (*Manta alfredi*) are migratory species and can be found off the Sofala Bank, Inhambane and Maputo province. New fish species have been described between 2009-2016, and were found during the 2007/2008 Dr Fridtjof Nansen surveys in Mozambique: Sawshark (*Pristiophorus nancyae*), Threadfin bream (*Nemipterus flavomandibularis*), goatfish (*Parupeneus nansen* and *Upeneus seychellensis*), Seabreams, (*Polysteganus cerasinus* and *P. flavodorsalis*), Frogmouth (*Chaunax atimovatae*) and a Wrasse (*Novaculops alvheimi*). Fish diversity in Mozambican waters still an open research field (Huggett and Kyewalyanga, 2017) and investment in this knowledge gap should be a research priority.

Table 13: Diversity and richness of Marine fish of Mozambique (source: https://www.fishbase.se/Country/CountryChecklist.php?resultPage=8&c_code=508&vhabitat=fresh&cpresence=present).

Order	Family	Gender	Species	Order	Family	Gender	Species
Albuliformes	1	1	1	Myctophiformes	1	10	18
Anguilliformes	9	33	74	Myliobatiformes	7	13	16
Atheriniformes	1	4	6	Notacanthiformes	1	1	1
Aulopiformes	5	11	19	Ophidiiformes	3	12	14
Beloniformes	5	12	20	Orectolobiformes	3	3	3
Beryciformes	4	8	27	Osmeriformes	3	5	5
Carcharhiniformes	7	18	35	Perciformes	85	353	840
Chimaeriformes	2	2	2	Pleuronectiformes	10	25	40
Clupeiformes	5	12	19	Polymixiiformes	1	1	2
Coelacanthiformes	1	1	1	Pristiophoriformes	1	2	2
Elopiformes	2	2	2	Rajiformes	3	8	11
Gadiformes	2	11	19	Rhinopristiformes	3	5	9
Gasterosteiformes	1	2	2	Scorpaeniformes	11	30	61
Gobiesociformes	1	2	2	Siluriformes	2	4	8
Gonorynchiformes	2	2	2	Squaliformes	5	8	16
Heterodontiformes	1	1	1	Squatiniformes	1	1	1
Hexanchiformes	1	2	3	Stomiiformes	3	7	8

Lamniformes	4	5	6	Syngnathiformes	5	23	35
Lampriformes	3	3	3	Tetraodontiformes	9	37	72
Lophiiformes	8	9	20	Torpediniformes	2	3	4
Mugiliformes	1	7	14	Zeiformes	4	5	8
				Total	**229**	**704**	**1452**

Great number of teleost fish and elasmobranchs with decreasing populations deserve special attention in the country due to their conservation status (Table 14). Overfishing and fisheries targeting spawning aggregations and refuge areas are threats of major concern (van der Elst, 2015). The elasmobranchs fished in the country are captured by all fisheries both, as target species and by-catch, being eventually discarded or kept. They represent by-catch particularly for the shrimp fishery (Kiszka and van der Elst, 2015). Many elasmobranchs are also captured by illegal fishing activities for international trade.

Table 14: A short list of globally threatened fish species occurring in Mozambique (source: IUCN, 2020).

Scientific Name	Conservation status
Aetomylaeus nichofii	Vulnerable
Bolbometopon muricatum	Vulnerable
Carcharhinus leucas	Near threatened
Carcharhinus melanopterus	Vulnerable
Carcharhinus obscures	Endangered
Carcharhinus sealei	Near threatened
Carcharias Taurus	Vulnerable
Carcharodon carcharias	Vulnerable
Cheilinus undulates	Endangered
Galeocerdo cuvier	Near threatened
Glaucostegus halavi	Critically Endangered
Himantura gerrardi	Endangered
Kajikia audax	Near threatened
Latimeria chalumnae	Critically Endangered
Makaira nigricans	Vulnerable
Manta alfredi	Vulnerable
Manta birostris	Endangered
Mustelus canis	Near threatened
Mustelus mustelus	Vulnerable
Petrus rupestris	Endangered
Polysteganus undulosus	Critically Endangered
Rhincodon typus	Endangered
Rhynchobatus djiddensis	Critically Endangered
Scomberomorus commerson	Near threatened

Sphyrna lewini	Critically Endangered
Sphyrna mokarran	Critically Endangered
Sphyrna zygaena	Vulnerable
Stegostoma fasciatum	Endangered
Taeniurops meyeni	Vulnerable
Thunnus obesus	Vulnerable

Focus on Endemic species

National conservation status for marine fish species is not available. A full list of marine fish species occurring in Mozambique needs a deep national assessment. A number of endemic species is estimated at 14 divided into 13 families and equal number of genera. Two species (*Parablennius lodosus* (VU) and *Upeneus saiab* (EN) are threatened, about 14% (n = 14) and 42.9% are classified as DD and the same percentage of the species possible are not listed on IUCN categories or have an unknown conservation status (see Table 15).

Table 15: Endemic marine fish species of Mozambique and the global conservation status (IUCN, 2020; http://lntreasures.com/mozambiquer.html).

Family	Species	Conservation status
Ammodytidae	*Ammodytoides xanthops*	Unknown?
Blenniidae	*Parablennius lodosus*	VU
Callionymidae	*Callionymus stigmatopareius*	Unknown?
Chaunacidae	*Chaunax africanus*	DD
Gerreidae	*Gerres mozambiquensis*	Unknown?
Gobiesocidae	*Lissonanchus lusheri*	DD
Haemulidae	*Pomadasys laurentino*	DD
Labridae	*Decodon grandisquamis*	DD
Microdesmidae	*Gunnellichthys irideus*	Unknown?
Mullidae	*Upeneus saiab*	EN
Pempheridae	*Pempheris cuprea*	Unknown?
	Pempheris peza	Unknown?
Pomacentridae	*Neopomacentrus fallax*	DD
Syngnathidae	*Campichthys nanus*	DD

2.3.4.5. Invertebrates

According to SeaLifeBase (Palomares and Pauly, 2020) there are 295 species of crustaceans, 185 of molluscs, 51 of echinoderms and 5 species of sponges, in Mozambique waters. Invertebrate research is still an open topic; recently two new species of sea slugs were reported in Zavora (Inhambane) (Tibiriçá *et al*., 2017).

The crustacean species of major interest are usually the commercially important species of shrimps, lobsters and crabs. Species of shrimp are abundant, usually in shallow waters (Sofala Bank and Maputo Bay), occurring as well in deeper waters. The most common shrimp captured within the country fishing grounds include Indian prawn (*Penaeus indicus*) and Speckled shrimp (*Metapenaeus monoceros*), Giant tiger shrimp (*Penaeus monodon*), Japanese tiger prawn (*Penaeus japonicus*) and Western king prawn (*Penaeus latisulcatus*). The slope zone (200-800m depth) of Sofala Bank, harbours the commercially important pink prawn (*Haliporoides triarthrus*), the giant red shrimp (*Aristaeomorpha foliacae*) and the blue and red shrimp (*Aristeus antennatus*) (Huggett and Kyewalyanga, 2017). Crab species such as *Chaceon macphersoni* can be found in deep waters (200 to > 1000m depth). Rock lobsters (*Palinurus* spp.) are found not only on intertidal rocky shores, but also deep depressions of rocky reefs, e.g. Natal deep-water spiny lobster (*Palinurus delagoae*) (Groenveld and Everett, 2015).

Excluding the commercially important invertebrates, there is little information on the benthic invertebrate fauna that inhabits the seafloor. In regard to endemicity, Bazaruto Archipelago harbours the bivalve species *Retrolucina voorhoevei*, which is considered a rare species and six endemic species of gastropods *Conus pennaceus*, *Epitonium pteroen*, *E. repandior*, *Fusiaphera macrospira*, *Limatula vermicola* e *Thracia anchoralis* (Parker, 2001; MICOA, 2012). *Nassarius kraussianus* is a gastropod that its distribution limit is Bazaruto.

Through international shipping over 3,000 marine species may travel in ballast waters and invade foreign waters (Gollasch *et al*., 2000). Mozambique is no exception with its three major harbors receiving large ships every day that can bring alien species to territorial waters (ASCLME, 2012). Two species of shrimps: Kedal shrimp (*Metapenaeus dobsoni*) and the Rainbow shrimp, (*Mierspenaeopsis sculptilis* formerly known as *Parapenaeopsis sculptilis)*, have become very common in the shrimp captures from the two major fishing grounds in the country (Sofala Bank and Maputo bay). These are believed to be introduced species (IIP, 2013). Both of these shrimp species are associated with estuarine habitats, once they are important nursery areas for both species early life stages. Sub-adults and adults are distributed across the continental shelf in sand-mud and/or mud-sandy sediments, generally in the lower shelf (Palomares and Pauly, 2020).

2.3.4.6. Plankton

Sofala Bank and Angoche regions and Delagoa Bight are among the most productive areas of phytoplankton in the Mozambican continental shelf (Huggett and Kyewalyanga 2017). High productivity in Angoche and Delagoa Bight is believed to be related to passage of eddies, although the productivity in Sofala Bank is related to the combination of mesoscale oceanographic characteristics and the Zambezi river discharge (Leal *et al*., 2009).

Bacillariophytes, Cyanophytes, Dinophytes, Haptophytes and Prochlorophytes are the main phytoplankton groups present in Mozambican waters. The diatoms *Chaetoceros* spp*., Proboscia alata, Pseudo-nitzschia* spp*., Cylindrotheca closterium* and *Hemiaulus haukii*are the most abundant micro phytoplankton in national waters, while the cocolithophores, *Discosphaera tubifera* and *Emiliania huxleyi* are the most abundant nano phytoplankton (Huggett and Kyewalyanga, 2017). The marine cyanobacteria *Trychodesmium* (probably *T. erythraeum*, endemic to the Indian Ocean) have been reported twice to forms dense bloomsin autumn and beginning of summer between Beira and Angoche (Huggett and Kyewalyanga, 2017).

Zooplankton shows a more pronounced horizontal distribution in areas where the influence of estuaries is stronger (Leal *et al*., 2009). The meso zooplankton (>180 µm) seems to be in higher biomass in the southern and central regions of the country when compared to the northern part, but the macro zooplankton (>500 µm) doesn’t show any clear latitudinal gradient (Huggett and Kyewalyanga, 2017). Nevertheless, epipelagic copepods biogeography shows the latitudinal species distribution along Mozambican waters, with *Clausocalanus arcuicornis, C. furcatus, C. jobei, C. lividus, C. mastigophorus and C. parapergens,* characteristic from Ponta do Ouro to Beira; *Pareucalanus attenuatus* and *Euchaeta indica* characteristic from Beira to Angoche region and *Candancia guggenheimi, C. varicabs, Scolecithricella ovata* and *Paracalanus denudatus* characteristic from Angoche northwards (Huggett and Kyewalyanga, 2017).

2.4. **Areas of Conservation Importance**

Mozambique possesses valuable ecological attributes, geographical areas with a unique and exceptional richness inside and outside the conservation areas.

2.4.1. Conservation areas

Mozambique protects natural areas and their respective biodiversity through conservation areas (CA) and has a large network of protected areas with significant conservation importance and the potential to benefit the local economy (USAID SPEED+, 2018). From 2009 to 2020, the area of land consigned for conservation in Mozambique has shown an increasing trend, from 15.8% to 26% (including marine-1,7%and terrestrial areas – 24.3%) respectively, exceeding the international target of 17% set by the CBD for terrestrial areas (MITADER, 2019a).

The conservation areas in Mozambique represent about 197,033 Km² that encompass at least 87 ACs (MITADER, 2018a), of which 10 are national parks, namely Gorongosa, Mágoè, Bazaruto, Limpopo, Zinave, Banhine, Quirimbas, Gilé and Chimanimani; 7 reserves (Niassa, Marromeu, Lake Niassa, Maputo, Pomene, Ponta de Ouro and the Inhaca Biological Reserves); the Total Protection Area of Cabo de São Sebastião, the Environmental Protection Area of Ilhas Primeiras e Segundas and the Environmental Protection Area of Maputo (www. biofund.org.mz/mocambique/areas-de-conservacao-de-mocambique/); 4 Community Conservation Areas namely Chipanje Chetu, Mitcheu, Tchuma Tchato and Manda; 20 coutadas, 34 Games Farms, and more than 13 areas under community program and 9 blocks with synergetic or contemplative activities (MITADER, 2018a), as illustrated in Fig. 6.

Some CA includes various ecosystems including terrestrial, coastal and marine, for example the Maputo Special Reserve, the Bazaruto Archipelago National Park, the Quirimbas National Park and the Niassa Lake Reserve. Other conservation areas are located along the border with neighbouring countries, such as the Limpopo National Park, Magoé National Park, Maputo Special Reserve, Chimanimani National Reserve, Niassa National Reserve and Ponta d'Ouro Partial Marine Reserve (ANAC, sd).

The country also has 14 forest reserves, namely R F. de Mapalue, R F. de Ribaue, R F. de Matibane, R F. de Mecuburi, R F. do Baixo Pinda, R F. de Inhamitanga, R F. de Nhapacue, R F. de Mucheve, R F. de Derre, R F. de Maronga, R F. de Moribane, R F. de Zomba, R F. de Chirindzene, R F. de Licuati (MICOA, 2011).

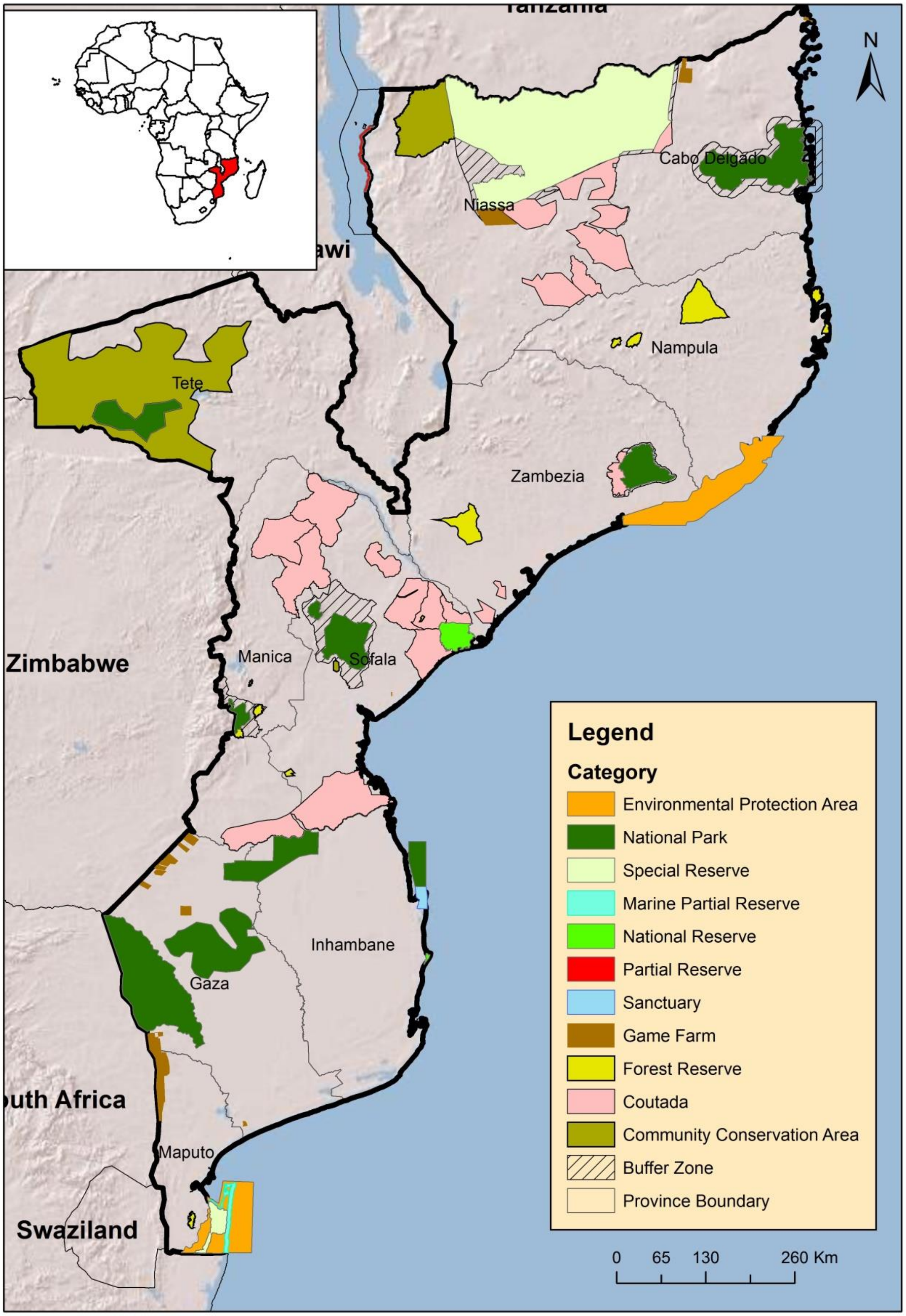


Figure 6: Protected areas of Mozambique.

In addition to these areas, the law attributes conservation value to Afromontane ecosystems (e.g. Mabu, Inago, Namuli, and others); mangroves, wetlands, IBAs and IPAs, and sacred forests that add value to biodiversity (MITADER, 2019a).

Management of conservation areas

Mozambique has a Collaborative Management Partnership system to help generate investment and improve the management of its conservation areas system. The conservation areas are under the supervision of the State, which is represented by the National Administration of Protected Areas (ANAC). However, the conservation areas are managed in a participatory manner, with their own mechanisms in place for the participation of public, private and community entities.

a) Conservation areas management models

The State is committed to ensuring the protection of biodiversity in the CA, but recognizes the need to involve other actors and partners to ensure the resources necessary for effective and sustainable management of CA. There are four CA management models that involve direct state participation or with the participation of other actors that can act alone or in partnership (USAID SPEED+, 2018):

(i) State management, in this case represented by ANAC - the resources for the management of CA is provided by the State Budget and hunting fees, as is the case of RN de Marromeu and PN de Magoé. ANAC is responsible for the protection and conservation of biological diversity, promotion of studies and development programs of the conservation areas, promotion of economic and recreational activities in the conservation areas and partnerships with private institutions and NGOs in the development and coordination of activities in the conservation areas (ANAC, sd).

(ii) Delegated Management Model - resources and management responsibilities are delegated to partners, who create and manage the conservation area for a long term, usually 20 years or more, as in the case of the Cabo de São Sebastião Total Protection Area (USAID SPEED+, 2018).

(iii) Co-management Model - governance and management are shared among partners. Co-management partnerships vary in their arrangements; there are two main institutional structures of co-management: a) Integrated Co-management Model - the state and non-profit organizations act as partners and share the governance and management of the conservation area. This model is characterized by a more equal division of responsibilities among partners. Gorongosa National Park benefits from this type of management. b) Bilateral Co-management Model - in this management model, the two organizations work side by side as entities and keep their structures and hierarchies separate. The Gilé National Park and the Niassa Special Reserve benefit from this type of management (USAID SPEED+, 2018).

(iv) Technical-Financial Support Model - In this model, the government maintains full governance and benefits from external support from non-governmental organizations and non-profit partners who simply provide financial support and technical advice. The Banhine, Zinave, Bazaruto, Limpopo, Quirimbas, Gilé and Chimanimani National Parks and Maputo Special Reserve benefit from this type of management (USAID SPEED+, 2018).

The management of Official Coutadas and Fazendas do Bravio is done by the private sector. The State, through a contract, agreement or other legal instrument, transfers the management of the CAs under certain conditions that allow the private sector to develop economic activities compatible with the object of the CAs that is the conservation of biodiversity (ANAC, sd). Among the mentioned four models, Co-management Model seems most effective to preserve biodiversity; fund raising is efficient and CA management is optimized and thus, degradations can be better controlled.

Main threats to conservation areas

Several ecosystems, including those located within the boundaries of the CA, have suffered different levels of degradation. The main pressures and threats to the conservation areas are uncontrolled burning, the cutting of trees for various purposes, land use conversion, grazing and poaching. The conservation areas in Mozambique are under excessive human pressure that manifests itself through illegal logging, illegal mining, deforestation for agriculture, extraction of wood fuels, construction materials and other timber and non-timber forest products. This has led to degradation and fragmentation of terrestrial and marine habitats, and to the drastic reduction of species of high ecological and economic value (MICOA, 2014).

On the other hand, conservation in marine conservation areas is threatened by illegal fishing, climate change, irresponsible exploitation of marine resources, pollution from various sources and the degradation by human action of coastal areas and marine flora; poor or non-existent planning that allows disorderly access and unrestrained use of sea and coastal resources with signs of their depletion and environmental degradation (MITADER, 2018a).

Restoration activities in the conservation areas

The success of biodiversity conservation in Mozambique depends mainly on the ability to find effective and sustainable responses that can reconcile the different conflicts that currently exist (MICOA, 2014). In view of this, the country has developed actions aimed at improving and strengthening the conservation areas, such as monitoring of mangroves, identification of ecosystems within the project for identifying Key Biodiversity areas (KBAs), development of management plans, creation of marine areas of community protection in Inhambane Bay and Cabo Delgado and conservation actions in centers of endemic Afromontane located outside the network of ACs such as Mts. Namuli, Mabu, Chiperone, Ribáuè and Inago (MITADER, 2019a). In 2015 and 2016, about 4,140 hectares were reforested for conservation and community purposes with native and exotic species (MITADER, 2019a). There was also translocation of animals into protected areas (MITADER, 2018).

2.4.2. Key Biodiversity Areas

Mozambique has considerable biodiversity both inside and outside the conservation areas (MITADER, 2018a). With the high human pressure on natural resources, a need has arisen to define conservation priorities not only for conservation areas that are already protected but also for places where rare species or ecosystems are concentrated or at greater risk of extinction (WCS, Governo de Moçambique, 2021). In light of this, efforts have been made in recent decades to identify significant sites for biodiversity (https://www.iucn.org/), since many important species and ecosystems are absent from current conservation area systems.

In 2016 IUCN and partners promoted a means of identifying sites of significant importance to the persistence of global biodiversity, which it called Key Biodiversity Areas (KBAs) in terrestrial, freshwater and marine ecosystems. KBAs are established based on clearly defined scientific criteria (https://www.iucn.org/resources/conservation-tools/world-database-of-key-biodiversity-areas). The species and ecosystem of an area identified as KBA are considered of great importance for the persistence of biodiversity globally (WCS, Governo de Moçambique, 2021).

In Mozambique, 29 KBAs have recently been identified, mapped and validated validated by the KBA Secretariat, occupying 12% (159,135.17km2) of the entire national territory, 17% of which are terrestrial and 4% marine KBAs (See Fig. 7). Not all conservation areas are considered KBAs; about 82% of the KBAs area is within Conservation areas (CA) and 18% is outside. The identification of KBAs is based on standardized technical-scientific criteria, while the conservation areas obey legal agreements for recognition, governance and management that may have been established due to various reasons (WCS, Governo de Moçambique and USAID, 2021).

As with conservation areas, KBAs also suffer threats to their biodiversity (see table 16) and the various unique ecosystems risk disappearing if urgent and effective measures are not taken. By mapping the KBAs and providing information about their biodiversity, the government and civil society can make the best decisions about how to manage and protect biodiversity in these important sites (http://www.keybiodiversityareas.org/) in order to achieve the Aichi Biodiversity Goals.

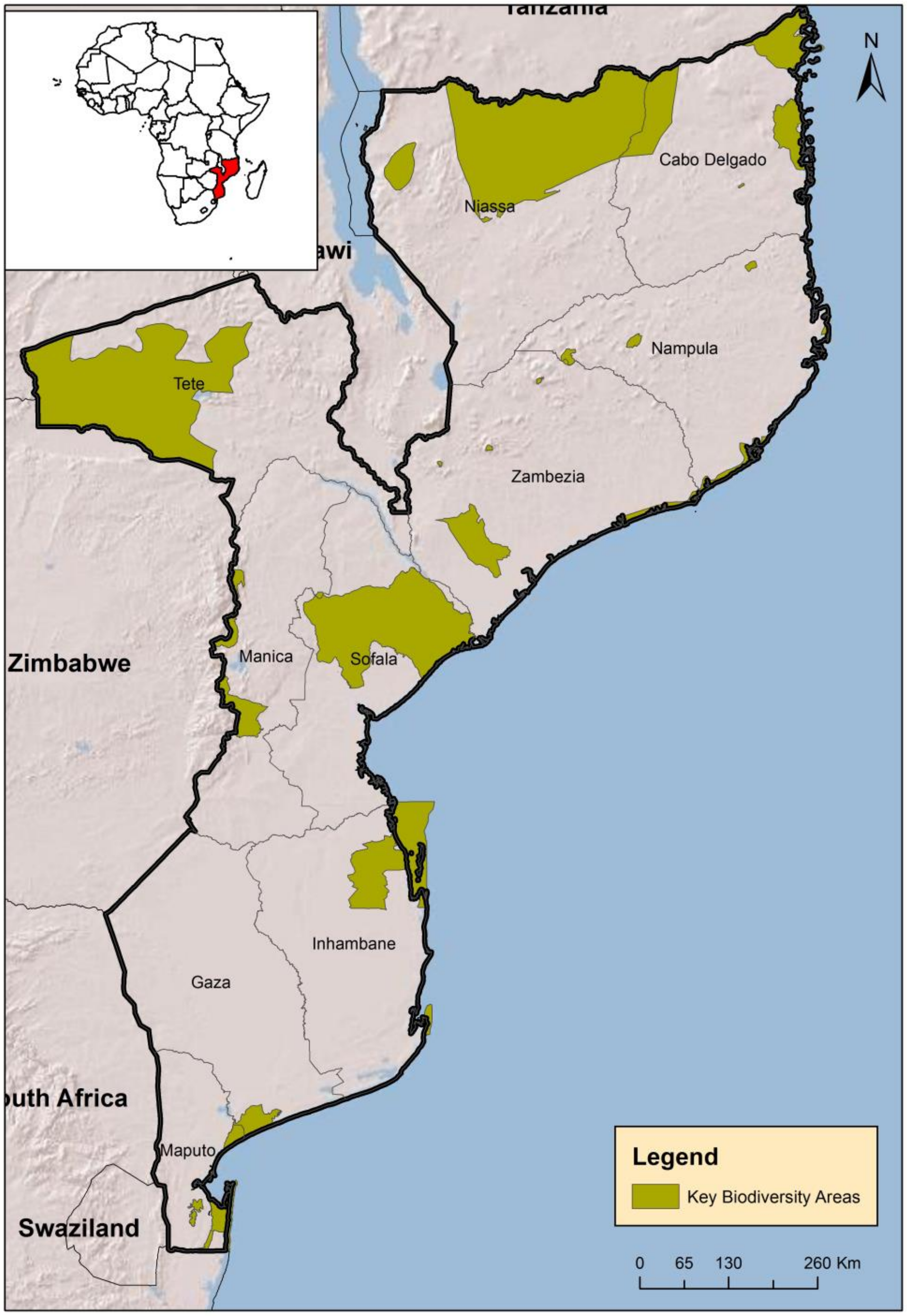


Figure 7: KBA's of Mozambique (Source: WCS, Governo de Moçambique, 2021).

