Rapid Ecological characterization of the Licuáti Forest Reserve (LFR): setting up information to develop a Baseline Assessment for the Implementation of a biodiversity offsets pilot project

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In collaboration with:

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Cover photo: *Afzelia quanzensis*, woody species found in Licuáti Forest Reserve, Maputo. ©Denise Nicolau/BIOFUND

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Index

LIST OF FIGURES

LIST OF TABLES

GLOSSARY AND ABBREVIATIONS

Abbreviation or term	Definition
AOI	Area of Interest
BIOFUND	Foundation for Biodiversity Conservation
DINAB	National Directorate for the Environment
DINAF	National Directorate of Forests
EN	Endangered
FNDS	National Foundation for Sustainable Development
IIAM	Agricultural Research Institute of Mozambique
IPA	Important Plant Area
IUCN	International Union for Conservation of Nature
LC	Least Concern
LFR	Licuáti Forest Reserve
MTA	Ministry of Land and Environment
NT	Near Threatened
ROAM	Restoration Opportunities Assessment Methodology
VU	Vulnerable
WCS	The Wildlife Conservation Society

1 Background

Over the past decade, there has been a significant increase in the exploitation of natural resources in Mozambique, including the development of infrastructure, generally resulting in negative environmental and social impacts. Therefore, there is an urgent need to find ways to reconcile the economic development of Mozambique with the conservation of biodiversity and ecosystem services, on which the majority of the population depends for their survival.

A promising approach that has been used internationally is the implementation of the mitigation hierarchy[1], which requires economic operators to avoid and minimize impacts, restore biodiversity and its ecosystem services in impacted areas where possible and, if acceptable residual impacts persist, they must implement biodiversity offsets, in accordance with an appropriate management plan, in order to achieve No Net Loss (NNL) or Net Gain (NG) for biodiversity[2].

In this context, the Government of Mozambique represented by the Ministry of Land and Environment (MTA), National Directorate for the Environment (DINAB), in partnership with the Wildlife Conservation Society (WCS) and the Biodiversity Conservation Foundation (BIOFUND[3]) are at collaborate to design legal instruments and technical and financial procedures to enable the application of the mitigation hierarchy and biodiversity offsets in Mozambique, as required by Article 8, n. 4 of the Environmental Impact Assessment Regulation (Decree 54/2015 of 31 December).

Within the scope of national legislation (Decree 89/2017), international good practices (*Business and Biodiversity Offset Program*[4] – BBOP – and Performance Standard 6 of the *International Finance Corporation*[5]), biodiversity offsets are defined as measurable conservation results that come from of actions aimed at offset the significant residual adverse impacts on biodiversity resulting from the development of an activity or project, after the appropriate measures have been taken to avoid and minimize the impacts and restore the affected areas. In such cases, it is necessary to determine the residual impacts and quantify in order to define the results to be achieved and the way in which it should be carried out, in technical terms, space, time and who will implement it, always safeguarding that the impacted biodiversity must be balanced.

Interventions for biodiversity offset projects may consist of improving, restoring, rehabilitating, or removing current or future pressures on a given biodiversity, including maintaining and effectively protecting the conservation results obtained. The conservation actions promoted in these projects are similar to those that are already developed within the scope of the various conservation projects implemented in Mozambique, however, in the case of offset, this type of conservation activities are directly related to an impact caused by a project, existing results to be

[1] Mitigation Hierarchy "consists of the order of importance of measures to mitigate impacts that focus on the principles of avoiding, minimizing, rehabilitating, restoring and offsetting".

[2] A key factor for the adoption of the mitigation hierarchy, with the aim of reaching the NNL / NG, was established by the environmental and financial sector (IFC, World Bank, Equator Principles) in 2013.

[3] http://www.biofund.org.mz/projects/programa-de-contrabalancos-de-biodiversidade/

[4] BBOP, 2012.

[5] IFC, 2012.

achieved and clear biodiversity indicators duly identified in the biodiversity offset management plan.

Throughout the development of this mechanism, several companies in the private sector, particularly multinationals operating in the country in the extraction of mineral and energy resources, have expressed their commitment to the application of the best practices of international standards, as well as the application of the concept as a valuable tool to mitigate the negative impacts of large-scale development projects and promote the management of biodiversity and its ecosystem services.

A fundamental step towards the implementation of biodiversity offset projects is the test of the legal, technical, and financial viability of this concept on the ground, involving the various stakeholders throughout its implementation.

2 Rationale for the implementation of a Biodiversity Offsets Pilot Project in the Licuáti Forest Reserve

Mozambique has a network of thirteen forest reserves, which are managed by the National Directorate of Forests (DINAF) under the Ministry of Land and Environment (MTA). Forest reserves were created with the main objective of protecting forest areas to maintain stocks of wood of high commercial value. However, they offer several ecosystem services in addition to those described above, as is the case of creating habitats for relevant species of fauna and flora, maintaining water resources, carbon storage, food source and resources for local communities, among others. Additionally, some of them have a high conservation value, and hold habitat for endemic and / or threatened species of fauna and flora, which is why it has recently been found that several meet the requirements to be designated as Key Areas for Biodiversity (KBAs[6]) according to the criteria of the new Global Standard from the International Union for the Conservation of Nature (IUCN).

Between 2019 and 2020, WCS, DINAB and the members of the KBA and Red Listing National Coordination Group (DINAF included) completed a national KBA assessment, identifying 29 KBAs that were validated by the KBA Secretariat. This included Licuáti Forest Reserve due to the fact that it is home to six endemic KBA trigger species (*Empogona maputensis, Warneckea parvifolia, Xylopia torrei* – EN; *Polygala francisci* and *Sclerochiton apiculatus* – VU; *Psydrax fragrantissima* - NT), and it holds cultural value for the local communities (xxx et al., 2021).

Despite the relevance, the area is under great human pressure, essentially for charcoal production, illegal logging and agriculture expansion. The urban expansion itself is a threat to the region, which has become significantly more accessible to the citizens of Maputo and other districts of the Province with the construction of the new Maputo-Katembe bridge and respective road accesses connecting Boane and Ponta do Ouro. To address this threats, the Licuáti Forest Reserve urgently needs an effective management structure to ensure its adequate protection. The suggestion would be that its management plan define the boundaries of the KBA as a core

[6] Key areas for Biodiversity (KBAs) are areas that contribute to the global persistence of biodiversity according to internationally defined criteria.

zone, and that a buffer zone be established around it, where some activities for local communities would be allowed. It

In 2015, the Instituto de Investigação Agrária de Moçambique (the Agrarian Research Institute of Mozambique – IIAM) and the Royal Botanic Gardens, Kew (Kew), together with in-country and international collaborators, launched the "Tropical Important Plant Areas: Mozambique" project. LFR is also part of the current assessment and is likely to be designated as an Important Plant Area (IPA[7]).

Recognizing the ecological and socio-economic relevance of forest reserves, the opportunity to use the legal status of these areas of permanent forest cover and the potential for capacity building in the surrounding communities to support the implementation of techniques for the sustainable use of forest resources by reducing of forest degradation and its maintenance, BIOFUND - Foundation for Conservation of Biodiversity and WCS - Wildlife Conservation Society under the Biodiversity Offsets Program propose to the Government of Mozambique represented by the National Directorate of Environment (DINAB) and the National Directorate of Forests (DINAF), the implementation of a pilot project to improve natural habitats in the Licuáti Forest Reserve.

Therefore, the first step consists of conducting a biodiversity baseline including a list of interventions for improving, rehabilitating, or reducing current or future pressures, including maintenance and effective protection of the conservation results.

3 Objectives

The current document has the following objectives:

- Provide a brief description of the Licuáti Forest Reserve (LFR) ecological and biophysical status
- Select priority biodiversity elements that could be used as a model for testing possible offset activities
- Test the ROAM tool to identify and mapping restoration priorities in the LFR
- Determine the next steps to establish an ecological baseline for the implementation of a pilot-project in Licuáti Forest Reserve

[7] Important Plant Areas (IPA) are intended to be areas of great botanical importance for threatened species, habitats and plant diversity in general, that can be identified, protected and managed as sites.