Table 16: KBA of Mozambique (Source: WCS, Governo de Moçambique, 2021).

No	Name of KBA	Area (km²)	Taxanomic group	Current category type	Main threats
1	**Planalto de Njesi**	1996	Birds, reptiles	Partially covered by Community Conservation Area	Hunting pressure (high density of snares) , and burning
2	**Reserva Especial do Niassa**	42708	Mammals, Reptiles, Freshwater Fishes	Special Reserve, Buffer Zone	shifting agriculture, alluvial mining of gold and rubies, bushmeat snaring, poisoning for bushmeat
3	**Palma**	4556	Plants, Reptiles, Freshwater Fish	Partially cover by Fazendas do Bravio	High Development Areas, Oil & Gas
4	**Vamizi**	87	Marine Fish	Community Conservation Area (informal)	Overfishing, illegal fishing, use of harmful gear (including mosquito nets), oil & gas related activities and climate change.
5	**Quitérajo**	3064	Plants	Partially cover by National Park, Buffer zone Fazendas do Bravio	Agricultural expansion, logging
6	**Taratibu**	25	Amphibians, Plants	Concession, National Park, Zone Cap	Logging, shifting agriculture
7	**Eráti**	148	Plants	None	Agricultural expansion
8	**Reserva Florestal de Matibane**	109	Plants	Forest Reserve	Agricultural expansion, shiftingagriculture
9	**Ribáuè- Mphalwe**	265	Plants, Amphibians, Reptiles	Forest Reserve	Agricultural expansion shiftingagriculture

10	**Monte Inago**	326	Reptiles, Amphibians, Insects	None	Deforestation for small-scale agriculture, ongoing slash and burn of forest and no regulation, logging and unsustainable
11	**Arquipélago das Primeiras & Segundas**	2207	Plants	Environmental Protection Area	Agricultural expansion, coastal mining
12	**Monte Namúli**	53	Mammals, Birds, Amphibians, Reptiles, Insects, Plants	None	Agricultural expansion (mainly potato farming), widespread and frequent fires, logging and the impacts of domestic livestock
13	**Monte Mabu**	61.9	Birds, Amphibians, Reptiles, Insects, Plants	None	Burning, hunting of wild animals (small mammals)
14	**Monte Chiperone**	36	Reptiles, Birds	None	Shifting agriculture, farm opening, hunting and fishing
15	**Reserva Florestal de Derre**	3901	Freshwater fish, Plants	Forest Reserve	Agricultural expansion,
16	**Tchuma-Tchato**	38175	Mammals, Freshwater Fishes	Community Conservation Area , National Park	Agricultural expansion, illegal hunting (including use of traps and poison)
17	**Serra Choa**	516	Birds	None	Area largely disturbed by human habitation, agriculture, macadamia nut orchards, cattle grazing together with intensive and frequent burning.
18	**Machipanda**	756	Birds, mammals	None	Bauxite mine, agricultural expansion
19	**Parque Nacional Chimanimani**	2371	Plants, Mammals, Reptiles, Amphibians , Insects	National Park, Buffer Zone, Reserve Forestry	Gold mining, invasive species, burning
20	**Gorongosa- Complexo de Marromeu**	23088	Mammals, Birds, Reptiles, Butterflies, Plants, Freshwater Fishes	National Park, potential Buffer Zone, Coutadas, National Reserve, Forest Reserve	Unsustainable wildlife hunting, itinerant agriculture, timber extraction, exploration, drilling, oil, natural gas and other resource mining

21	**Inhassoro- Vilanculos**	5357	Plants	None	Human settlement, housing development for tourism, agricultural expansion, shifting agriculture
22	**Grande Bazaruto**	5236	Marine Mammals, , Land Reptiles, Plants	Partially cover by National Park, Sanctuary	Artisanal fishing, Oil & Gas related activities, subsistence and shifting agriculture,
23	**Tofo**	342	Sharks and Rays	None	Overfishing and Illegal Fishing
24	**Chongoene**	33	Insects	None	Human settlement, housing development for tourism, agricultural expansion
25	**Manhiça- Bilene (Baixo Limpopo)**	2070	Freshwater fish, Plants	Partially cover by Fazendas de Bravio	Industrial agriculture, wood cutting for charcoal production and fires caused by the change in agriculture.
26	**Matutuíne**	195	Plants	None	Human settlement for housing and small business infrastructure
27	**Reserva Florestal de Licuáti**	141	Plants	Forest Reserve	Wood-cutting for charcoal production , Agricultural expansion,
28	**Reserva Especial de Maputo**	1040	Freshwater fish, Insects, Plants	Special Reserve, Environmental Protection Area	harvesting of food and medicinal plants, pasture, ilegal hunting
29	**Reserva Marinha Parcial da Ponta do Ouro**	698	Marine fish, Marine Mammals	Partial Marine Reserve, Environmental Protection Area	Overfishing, illegal fishing, tourism and uncontrolled urban coastal expansion

Part III: Biodiversity Threat Assessment

3.1. National Level Assessment – Literature Review

Economic activities, anthropogenic actions, demographic changes, poverty, iniquitous policies and climate change are the main drivers contributing to the loss of biodiversity in Mozambique. The combination of these drivers results in conversion, loss, degradation, and fragmentation of natural ecosystems, overexploitation of species, introduction of invasive species and pollution (MICOA, 2014; USAID, 2013).

3.1.1. Conversion, loss, and fragmentation of natural habitats

The weak capacity and indulgent application of the law, the increase of urban population and associated demand for charcoal, high profitability of export markets, low productivity agriculture; inefficient production and consumption of charcoal; lack of alternative/abundant energy sources are the main causes of forest loss.

Mozambique has about 30.6 million hectares of forest. It is estimated that 438,000 hectares of forest were deforested in the period from 2016 to 2017, with an annual deforestation rate of 219,000 hectares per year, which means an annual rate of change of 0.58% (MITADER, 2018a). Small-scale subsistence agriculture causes two-thirds of forest loss in Mozambique, followed by the expansion of urban areas and infrastructure, responsible for approximately 12%, logging with approximately 8%, and firewood and charcoal production responsible for 7% of forest loss (USAID, 2013).

The increase in population (about 29 million people in Mozambique today) generates a greater demand for land for agriculture. In Mozambique, fires are used as a tool for clearing up cultivated areas and for artisanal charcoal production and are responsible for the loss of 40 to 50 thousand hectares annually, with a slight reduction after 2010 (MITADER, 2018a).

By 2016, about 4,740,448 hectares of arable land were being cultivated, of which 4,363,294 hectares were cultivated and 377,154 hectares were left fallow (MASA, 2016). Small-scale agriculture (itinerant and dry farming) occupied an area of 4,594,945 hectares by 2015, of which 4,312,315 hectares were cultivated and 282,630 hectares were set-aside, while large-scale/commercial agriculture (large farms) occupied an area of 148,498 hectares, of which 53,981 hectares were cultivated and 94,517 hectares were set-aside (MASA, 2016).

Fuelwood and charcoal are the largest domestic fuels used by the population. And they satisfy more than 85% of total domestic energy needs, and up to 95% in rural areas. The consumption of woody fuels by large users is about 52.5 thousand tons (dry weight in the greenhouse) per year at the national level (MEF, 2017).

Mozambique is a country with vast mineral resource potential. In 2014, a total of 150 mapped mining concessions and 18 hydrocarbon projects were estimated (Bihale, 2016). These are concentrated in Manica, Tete, Zambézia and Cabo Delgado provinces and in some cases overlap with protected areas (MICOA, 2014). The growing discovery and exploitation of mineral resources is accompanied by the transformation and degradation of areas reserved for mining. This, coupled with the government's weak environmental oversight capacity, poses a significant threat to biodiversity, particularly in coastal and marine habitats where the impacts resulting from offshore oil and gas development in the Rovuma basin are still unknown.

In freshwater ecosystems, abstraction of water for human consumption, irrigation, industry in river basins can impose habitat change and degradation and, consequently, the reduction or loss of biodiversity.

3.1.2. Over-exploitation of certain species

The over-exploitation of flora species occurs mainly through wood exploitation. The country holds a high potential of natural forests for the wood industry. The current total commercial volume of forests in Mozambique was estimated at 123 million m^3, of which 4% belong to precious wood producing species, 21% to 1st class, 44% to 2nd class, 14% to 3rd class and 17% to 4th class (MITADER, 2018).

The exploitation levels of natural forest wood species have exceeded the permitted annual cutting volumes (515,700 to 640,500 m^3) due to a variety of unsustainable forest management practices (MITADER, 2018a). Sawn timber, sleepers, parquet, veneers, and panel wood are the main products of wood processing in Mozambique. Sawn timber production volume was 301,338 m^3 in 2016 against 192,271 m^3 in 2010. The volume of sleepers was 713 m^3 in 2016 against 2,762 m^3 in 2010.

The volume of licensed timber in 2017 was 255,492 m^3. On the other hand, the levels of logged timber have been dominated by illegally obtained tmber. In 2013, 93% of all commercial timber exploitation was illegal, against an average of 81% between 2007 and 2012. Current levels of overexploitation combined with illegal logging may contribute to the extinction of timber species in the long term, which will jeopardize the future of forests in Mozambique. The increase in inspection, and especially due to the entry into operation of AQUA (Environmental Quality Agency), increased the volumes of timber seized in 2016 and 2017 and the consequent reduction in illegal logging.

The over-exploitation of inland fauna occurs mainly through poaching of wildlife, which is the most visible cause of the reduction of wildlife populations. The most sought-after species include elephant (*Loxodonta africana*), rhinoceros (*Ceratotherium simum*), buffalo (*Syncerus caffer*), zebra (*Equus burchelli*), lion (*Panthera leo*), reedbuck (*Redunca arundinum*), cudo (*Tragelaphus strepsiceros*) and duikers (MICOA, 2014). Elephants have reduced in about 48% of herds in the last 6 years and in 2016 about 670 rhinos were illegally killed. Except for occasional records along the border between Mozambique and South Africa, rhinos are no longer present.

According to ASCLME/SWIOFP (2012b) overexploitation of fisheries resources causes a decrease in living marine resources (marine mammals, sea turtles; seabirds), commercial fish (pelagic and demersal) and invertebrate populations, as well as extreme by-catch and discards (ASCLME/SWIOFP, 2012b).

Illegal fishing has led to both extinction and threat levels of some species (e.g., some shark species that are still exploited), as well as a reduction in commercial catch volumes of some species. It was estimated in Maputo Bay that semi-industrial shrimp fishing for the production of 12.5 tons of shrimp per month captured about 50.8 tons of a diversity of marine fauna and discarded 36.4 tons (Machava *et al*., 2014). These figures represent a huge impact on local biodiversity, especially with regard to the functioning of the ecosystem for affected species. A study in 2011 "analyzed 34 species of small pelagics, demersal fish, and crustaceans, which contributed approximately 66 percent of total artisanal production. This study showed that 60 percent of these species are heavily exploited or overexploited" (Pereira *et al*., 2004 Cited by USAID, 2013). On the other hand, some fishing activities such as trawling and dredging can injure or kill benthic organisms and result in habitat damage and destruction.

The degradation of the habitat of aquatic mammals, for example by driving vehicles along beaches, which is common in Mozambique, may cause migration or mortality of the most sensitive species, such as sea turtles.

3.1.3. Invasion by non-native species

Biological invasion is one of the main determinants of biodiversity decline, causing socio-economic and human welfare impacts (Bacher *et al*. 2017). Anthropogenic pressure, land use change and climate change are causes that have accelerated invasion by these species in Mozambique (MITADER, 2018a).
Many animal and plant species have been introduced in Mozambique for commercial purposes (such as eucalyptus and pine trees), for livestock breeding and introduction into agroforestry systems (*Leucaena leucocephala* and *Azidirachta indica*), for ornamental purposes (*Lantana camera*), as common crow (*Corvus corvus*) and even for conservation purposes (Casuarina plantations along the coast) (MICOA, 2014).

Little is known about invasive species in Mozambique. Currently, about 53 plant species are considered invasive (MITADER, 2019a), with water hyacinth (*Eichornia crassipes*), water lettuce (*Pistia stratiotes*), salvina (*Salvina molesta*), water red fern (*Azolla filiculoides*), parrot feather (*Myriophyllom aquaticum*), lantana (*Lantana camara*) causing the greatest impacts on aquatic and terrestrial ecosystems, forestry and agriculture (MICOA, 2014).

Nile tilapia (*Oreochromis niloticus*) has been reported to have negative effects on the native fish fauna of Lake Cahora Bassa. The Indian crow (Corvus splendens), an invasive bird, has seen a considerable increase in the number of species, which can displace and harm native bird populations (USAID, 2013). Different size classes of *Cherax quadricarinatus* (which is considered a non-native crayfish) including ovigerous females, were caught in the Pequenos Libombos Lagoon in southern Mozambique, indicating that this crayfish is already established in this ecosystem (Chivambo *et al*., 2011; 2019).

Since 2014/5, two new exotic species of shrimp are captured by artisanal and commercial fishers in Mozambican waters. These are *Mierspenaeopsis sculptilis* (Heller, 1862) and *Metapenaeus dobsoni*. It is not clear how the two species were introduced in Mozambican. Both are native to the Indo-West Pacific, were also commercially exploited (Simbine, 2015).

3.1.4. Pollution or contamination of natural habitats or species

There is greater potential for pollution in the vicinity of industrial and urban developments (including sewage effluent and oil and chemical manufacturing plants and ports), as well as agricultural activity. Industrial activities have caused both air and water and soil pollution.
There are 15 sites in the country contaminated by persistent organic pollutants (POPs) and obsolete pesticides, namely Nguri, Unango, Matama, Lichinga hospital, Lichinga military base, Nacala, Muziva,

Ifloma, Lamego, Beira CFPA, ChokweBarro, Chokwe ICM, Matola PAS, Matola WS, MatolaFrigo and Matola SDAE.

Freshwater pollution comes from many sources such as untreated human and industry wastewater, pesticides and fertilizers from agriculture. Contaminations of freshwater ecosystems are seen almost around the world. Although we do not have real figures of what is happening in Mozambique signs of pollution such as eutrophication in some reservoirs like Pequenos Libombos, Corumana, Massingir and CaboraBassa are apparent, however further studies to assess the degree of biodiversity loss need to be done.

In 2015, in all watersheds of the South region high levels of turbidity were recorded compared to other years. The high turbidity was due to the concentration of suspended particles in the water causing a darker color and the continuous presence of sediments in the basin.

Environmental problems in mining include mercury pollution (pollution levels exceeded the annual average recommended by WHO (26μg/m3 against 20 μg/m3 with PM10), cyanide pollution, direct discharge of effluent into rivers, acid drainage, incorrect closure, damage to rivers in alluvial areas, silting of rivers and many others (MITADER, 2018a).

For the disposal and treatment of the solid waste produced, the country does not have adequate infrastructure, making the deposit in open dumps, receiving approximately 2.5 million tons of waste per year. In the peripheral areas of the municipalities, the burning of waste by residents is a common practice, as access to waste collection trucks on residential roads is limited.

In Mozambique, the treatment of liquid effluents is still deficient. Extensive areas of Maputo and Beira cities and other urban areas resort to septic tanks, while most use improved latrines. In coastal areas, untreated sewage contaminates aquatic ecosystems, causing pollution and coral destruction (MICOA, 2014).

Mozambique has enormous potential for aquaculture development. Although the development of aquaculture in Mozambique plays an important role in the socio-economic development of the country: providing cheap protein, improving the population's diet, creating jobs, generating income and promoting regional development, attention should be deserved because coastal aquaculture is potentially source of organic pollution turning freshwater ecosystem to eutrophication condition.

3.1.5. Climate change that damages natural habitats or species

Climate change is a potential threat of unknown magnitude that may accentuate other direct threats, especially habitat loss, degradation and fragmentation, and threats from invasive species. These include changes in rainfall patterns, sedimentation, increased frequency and/or intensity of meteorological phenomena (e.g., cyclones), temperature increases, severe floods, and droughts, etc., which disrupt the natural functioning of ecosystems and can cause critical changes and habitat loss.

Mozambique is the 4th most vulnerable country to natural disasters in Africa. Some examples recorded in Mozambique are coral bleaching after the 1998 El Niño event, and the massive loss of mangroves after cyclones Eline (2000) and Idai (2019) in the Limpopo Estuary, Save delta and Buzí and Pungue estuaries (Bandeira and Balidy, 2016; Macamo *et al*., 2016; PDNA, 2019). In marine environment there is Ocean acidification; water temperature change; changes in productivity (ASCLME/SWIOFP, 2012b).

The monthly maximum and minimum temperatures registered in the country have been increasing. Because of the temperature changes around 20 to 30% of the plant and animal species so far assessed as being at risk, they may suffer a mass extinction if the temperature exceeds 2 to 3°C above the pre-industrialization level (Zolho, 2010).

Rainfall has also shown an increase, with an annual average of 600 to 1000 mm in the south and 800 to 1400 mm in the north. Extreme weather events, such as droughts and floods, are likely to become more frequent and intense.

The increase in ocean temperatures will also have an effect on marine species and ecosystems, especially corals. However, apart from slight variations in Maputo Bay, no notable differences have been observed on a national scale (MITADER, 2018a).

In the last 50 years, the most extreme values of sea level have not exceeded 1 meter in the southern region and 2 meters in the northern. Incentral region of the Mozambican coast, the sea level has increased to almost 3 meters (Bié, 2017) (MITADER, 2018a). The rise in sea level will also shift the intertidal hydrological regime towards the interior, thus displacing suitable areas for mangroves (USAID, 2013).

The main disasters affecting Mozambique are floods, cyclones, droughts and, to a lesser extent, earthquakes (UNECA, 2015). From 1980 to 2016, 27 flood events, 12 drought events, 16 tropical cyclones and 27 epidemics were recorded (INGC, 2017). Recently, in 2019 cyclones IDAI and Kenneth severely devastated the central and northern provinces of Mozambique, the damage of which was estimated and about US$1.5 billion, with about US$80 million going to the environment sector (GoM, 2019). Exposure to natural disaster risk in the country (floods, cyclones, droughts and, to a lesser extent, earthquakes) is expected to increase significantly over the next 20 years and impacts related to climate change will impose additional pressures on biodiversity. It is the capacity for mitigation and adaptation that will dictate the magnitude of climate change impacts on biodiversity in Mozambique.

3.2. National Level Assessment - Expert-based Threat Assessment Tool (EBTAT)

Eighteen (18) Experts from thematic groups identified a total of 64 level-two and level-three threats as having an impact on at least one biological target. Plants, Mammals and herpetofauna taxonomic domains were top ranked, while ecosystems were ranked as less impacted (Fig. 8A). Biological resource use, agriculture and aquaculture as well as energy production & mining, were the top ranked threats domains (Fig. 8B), while Commercial and industrial areas, Mining & quarrying, Housing & urban areas, Logging & wood harvesting, Habitat shifting & alteration, Oil & gas drilling were top-ranked level-two and level-three threats (Fig. 9). For more details on the results of EBTAT, see Annex D.

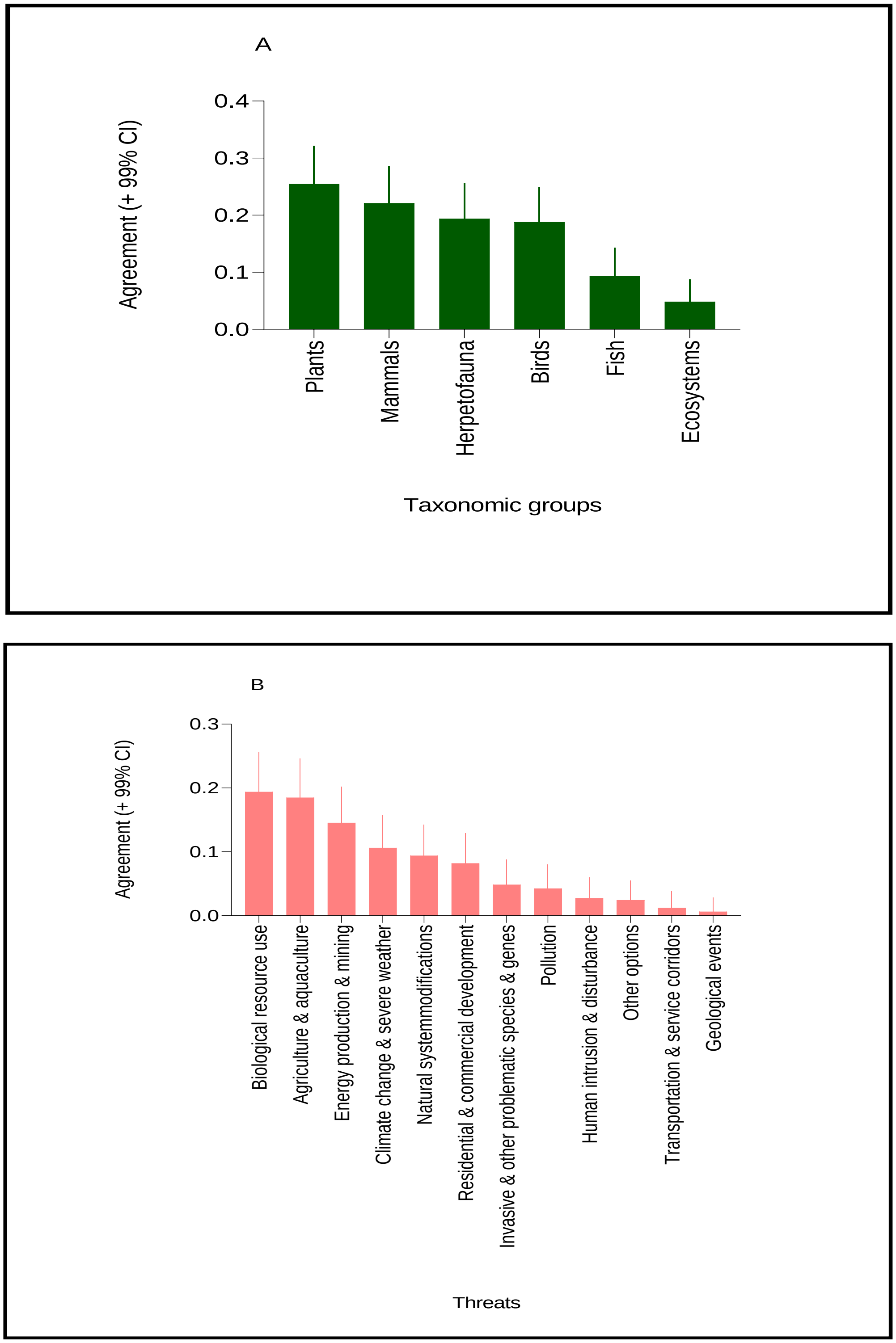


Figure 8A-B: Threat frequency agreement on taxonomic groups and domais of IUCN-CMP Threat Classification System level-one reported by experts using the Expert-based Threat Assessment Tool (EBTAT).

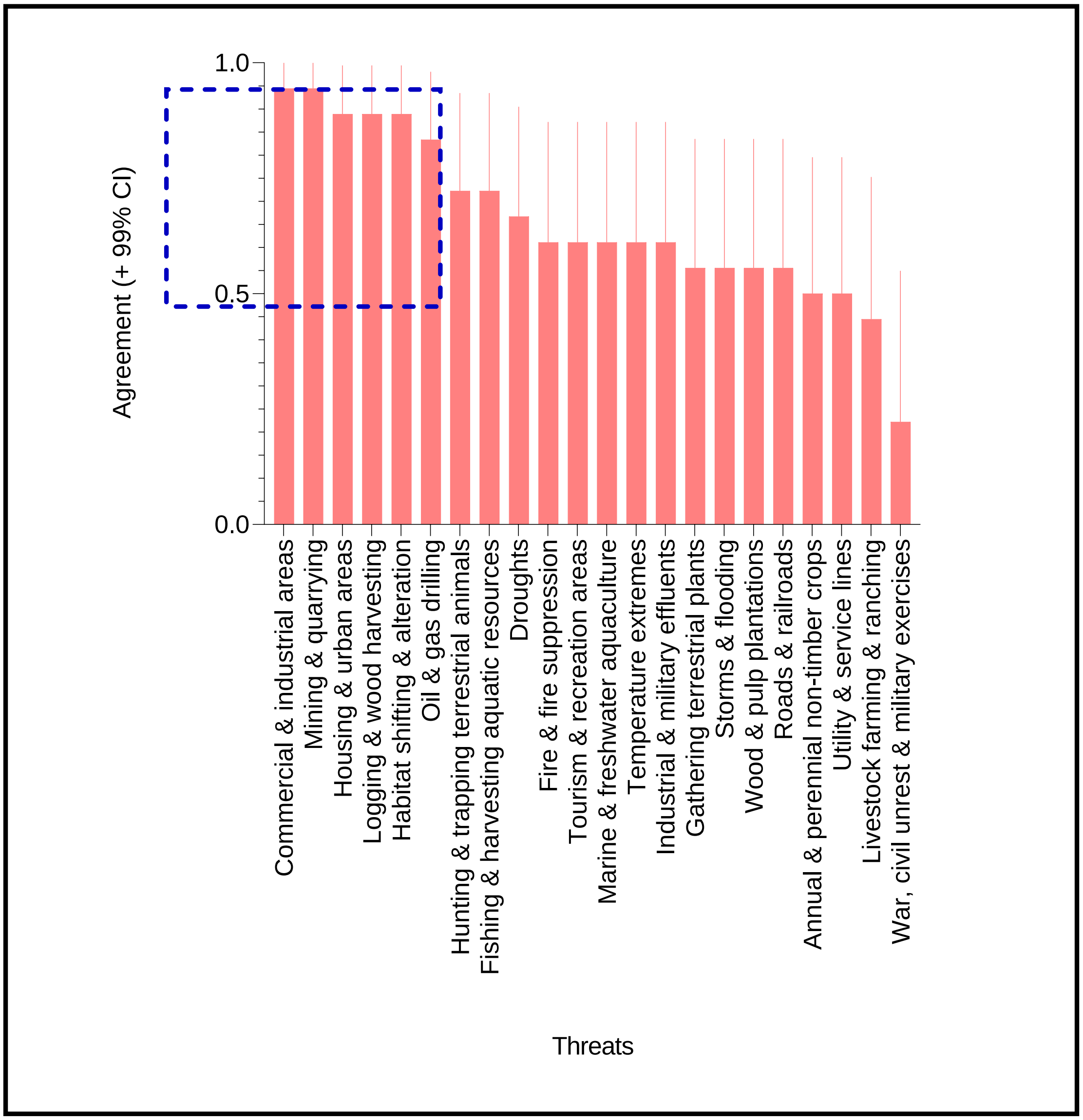


Figure 9: Threats agreement frequency of IUCN-CMP Threat Classification System level-two reported by experts using the Expert-based Threat Assessment Tool (EBTAT).

Residential & commercial development

Table 17: Threat ratings of *Residential & Commercial Development* on target species and ecosystems in Mozambique (Very high (Very relevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant) +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Housing & urban areas	++++	+++	++++	+++	-	+++	-	++++
Commercial	++++	+	-	++++	-	+++	++++	++++

& industrial areas								
Tourism & recreation areas	-	-	-	-		+	-	-

In general, the experts mentioned that 3 threats in this domain have an impact on mammals. But plants and terrestrial ecosystems suffer much more from urban & Housing and Commercial & industrial areas. These threats were classified by experts as continuing threats and with minor effects and severity on some populations, but very relevant for others. For instances, according to experts, Housing & urban areas and Commercial & industrial areas may impose severe threats to plants, marine biodiversity, mangrove and terrestrial ecosystems.

Urban and industrial development on the coast have reduced mangrove cover and fishing resources. For instances, the change of 44% in area of mangrove forests since 1958 in Maputo Bay, was linked urbanisation (de Boer, 2002). Urban expansion was also pointed as major concern by Macamo *et al*. (2016) and Sayer *et al*. (2019). These authors have noted that many studies indicate relatively good conservation condition of the most remote habitats, while those close to large human settlements show higher levels of stress or degradation. Macamo *et al*. (2016) pointed that signicant changes have also been reported on Seagrass beds and Coral reefs in densely populated areas (Moz Island, Nacala Bay, Maputo Bay); death by unknown causes at Inhassoro / Vilankulos decreasing (UNEP, 2009; UNEP, 2015; Obura, 2012; Obura *et al*., 2012; UNEP, 2015). In some specific areas of the interior, such as the cities of Nampula and Tete, urbanization has been having significant impacts on plant cover and terrestrial ecosystems. Pollution from urban sources is a serious threat, with the most affected areas coinciding with areas of greatest species richness (the shallow waters of southern Lake Niassa) (Sayer *et al*., 2019).

Both experts and assessors representing government institutions, private sector, and NGOs reported that, despite much existing legislation on land use planning and land use cover coverage plans, there are challenges in its implementation. Since the vast majority of the population in Mozambique resides in the coastal zone, mangroves, Seagrass beds, Coral reefs and marine biodiversity suffer much more from the effects of Residential & commercial development.

According to Niquice *et al*. (2017), it is likely that in the long-term cropland will continue to grow due to the need for food production to address the increasing population of the country (World Bank, 2016).

This will have an important impact on ecosystem services provided mostly by shrubland and grasslands, as these are the land covers that will most likely change into cropland.

In order to ensure the protection of biodiversity of coastal ecosystems, Mozambique has adopted several approaches. This includes reviewing, updating and creating new instruments in the legislative and strategic frameworks in order to respond to the increasing challenges to the conservation of coastal ecosystems in Mozambique. Recent and innovative tools include the Sea Policy (POLMAR) and the recently approved (2020) Mangrove Management Strategy and Action Plan. The country has also adopted more integrated intervention approaches, such as marine spatial planning, where the harmonization of conservation and strategic development actions is assigned, involving all stakeholders. Initiatives such as the promotion of the blue economy and nature based solutions are also stimulated in government interventions and in most programs implemented by organizations linked to the environment. In practice these translates into the creation of new conservation areas, expansion of existent areas, legislation enforcement, habitat restoration, etc.

Agriculture & aquaculture

Table 18: Threat ratings of *Agriculture & aquaculture* on target species and ecosystems in Mozambique (Very high (Veryrelevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant) +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Annual & perennial non-timber crops	++++	++++	++++	-	++++	+++	-	++
Wood & pulp plantations	+++	+++	-	-	-	+++	-	++
Livestock farming & ranching	+++	+	-	-	-	+++	-	++
Marine & freshwater aquaculture	+++	+	-	++++	-	+	++	-

Annual & perennial non-timber crops have been referred to by experts as having a significant impact on plants, herpetofauna and birds. In addition to plants the four threats in this domain have impact on hepetofauna and mammals. Thus, Annual & perennial non-timber crops were indicated as being a priority threat for conservation action for plants, herpetofauna, birds and mammals. Assessors reported that Shifting Agriculture, Small-holder Farming and Agro-industry Farming convert annually extensive areas of natural vegetation in areas of maize, rice, beans, cassava, sugar cane and banana monocultures, and constitute a main causes of habitat loss and land cover changes (Niquisse, 2017; MITADER, 2018b). In general, in Mozambique these are continuing threats mainly to mammals, herpetofauna, birds, plants and terrestrial ecosystems and may affects the minority of the herpetofauna populations, but majority (50 to 90%) of the ecosystems. Annual & perennial non-timber crops were also considered by experts as top severity threat to terrestrial ecosystems, herpetofauna and birds; contributes about 86% of annual deforestation (MITADER, 2018b) mainly in the provinces of Nampula, Zambézia and Manica. As concluded by Millennium Ecosystem Assessment (MA), agriculture is the primary driver of habitat loss in all human-dominated landscapes (Millennium Ecosystem Assessment, 2005); promotes habitat loss, fragmentation and habitats conversion and hence to a reduction in the number and abundance of species that can be supported on unconverted land (Perrings and Halkos, 2015). Freshwater biodiversity was also driven by agricultural expansion, most due to **i)** land use change leading to drainage of wetlands, or deforestation and resulting increased sedimentation; **ii)** pollution from agricultural sources; and **iii)** poor water management leading to over-abstraction of water (Sayer *et al*., 2019).

At least 756,058 ha were owned by forest plantation development companies in 2013 and of these, 58,763 ha were planted (MA, 2015). For example, only the area of Portucel Mozambique totals 360 thousand hectares, of which 270 thousand hectares are intended for planting with species of the genus Eucalyptus (non-native and invasive spicies) in the provinces of Manica and Zambézia (Aquino *et al*., 2018). Government officials have reported fears that forest plantations will interfere with water management and this may contribute to altering the quality of habitats for dependent species such as plants, amphibians and some mammals. A similar feeling was expressed in relation to Livestock farming & extensive ranching. Although Marine & freshwater aquaculture in Mozambique is a relatively new activity, the culture of tilapia backs since the 1950s, whereas the cultivation of marine species has emerged over the last five years. Marine & freshwater aquaculture is potentially source of organic pollution turning freshwater ecosystem to eutrophication (Pruder, 1986). Although real figures are lacking what is happening in Mozambique signs of pollution such as eutrophication in some reservoirs (*e*.g., Pequenos Libombos, Corumana, Massingir and Cabora Bassa) are real, however further studies to assess the degree of biodiversity loss need to be done.

Energy production & mining

Table 19: Threat ratings of *Energy production & mining* on target species and ecosystems in Mozambique (Very high (Veryrelevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Oil & gas drilling	++++	+++	-	+++	-	+++	++	++++
Mining & quarrying	++++	+++	+	+++	-	+++	++++	++++

The impact of Oil & gas drilling and Mining & quarrying was considered by experts to be very high for plants, mangroves and terrestrial ecosystems and high for herpetofauna, freshwater fish marine biodiversity and mammals. Both, although they have low STAR Threat Abatement Score (see section 3.4), were also considered by government officials to be of significant impact and are therefore a Priority for Conservation Action. The extractive industry in Mozambique has been growing and occupying extensive areas in the land area (for example Tete, Manica and Zambézia provinces) as well as in the coastal and marine areas (for example in the provinces of Cabo Delgado and Nampula) (EITI, 2018). For example, coal mining in Tete province as well as the oil and gas industry in Inhambane province can pose a threat to terrestrial flora and its ecosystems. On the other hand, the exploitation of hydrocarbons in the province of Cabo Delgado and heavy sands in the coastal zone can threaten mangroves and marine biodiversity (CU, 2013).

Of concern were inadequate knowledge and awareness as well as the lack of knowledge on ecosystems biodiversity and ecological functioning, which hamper decision-making process. Assessors representing government institutions, private sector, and NGOs stressed the unplanned development and lack of law enforcement.

Transportation & service corridors

Table 20: Threat ratings of *Transportation & service corridors* on target species and ecosystems in Mozambique (Very high (Veryrelevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Roads & railroads	+++	-	-	-	-	++++	-	++++
Utility & service	+++	-	-	-	+	+++	-	++++

lines								

Transportation & service corridor was considered by experts to be of very high impact on mammals and terrestrial ecosystems. Although this threat is not considered a priority for Conservation Action, Roads & railroads and Utility & service lines are top of the government agenda. For instances, around 2018, there were about 19,170 km of roads, of which 12,603 km of tertiary roads and 6,567 km of back roads (MITADER, 2018b) and four major urban polarizations (Maputo, Beira, Nampula / Nacala and Tete) structuring three more dynamic cross-cutting development corridors (MITADER, 2019b). Indirectly, roads cause the reduction of the total area of an ecosystem, by the conversion of the original land cover into an artificial surface, which reduce the capability of an ecosystem to sustain its original biodiversity; directly may pose fragmentation and degradation of ecosystems (Geneletti, 2003). As an added impact, roads act as barriers to animal movements, increase their mortality rates and cause other negative impacts on biodiversity (Vaiškūnaitė *et al*., 2012), as now observed in the Maputo Special Reserve.

Biological resource use

Table 21: Threat ratings of *Biological resource use* on target species and ecosystems in Mozambique (Very high (Veryrelevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant) +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Hunting & trapping terrestrial animals	+++	+++	-	-	++++	++++	-	++++
Gathering terrestrial plants	++++	+++	-	-	+++	+++	-	++
Logging & wood harvesting	++++	++++	-	-	+++	++++	++++	++++
Fishing & harvesting aquatic resources	+++	++	++++	++++	-	+++	++++	-

Activities associated with Biological Resource Use appear to have the greatest reported impact on plants, herpetofauna, marine biodiversity, birds, mammals, freshwater fish, mangrove and terrestrial ecosystems. Experts reported very high impact of Hunting & trapping terrestrial birds and mammals; Gathering terrestrial plants may pose high impact on plants; Logging & wood harvesting was reported to impact plants, herpetofauna, mammals, mangrove and terrestrial ecosystems and Fishing & harvesting aquatic resources has Very High impacts to Marine biodiversity and mangrove.

According to assessors, rural subsistence living is most based on land and associated resources (Ntumi *et al.*, 2012), which in turn may pose risk to biodiversity. For instances, subsistence hunting and simple licenses for Logging & wood harvesting, firewood and Coal are common across the country (MITADER, 2018b), whose control is difficult. Although poaching aimed at large animals such as rhinos, elephant and lion has significantly reduced, government advisers noted that hunting for meat remains a challenge (Lindsey *et al*., 2012) and continues to decimate many species in almost all conservation areas in the country. Hunting birds for consumption in rural areas is not prohibited and certain problematic species such as the Indian crow (*Corvus splenderis*) have been officially declared a campaign for their elimination on the island of Inhaca. On the other hand, slaughter of animals considered problematic in response to a legal command in the management of conflict between humans and wildlife contributed to the reduction of some populations. For example, between 2006 and 2014, 607 crocodiles; 260 elephants; 140 hippos and 34 lions were killed in retaliation due to damage caused to humans (Dunham *et al*., 2010; Ntumi *et al*., 2016).

Fishing & harvesting aquatic resources (trawling, beach seining, long lining, among other) are the most widespread and common fishery in Moçambique. Under fishing activities, many species are posing on risk. For instances, sea turtles anthropogenic induced threats in Mozambique are related to fishing activities as well as coastal development interference with nesting sites and habitat degradation. Estimates suggest that thousands of turtles are bycatch in the commercial shrimp fishery in Sofala Bank. Direct exploitation of eggs and meat (both serve as food to coastal population) and shell (artisanal value) of sea turtles is still an issue in the country (Bourjea, 2015). Potential major concern for the conservation of turtles is the recent discovery of gas fields in the Mozambique Channel. As for sea turtles, marine mammals, coral reefs, seagrasses and mangrove all are impacted by fishing activities.

Overfishing and fisheries targeting spawning aggregations and refuge areas are threats of major concern (van der Elst, 2015). The elasmobranchs fished in the country are captured by all fisheries both, as target species and by-catch, being eventually discarded or kept. They represent by-catch particularly for the shrimp fishery (Kiszka and van der Elst, 2015). Many elasmobranchs are also capturedby illegal fishing activities for international trade. In recent study (see Sayer *et al*., 2019), over-harvesting in Lake Niassa was identified as the major threat to freshwater biodiversity and leads to direct mortality of individuals, as well as degradation of habitats due to destructive fishing methods.

Natural System Modification

Table 22: Threat ratings of *Natural System Modification* on target species and ecosystems in Mozambique (Very high (Veryrelevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant) +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Fire & Fire Suppression	++++	+	-	-	++++	++++	-	++++
Dams & Water Management/Use	+++	+	-	-	+++	+++	-	++
Other Ecosystem Modifications	++	+	-	-	+++	+++	+++	++

Among the threats in this field, experts indicated that Fire & Fire Suppression had very high impact on plants, terrestrial ecosystems and on mammal's habitats. As also recognized by assessors representing government institutions, private sector, and NGOs, fires are one of the main factors in deforestation and forest degradation in Mozambique. During the last 10 years, between 40 and 50 thousand hectares have been burned annually (MITADER, 2018b). Ribeiro *et al*. (2007) documented changes on species diversity, composition and the overall structure of the woodlands in the Niassa Especial Reserve. These authors have postulated that with increasing fire frequency the woodlands of the eastern Niassa Reserve would evolve to a more homogenous ecosystem dominated by a few disturbance-resistant species, with less woody density and higher grass biomass (Ribeiro *et al*., 2007), which can reshape animal distribution. It thus follows that Fire & Fire Suppression was considered as Priority for Conservation Action.

Climate change & severe weather

Table 23: Threat ratings of *Climate change & severe weather* on target species and ecosystems in Mozambique (Very high (Veryrelevant) ++++, High (Relevant) +++, Medium (Moderately relevant) ++, Low (Not relevant) +).

Threats	Plants	Herpetofauna	Freshwater fish	Marine biodiversity	Birds	Mammals	Mangrove	Terrestrial ecosystems
Habitat shifting & alteration	++++	++++	-	+++	+	++++	++++	+
Droughts	++++	+++	-	++	-	++++		+
Temperatur e extremes	+++	+++	-	++++	-	+++	++++	-

Storms & flooding	++++	+++	-	++++	-	-	++++	-

Climate change & severe weather was believed by experts to have very high impact to plants, herpetofauna, Marine biodiversity, mammals and mangrove. More specifically, climate change is most likely to exacerbate the impacts of habitat shifting & alteration for those known as for terrestrial amphibian, bird, mammal, and reptile species (Segan *et al*., 2016). Government officials supported the notion of considering a Priority for Conservation Action, because many other threats may end up to habitat shifting & alteration. Excluding very few remnant areas in the country, others have experienced changes that resulted in some species extinctions.

Climatic events are known to alter the timing of species life cycle events, change radically species distributions, affecting trophic networks and severely impairing ecosystem functioning (Bellard *et al*., 2012). In Mozambique this is mostly true in coastal and marine ecosystems, which are permanently being impacted.

Here, climate and natural processes changes include changes in rainfall patterns, sedimentation, increased frequency and/or intensity of meteorological phenomena (ex. cyclones), temperature rise, severe flooding and drought, etc, which disrupt the natural functionality of ecosystems and may cause critical changes and habitat loss. A few examples recorded in Mozambique are coral bleaching after the 1998 El Niño event, and massive mangrove loss after cyclones Eline (2000) and Idai (2019) in the Limpopo estuary, Save delta and Buzí and Púngue estuaries (Bandeira and Balidy, 2016; Macamo *et al*., 2016; PDNA, 2019).

3.3. Nacional Level Assessment - Simplified Threat Assessment Tool (STAT)

Twenty three (23) assessors representing government institutions, private sector, and NGOs (See Annex A, Table 2) identified a total of 13 (level-two) threats using the IUCN-CMP Threat Classification System through the Simplified Threat Assessment Methodology (STAM). Out of these, five were perceived by them to be top threats, and have the greatest impact on biodiversity in Mozambique (Figure 10). For instances, Annual & perennial non-timber crops, Logging & wood harvesting, Mining, Oil and gás, Fishing and harvesting and Fire & fire suppression, were reported by more than 80% of assessors as having the greatest impact on biodiversity in Mozambique.

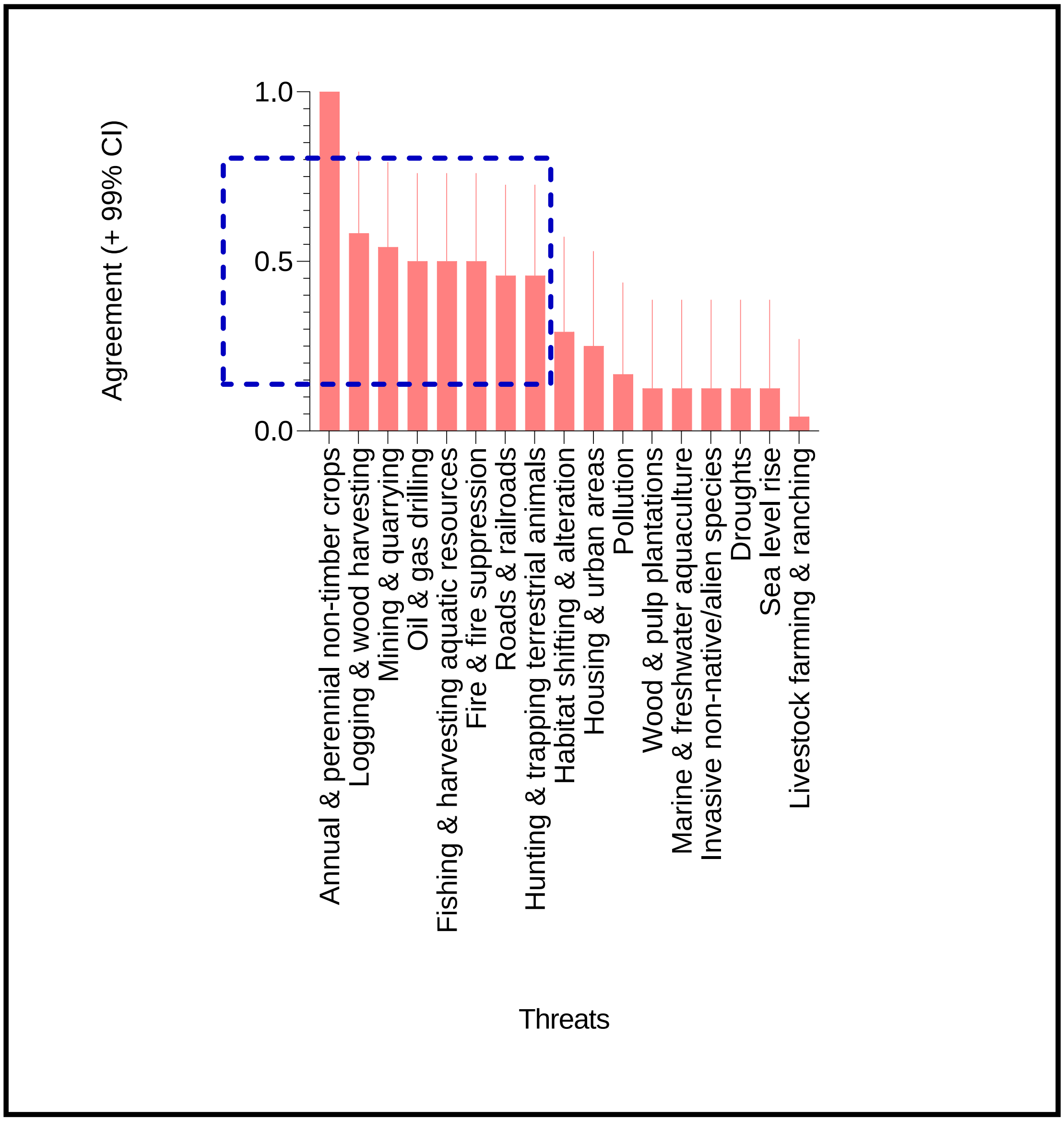
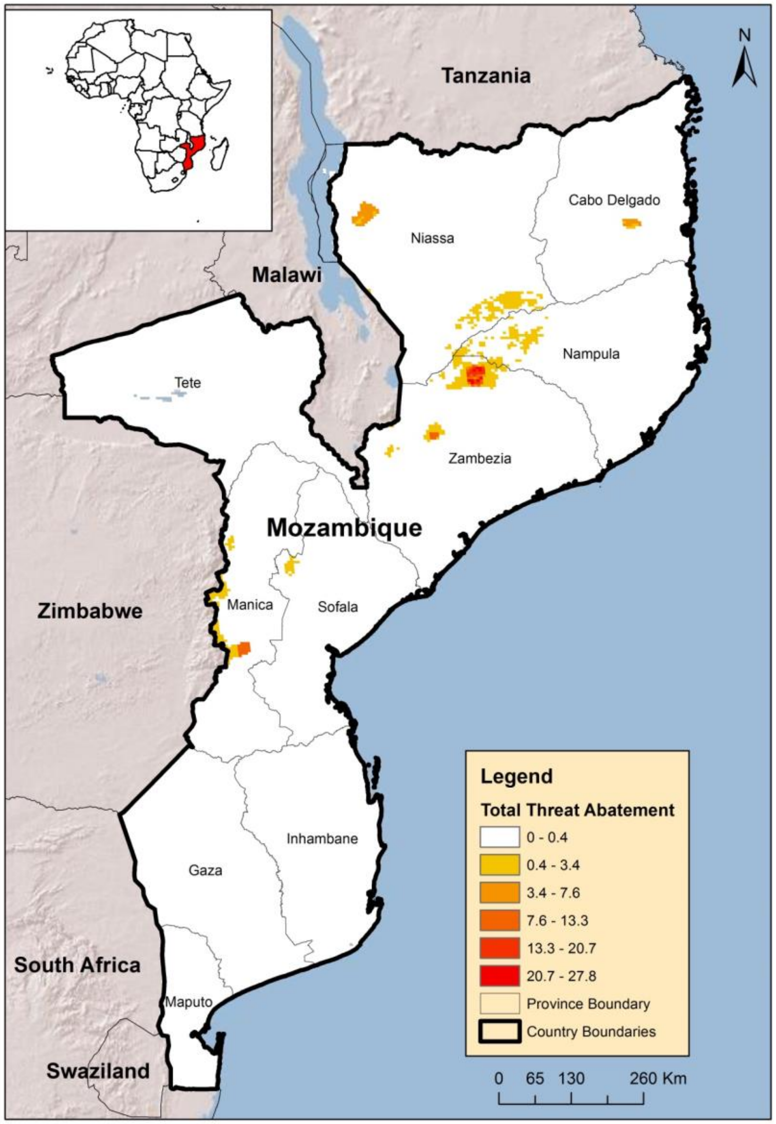


Figure 10: Frequency of IUCN-CMP Threat Classification System level-two threats reported by government officials and private and civil society using the Simplified Threat Assessment Tool (STAT).

3.4. National Level Assessment - STAR Metric Scores

The STAR score for Mozambique for terrestrial mammals, birds and amphibians is 3,153, where the threat abatement score is 2,730 (87% of the national STAR score) and the restoration score is 423 (13% of the national STAR score). Mozambique contributes 0.22% of the global STAR scores.



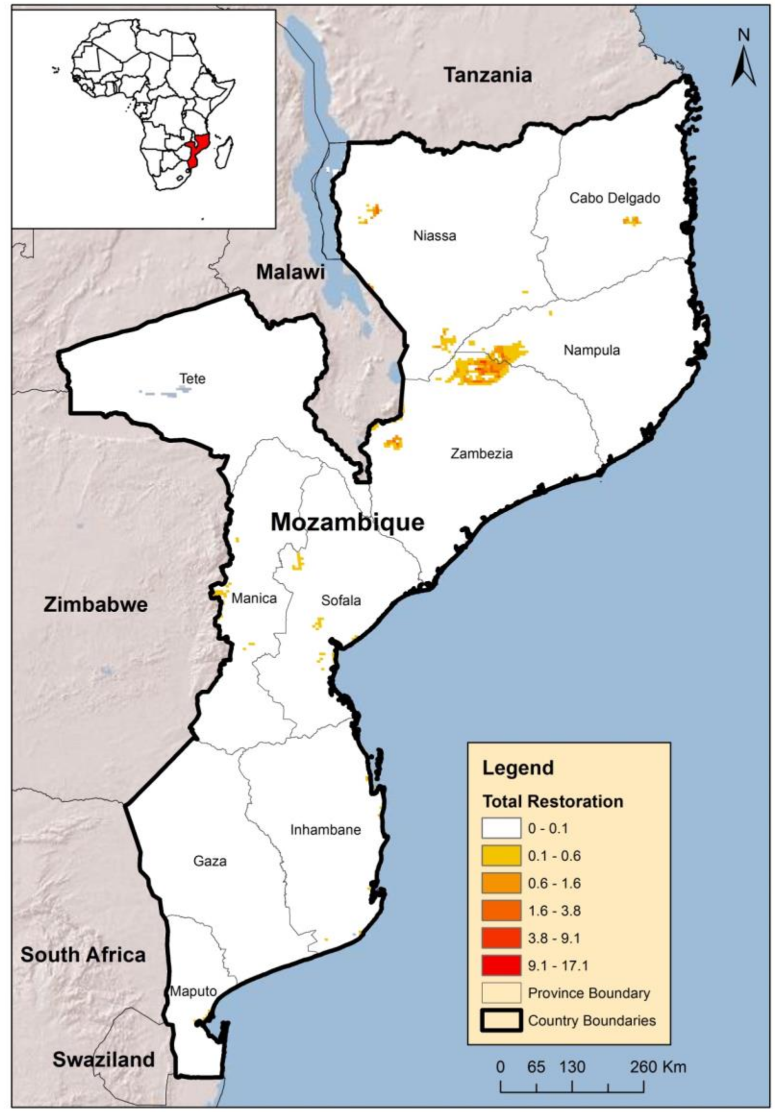


Figure 11: Mapped STAR Scores for Mozambique showing threat scores per grid cell (left) and restoration scores per grid cell (right) at the 10km resolution.