4 Description of the Licuáti Forest Reserve

4.1 Location and climate

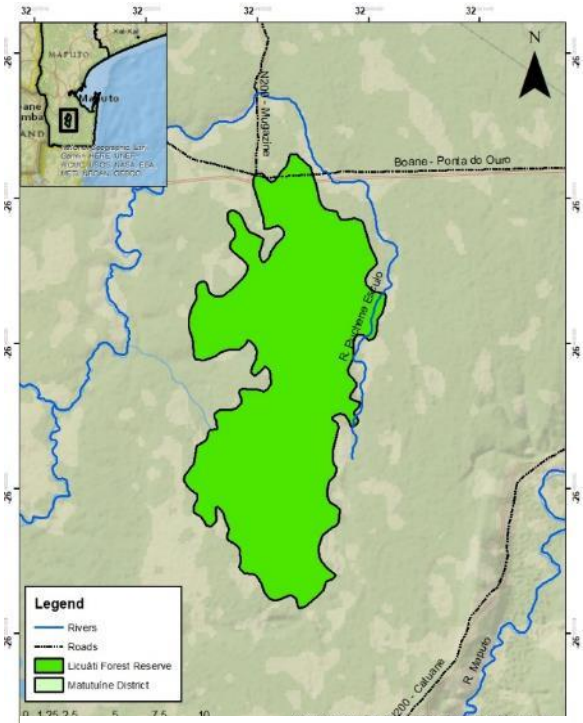

Figure 1. Licuáti Forest Reserve, southern Mozambique. Source: WCS

The Licuáti Forest Reserve (LFR) was established on 14 December 1943 by "Portaria number 54" (Gomes e Sousa, 1968), aimed at protecting woody species particularly *Afzelia quanzensis*. It occupies an area of 141 km^2 and lies in the northern part of Maputaland Centre Endemism (MCE), in Matutuíne District in southern Mozambique, approximately 50 km south of Maputo (see Figure 1) (Tokura et al., 2020).

In southern Mozambique, mean annual rainfall declines from east to west with approximately 1100 mm falling along the coastline and 600mm further inland in the LFR (Van Wyk 1996 in Izidine 2003). The land is mostly flat and comprises predominantly of Aeolian sand. Along the Maputo and Tembe rivers, however, alluvium clayey soils, which are more suitable for farming, are also common (Izidine et al., 2003).

4.2 Ecological characterization

The LFR contains a floristically unique Licuáti Thicket (also known as Short Sand Forest) and Licuáti Forest (Tall Sand Forest). It represents a type of vegetation with restricted distribution and contains many rare, endemic and near endemic species and several threatened with extinction of both flora and fauna (Duarte et al, 2020). LFR forms the core of Maputaland Centre of Endemism (MCE) and one of the most important plant communities within this region. This is an area of about 26,734 km^2 stretching northern KwaZulu-Natal in South Africa to the Limpopo River in southern Mozambique (van Wyk, 1996 *in* Matimele, 2016). This area holds endemic species spread across virtually the whole taxonomic spectrum, including both flora and fauna (Steenkamp et al., 2005 in Izidine et al., 2008). The MCE is a region within the Maputaland-Pondoland-Albany (MPA) biodiversity hotspot, which is located along the eastern coast of southern Africa from Maputo in Mozambique to Port Elizabeth in South Africa's Eastern Cape Province, extending inland to reach an altitude of 1800m a.s.l. along the Great Escarpment (Steenkamp et al., 2004 in Perera, 2013). High levels of endemism and biodiversity have been recognized in this hotspot (Izidine, 2003). Figure 2 illustrates the map of the MCE and the MPA biodiversity hotspot in southern Africa.