STAR Metric threat abatement approach has identified areas with the highest potential for threat abatement and restoration in the country (see Fig. 11). For instance, the areas with the highest potential for threat abatement and restoration in Mozambique are coincidentally the same (Lioma and Gurue in the Zambezia province) and Chimanimani National Park (Manica province), Lichinga and Chimbonila (Niassa province) and Namanhumbir (Cabo Delgado province). In general, those areas from Zambezia province are threatened by agriculture, Mining & quarrying, Housing & urban áreas, Habitat shifting, Annual & perennial non-timber crops, Wood & pulp plantations, Roads & railroads, Logging & wood harvesting and Fire & fire suppression. Mining & quarrying is also a threat at Chimanimani National Park and Namanhumbir. Wood & pulp plantations and Housing & urban areas were identified as major threats at Lichinga and Chimbonila.

Biological resource use, Agriculture & aquaculture, Energy production & mining, Climate change & severe weather and Natural system modifications threats domains had top ranked scores at the national scale (Fig. 12 A).

Annual & perennial non-timber crops had the highest STAR threat abatement score of 575, followed by Logging & wood harvesting with a score of 465; Fire & fire suppression scored 458; Habitat shifting & alteration scored 297 and Hunting & trapping terrestrial animals scored 178. Roads & railroads, Invasive non-native/alien species, Mining & quarrying, Livestock farming & ranching had STAR threat abatement scores below 100, while threats as Fishing & harvesting aquatic resources, Gathering terrestrial plants, Oil & gas drilling scores below 10 (Fig. 12 B).

As for amphibia, mammals and birds, STAR approach has experimentally demonstrated potentialities in identifying threats that should be tackled to increase endangered species survival. Near Threatened, endangered and vulnerable birds; critically and endangered mammals as well as endangered and vulnerable amphibians were the Taxonomic Group highly scored (Fig 13). Among amphibians, *Mertensophryne anotis* was highly scored, while *Mertensophryne anotis* (bird) and *Paraxerus vincenti* (mammal) were also highly scored (Fig. 14 A and B). Threats abatement highly scored were also highly scored for restoration.

Threats abatement scores at species level indicated that four species (*Paraxerus vincenti*, *Artisornis sousae*, *Rhinolophus mabuensis* and *Mertensophryne anotis* represent 40% of the country's Total Threats abatement scores (Fig. 15A), which may be due to the fact that *Paraxerus vincenti*, *Artisornis sousae* and *Rhinolophus mabuensis* are both endemic species, and endemic species tend to increase the

STAR scores. This may suggest if actions were focused on tackling the threats on these species, then the STAR score would be reduced dramatically. On the other hand, it allowed analyzing in detail the contribution of each threat to the risk of species extinction, as shown in Fig. 15B for the buffalo.

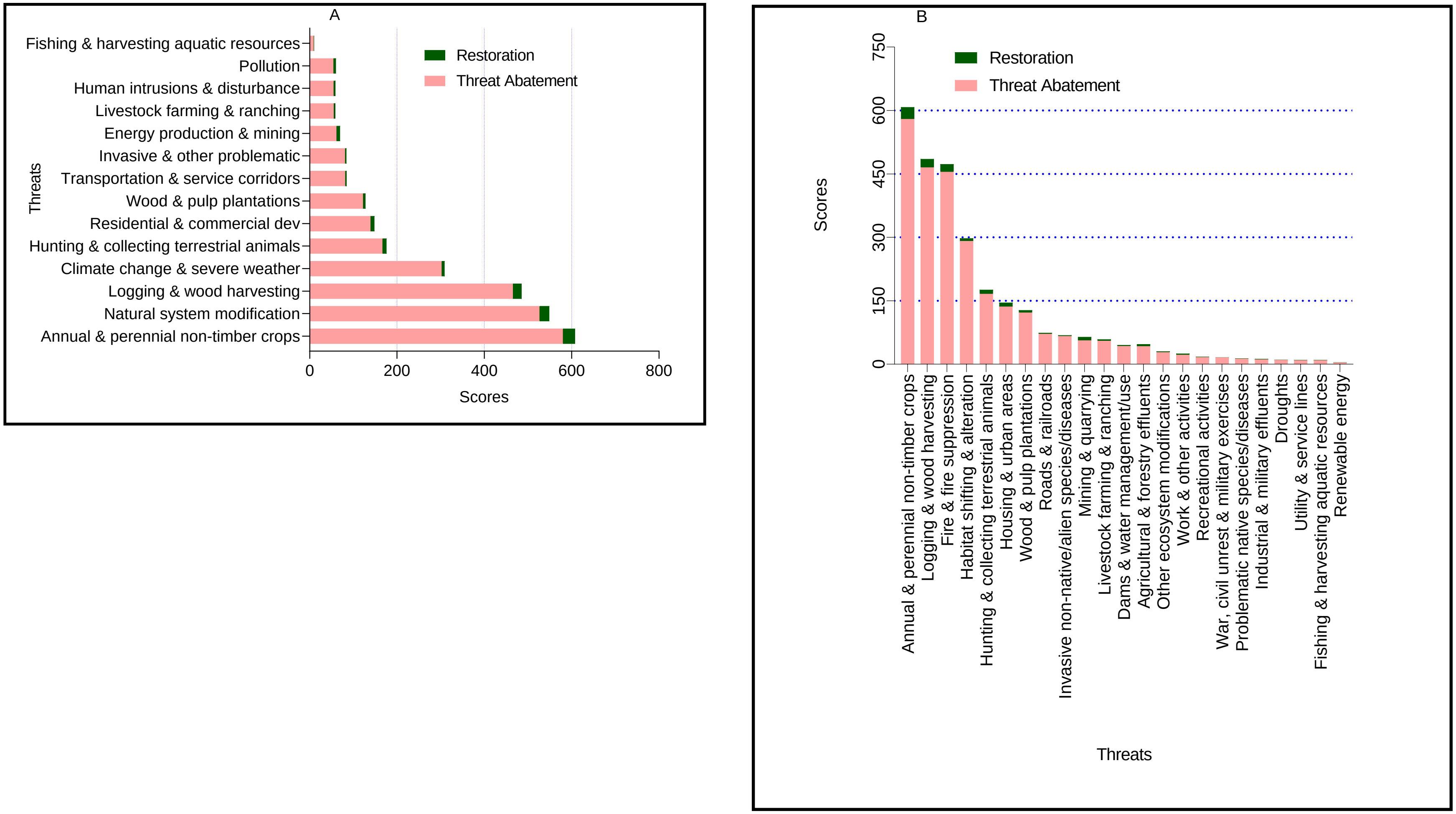


Figure 12A-B: STAR Threat abatement and restoration scores for IUCN-CMP Classification System level-one (A) and two (B) threats for Mozambique.

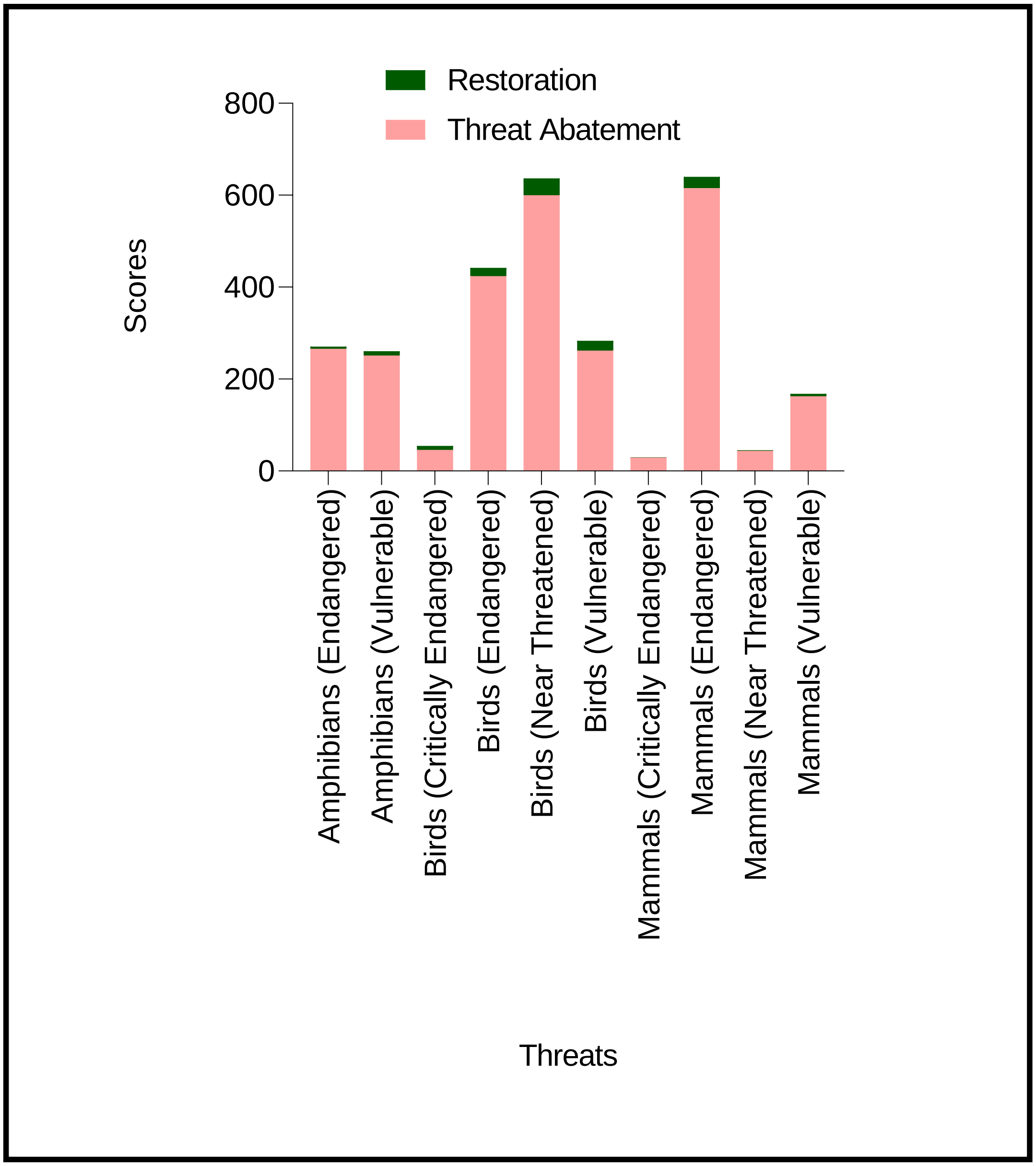


Figure 13: Species STAR Threats abatement scores for Mozambique.

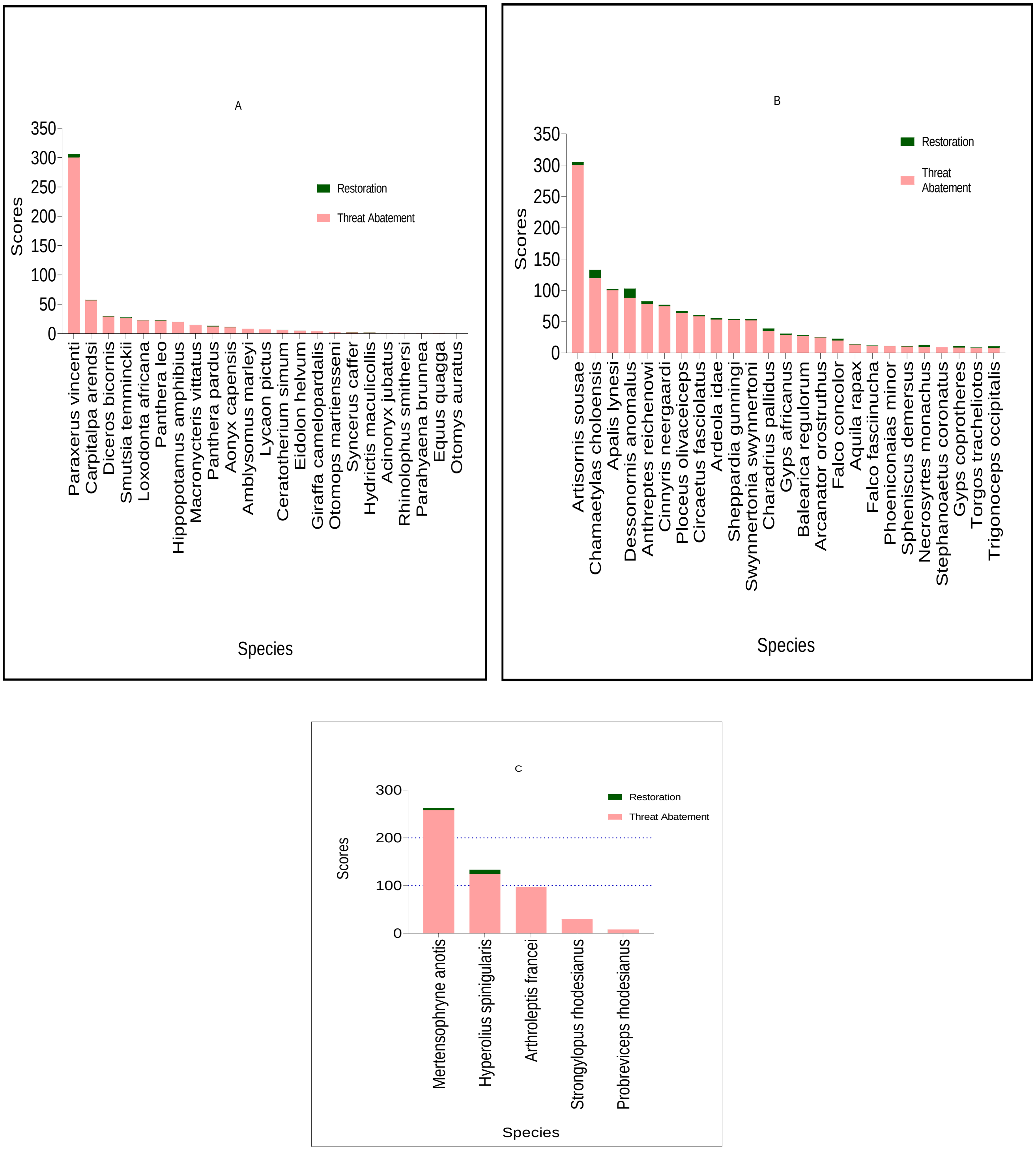
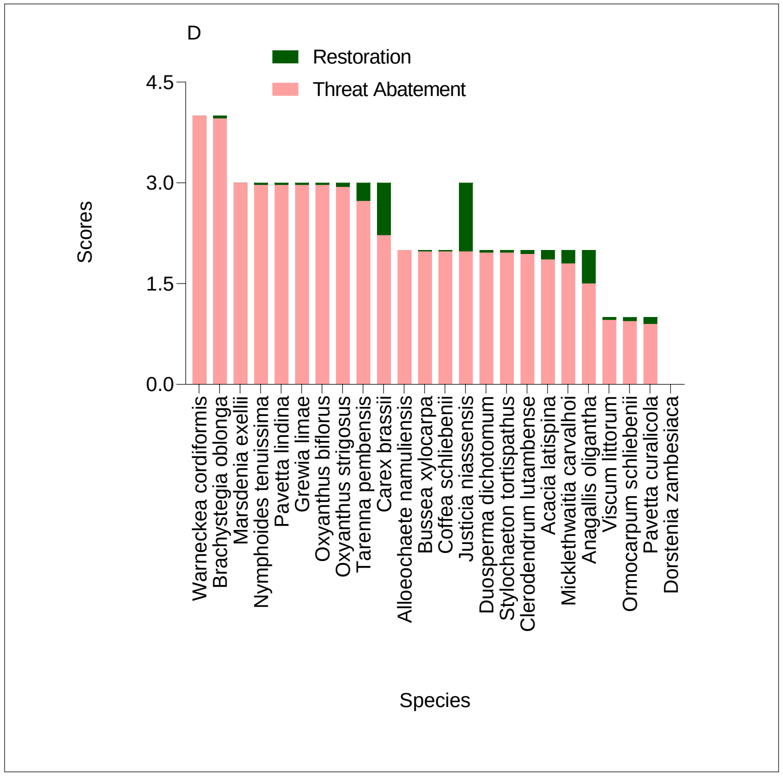


Figure 14 A: STAR Threats abatement by taxonomic groups in Mozambique (A: mammals; B: birds; C: amphibian) that were calculated by the global team.



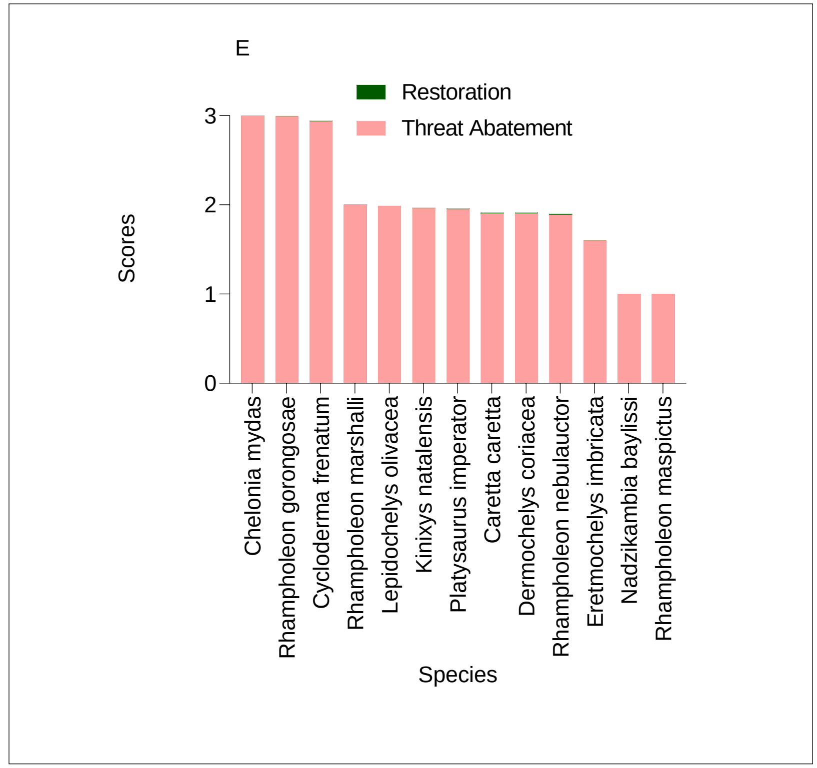


Figure 14B: STAR Threats abatement by taxonomic groups in Mozambique (D: plants and E: reptiles), that were calculated by the country team.

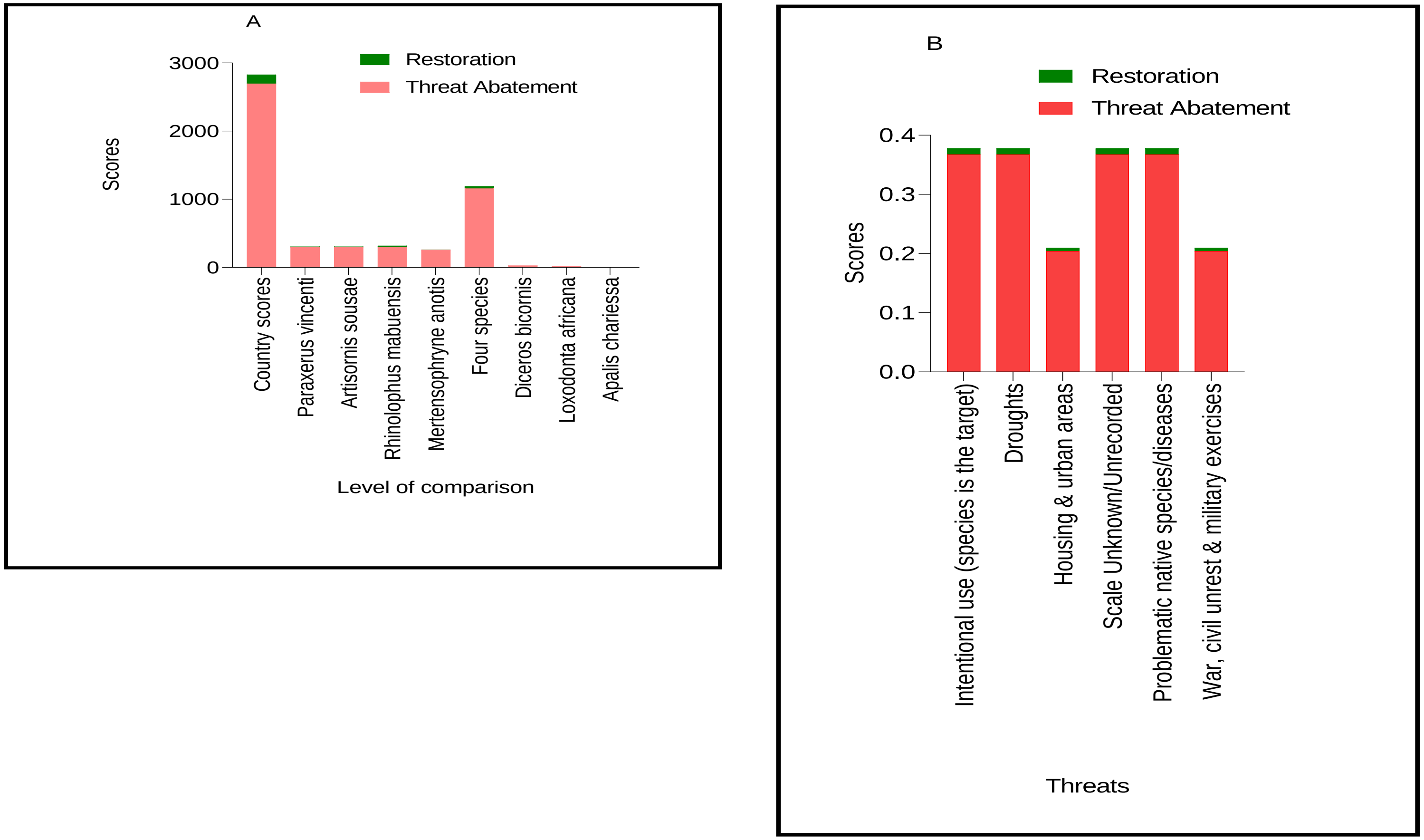


Figure 15 A-B: STAR Threat abatement of four species against the country scores (A); threats scores to buffalo (B).

3.5. Local Level Assessment

Case Study 1: Mining in Moatize District

The District of Moatize is located in the region of Lower Zambezi, Tete Province, with an area of 8 428 km^2. It is located northwest of the provincial capital city, between the parallels 15° 37' and 16° 38' South latitude and between the meridians 33° 22' and 34° 28' East longitude. According to the National Census of 2017, the District has a population of about 343,546 inhabitants (INE, 2018). Moatize's vegetation is dominated by Mopane forests, which represent about 50% of the vegetation, Miombo forest, which makes up 11%, Forests and Dry forests, Acacia thicket and Savanna, which together occupy 37% of its surface. It is also possible to observe riparian vegetation areas along the existing water lines (MEF, ADVZ & MITADER, 2015).

Formally, the area has no recognized protected areas or sites of importance for biodiversity conservation. The closest recognized protected areas are the Mágoè National Park (200 km West); Coutada Oficial Nº 7 which is located approximately 50 km South of Moatize; the Majete Nature Reserve and the Lengwe National Park, located in Malawi, 90 km and 100 km east respectively (UNEP-WCMC and IUCN, 2019).

Mining in the Moatize District dates back to colonial times; it was only interrupted between 1978 and 1992 by Carbomoc due to the war. The stoppage of mining has diversified economic activities, with agriculture, livestock, fishing and forestry being the most practiced until then. The reactivation of its main activity, the exploration of mineral coal started with the granting of licenses to multinational companies from 2004. Thus, 36 licenses were granted in an area of 434,155 ha, from exploration and prospecting licenses, mining certificate and mining concession (Cuambe and Filho, 2017) (Fig. 16).

Thus, mining activity has been putting great pressure on the soil, mainly in Moatize (where the coal basin is located), especially in the areas with the highest concentration of major mining projects, modifying the landscape, polluting the environment and mainly altering the types of land use and occupation (Cuambe and Filho, 2017).

The area was home to a great diversity of 799 plant species, of which six have Vulnerable status on the Red List of Flora of Mozambique (Izidine & Bandeira, 2002), nine are Endemic species and two are almost endemic; and 760 species of fauna of which eight birds and three mammals are globally hreatened according to the IUCN Red List (MEF, ADVZ & MITADER, 2015).

The continued deforestation resulting from wildfires, itinerant agriculture and overexploitation of forests and mining threatens species, ecosystems and environment of the Moatize District (MEF, ADVZ & MITADER, 2015). The potential in energy and natural resources has been attracting foreign investment. However, the mining megaprojects developed in Moatize have created a new dynamic, which has resulted in significant changes in land use where extensive areas of vegetation cover have been devastated to give way to the occupation and extraction of greater quantities of mineral resources, such as coal.

One of the largest multinationals operating in this district is Vale Mozambique. Vale Mozambique is a Brazilian multinational in the mining industry and the second largest mining company in the world. Operates in District of Moatize since 2011, by implementing the Moatize Coal Project, which drains up to about 11 million tons of coal per year (INE, 2017).

In managing biodiversity, Vale follows the best international practices, which are also incorporated into its internal policies and standards, and has implemented the impact mitigation hierarchy in its new projects and expansions. For example, as part of its best practices, Vale has in its 2030 agenda in Brazil a specific target on forests that is a voluntary commitment of the company – Recover and Protect 500 thousand hectares. This goal includes the recovery of 100,000 ha, which has been developed based on actions related to the implementation of agroforestry systems, and the protection of 400,000 ha, within the scope of the model of partnerships with third parties for the effective protection of protected areas.

Following his international standard in mining operations, which recognize that mining may threatens biodiversity, the Vale Mozambique has committed to protect biodiversity. In view of this, Vale Mozambique protects an area of about 16.7 km² that is in the Moatize coal basin. Vale Mozambique call this area the “Environmental Protection Private Area (APAP)” (Fig. 17), thus contributing to the protection of native flora and fauna species, mainly endemic and threatened with extinction (http://www.vale.com/esg/pt/Paginas/Biodiversidade.aspx). This area was included in mine planning as an area intended for environmental protection and education, as a voluntary proposal by the company, long before Mozambique's legislation included the concept of a mitigation hierarchy. From this proposal formally made to environmental authority, as part of their environmental management program for the biotic environment, it became an initial formal voluntary commitment, becoming part of the conditions for the licenses that brought about compliance with the EMP. The APAP is dominated by pioneer vegetation, with formations that represent different stages of succession of the closed forest of

Mopane, scrubland and agricultural and pasture areas resulting from the exploitation of natural resources by the populations.

To reverse impacts caused by mining, Vale Mozambique has a reforestation program for mined areas, which is strengthened by planting seedlings of native trees as a way of returning the land to its original habitat. Under this program, Vale Mozambique surveys native species, gathers seeds for seedling production. This process has resulted in more than 90 thousand seedlings of local plants in their nurseries, thus preserving plants of the native flora that will guarantee the preservation of the regional flora. Another initiative that is part of the program is the donation of seedlings and the training of local communities in techniques of cultivation and treatment of trees. By 2013 more than 12 thousand seedlings have been donated to communities, schools, and institutions in Tete and Moatize (http://www.vale.com/esg/pt/Paginas/Biodiversidade.aspx).

To ensure the balance between nature and its activities, Vale Mozambique permanently monitors the flora and fauna of the area where they operate, translocating animals from the areas of operation to safer environments and suitable for their persistence (http://www.vale.com/mozambique/pt/initiatives/environmental-management/preservation-flora-fauna/paginas/default.aspx).

Vale Mozambique always seeks to be aligned with the commitments and goals established by the Convention on Biological Diversity (CBD). Of the 0.85 km² of area impacted by mining activities in Mozambique in 2019, about 0.30 km² have been recovered through protection and recovery of natural environments, maintenance of essential ecosystem services, and reduction of threats to species (http://www.vale.com/esg/pt/Paginas/Biodiversidade.aspx).

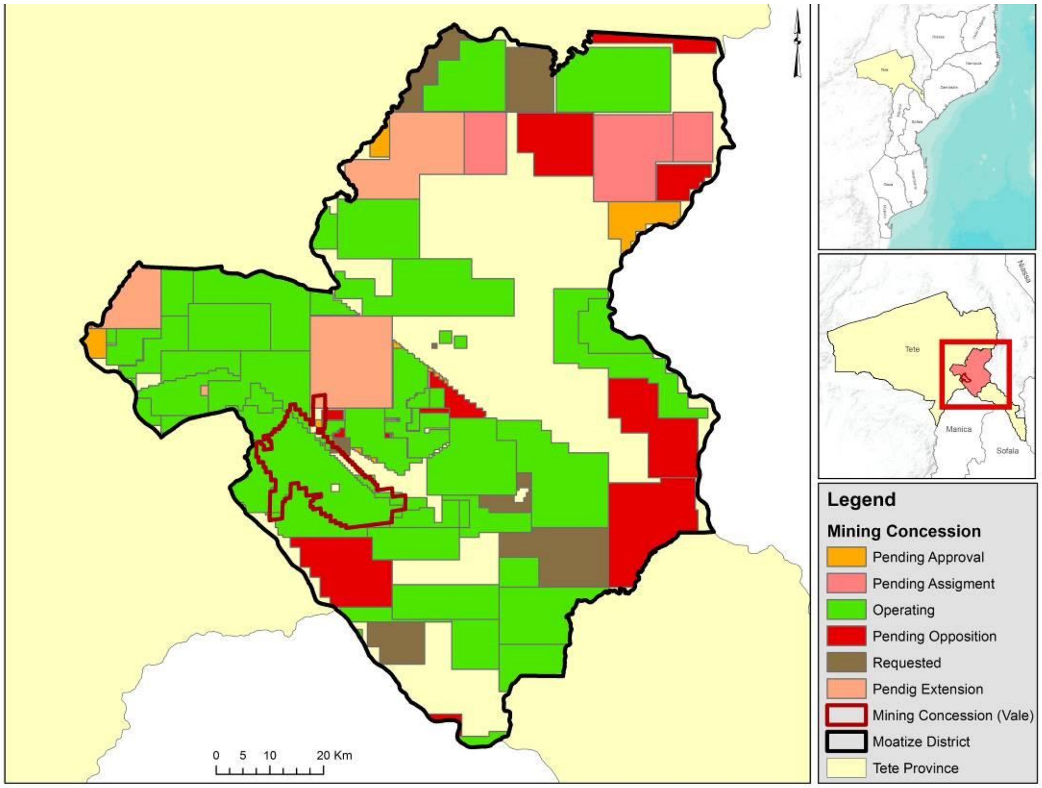


Figure 16: Mining licences of Moatize District (Source: Ministry of Natural Resources, 2018).

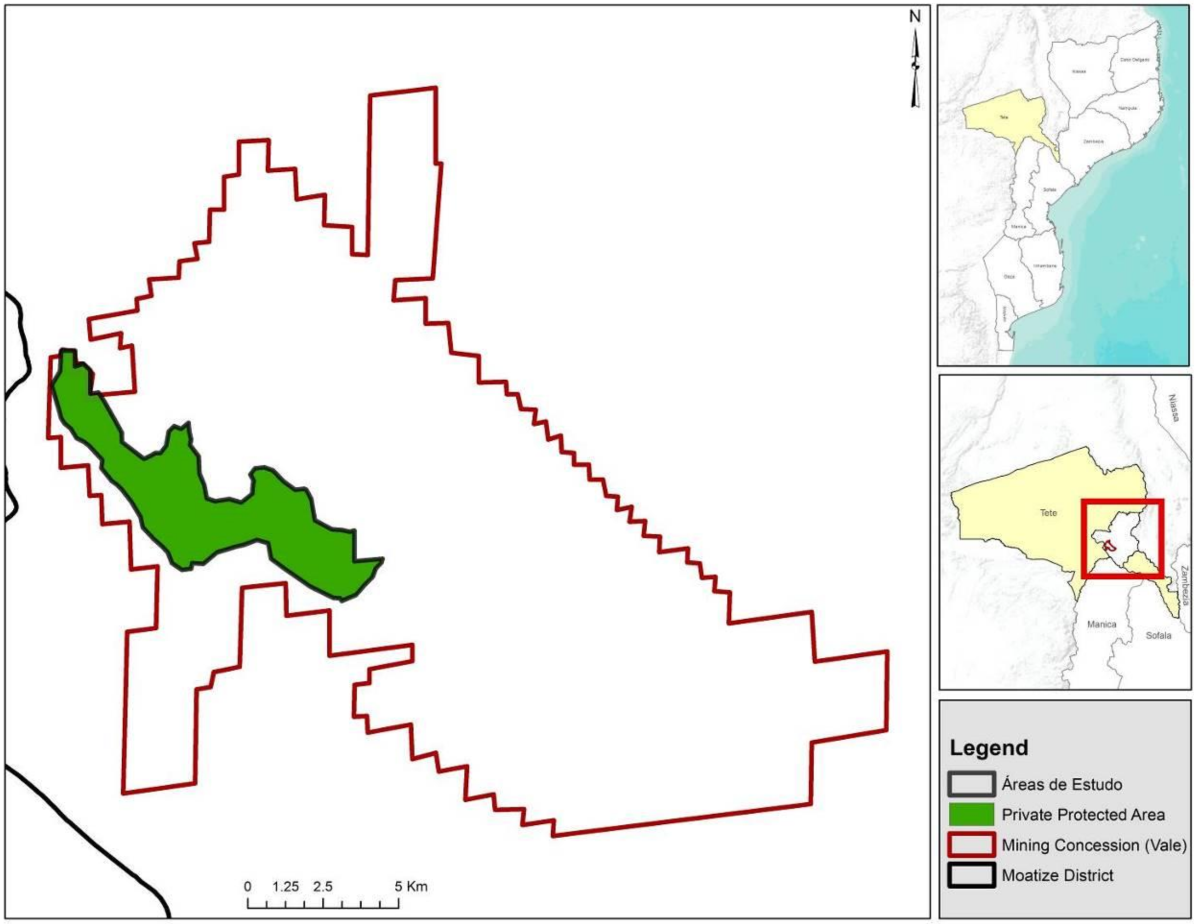


Figure 17: Location of Vale Mining Concession and respective PPA (Source: Ministry of Natural Resources, 2018).

Case Study 2: Oil and gas in Palma District

The District of Palma is located in the Mtwara-Quirimbas Complex, Cabo Delgado Province, with an area of 3.537 km2. According to the National Census of 2017, the District has a population of about 62 667 inhabitants (INE, 2018). Palma's vegetation is dominated by Deciduous Miombo Savannah Woodland / Deciduous Woodland (North-east Sublittoral), separated into Rovuma Coastal Woodland (Parinari – Strychnos Open Woodland); Rovuma Basin Coastal Thicket – Forest (Berlinia orientalis Forest /Thicket); Dune Thicket – Forest (Coptosperma littorale Dune Thicket); Hygrophilous Coastal Grassland (Cyperus prolifer Wetlands) (Burrows et al., 2018). Miombo forests represent about 33.71% of the vegetation; while Miombo thicket, makes up 38.01 %, Inundated areas (10.73%) and Mangroves, occupy 2.63% of its surface (MAE, 2014).

Formally, the area has no recognized protected areas, but two sites of importance for biodiversity conservation of Vamizi and Palma, recently recognised as KBAs. The closest recognized protected areas are the Quirimbas National Park (84 km South) and Mnazi Bay-Rovuma Estuary Marine Park (in the border with Tanzania).

However, due to the richness in biodiversity (sandy beaches, Rovuma dunes, coral reefs, seagrass and macroalgae, small pelagic, large pelagic, mesopelagic, demersal and coelacanths), mammals and sea turtles and cephalopods (squid and octopus), terrestrial mammals, birds, herpetofauna and insects), there are proposals for enactment of some areas as conservation areas (e.g., proposed Rovuma National Reserve).

Although not a secular tradition, mining and especially oil and gas exploration have been the dominant activity in the district for the past 15 years. In fact, since 1986, when Esso Exploration Moçambique Limitada opened the Onshore Mocímboa 1 borehole, agriculture, fishing, wood exploitation and poaching have been together with mining threatening activities to biodiversity. For example, cultivated areas occupy 3.7% of the district's area; 23% of the total 32,392 fishermen from Cabo Delgado Province were from this district in 2008 (Ministério das Pescas, 2008); about 7,079 hectares were identified for cage aquaculture and 3,375 hectares for seaweed aquaculture (INAQUA, 2011). Research in oil and gas was resumed in the 90's by the Lonropet company. As of 2006, there was a widespread of oil & gas exploration activity in the district. For instance, Area 1 (offshore) was granted to Anadarko and its partners; Area 4 (offshore) to ENI and its partners; Areas 3 & 6 to Petronas Carigali and the Onshore Area to Artumas. Subsequently, Artumas ceded part of its participatory interest to Anadarko. Additionally, areas 2 & 5 were awarded to Norsk Hydro (later StatoilHydro) (http://www.inp.gov.mz/pt).

Currently, three projects are active: Golfinho / Atum Project, to be executed in Area 1 by Total E&P Mozambique Área 1 Limited; the Coral Sul FLNG Project to be implemented in Area 4 by Eni and the Rovuma LNG Project, also to be implemented in Area 4 by Mozambique Rovuma LNG (MRV) (Fig. 1).

Oil and gas projects are still in their pre-production phase. Notwithstanding, initial activities suggest that impacts may occur in landscape and biodiversity. Considering the current density of the district's population stands at 18 inhabitants / km^2, this density may increase in the coming years. This is also true, due to current security conditions deterioration in northern of Cabo Delgado province. Adding this to the dependence on the population's land and forest resources, major concerns are those with harmonization of diversity of projects and interests, protecting ecological and environmental balances and ensuring sustainable economic development.

The area was home to a great biodiversity which appears to be declining in recent years. Several factors are responsible for declining of this biodiversity, with anthropogenic factors being the most relevant. For example, the continued deforestation resulting from itinerant agriculture and overexploitation of forests and mining threatens species, ecosystems and environment of the Palma District (Impacto, 2012). For instance, according to Timberlake *et al*. (2011), the Palma miombo forests have suffered losses of around 90% of the area of their original natural habitat during the last 100 years, well before oil & gas exploration and production activities. The potential in energy and natural resources has been attracting foreign investment. However, oil and gas megaprojects under development in Palma district are creating a new dynamic, which can result in significant changes in land cover and land use.

However, significant biodiversity still remains in the area. Studies conducted in connection with development of Area 1 LNG Project indicate the existence of approximately 250 different plant species, predominantly trees and shrubs; at least one hundred and ten benthos taxa; up to 45 taxa of fish fauna; at least 21 species of marine mammals; six taxonomic families of seabirds; a total of 72 species of reptiles and amphibians; 323 and 40 inland bird and mammal species, respectively (ERM and Impacto, 2013).

One of the largest entities operating in Palma district is Total E&P Mozambique Area 1, Lda. (TEPMA1), which is operator of Area 1 Mozambique LNG Project. TEPMA1 is a wholly owned subsidiary of Total Group, a globally known energy company that produces and markets fuels, natural gas and low-carbon electricity. The total gas reserves discovered in the area granted to TEPMA1 and partners is estimated at around 170 Tcf and, directly and indirectly, its exploitation may involve a minimum of about 20 thousand jobs.

Activities under Mozambique LNG Project will encompass both offshore and onshore areas. The offshore project location is in deep waters up to 2,300 m. As stated above, this area supports a large number of marine mammals, as well as numerous fish species, turtles, and sea birds. Reef structures and seagrasses have also been observed in particularly in the near shore and offshore environments. The onshore project area includes three main habitat types: marshlands, wetlands and woodlands. They support important animal and plant life within the Project Site (Fig. 2).

Project activities in both areas that could potentially impact biodiversity include well drilling and the discharge of treated drill cuttings, disposal of dredged material, and installation of subsea infrastructures (offshore) and clearing of vegetation, infilling of estuaries as well as accidental spills, runoff and sedimentation (onshore). External to the Project, population influx in the region, which may be induced by the Project and other factors such as the situation of insecurity in Northern Cabo Delgado, which causes a significant number of internally displaced people, also is a potentially significant risk for most natural resources.

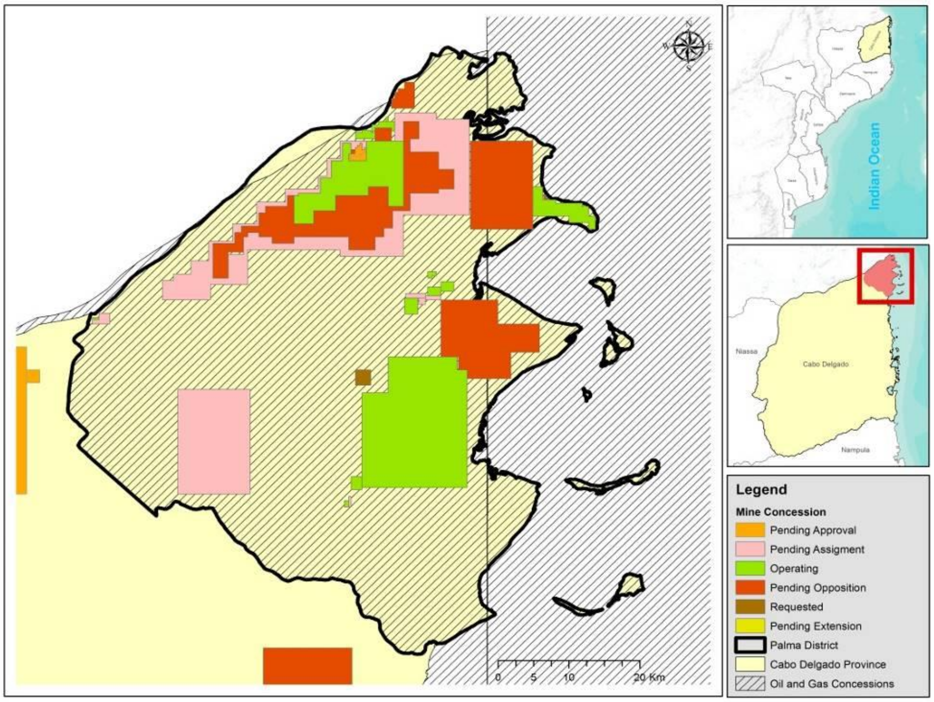


Figure 18: Oil and gas concessions in the Palma District (Source: Ministry of Natural Resources, 2018).

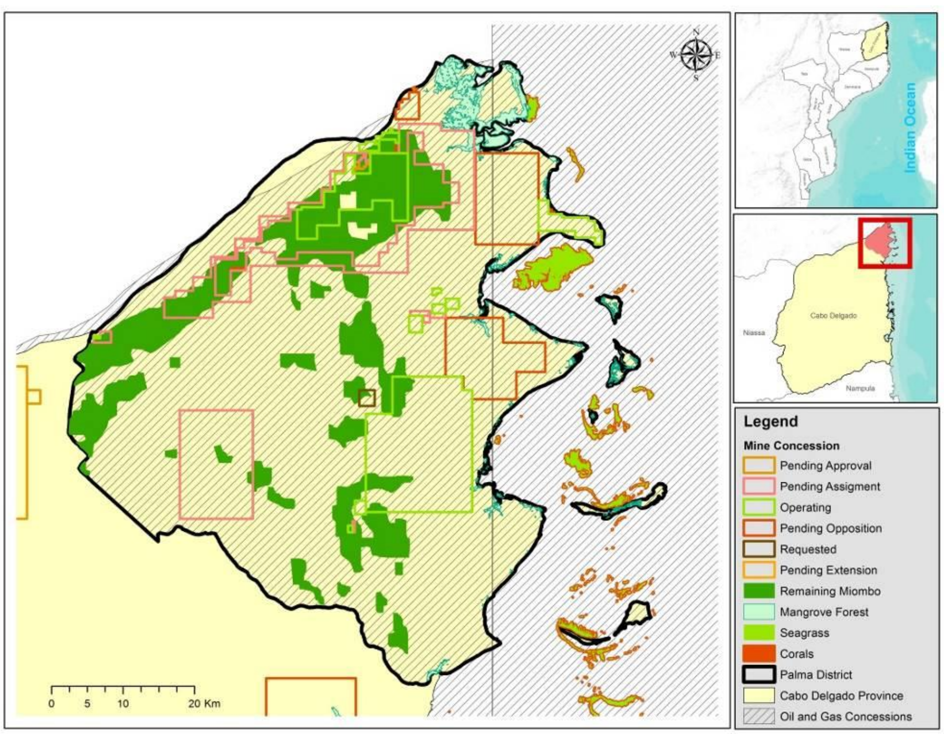


Figure 19: Oil and gas concessions overlap with biodiversity and ecosystem services values in the Palma District (Source: Ministry of Natural Resources, 2018).

3. Discussion

This study aims to assess direct threats and determine which ones have the greatest impact on biodiversity in Mozambique. In the end, it aims to identify economic sectors that drive the threats with the greatest impact in order to prioritize them within the scope of the implementation of the BIODEV2030 Project. The Table 24 summarizes the results of the assessment performed with 3 different approaches.

Table 24: Summary of threats with their corresponding STAR threat abatement scores. In the table, red dotes mean top ranked threat and black, mean referred threat.

IUCN-CMP Level-two Threats with Severe Impacts	STAR Threat Abatement Score	Most Frequently Reported as a Threat - EBTAT	Most Frequently Reported as a Threat – STAT	Priority for Conservation Action Threats
1 Annual & perennial non-timber crops	575	● (red)	● (red)	✓
2 Logging & wood harvesting	465	● (red)	● (red)	✓
3 Fire & fire suppression	458	● (red)	● (red)	✓
4 Habitat shifting & alteration	297	● (red)	● (black)	✓
5 Hunting & trapping terrestrial animals	178	● (red)	● (red)	✓
6 Housing & urban areas	136	● (red)	● (black)	
7 Wood & pulp plantations	121	● (black)	● (black)	
8 Roads & railroads	71	● (black)		
9 Invasive non-native/alien species	61	● (black)	● (black)	
10 Mining & quarrying	56	● (red)	● (red)	✓
11 Livestock farming & ranching	51	● (black)		

12 Dams & water management/use	49	●		
13 Fishing & harvesting aquatic resources	9	●	●	✓
14 Gathering terrestrial plants	3	●		
15 Oil & gas drilling	1	●	●	✓
16 Sea level rise		●	●	

The trends of biodiversity are decreasing in Mozambique. A worrying decline has been observed in populations of plants, mammals, birds, amphibians, reptiles, fish and some terrestrial, aquatic and marine ecosystems. Although there is a vast descriptive and qualitative literature on threats to biodiversity in Mozambique, quantitative data on the severity of the impact of direct threats to biodiversity in Mozambique are lacking. Thus, STAR identified which threats are particularly responsible of the loss of species already as threatened. This STAR approach is complemented by expert knowledge and insight from government officials, from private sector and civil society.

STAR threat abatement scores were highest for Annual & perennial non-timber crops, Logging & wood harvesting; Fire & fire suppression; Shifting & habitat, and Hunting & trapping terrestrial animals. In general, experts as well as advisors from the government, the private sector and civil society converge on the negative potential that these threats represent for biodiversity in Mozambique and have also added mining and oil & gas (see Table 24).

Although this potential is recognized, the threats mentioned can collectively cascade; the effect of one threat may induce the occurrence of the other. For instances, commercial logging is done selectively and known to be unsustainable. It is less directly associated with deforestation, but instead with forest degradation; can promote charcoal production and agriculture. This fact suggests that the potential impact of threats is also dependent on the respective context, as detailed below.

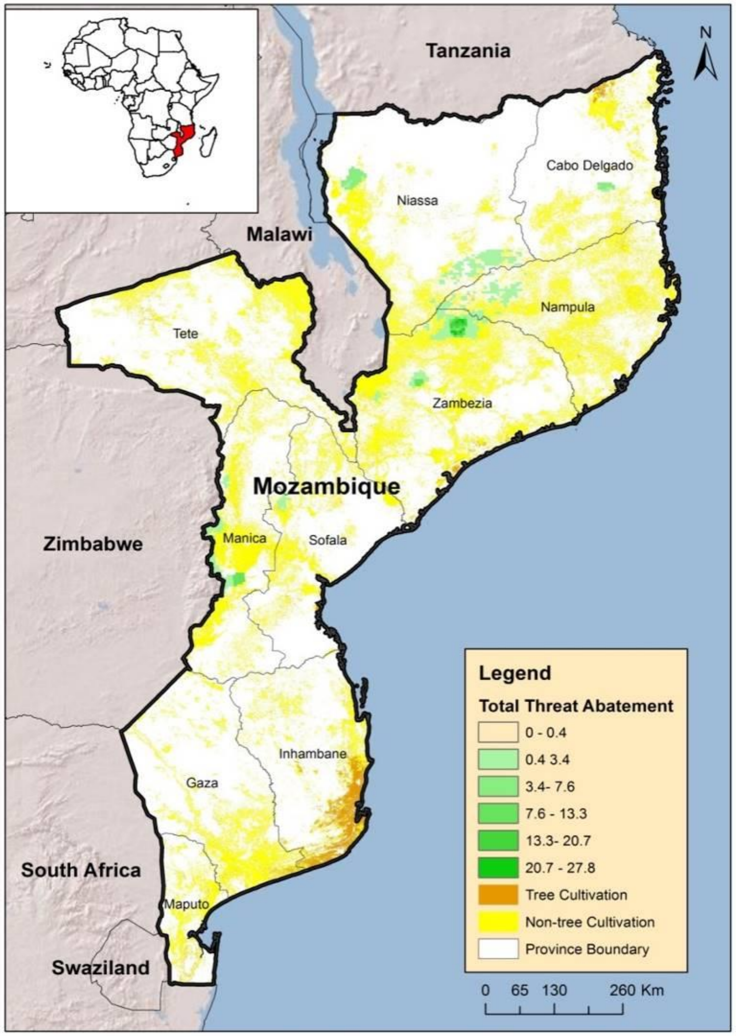
3.1. Annual & perennial non-timber crops

STAR threat reduction scores were highest for Annual & perennial non-timber crops, Logging & wood harvesting and Fire & fire suppression. This result suggests that the three threats have the greatest impact on biodiversity. However, once controlled, also offer the greatest potential to improve the species' chances of survival. In fact, the three threats were also perceived by experts as representing greater pressure on mammals, birds, herpetofauna and plants, as well as by government officials, the private sector and civil society. In Mozambique, Annual & perennial non-timber crops include two subcategories responsible for deforestation: shifting agriculture (65%) and small-holder farming and agro-industry farming (4%) agriculture between 2000 and 2012 (MITADER, 2016). Although historically, Traditional practices of shifting cultivation (labeled “itinerant agriculture”) were ecologically sustainable in Mozambique’s forest ecosystems for millennia (USAID, 2013), the population increase of 3.8 million in 1891 to 29 million inhabitants in 2017 (INE, 2017) drives a reduction of fallow periods. In Mozambique, the traditional shifting cultivation is able to support 2-4 persons / km^2 (USAID, 2013).

Yet Large-Scale Commercial Agriculture is the main threat in the country, but in localized areas. Mainly practiced by large companies, and oriented towards areas where the land is fertile, it has been implemented in areas that are not always coincident with shifting cultivation (USAID, 2013). In general, agriculture leads to loss of habitats due to farming and a reduction in species abundance due to land conversion.