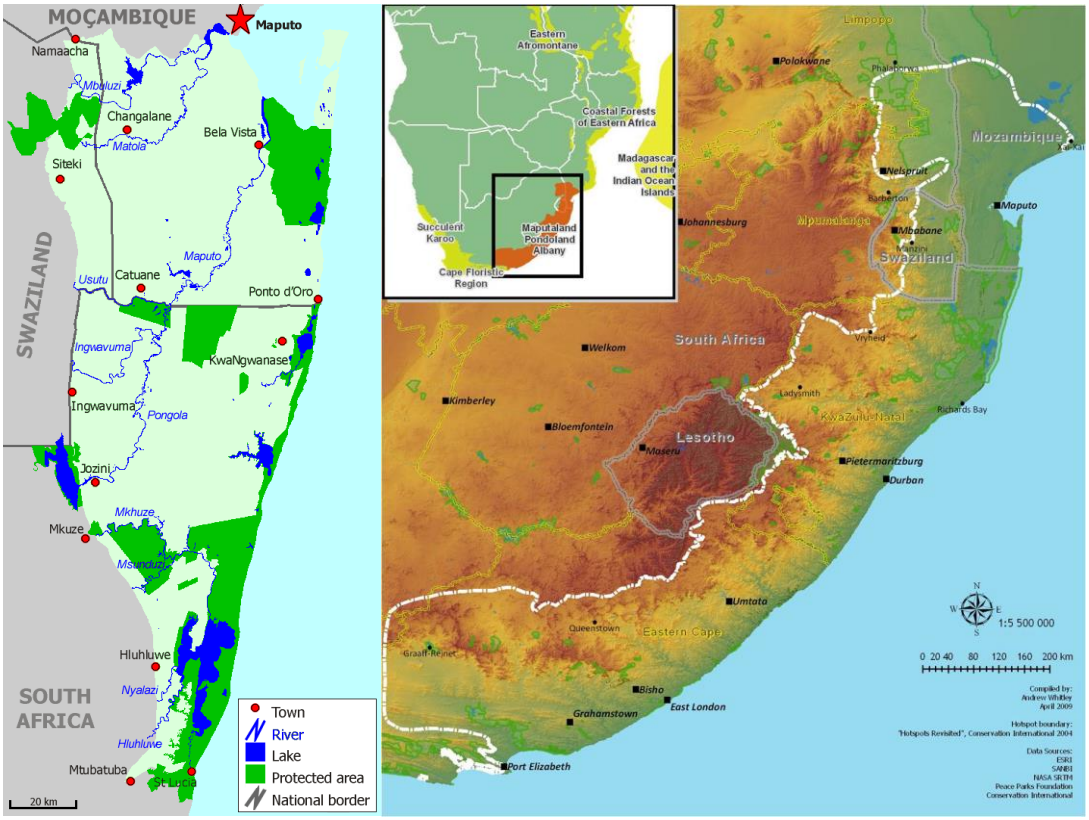

Figure 2. Map of i. Maputaland Centre of Endemism (left) and ii. Maputaland-Pondoland-Albany Biodiversity Hotspot. Source: Smith and Leader-Williams (2006) and Critical Ecosystem Partnership Fund (2010), respectively.

The LFR vegetation communities occur in a mosaic with dry woodland and other types of thicket (Matthews et al. 2001), therefore, are classified as a dry tropical forest (Izidine et al., 2008). It occurs on the ancient north-south trending dune cordons of the coastal plain of Plant Endemism (Izidine, 2003). According to Izidine et al. (2003), the LFR is characterized by tree species such as *Afzelia quanzensis, Albizia forbesii, Balanites maughamii, Cleistanthus schlechteri, Cola greenwayi, Croton pseudopulchellus, Dialium schlechteri, Drypetes arguta, Erythrophleum lasianthum, Hymenocardia ulmoides, Hyperacanthus microphyllus, Monodora junodii, Newtonia hildebrandtii, Psydrax fragrantissima, Pteleopsis myrtifolia, Ptaeroxylon obliquum, Spirostachys africana, Strychnos madagascariensis, Terminalia sericea and Uvaria lucida subsp. virens*. These are all species that are typical in southern African ecosystems with sandy soils where rapid fluctuations of both water and nutrient availability control primary production (Midgley et al. 1997 in Izidine, 2003).

In the 50s, Pedro & Barbosa (1955) described an Inland area of Maputo and marginal strips of the Incomati River, in Sábié, corresponding to the limestone, sandstone and conglomerate formations of the upper Cretaceous, with a rainfall (a. m.) of 600 to 800 mm. It covered a low or medium-sized forests, evergreen or sub-deciduous, with sub-humid or sub-dry, of the type commonly called "Licuáti Forest", consisting essentially of sclerophils such as *Pteleopsis myrtifolia, Piptadenia pseudacacia, Spirostachys Africana, Afzelia quanzensis, Balanites maughamii* and, occasionally, *Entandophragma caudatum*, succulents such as *Euphorbia spp. (E. ingens, E. cooperi), Aloe spp. (A. bainesii, A. marlothii*), evergreen shrubs and woody vines and succulents, in brown, reddish-brown and brown yellowish, sandy-loamy.