Although small-scale agriculture is the predominant form of agriculture in Mozambique, the use of inputs such as fertilizers, pesticides and agricultural machinery is less than in commercial agriculture. Even in the latter one, its use is weak and irregular throughout over the years, except in sugarcane, one of the few with high levels of mechanization and intensive use of inputs (MITADER, 2018a). This fact suggests its minor impact on biodiversity.

Available data indicate that Mozambique has 36,000,000 hectares of arable land, of which about 4,740,448 were being cultivated by 2016, with 4,363,294 ha of cultivated area and 377,154 ha of fallow area (MASA, 2016) (Fig. 20). Of the more than 3.3 million irrigable hectares, only about 50,000 ha (0.13%) were being irrigated by 2011. By 2015 there were about 4 million farms in the country (corresponding to a cultivated area of about 4,7 million hectares), of which 99% were small, 1.3% were medium and less than 1% were large farms (MASA, 2016). The dominant agricultural holdings are based on the agriculture of food products, through small- and large-scale agricultural systems (MITADER, 2018a). As lustrated in Fig. 20, the areas highly scored by STAR are also those for shifting agriculture directed for food products.



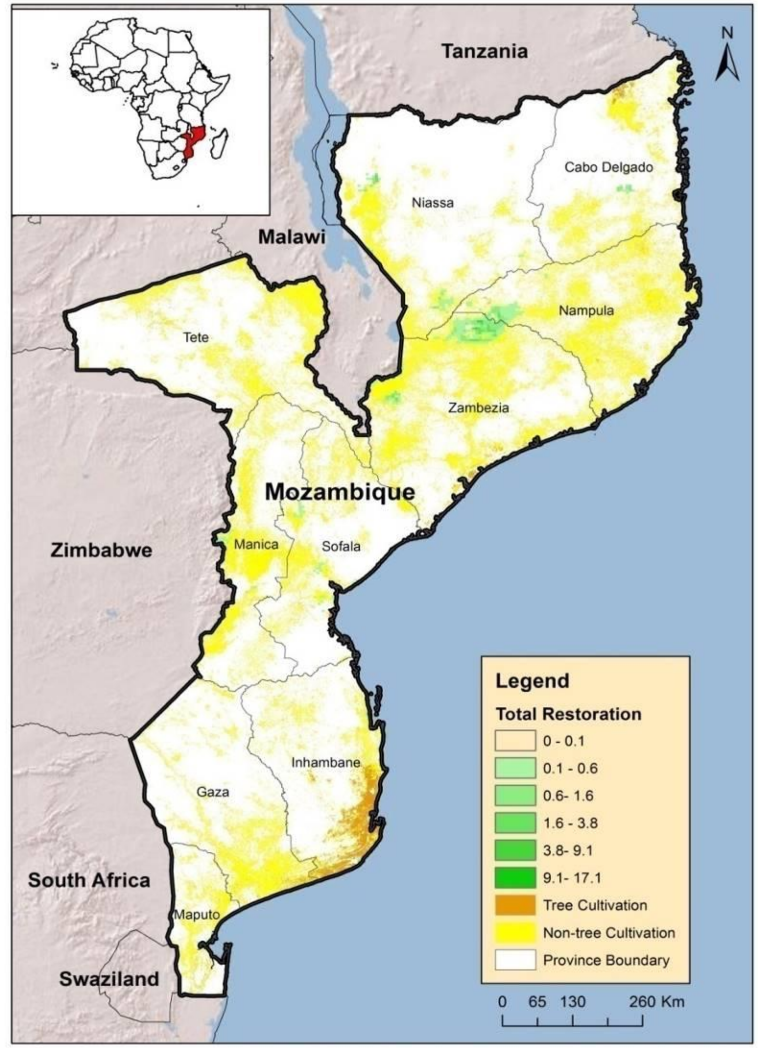


Figure 20: Cultivated areas in Mozambique (Source: Ministry of Land and Environment, 2020).

3.2. Logging & wood harvesting

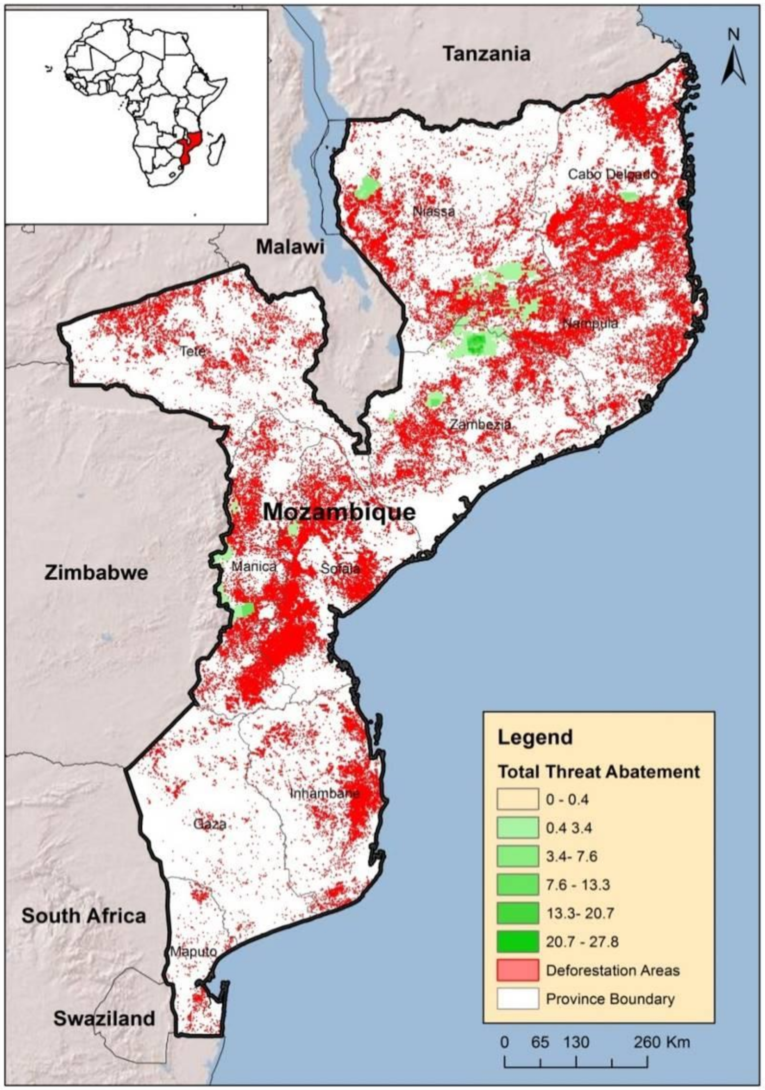
Logging & Wood Harvesting had the second highest STAR threat reduction score. Although experts are aware that this threat is the third most scoring, government officials, the private sector and civil society have also considered the second threat to biodiversity.

In fact, Logging & Wood Harvesting (mostly timber and fuelwood) (Malatesta *et al.*, 2019) was responsible for deforestation in about 13% in the country between 2000 and 2012 (MITADER, 2018) (Fig. 21). Mozambique has a current total commercial volume of forests estimated at 123 million m^3 (MITADER, 2016). There are 119 species of commercial value, of which 6 are being overexploited. The species of commercial value that present higher volumes are, mopane (*Colophospermum mopane*), umbila (*Pterocarpus angolensis*), jambirre (*Millettia stuhlmannii*) and chanfuta (*Afzelia quanzensis*) (MITADER, 2018a).

After a long period of illegal timber trade in the country, significant changes in the management of the forest sector have been introduced in the last five years (MITADER, 2018a). However, enormous challenges still persist. This is partly due to corruption (MITADER, 2018a), but also because the timber business is associated with the subsistence economy of rural communities as well as with Unsustainable Exploitation of High-Value Wildlife for International Trade (USAID, 2013).

Indeed, over 80 percent of the population depends directly on fuelwood and charcoal for their energy needs. Between 2000 and 2012, it accounted for about 7% of deforestation in the country (MITADER, 2016). According to USAID (2019), “Fuelwood is generally used in rural areas while charcoal is primarily used in urban areas. Fuelwood use by local communities has less impact on forests than the production of charcoal for urban areas, which requires whole tree cutting rather than pruning, as well as the wood needed to produce it”.

The wood business is associated with other cascading threats. For example, Logging & Wood Harvesting results mainly in forest degradation, rather than complete deforestation, as high-value species are selectively removed, may also increase access to otherwise closed and remote areas, leading first to further forest degradation; from charcoal production, often followed by the opening of new smallholder agricultural lands (USAID, 2013), as probably suggested in Fig.21 and the resulting net higher STAR scores in some areas.



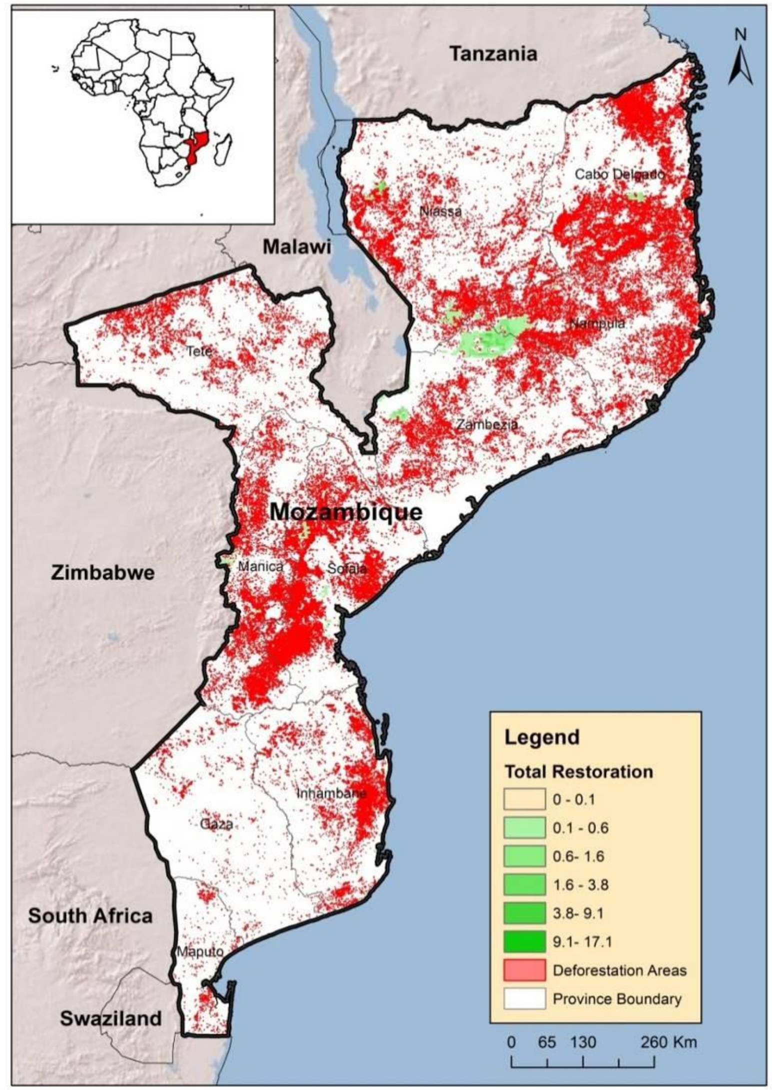


Figure 21: Deforestation areas in Mozambique (Source: MITADER, 2018b).

3.3. Fire & fire suppression

The previous discussion points to a rural economy based on the exploitation of resources such as soil and forest. Fires are a tool for cleaning cultivation areas and artisanal charcoal production (MITADER, 2018a). In the last 10 years, between 40 and 50 thousand hectares have been burned annually, with a slight reduction after 2010 (MITADER, 2018a). Despite the reduction in the number of uncontrolled fires and fires per year, the area affected by uncontrolled fires per year between 2010 and 2016 has increased. For example, around 2000, fires affected 35,000 ha (MITADER, 2018a), today this figure has risen to 45,000 ha / year (MITADER, 2016).

The use of fires to prepare fields contributes to an increase in the frequency of uncontrolled fires, leading to loss of biodiversity and increased carbon emissions. Pasture and the use of burning for the revitalization of pasture are common, which can lead to soil degradation and loss of biodiversity.

It is estimated that the small-scale agriculture sector contributes the highest level of greenhouse gas emissions, emitting 7,772,764 tons of $CO2$ per year (65% of total emissions). These emissions are related to traditional practices such as deforestation and burning to open new fields (MITADER, 2018a).

3.4. Mining and Oil & gas

Mining and oil and gas industry had a very low STAR Threat Abatement Score (56 for mining and only 1 for oil and gas). Contrary to this result, they were both most frequently reported as a threat by experts. On the one hand, this may be related to the non-updated mapping of the two threats used for the STAR calculation, but on the other hand due to the experts' relatively deep knowledge of the two threats. For instance, during the last 20 years or so there has been a notable growth in mining and 15 years in the oil and gas industry (see Fig. 22). In Mozambique, the main products of the extractive industry include mineral coal (coke and thermal), natural gas, hydrocarbons, heavy sands, condensate, bauxite, tantalite, ilmenite, zircon, rutile, construction sand, gravel, clay, beryl, quartz, limestone, tourmaline, refuse tourmaline, faceted garnet, refuse garnet and ruby (MEF, 2017; EITI, 2018). The extractive sector in Mozambique is divided between industrial production, dominated by large multinational corporations (Total, Eni East Africa spa, Sasol Petroleum Temane Lda, for oil and gas; Vale Moçambique, Kenmare Moma Mining (Mauritius) Limited and Montepuez Ruby Mining, for coal, heavy sands and ruby) and artisanal production carried out by miners, both individual and associated.

The main epicentres of the extractive industry in Mozambique are the province of Tete (with coal reserves of around 25 billion tons), the province of Inhambane (222, of which 44 are production wells, for gas with reserves of around 5.5 Tpc), Cabo Delgado province (with gas reserves of more than 160 Tpc in the Rovuma basin) and 115.9 million tons of graphite as well as 3.93 million tons of vanadium oxide in the district of Balama; rubies in the Montepuez district (EITI, 2018; USAID, 2019) and the province of Nampula (163 million tonnes of heavy sand reserves in the district of Moma). In addition and scattered throughout the country there are 65 artisanal mining areas (MITADER, 2018a). Apparently, new areas, mainly for gas research and exploration, will be opened in the near future, especially along the coast of the country.

Although the extractive industry is seen as hope for the country's economy, it does represent a potential threat to biodiversity, as suggested by experts. On the one hand, large operators explore extensive areas and can voluntarily and legally protect the environment (see Sonter *et al*., 2018), but on the other hand artisanal mining can pose a severe challenge and threat to the environment, without known adopting of good environmental practices (Mujere and Isidro, 2016). This statement may align the results illustrated in Fig. 22 on the high STAR scores in Manica province, one of with high artisanal mining incidence.

As a fact of the extractive industry, drilling operations have the potential to affect water quality (and marine fauna) and important ecosystems such as mangroves, sea grass, and coral communities; coastal and seabed infrastructure would likely have adverse impacts on important habitats such as sea grass and corals and may adversely affect fish that use these areas for spawning; vessel movement could potentially adversely affect marine mammals such as dugongs; the LNG plant will displace terrestrial habitats and could affect sensitive species of flora and fauna, as well as have important air emissions associated with combustion sources, and would generate waste in need of appropriate waste disposal; drilling and construction of coastal and seabed infrastructure can temporarily displace fish, limit fishing, and decrease catch by artisanal fisheries; any potential liquid spills (such as oil and diesel spills from ships) can have major and long-lasting adverse impacts on marine and coastal ecosystems, including human populations and nearby protected areas (IUCN, 2013); coal industry can affect sensitive habitats and associated fauna; removal of heavy sands can affect species dependent on this habitat and the use of mercury and other techniques harmful to the environment can put biodiversity at risk (CU, 2013;

USAID, 2019). Government of Mozambique recently declared that all the coastal line was opened for heavy sands mining. This will be an important threat for biodiversity (mangroves, marine biodiversity) but also will participate to the erosion of the coastal line. On the other hand, artisanal and small scale gold mining may reduces grazing areas and biodiversity, increases levels of toxic heavy metals, especially mercury (Hg), sodium of cyanide, silver, and arsenic; directs dumping of tailings and effluents into rivers; imposes river damage in alluvial areas and degradation of river banks and water sources; increases river siltation and soil degradation due to erosion and deforestation and landscape destruction (Mujere and Isidro, 2016).

However, and considering Fig. 22, the extractive industry does not conclusively explain the high STAR scores since in the areas of high STAR Threat Abatement and restoration scores there is a limited mining and no oil & gas activity. This partly explains the very low STAR Threat Abatement Score (56 for mining and only 1 for oil and gas). It is understandable that experts and government officials, the private sector and NGOs have anticipated the value of this threat today, given their knowledge of the country's reality. STAR's analysis was based on the situation prevailing in the years 2015, when the vast majority of activities in the extractive industry were still emerging.

4.0 Fishing & harvesting aquatic resources

Fishing & harvesting aquatic resources was often reported as a threat by government officials, NGOs and private sector representatives, despite a very low STAR threat abatement score. However, it is not surprising that was most frequently reported as a threat by government officials.

It is not surprising that STAR results have resulted in low scores. The STAR assessment does not yet include marine and aquatic species. Experts who participated in semi-structured interviews on this topic were also few. However, the officers' recognition of this threat is also not surprising. The marine and aquatic environment has been suffering perceptible impacts by the majority of users, since they are dependent on their richness in biodiversity. For instance, the kapenta fishery (freshwater) represents only 10 thousand tons/year (Ribeiro, 2010) against about 237957 tons/year in the marine realm (Chacate and Mutombene (2019).

For example, the drivers for marine environmental degradation include inappropriate governance; economic drivers; inadequate financial resources; population pressure and demographics and climate change and natural processes (ASCLME / SWIOFP, 2012b). On the other hand, population Growth, Climate change, Pollution, Invasive Species, and River damming are the main threats to freshwater biodiversity. These above drivers lead to the impacts on marine and aquatic environment and thus to biodiversity as follow:

Degradation of marine waters quality, which includes nutrient enrichment from land and marine (e.g. boats) base sources; chemical contamination from land-based and marine sources; suspended solids in coastal waters due to human activities on land and in the coastal zone; solid wastes / marine debris (plastics etc.) from marine and land-based-sources; hydrocarbons spills (drilling, exploitation, transport, processing, storage, shipping) (ASCLME/SWIOFP, 2012b). Such as the activity of oil and gas exploitation in northern Mozambique that according to the Ministry for the Coordination of Environmental Affairs (2014) caused the death of fish and promoted harmful algal blooms affecting the catching of fish by the local communities.

Habitat and community modification- Disturbance, damage and loss of subtidal benthic (deep water habitats, including reefs, banks canyons, etc.) and pelagic habitats (neritic 30-200m and oceanic >200m depth); increase in the occurrence of harmful or toxic algal blooms (HAbs); introduction of exotic (non-native) and invasive species.

Declines in living marine resources - Decline and/or risk of further decline in populations of focal species (marine mammals, sea turtles; marine birds), commercial fish (pelagic and demersal) and invertebrate stocks, as well as extreme by-catch and discards(ASCLME/SWIOFP, 2012b). It was estimated, in Maputo Bay, that the semi-industrial shrimp fishery for the production of 12.5 tons of shrimp per month, was by-catching about 50.8 tons of a diversity of marine fauna and discarding 36.4 tons (Machava *et al*., 2014). These numbers represent a huge impact to local biodiversity, especially regarding ecosystem functioning to the affected species.

The growth of Mozambican population (population size in 2020 estimated in 30 million people) with the accompanying economic development and industrialization, will have some effects on transformations of freshwater ecosystems and resulting in a loss of biodiversity. Water abstraction for human consumption, irrigation, industry in river basins can impose habitat change and degradation and consequently reduction or loss of biodiversity.

Freshwater pollution comes from many sources such as untreated human and industry wastewater, pesticides and fertilizers from agriculture. Contamination of freshwater ecosystems is seen almost around the world. Although we don’t have real figures of what is happening in Mozambique signs of pollution such as eutrophication in some reservoirs like Pequenos Libombos, Corumana, Massingir and Cabora Bassa are real, however further studies to assess the degree of biodiversity loss need to be done.

Mozambique has enormous potential for aquaculture development. Although the development of aquaculture in Mozambique plays an important role in the socio-economic development of the country: providing cheap protein, improving the population's diet, creating jobs, generating income and promoting regional development, attention should be deserved because coastal aquaculture is potentially source of organic pollution turning freshwater ecosystem to eutrophication condition.

The consequences of habitat fragmentation are alterations of river natural flow from upstream to downstream and also affect lateral connections of the river flow with drainage basin. The riverine concept and flood pulse concepts which describes the longitudinal and transversal interactions in river system which is important to maintain biodiversity are affected by damming. Thus, habitat fragmentation could be a major cause of biodiversity loss in river systems.

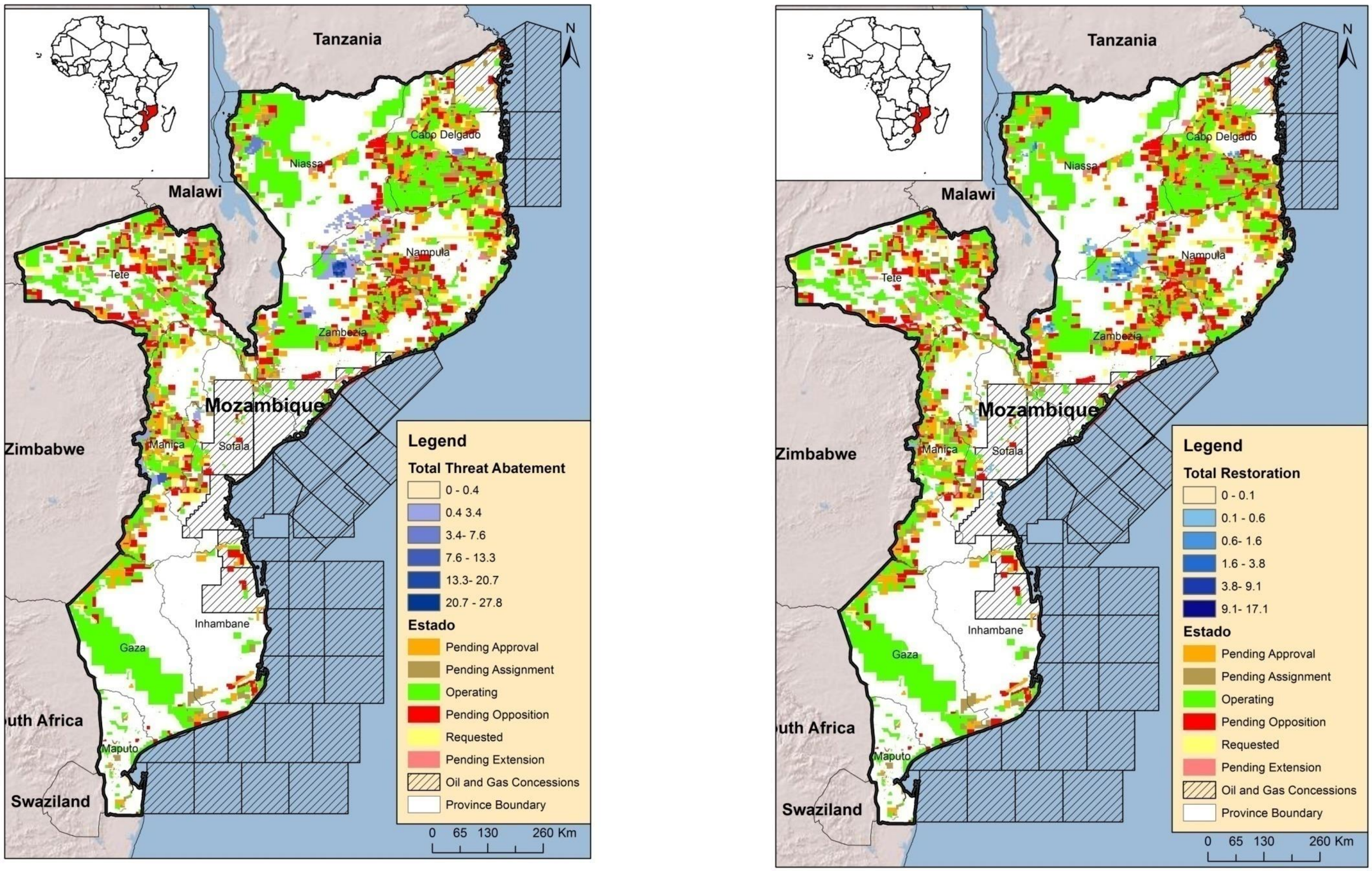


Figure 22: Mining concessions in Mozambique (Source: Ministry of Natural Resources, 2018).

4.1 Threats to biodiversity conservation

This study has identified Annual & perennial non-timber crops, Logging & wood harvesting; Fire & fire suppression; Mining and Oil & gas, Shifting & habitat, and Hunting & trapping terrestrial animals as threats with highest potential to impact biodiversity in Mozambique.

These threats can act in isolation or in combination, which makes it possible to assess possible impacts imposed on biodiversity in time and space.

Therefore, the STAR Threat Abatement and restoration scores were tested against the distribution of key biodiversity areas as well as biodiversity provinces (especially mammals). The results indicate that the high scores for STAR Threat Abatement and restoration are not necessarily related to key areas of biodiversity or to the distribution of mammals (see Figs. 23 & 24). On some KBAs (Njesi, Chimanimani, Serra Choa, Machipanda, Taratibu, Chiperone, Mabu, Namuli and Inago) there is an overlap with high STAR scores, while partially, the Gorongosa-Marromeu Complex faces high levels of threats and restoration. These results may be due to the fact that the mentioned areas may be inhabited by endemic and threatened species, which tend to increase the STAR scores.

The results illustrated in Figures 23 & 24 suggest that mapped data regarding the distribution of species as well as threats require careful analysis and correction before using them for the calculation of STAR Threat Abatement and restoration. Even though the overlap of some KBA and some mammal biogeographic areas with highy STAR scored areas is evident, information of this nature could have improved the results obtained.