According to Gomes e Sousa (1968), in that decade of the 20th century Licuáti Forest was comprised of the following botanical aspects:

- **Open forest**: this type of forest presented only one arboreal layer and it was very uniform, both in size and in the floristic composition of the trees. Seen from higher points, the open forest was comprised of large arboreal masses, of different shades of green; the difference in size made the top of the forest undulating, which highlighted the variety of the floristic composition of the forest. Certain arboreal species in the open forest like *Afzelia quanzensis, Dialium schlechteri, Terminalia sericea, Sclerocarya caffra, Trichilia emetica*, dominated it, providing the forest certain characteristic features and in some cases economic value. The open forest had such a mixture of tree species that it made no distinction possible. For most of the area, new trees were few due to the fires that, every year, invaded large spans of forest and steppe, thus destroying new plants. In many places, where the open forest had disappeared for many years, a secondary, shrub or arboreal, low, fast-growing woody forest appeared. This vegetation served to protect the spread of larger and slower-growing trees, but fires prevented their spread. The shrub stratum was quite varied not only in species but also in form, and was clearer in the less dense forest, as it was natural, or dispersed over land where the adult forest had disappeared totally or almost totally, thus constituting the pioneers of the future forest cover. There were also climbing plants and sub-shrub and herbaceous substrates, with different grasses, species of ciperos, bulbous or succulent plants and ferns.
- **Sub-hygrophilous forest** - this type of forest, which in backward times should have been somewhat extensive was reduced to small patches occupying sandy-clay soil. It was more frequent in the southern part of the Licuáti region, rare in the central part and almost inexistent in the northern part. Its physiognomy was characterized by large trees, not very dense shrub stratum, the existence of several climbing plants and the presence of ferns from the shady places. The features of sub-hygrophilous forest showed that once it occupied a large area of the Licuáti region, but then it was reduced to small fragments. One of these fragments was located near the Maputo River and was crossed by the Bela Vista-Catuane road, in the place called Tinonganine. This area, in its herbaceous stratum, stand out as aloe of high size and numerous bulbous plants.
- **Gallery forest** - this type of forest was almost extinct, only a few specimens were left but everything was disappearing. In the lower course, near the mangrove there were still gallery remains with species corresponding to a low degree of water salinity.

In the places devoid of the forest there were steppes almost always entombed with shrubs and creeping palm trees, the most common type being the savannah shrub.

Gaugris & Van Rooyen (2008), characterized Licuáti Thicket as dense woody vegetation in the shrub layer, which occurs to a height of 5-6m (Gaugris & Van Rooyen, 2008). Common species in the shrub layer include *Psydrax locuples, P. fragrantissima and Warneckea parvifolia,* while *Balanites maughamii* and *Afzelia quanzensis* emerge above the canopy. Licuáti Forest has similar species composition but has a taller structure up to 15m in height. These two vegetation types, Licuáti Thicket and Licuáti Forest, are typically located in a matrix of open woodland dominated

by *Terminalia sericea, Albizia versicolor, Albizia adianthifolia* or grassland, which is structurally and floristically different (Izidine, 2003).

5 Key biodiversity occurring at Licuáti Forest Reserve

The Licuáti Thicket is particularly important habitat for many endemic flora species in the region. Izidine (2003) compiled an annotated checklist of the plants of the Licuáti Thicket, with around 112 species, using specimens collected, preexisting checklists and plant collections of different herbariums. According to Matimele (2016), two species in particular, *Empogna maputensis* and *Warneckea parvifolia*, have restricted distributions in the LFR.

Licuáti Forest Reserve was recently identified as a Key Biodiversity Area (KBA), because it is home to several KBA trigger species, such as *Xylopia torrei, Empogna maputensis, Sclerochiton apiculatus, Polygala francisci* and *Warneckea parvifolia*, that are threatened with extinction and *Psydrax fragrantissima* with a restricted distribution, LFR is home for at least 10% or more of its global population. Therefore, these are also floristic species of particular relevance.