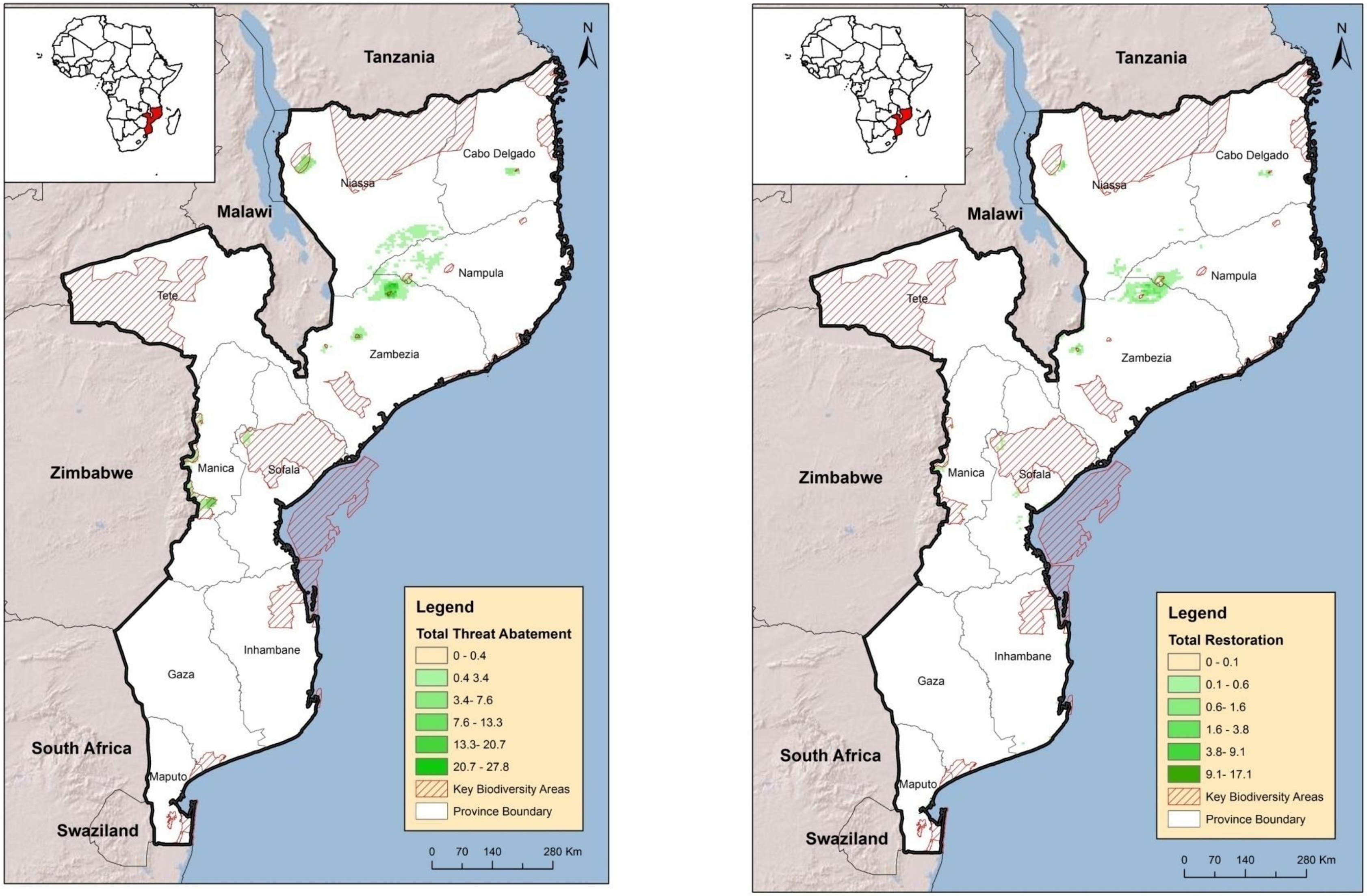


Figure 23: Key Biodiversty Areas of Mozamique (Source: USAID SPEED+ ,2020)**.**

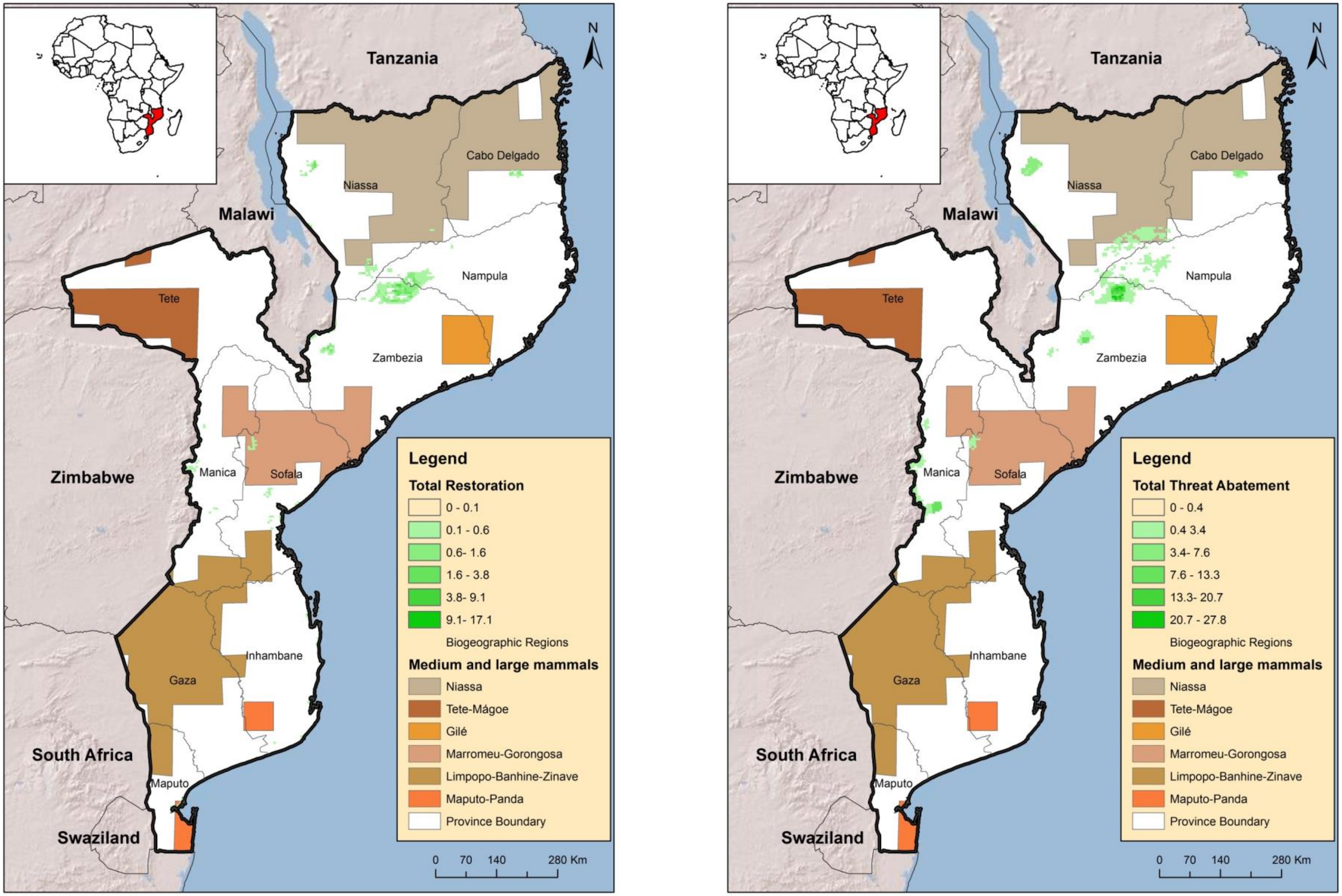


Figure 24: Medium and large mammal biogeographic regions in Mozambique (Source: Bento et al., 2021).

Part IV: Conclusion and Recomendations

5.1. Conclusion

This study aims to identify threats with the greatest impact on biodiversity in Mozambique and the economic sectors that drive them.

To assess threats to biodiversity, semi-structured interviews with 18 biodiversity experts in Mozambique and 23 assessors representing government institutions, private sector, and NGOs, through the Expert-based Threat Assessment Tool (EBTAT) and a Simplified Threat Assessment Tool (STAT) were carried. A global assessment of the same threats to biodiversity through STAR metrics (Species Threat Abatement and Restoration) was also carried out for Amphibians, Birds and Terrestrial Mammals. Accordingly, using the same routines outlined in the global STAR metric scores, the country team calculated STAR scores for Reptilians and Plants.

The results obtained using the three methodological routines indicate strong convergency on those threats posing the greatest impact on biodiversity in Mozambique and included Annual & perennial non-timber crops, Logging & wood harvesting, Fire & fire suppression; Habitat shifting & alteration and Hunting & trapping terrestrial animals. On the other hand, from STAR Threats abatement scores framework, Fishing & harvesting aquatic resources, Gathering terrestrial plants, Oil & gas drilling had a negligible impact. However, these threats received strong supports from experts and officials as with high impact. Agriculture, forestry, mining and oil and gas, fishery and infrastructure are the economic sectors, which drive the threats.

Notwithstanding, all the methodologies used were dependent on the existence and quality of data, as well as on the participation and commitment of experts and officials. The STAR metric, does not include aquatic and marine species. The inclusion of herpetofauna and plants in this report proved to be a challenge for the management of existing quality data in Mozambique. These facts support the notion that the results are strongly dependent on gaps and data quality and availability. There is a need of improving and including marine biodiversity in the STAR metric.

5.2. Recommendations

In Mozambique, marine, coastal, aquatic and terrestrial biodiversity are under constant and growing pressure. On the one hand, due to the dependence of local coastal economies on marine and terrestrial resources. The results of this study demonstrate that biological resource use, agriculture & aquaculture and mining threat biodiversity.

To effectively conserve terrestrial, marine, and freshwater biodiversity in Mozambique, it is recommended that agriculture (small-scale/shifting cultivation), mining and oil & gas and fisheries sectors are prioritized for engagement when setting voluntary commitments through BIODEV2030.

Given that, the adoption of voluntary commitments presupposes the existence of a functional implementation structure and some activities are better followed through the normal functioning flow of government institutions, it is recommended that logging & wood harvesting as well as infrastructures are not addressed in the frame of voluntary commitments. Some voluntary commitments in the agriculture, mining and oil & gas sectors as well as fishery may help to lower the impact of logging & wood harvesting as well as infrastructures on biodiversity.

Therefore, the following recommendations have been made to help guide the process of establishing voluntary commitments:

Agriculture

Almost all conservation areas in Mozambique have a population living inside and the current system of conservation areas in Mozambique does not include a large part of biodiversity conservation targets. Some of these targets are outside their limits and in constant threat by Shifting Agriculture, Small-holder Farming and poaching. Here, agriculture is developed in small-scale both for subsistence (mainly maize) and for commercial purposes (sesame seed, tobacco and cotton) in family-based models with no external inputs.

Although small scale agriculture is practiced for about 99% of the total number of farming units, it uses small farms (1.35 ha on average), uses little chemical fertilizers, pesticides, animal traction and low irrigation schemes (Silici, 2015). The large-Scale Commercial Agriculture is done in localized areas and most oriented towards areas where the land is fertile. This fact may offer opportunity to implement voluntary commitments by those large companies.

Establishing voluntary commitments focusing on promoting conservation-friendly agriculture inside and outside conservation areas may have a high potential to conserve biodiversity. The novel SUSTENTA project approach on the Environmental safeguards for agriculture seems to be a good political will.

SUSTENTA requires that projects to be financed must draw up Environmental and Social Management Plans (PGAS) so that (i) they avoid activities that may result in negative environmental and social impacts, as well as which fall on resources or areas considered sensitive; (ii) prevent the occurrence of negative environmental and social impacts; (iii) prevent any future actions that may adversely affect environmental and social resources; (iv) limit or reduce the degree, extent, magnitude and duration of adverse impacts through minimization, displacement, redesign of elements of the project; (v) repair or improvement of affected resources, such as natural habitats or water resources, especially when previous developments have resulted in significant degradation of those resources; (vi) restoration of resources allocated to the previous state (and possibly more stable and productive state), typically more natural, and (vii) create, improve or protect the same type of resources in another suitable and acceptable location, compensating for lost resources, including compensating individuals and other entities for any loss of assets and / or opportunities (MITADER, 2016).

If the large-Scale Commercial Agriculture companies (AC Matama Lda, Alif Química Industrial Lda, Kurimane Ne Povo Lda, Phoenix Seeds Lda, The African Food Company Lda, Agro Serviços Lda, DADTCO Mandioca Moçambique Lda, Frutimel Lda, Mozambican Honey Company Lda) (Monitor Deloite, 2016), designed agregators are linked to the implementation of the SUSTENTA project, they can adhere to voluntary commitments for themselves as a company, but also, due to the spill over effect, to guarantee the implementation of voluntary commitments by the producers associated with the company. In this way, voluntary commitments will be implemented in specific places where agribusiness is being developed by specific company and respective network of producers.

Forestry/silviculture

Mozambique is one of the few countries in southern Africa that still has a considerable area of natural forests (Sitoe, Salomâo and Wertz-Kanounnikoff, 2012). Estimates of the total forest cover vary, but a recent evaluation of forest resources indicates the country has 50% forest cover, a little more than 40 million ha (FAO, 2010). For example, about 51% of the national territory (40.1 million hectares) is covered with forests, while other woody formations (shrubs, scrub and forests with shifting agriculture) cover about 14.7 million hectares (19% of the country). Of the forest cover, 22.5 million hectares (56.2%) are dense forests and 16.4 million hectares (40.9%) open forests. Mangrove forests occupy 357 thousand hectares (0.9% of forests) and open forests in humid areas 802 thousand hectares (2.0% of total forests). In absolute terms, Niassa is the province with the largest forest area (9.4 million hectares, followed by Zambézia (5.1 million hectares) and Cabo Delgado (4.8 million hectares) (MITADER, 2018).

Levels of exploitation of wood species from forests natural resources have exceeded the permitted annual cut volumes, which are in the range of 515,700 to 640,500 m³ (MITADER, 2018). It is estimated that 438,000 hectares of forest were deforested in the period from 2016 to 2017, with the annual deforestation rate for the entire country estimated at 219,000 hectares per year, which means an annual rate of change of -0.58% (MITADER, 2018).

The underlying causes of deforestation and forest degradation include (i) technological factors (inefficient use of wood fuel, low agricultural land-use intensity); (ii) demographic factors (high demand from urban areas); (iii) economic factors, such as those related to export markets for agricultural commodities (sesame seed, tobacco and cotton) and timber; and (iv) institutional factors, especially the remarkably weak institutional capacity, particularly at the sub-national level (province and district) and the associated difficulties including poor enforcement of laws and regulations, as well as problems with punishing offenders (Sitoe *et al.*, 2012). As noted by Sitoe *et al.* (2012), in some cases, the mentioned causes of deforestation act together, insofar as agriculture needs energy (for example, to dry tobacco) and fuel wood and charcoal production promote the establishment of agricultural fields.

As commercial logging is done selectively and known to be unsustainable is less directly associated with deforestation. But instead with forest degradation, can promotes charcoal production and agriculture. There is no need at this stage to stablish voluntary commitments in this sector; a sectoral coordination between the Ministry of Land and Environment and Ministry of Mineral Resources and Energy is needed to curve the negative impact of Logging & wood harvesting.

A detailed and elaborated land management plan, based on participation, as being done with the National Plan for Territorial Development in preparation (MITADER, 2019) is one of these strategies. In the other hand, the implementation of REDD+ initiatives may prevent forest degradation. But the degree of equitable outcomes and the generation of co-benefits will depend largely on (i) whether the processes are inclusive and under national ownership, (ii) whether those who bear the costs of REDD+ are also being compensated, and (iii) the definition of rights over carbon and environmental services (Sitoe *et al.*, 2012). The degree to which local communities can benefit from REDD+ depends on the definition of rights over carbon and other environmental services (for example, hydrological and biodiversity).

Promoting woodfuel and charcoal management, intensive crop farming, uses of tree crops and agroforestry systems and on-farm woodlots and fuel-efficient stoves for cooking fuel may have a high potential to conserve biodiversity. Furthermore, integration of biodiversity conservation into its development portfolio, supporting Conservation-Friendly Sustainable Agriculture and Livelihoods, supporting and Empowering Coastal Communities to Manage and Benefit from Biodiversity and supporting Anti-Corruption Efforts and Law Enforcement to Reduce Illegal International Trade in Wildlife and Timber may also improve biodiversity conservation.

Implementation of a massive program for the use of cooking gas in rural areas by the Ministry of Mineral Resources and Energy could also be to reduce pressure on the forestry sector and thus reduce the risk of species extinction.

Mining and Oil & Gas

Mining activity has grown a lot in the last ten years in Mozambique in almost all provinces. The main mining companies in Mozambique include Vale Mozambique, Twigg Exploration Mining Lda, Montepuez Rubi Mining Lda, Kenmare Moma Mining (Mauritius) LTD, GK Ancuabe Graphite Mine SA, while Sasol Petroleum Moz Exploration LTD, Galp Energia Rovuma BV, Eni East Africa SPA, ENH EP, Exxon Mobil Moçambique, Total Moçambique, Mitxui & CO, ONGC Videsh, PTTEP, Bharat Petroleum and Oil India Limited are oil and gas companies operating in Mozambique. The oil & gas industry has also been established across the country. Although the analysis of STAR threats has not identified as a substantial threat, both experts and government officials, the private sector and civil society have overestimated, which suggests some attention. Mining mainly affects the coast and terrestrial biodiversity and oil & gas, mainly marine biodiversity.

Although the current focus on the extractive industry is on direct site-level impacts of mining, knowledge is needed across the full range of scales and from different contexts to understand how these factors affect threats to biodiversity as well as understanding the role of changing technologies and the role of research. Particularly, Oil and Gas Company can have primary (on biodiversity) and secondary (around the site) impacts. For instance, deforestation can be a direct and indirect. Therefore, deforestation resulted from access from settlers across the project area is a secondary impact. Project implementers can prevent these impacts by integrating biodiversity consideration in the management decisions, by undertaking investments that benefit biodiversity conservation (e.g. to protect environment; to support research; to prevent human incursions into the area or to support government capacity building.

Establishing voluntary commitments concerning on biodiversity offsetting areas may have a high potential to conserve biodiversity. Restoring species richness and Ecosystem services and Evaluating biodiversity importance. In doing so, companies can hire consultants to undertake biodiversity surveys; engage a conservation organization as for biodiversity surveys and to be potential future partners in conservation initiatives and involve a research institution or university as valuable sources of expertise and knowledge.

Fisheries

The country is characterized by a wide diversity of habitats including sandy and rocky beaches; sand dunes, coral reefs, estuaries, bays, seagrass beds, mangrove forests, rivers, lakes and reservoirs which support pristine ecosystems, high biological diversity, high endemism, and endangered species.

Around 366 species of fishes are currently reported in the country, of which 32 are endemic. The species diversity of coral reefs in Mozambique is highly underestimated, with more than 300 species recorded so far (Obura, 2012). The marine biodiversity is rich with 32 species of cetaceans, five species of marine turtles, 36 species of seabirds and around 2200 species of fish (ASCLME/SWIOFP 2012a).

Pollution, fisheries, Invasive species, Climate change, Major threats to the coastal and marine ecosystems of Mozambique include overfishing, industrial and coastal development, natural resources exploitation, unregulated and damaging tourism practices, pollution and weather extremes such and storms and cyclones.

Commercial fisheries (industrial and semi-industrial) exploit the most important and valuable resources such as shallow and deep-water shrimp that occur on the Sofala Banks as well as pelagic fish species such tuna, billfishes, and sharks. Artisanal fishery occurs along the entire coast and captures shallow water demersal and pelagic species using traditional gears. Artisanal fishing uses traditional fishing techniques such as rod and tackle, fishing arrows and harpoons, cast nets, and small (if any) traditional fishing boats. In all, about 18914 licensed fishing units participate; while 142 Fishing Units are involved in industrial fishing; on average, artisanal fishing is responsible for almost 90% of the total national production. These data suggest that artisanal fishing poses a threat to marine and coastal biodiversity.

Establishing voluntary commitments concerning on CCP (Community Management Fishing Area) concept may have a high potential to conserve biodiversity. CCPs are created with direct support from government, NGOs and other entities. These institutions identify and facilitate the organization of a small number of fishers into a CCP. Fishers that belong to a CCP are allocated a small marine area for them to control (decide how fishing can be done there, by who, with what gears, etc.) called Community Reserve. This means that rule setting and enforcement are ensured by fishers themselves (within their CCP allocated area). Thus, this may give them some power to determine fisheries rules within limited spatial areas and empowers fisheries and their communities to address their marine-related problems. By involving fishers in problem resolution, fisheries management gains automatically a focus on sustainable use, an important aspect in a context of biodiversity conservation.

Global

To provide robustness and relevance in the implementation of the actions to be planned, countries should be encouraged to replicate STAR metric procedures based on their context, available data and the respective quality.

In recent years, there has been a lot of effort in Mozambique to organize environmental data in general and biodiversity in particular. The database of the FNDS (Sustainable Development Fund), the PEOTs of the Zambezi Valley and part of the Matutuine district were developed; the PNDT (National Plan for Territorial Development), national inventory of forests, analysis of land use and coverage in the last 20 years were also carried out. The level of knowledge on the distribution of biodiversity in the country through the design of a unified database, almost regular national wildlife inventories and the implementation of several projects that generated mapping milestones allows the country to have a lot of information that can improve the methodology of STAR and its performance.

Mozambique has made significant advances in legislation linked to the conservation of biodiversity in the environmental impact assessment decree for mega-projects where the mitigation hierarchy is a prerequisite to avoid damage to biodiversity. However, in addition to the role and responsibilities of government agencies, as a regulatory and supervisory authority, further efforts should be made to develop an inclusive matrix and forms of public-private partnerships as well as to increase the growing role of NGOs and groups in civil society, encouraging the understanding of biodiversity offsets in a context of different implementation from that of developed countries, levels of transformed landscapes, but also different cultural and legal traditions as well as different forms of governance associated with them.

These are still obstacles to the full implementation of legislation in this area. BIODEV2030 can be the beginning of mainstreaming biodiversity for building understanding, building the internal environment of people and sectors for full implementation of legislation.

5.3. Study Limitations

Reduced number of participants from institutions and experts. In some cases (p.e birds and freshwater fish), only one expert participated for each taxonomic group. This fact weakens the conclusions made based on the outputs.

The STAR metric approach was based only on mammals, birds, and amphibians. Following the same procedures, Mozambique included reptiles and plants. The marine and coastal environment has not been included in this assessment despite being areas with potential threats to biodiversity.

The maps of some threats as well as the distribution of some species used to run the STAR metric analyses would need adjustments to correspond with the reality on the ground.

There is a lot of up-to-date and available information in the country that could be used to improve the results of the report.

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5.5. Attachments

Annex A:

Table 1: Name of experts who participated in the National Level Assessment - Experienced Based Threat Assessment Tool (EBTAT).

Name	Taxonomic group
Alice Massingue	Plants and Terrestrial ecosystems
Muri Soares	Plants and Terrestrial ecosystems
Regina Cruz	Terrestrial ecosystems
Clayton Langa	Plants
Célia Macamo	Mangroves
Denise Nicolau	Mangroves
Avelino Miguel	Herpetofauna
Acácio Chechene	Herpetofauna
Érica Tovela	Freshwater fish
Paula Santana Afonso	Marine Biodiversity
Eduardo Videira	Marine Biodiversity
Almeida Guissamulo	Marine Biodiversity
Jorge Sitoe	Marine Biodiversity
Andre Botha	Birds
Valério Macandza	Mammals
Joaquim Campira	Mammals
Marcelino Foloma	Mammals
Baldeu Chande	Mammals

Table 2: Name of government institutions, private sector, and NGOs that participated in the Tiered Assessment - Simplified Threat Assessment Tool (SAT).

Name	Institution
Leticia Guimarães	Vale Moçambique

Alves Sandramo	Vale Moçambique
João Júnior	Vale Moçambique
Estevao Mabjaia	Total Moçambique
Laurent Cazes	Total Moçambique
Pascal Jacques	Total Moçambique
Paulina Laice	Total Moçambique
Stephane Caillau	Total Moçambique
Antony Alexander	PPF
Hugo Costa	WCS
Eleuterio Duarte	WCS
Naseeba Sidat	WCS
Armindo Araman	ANAC
Almeida Guissamulo	Museu de História Natural
Carlos Bento	Museu de História Natural
Guilhermina Amurane	DINAB
Alexandre Bartolomeu	DINAB
Ana Paula Francisco	DINAB
Imede Falume	DNF
Alima Issufo	DNF
Nilza Joubert	Gabinete de Salvaguardas Sociais e Ambientais
Aristides Muhate	FNDS
Adélia Artur	Direcção Nacional de Assistência a Agricultura Familiar

Annex B: Identification list of threats to national biodiversity.

Code	Threat	Agreement	Time							Scope				Severity				
			1	2	3	4	5	6	7	1	2	3	4	1	2	3	4	5
1	1. Residential & commercial development																	
1.1	1.1 Housing & urban areas																	
1.2	1.2 Commercial & industrial areas																	
1.3	1.3 Tourism & recreation areas																	
2	2. Agriculture & aquaculture																	
2.1	2.1 Annual & perennial non-timber crops																	
2.2	2.2 Wood & pulp plantations																	
2.3	2.3 Livestock farming & ranching																	
2.4	2.4 Marine & freshwater aquaculture																	
3	3. Energy production & mining																	
3.1	3.1 Oil & gas drilling																	
3.2	3.2 Mining & quarrying																	
3.3	3.3 Renewable energy																	
4	4. Transportation & service corridors																	
4.1	4.1 Roads & railroads																	
4.2	4.2 Utility & service lines																	
4.3	4.3 Shipping lanes																	
4.4	4.4 Flight paths																	
5	5. Biological resource use																	
5.1	5.1 Hunting & trapping terrestrial animals																	
5.2	5.2 Gathering terrestrial plants																	
5.3	5.3 Logging & wood harvesting																	
5.4	5.4 Fishing & harvesting aquatic resources																	
6	6. Human intrusion & disturbance																	
6.1	6.1 Recreational activities																	
6.2	6.2 War, civil unrest & military exercises																	
6.3	6.3 Work & other activities																	
7	7. Natural system modifications																	
7.1	7.1 Fire & fire suppression																	

Code	Threat	Agreement	Time							Scope				Severity				
			1	2	3	4	5	6	7	1	2	3	4	1	2	3	4	5
7.2	7.2 Dams & water management/use																	
7.3	7.3 Other ecosystem modifications																	
8	8. Invasive & other problematic species & genes																	
8.1	8.1 Invasive non-native/alien species																	
8.2	8.2 Problematic native species																	
8.3	8.3 Introduced genetic material																	
8.4	8.4 Problematic species/diseases of unknown origin																	
8.5	8.5 Viral/prion-induced diseases																	
8.6	8.6 Diseases of unknown cause																	
9	9. Pollution																	
9.1	9.1 Domestic & urban waste water																	
9.2	9.2 Industrial & military effluents																	
9.3	9.3 Agricultural & forestry effluents																	
9.4	9.4 Garbage & solid waste																	
9.5	9.5 Air-borne pollutants																	
9.6	9.6 Excess energy																	
10	10. Geological events																	
10.1	10.1 Volcanoes																	
10.2	10.2 Earthquakes/tsunamis																	
10.3	10.3 Avalanches/landslides																	
11	11. Climate change & severe weather																	
11.1	11.1 Habitat shifting & alteration																	
11.2	11.2 Droughts																	
11.3	11.3 Temperature extremes																	
11.4	11.4 Storms & flooding																	
11.5	11.5 Other impacts																	
12	12. Other options (NOTE, this threat is not used in the current dataset)																	
12.1	12.1 Other threat (NOTE, this threat is not used in the current dataset)																	

Annex C: Global Ecological Zone Typology for Mozambique (Keith *et al.*, 2020).

Realm	Biome	Ecosystem Functional Group (EFG)
Terrestrial	T1 Tropical-subtropical forests:	T1.1 Tropical-subtropical lowland rainforests
Terrestrial	T1 Tropical-subtropical forests	T1.2 Tropical-subtropical dry forests and scrubs
Terrestrial	T1 Tropical-subtropical forests	T1.3 Tropical-subtropical montane rainforests
Terrestrial	T4 Savannas & grasslands	T4.1 Trophic savannas
Terrestrial	T4 Savannas & grasslands	T4.2 Pyric tussock savannas
Terrestrial	T4 Savannas & grasslands	T4.5 Temperate subhumid grasslands
Terrestrial	T6 Polar-alpine (cryogenic ecosystems)	T6.5 Tropical alpine grasslands and herbfields
Terrestrial	T7 Intensive anthropogenic terrestrial ecosystems:	T7.2 Sown pastures and fields
Terrestrial	T7 Intensive anthropogenic terrestrial ecosystems:	T7.3 Plantations
Terrestrial	T7 Intensive anthropogenic terrestrial ecosystems	T7.4 Urban ecosystems
Subterranean	S1Subterranean lithic ecosystems:	S1.1 Aerobic caves
Subterranean	S2 Anthropogenic subterranean voids:	S2.1 Anthropogenic subterranean voids
Transitional Subterranean-Freshwater	SF1 Subterranean freshwater systems:	SF1.1 Underground streams and pools
Transitional Subterranean-Freshwater	SF1 Subterranean freshwater systems:	SF1.2 Groundwater ecosystems
Transitional Freshwater-Terrestrial	TF1 Palustrine wetlands	TF1.3 Permanent marshes
Transitional Freshwater-Terrestrial	TF1 Palustrine wetlands:	TF1.4 Seasonal floodplain marshes
Freshwater	F1 Rivers and streams:	F1.1 Permanent upland streams
Freshwater	F1 Rivers and streams:	F1.2 Permanent lowland rivers
Freshwater	F1 Rivers and streams:	F1.4 Seasonal upland streams
Freshwater	F1 Rivers and streams:	F1.5 Seasonal lowland rivers
Freshwater	F2 Lakes:	F2.1 Large permanent freshwater lakes
Freshwater	F2 Lakes:	F2.2 Small permanent freshwater lakes
Freshwater	F2 Lakes:	F2.3 Seasonal freshwater lakes
Freshwater	F3 Artificial wetlands:	F3.1 Large reservoirs
Freshwater	F3 Artificial wetlands:	F3.2 Constructed lacustrine wetlands
Transitional Freshwater-Marine	FM1 Transitional waters:	FM1.2 Permanently open riverine estuaries and bays
Marine	M1 Marine shelves:	M1.1 Seagrass meadows
Marine	M1 Marine shelves:	M1.3 Photic coral reefs
Marine	M1 Marine shelves:	M1.4 Shellfish beds and reefs
Marine	M1 Marine shelves:	M1.5 Photo-limited marine animal forests
Marine	M1 Marine shelves:	M1.6 Subtidal rocky reefs
Marine	M1 Marine shelves:	M1.7 Subtidal sand beds

Marine	M1 Marine shelves:	M1.8 Subtidal mud plains
Marine	M2 Pelagic ocean waters:	M2.1 Epipelagic ocean waters
Marine	M2 Pelagic ocean waters:	M2.2 Mesopelagic ocean waters
Marine	M2 Pelagic ocean waters:	M2.3 Bathypelagic ocean waters
Marine	M3 Deep sea floors:	M2.3 Bathypelagic ocean waters
Marine	M3 Deep sea floors:	M3.2 Submarine canyons
Marine	M3 Deep sea floors:	M3.3 Abyssal plains
Marine	M3 Deep sea floors:	M3.5 Deepwater biogenic beds
Marine	M4 Anthropogenic marine systems	M4.2 Marine aquafarms
Transitional Marine-Terrestrial	MT1 Shoreline systems:	MT1.1 Rocky shorelines
Transitional Marine-Terrestrial	MT1 Shoreline systems:	MT1.2 Muddy shorelines
Transitional Marine-Terrestrial	MT1 Shoreline systems:	MT1.3 Sandy Shorelines
Transitional Marine-Terrestrial	MT2 Coastal vegetation:	MT2.1 Coastal shrublands and grasslands
Transitional Marine-Freshwater-Terrestrial	MFT1 Brackish tidal systems:	MFT1.2 Intertidal forests and shrublands

Annex D: Results of EBTAT

MAMMALS

Agreement		
4.1	4.1 Roads & railroads	3
5.1	5.1 Hunting & trapping terrestrial animals	3
5.3	5.3 Logging & wood harvesting	3
6.2	6.2 War, civil unrest & military exercises	3
7.1	7.1 Fire & fire suppression	3
11.1	11.1 Habitat shifting & alteration	3
11.2	11.2 Droughts	3
1.1	1.1 Housing & urban areas	2
1.2	1.2 Commercial & industrial areas	2
2.1	2.1 Annual & perennial non-timber crops	2
2.2	2.2 Wood & pulp plantations	2
2.3	2.3 Livestock farming & ranching	2
3.1	3.1 Oil & gas drilling	2
3.2	3.2 Mining & quarrying	2
4.2	4.2 Utility & service lines	2
4.3	4.3 Shipping lanes	2
5.2	5.2 Gathering terrestrial plants	2
5.4	5.4 Fishing & harvesting aquatic resources	2
7.2	7.2 Dams & water management/use	2
7.3	7.3 Other ecosystem modifications	2
9.3	9.3 Agricultural & forestry effluents	2
9.4	9.4 Garbage & solid waste	2
11.3	11.3 Temperature extremes	2
11.4	11.4 Storms & flooding	2
1.3	1.3 Tourism & recreation areas	1
2.4	2.4 Marine & freshwater aquaculture	1
3.3	3.3 Renewable energy	1
6.1	6.1 Recreational activities	1
6.3	6.3 Work & other activities	1
8.1	8.1 Invasive non-native/alien species	1
8.2	8.2 Problematic native species	1
8.3	8.3 Introduced genetic material	1
8.4	8.4 Problematic species/diseases of unknown origin	1
8.5	8.5 Viral/prion-induced diseases	1
8.6	8.6 Diseases of unknown cause	1
9.1	9.1 Domestic & urban waste water	1

9.2	9.2 Industrial & military effluents	1
9.5	9.5 Air-borne pollutants	1
9.6	9.6 Excess energy	1
10.1	10.1 Volcanoes	1
10.2	10.2 Earthquakes/tsunamis	1
10.3	10.3 Avalanches/landslides	1

TIME		
9.4	9.4 Garbage & solid waste	6
1.3	1.3 Tourism & recreation areas	5
2.4	2.4 Marine & freshwater aquaculture	5
4.1	4.1 Roads & railroads	5
4.2	4.2 Utility & service lines	5
6.2	6.2 War, civil unrest & military exercises	5
7.1	7.1 Fire & fire suppression	5
7.2	7.2 Dams & water management/use	5
9.3	9.3 Agricultural & forestry effluents	5
11.2	11.2 Droughts	5
2.1	2.1 Annual & perennial non-timber crops	5
5.4	5.4 Fishing & harvesting aquatic resources	5
11.3	11.3 Temperature extremes	5
1.1	1.1 Housing & urban areas	4
5.1	5.1 Hunting & trapping terrestrial animals	4
5.2	5.2 Gathering terrestrial plants	4
5.3	5.3 Logging & wood harvesting	4
11.1	11.1 Habitat shifting & alteration	4
10.2	10.2 Earthquakes/tsunamis	3
1.2	1.2 Commercial & industrial areas	3
2.2	2.2 Wood & pulp plantations	3
4.3	4.3 Shipping lanes	3
8.1	8.1 Invasive non-native/alien species	3
8.3	8.3 Introduced genetic material	3
8.5	8.5 Viral/prion-induced diseases	3
9.6	9.6 Excess energy	3
10.3	10.3 Avalanches/landslides	3
3.1	3.1 Oil & gas drilling	3
7.3	7.3 Other ecosystem modifications	3
8.4	8.4 Problematic species/diseases of unknown origin	2
9.2	9.2 Industrial & military effluents	2
2.3	2.3 Livestock farming & ranching	2

3.2	3.2 Mining & quarrying	2
3.3	3.3 Renewable energy	2
4.4	4.4 Flight paths	2
6.1	6.1 Recreational activities	2
6.3	6.3 Work & other activities	2
8.2	8.2 Problematic native species	2
11.4	11.4 Storms & flooding	2
10.1	10.1 Volcanoes	1

SCOPE		
5.1	5.1 Hunting & trapping terrestrial animals	4
7.1	7.1 Fire & fire suppression	4
3.2	3.2 Mining & quarrying	4
2.2	2.2 Wood & pulp plantations	3
2.3	2.3 Livestock farming & ranching	3
6.2	6.2 War, civil unrest & military exercises	3
11.2	11.2 Droughts	3
11.3	11.3 Temperature extremes	3
3.1	3.1 Oil & gas drilling	3
5.2	5.2 Gathering terrestrial plants	2.5
5.4	5.4 Fishing & harvesting aquatic resources	2.5
7.2	7.2 Dams & water management/use	2.5
9.3	9.3 Agricultural & forestry effluents	2.5
1.1	1.1 Housing & urban areas	2
2.1	2.1 Annual & perennial non-timber crops	2
2.4	2.4 Marine & freshwater aquaculture	2
5.3	5.3 Logging & wood harvesting	2
9.5	9.5 Air-borne pollutants	2
11.1	11.1 Habitat shifting & alteration	2
4.2	4.2 Utility & service lines	1.5
7.3	7.3 Other ecosystem modifications	1.5
8.2	8.2 Problematic native species	1.5
11.4	11.4 Storms & flooding	1.5
1.2	1.2 Commercial & industrial areas	1
1.3	1.3 Tourism & recreation areas	1
4.1	4.1 Roads & railroads	1

SEVERITY		
5.1	5.1 Hunting & trapping terrestrial animals	5
7.1	7.1 Fire & fire suppression	4
11.1	11.1 Habitat shifting & alteration	4
11.2	11.2 Droughts	4
2.3	2.3 Livestock farming & ranching	3
5.2	5.2 Gathering terrestrial plants	3
5.3	5.3 Logging & wood harvesting	3
6.2	6.2 War, civil unrest & military exercises	3
11.3	11.3 Temperature extremes	3
3.1	3.1 Oil & gas drilling	2.5
5.4	5.4 Fishing & harvesting aquatic resources	2.5
9.3	9.3 Agricultural & forestry effluents	2.5
11.4	11.4 Storms & flooding	2.5
1.1	1.1 Housing & urban areas	2
2.1	2.1 Annual & perennial non-timber crops	2
2.2	2.2 Wood & pulp plantations	2
3.2	3.2 Mining & quarrying	2
3.3	3.3 Renewable energy	2
7.3	7.3 Other ecosystem modifications	2
1.2	1.2 Commercial & industrial areas	1.5
4.2	4.2 Utility & service lines	1.5
4.3	4.3 Shipping lanes	1.5
10.1	10.1 Volcanoes	1.5
10.2	10.2 Earthquakes/tsunamis	1.5
10.3	10.3 Avalanches/landslides	1.5
1.3	1.3 Tourism & recreation areas	1
2.4	2.4 Marine & freshwater aquaculture	1
4.1	4.1 Roads & railroads	1
6.3	6.3 Work & other activities	1
7.2	7.2 Dams & water management/use	1
8.2	8.2 Problematic native species	1
9.1	9.1 Domestic & urban waste water	1

MOST SEVERE THREATS TO MAMMALS

TOP SEVERITY	
5.1 Hunting & trapping terrestrial animals	9
7.1 Fire & fire suppression	8
2.3 Livestock farming & ranching	6
6.2 War, civil unrest & military exercises	6
11.3 Temperature extremes	6
3.1 Oil & gas drilling	6
5.2 Gathering terrestrial plants	6
3.2 Mining & quarrying	5
11.2 Droughts	4
2.2 Wood & pulp plantations	4

HERPETOFAUNA

AGREEMENT	Nr responses
2.1 Annual & perennial non-timber crops	3
5.3 Logging & wood harvesting	3
11.1 Habitat shifting & alteration	3
11.5 Other impacts	3
1.1 Housing & urban areas	2
2.2 Wood & pulp plantations	2
3.1 Oil & gas drilling	2
3.2 Mining & quarrying	2
5.1 Hunting & trapping terrestrial animals	2
5.2 Gathering terrestrial plants	2
8.1 Invasive non-native/alien species	2
8.5 Viral/prion-induced diseases	2
9.2 Industrial & military effluents	2
9.3 Agricultural & forestry effluents	2
9.4 Garbage & solid waste	2
11.2 Droughts	2
11.3 Temperature extremes	2
11.4 Storms & flooding	2
1.2 Commercial & industrial areas	1
1.3 Tourism & recreation areas	1
2.3 Livestock farming & ranching	1
2.4 Marine & freshwater aquaculture	1
3.3 Renewable energy	1
4.1 Roads & railroads	1
4.4 Flight paths	1
5.4 Fishing & harvesting aquatic resources	1
6.2 War, civil unrest & military exercises	1
6.3 Work & other activities	1
7.1 Fire & fire suppression	1
7.2 Dams & water management/use	1
7.3 Other ecosystem modifications	1
8.3 Introduced genetic material	1
8.4 Problematic species/diseases of unknown origin	1
8.6 Diseases of unknown cause	1
9.1 Domestic & urban waste water	1
9.5 Air-borne pollutants	1
9.6 Excess energy	1
10.2 Earthquakes/tsunamis	1

TIME	CODES	DESCRIPTION
2.2 Wood & pulp plantations	6	Future short term
11.1 Habitat shifting & alteration	6	Future short term
11.5 Other impacts	6	Future short term
1.1 Housing & urban areas	5	Continuing
1.2 Commercial & industrial areas	5	Continuing
2.1 Annual & perennial non-timber crops	5	Continuing
5.3 Logging & wood harvesting	5	Continuing
8.5 Viral/prion-induced diseases	5	Continuing
3.1 Oil & gas drilling	4	Now suspended (short term)
3.2 Mining & quarrying	4	Now suspended (short term)
3.3 Renewable energy	4	Now suspended (short term)
4.1 Roads & railroads	4	Now suspended (short term)
4.4 Flight paths	4	Now suspended (short term)
5.1 Hunting & trapping terrestrial animals	4	Now suspended (short term)
5.2 Gathering terrestrial plants	4	Now suspended (short term)
5.4 Fishing & harvesting aquatic resources	4	Now suspended (short term)
8.1 Invasive non-native/alien species	4	Now suspended (short term)
9.2 Industrial & military effluents	4	Now suspended (short term)
9.3 Agricultural & forestry effluents	4	Now suspended (short term)
9.4 Garbage & solid waste	4	Now suspended (short term)
11.2 Droughts	4	Now suspended (short term)
11.3 Temperature extremes	4	Now suspended (short term)
11.4 Storms & flooding	4	Now suspended (short term)

SCOPE	CODES	DESCRIPTION
5.3 Logging & wood harvesting	3	Affects the majority
11.1 Habitat shifting & alteration	3	Affects the majority
11.2 Droughts	3	Affects the majority
11.3 Temperature extremes	3	Affects the majority
11.4 Storms & flooding	3	Affects the majority
2.1 Annual & perennial non-timber crops	2	Affects the minority
3.1 Oil & gas drilling	2	Affects the minority
3.2 Mining & quarrying	2	Affects the minority
5.1 Hunting & trapping terrestrial animals	2	Affects the minority
1.1 Housing & urban areas	1	Affects a negligible proportion of the population
1.2 Commercial & industrial areas	1	Affects a negligible proportion of the population
2.2 Wood & pulp plantations	1	Affects a negligible proportion of the population
2.3 Livestock farming & ranching	1	Affects a negligible proportion of the population

4.1 Roads & railroads	1	Affects a negligible proportion of the population
5.2 Gathering terrestrial plants	1	Affects a negligible proportion of the population
8.5 Viral/prion-induced diseases	1	Affects a negligible proportion of the population
9.2 Industrial & military effluents	1	Affects a negligible proportion of the population
9.3 Agricultural & forestry effluents	1	Affects a negligible proportion of the population
9.4 Garbage & solid waste	1	Affects a negligible proportion of the population
11.5 Other impacts	1	Affects a negligible proportion of the population

SEVERITY	CODES	DESCRIPTION
1.1 Housing & urban areas	3	Relatively slow but significant declines
2.1 Annual & perennial non-timber crops	3	Relatively slow but significant declines
3.1 Oil & gas drilling	3	Relatively slow but significant declines
3.2 Mining & quarrying	3	Relatively slow but significant declines
5.3 Logging & wood harvesting	3	Relatively slow but significant declines
11.1 Habitat shifting & alteration	3	Relatively slow but significant declines
11.2 Droughts	3	Relatively slow but significant declines
11.3 Temperature extremes	3	Relatively slow but significant declines
11.4 Storms & flooding	3	Relatively slow but significant declines
1.2 Commercial & industrial areas	2	Fluctuations
5.1 Hunting & trapping terrestrial animals	2	Fluctuations
5.2 Gathering terrestrial plants	2	Fluctuations
2.2 Wood & pulp plantations	1	Negligible declines
2.3 Livestock farming & ranching	1	Negligible declines
2.4 Marine & freshwater aquaculture	1	Negligible declines
3.3 Renewable energy	1	Negligible declines
4.1 Roads & railroads	1	Negligible declines
6.2 War, civil unrest & military exercises	1	Negligible declines
6.3 Work & other activities	1	Negligible declines
7.1 Fire & fire suppression	1	Negligible declines
7.2 Dams & water management/use	1	Negligible declines
7.3 Other ecosystem modifications	1	Negligible declines
8.1 Invasive non-native/alien species	1	Negligible declines
8.5 Viral/prion-induced diseases	1	Negligible declines
9.2 Industrial & military effluents	1	Negligible declines
9.3 Agricultural & forestry effluents	1	Negligible declines
9.4 Garbage & solid waste	1	Negligible declines
11.5 Other impacts	1	Negligible declines

Most severe threats to herpetofauna

Threat	SCORE
5.3 Logging & wood harvesting	6
11.1 Habitat shifting & alteration	6
11.2 Droughts	6
11.3 Temperature extremes	6
11.4 Storms & flooding	6
2.1 Annual & perennial non-timber crops	5
3.1 Oil & gas drilling	5
3.2 Mining & quarrying	5
1.1 Housing & urban areas	4

MARINE BIODIVERSITY

Agreement	
Threat	**Score**
1.2 Commercial & industrial areas	4
1.3 Tourism & recreation areas	4
11.4 Storms & flooding	4
11.3 Temperature extremes	4
9.2 Industrial & military effluents	4
1.1 Housing & urban areas	3
3.1 Oil & gas drilling	3
3.2 Mining & quarrying	3
11.1 Habitat shifting & alteration	3
2.4 Marine & freshwater aquaculture	3
D5.4 Fishing & harvesting aquatic resources	3
11.2 Droughts	2

TIME	CODES	DESCRIPTION
Marine & freshwater aquaculture	2	Short term future
Housing & urban áreas	4	Continuing
Tourism & recreation áreas	4	Continuing
Fishing & harvesting aquatic resources	4	Continuing
Recreational activities	4	Continuing
Garbage & solid waste	4	Continuing
Habitat shifting & alteration	4	Continuing
Storms & flooding	4	Continuing
Housing & urban áreas	4	Continuing

SCOPE	CODES	DESCRIPTION
Tourism & recreation áreas	2	Affects the majority
Fishing & harvesting aquatic resources	2	Affects the majority
Tourism & recreation áreas	2	Affects the majority
Oil & gas drilling	2	Affects the majority
Industrial & military effluents	2	Affects the majority
Agricultural & forestry effluents	2	Affects the majority
Mining & quarrying	2	Affects the majority
Recreational activities	4	Affects the minority
Storms & flooding	3	Affects the minority
Commercial & industrial areas	2	Affects the minority
Housing & urban areas	2	Affects the minority

Tourism & recreation areas	2	Affects a negligible proportion of the population
Shipping lanes	2	Affects a negligible proportion of the population

Most severe threats t marine biodiversty

Threat	SCORE
Fishing & harvesting aquatic resources	5
Oil & gas drilling	6
Mining & quarrying	6
Oil & gas drilling	6
Shipping lanes	5

SEVERITY	CODES	DESCRIPTION
Fishing & harvesting aquatic resources	3	Rapid declines
Oil & gas drilling	3	Rapid declines
Mining & quarrying	3	Rapid declines
Marine & freshwater aquaculture	2	Relatively slow but significant
Oil & gas drilling	3	Fluctuations
Shipping lanes	2	Negligible declines

PLANTS AND ECOSYSTEMS

Threats	Impact on plants
Gathering terrestrial plants	Affects a negligible proportion of the population
Commercial & industrial áreas	Affects the minority (< 50%) of the population
Oil & gas drilling	Affects the minority (< 50%) of the population
Mining & quarrying	Affects the minority (< 50%) of the population
Habitat shifting & alteration	Affects the minority (< 50%) of the population
Commercial & industrial áreas	Affects the minority (< 50%) of the population
Oil & gas drilling	Affects the minority (< 50%) of the population
Fire & fire suppression	Affects the majority (50 to 90%) of the population
Roads & railroads	Negligible declines
Hunting & trapping terrestrial animals	Negligible declines
Housing & urban áreas	Fluctuations
Tourism & recreation áreas	Fluctuations
Gathering terrestrial plants	Fluctuations
Fishing & harvesting aquatic resources	Fluctuations
Recreational activities	Fluctuations
Other ecosystem modifications	Fluctuations
Domestic & urban waste water	Fluctuations
Industrial & military effluents	Fluctuations
Excess energy	Fluctuations
Commercial & industrial áreas	Relatively slow but significant declines
Annual & perennial 0n-timber crops	Relatively slow but significant declines
Oil & gas drilling	Relatively slow but significant declines
Mining & quarrying	Relatively slow but significant declines
Fire & fire suppression	Relatively slow but significant declines
Agricultural & forestry effluents	Relatively slow but significant declines
Garbage & solid waste	Relatively slow but significant declines
Habitat shifting & alteration	Relatively slow but significant declines
Droughts	Relatively slow but significant declines
Temperature extremes	Relatively slow but significant declines
Storms & flooding	Relatively slow but significant declines
Other impacts	Relatively slow but significant declines
Livestock farming & ranching	Rapid declines
Logging & wood harvesting	Rapid declines
Logging & wood harvesting	Severity
Fire & fire suppression	Severity
Housing & urban áreas	Top 1 threat
Commercial & industrial áreas	Top 2 threat
Oil & gas drilling	Top 3 threat
Mining & quarrying	Top 4 threat
Logging & wood harvesting	Top 5 threat
Fire & fire suppression	Top 6 threat

MANGROVE

Threats	**Impact on plants**
Housing & urban áreas	Continuing threat
Commercial & industrial áreas	Continuing threat
Oil & gas drilling	Continuing threat
Mining & quarrying	Continuing threat
Renewable energy	Continuing threat
Housing & urban áreas	Affects the minority (< 50%) of the population
Commercial & industrial áreas	Affects the minority (< 50%) of the population
Housing & urban áreas	Rapid declines (20 to 30% over 3 generations)
Commercial & industrial áreas	Relatively slow but significant declines (< 20% over 3 generations);
Housing & urban áreas	Severity
Logging & wood harvesting	Severity
Commercial & industrial áreas	Severity
Oil & gas drilling	Severity
Mining & quarrying	Severity
Housing & urban áreas	Top 1 threat
Commercial & industrial áreas	Top 2 threat
Mining & quarrying	Top 3 threat
Fishing & harvesting aquatic resources	Top 4 threat
Agricultural & forestry effluents	Top 5 threat

TERRESTRIAL ECOSYSTEMS

Threats	Impact on plants
Annual & perennial non-timber crops	Continuing threat
Wood & pulp plantations	Continuing threat
Livestock farming & ranching	Continuing threat
Oil & gas drilling	Continuing threat
Mining & quarrying	Continuing threat
Renewable energy	Continuing threat
Gathering terrestrial plants	Continuing threat
Annual & perennial 0n-timber crops	Affects the majority (50 to 90%) of the population
Logging & wood harvesting	Affects the majority (50 to 90%) of the population
Gathering terrestrial plants	Affects the majority (50 to 90%) of the population
Fire & fire suppression	Affects the majority (50 to 90%) of the population
Wood & pulp plantations	Affects the majority (50 to 90%) of the population
Annual & perennial 0n-timber crops	Very fast declines (> 30% over 3 generations)
Gathering terrestrial plants	Relatively slow but significant declines (< 20% over 3 generations);
Annual & perennial 0n-timber crops	Severity
Mining & quarrying	Severity
Renewable energy	Severity
Gathering terrestrial plants	Severity
Fire & fire suppression	Severity

Annual & perennial 0n-timber crops	Top 1 threat
Housing & urban áreas	Top 2 threat
Mining & quarrying	Top 3 threat
Fire & fire suppression	Top 4 threat
Oil & gas drilling	Top 5 threat