There are other species relevant for the good health of the ecosystem, which are also important for their economic value and necessary to conserve in LFR, such as: *Acridocarpus natalitius var. Linearifolius, Afzelia quanzensis, Balanites maughamii* and *Encephalartos ferox.*

LFR usually receives attention due to the flora component, which is why most of the existing studies are on flora. However, LFR is also home to many small mammals, birds and insects, some of which are endemic to the MCE region (Izidine, 2003). According to eBird (2020), there are 84 bird species recorded to LFR. As stated by a bird specialist which was consulted under the present project (Gary Allport, *com. pess.*), four bird species are endemic to Maputaland hotspot, namely: Neergaard's Sunbird *Cinnyris neergaardi;* Pink-throated twinspot *Hypargos margaritatus; Le*mon-breasted Canary *Crithagra citrinipectus* and Rudd's apalis *Apalis ruddi*. A globally threatened species, the Cape Vulture *Gyps coprotheres* classified as endangered (EN) in the IUCN Red List, also occurs in the area.

According to discussions with the flora and bird experts who know the area well, such as Hermenegildo Matimele and Gary Allport (*com. pess.)*, respectively, a list of 15 priority species (10 of flora and 5 bird species) has been compiled as a start point to identify priority species to target in the way to improve ecological condition of LFR's ecosystems.

5.1 Flora

Ten flora species have been compiled as priority species to target in the way to improve ecological condition of LFR's ecosystems, namely:

5.1.1 *Acridocarpus natalitius* var. *Linearifolius*

This species is classified as Vulnerable (VU) in IUCN Red List of Threaten Species and it is endemic to the MCE. It is a shrub or small tree, up to 5 m, sometimes scrambling or climbing. The taxon occurs as sparsely scattered individuals throughout the Maputaland coastal plain and also a few sporadic occurrences have been recorded further inland on sandy soils at higher altitude. The roots of *Acridocarpus natalitius var. linearifolius* have been documented as being used for medicine (Williams et al. 2001 in Matimele, 2016). Medicinal use combined with past habitat transformation has led to a 10% decline in the population over the past 45 years with future loss to urban and agricultural development suspected to cause a further 20% of the population to be lost by 2040 (Matimele, 2016). The habitat preferences are forest edges and in clearings, on rocky shallow red clay soils (Hyde et al.2020).

Figure 3. *Acridocarpus natalitius* var. *Linearifolius* (Photos: Naseeba Sidat/WCS)

5.1.2 *Afzelia quanzensis*

The species is classified as Least Concern (LC), it is characterized as medium-sized to large deciduous tree. Although not rare (yet) in Mozambique, this tree is very sought-after for its hardwood (Hyde et al. 2020). *Afzelia quanzensis* is commonly known as "*chanfuta*", it is one of the valuable wood producers in tropical African regions, and as such it has been exploited for many years in the Licuáti region (Gomes e Sousa, 1968). Habitat preferences include lowed woodland and forest (Hyde et al. 2020).

Figure 4. *Afzelia quanzensis* (Photos: Tereza Alvez/IIAM –left; Naseeba Sidat/WCS –right)

5.1.3 *Balanites maughamii*

The species is classified as Least Concern (LC), it is characterized to be medium-sized to tall deciduous tree, large specimens often with a fluted trunk. It is a species of dry open woodland, riverine fringes, sand forest and around springs and edges of pans (Hyde et al. 2020). *Balanites maughamii* is an important medicinal plant species in Southern Africa, the bark, fruits, leaves, and roots are used for various traditional and medicinal applications (Maroyi, 2019). The fruits are consumed by human and variety of animals such as monkeys, baboons, warthogs and antelope. It has other applications, being used for poisoning to some fish, tadpoles and snails when placed in the water and its well-known for its hard timber (Behr, 2006).

Figure 5. *Balanites maughamii* (Photos: Denise Nicolau/BIOFUND –left; Naseeba Sidat/WCS –right)

5.1.4 *Empogona maputensis*

The species is classified as Endangered (EN), it is endemic to the MCE and has very restricted distribution. This species is known from only two locations at the LFR where it occurs in the understory of the Licuati thicket vegetation. It is characterized as stiff woody shrub to 1 m high or more (semi-scrambling), occasional in very dense thicket on sands (Hyde et al.2020). There is severe ongoing habitat degradation due to charcoal production (Izidine et al. 2008). As one of the closest sources of charcoal for Maputo, Licuati Thicket is expected to be placed under severe pressure for wood and charcoal in the future. Past loss and degradation of habitat at Licuati due to timber and agriculture concessions (Gomes e Sousa, 1968), as well as harvesting is suspected to have resulted in 20% loss to the population (Matimele, 2016).

Figure 6. *Empogona maputensis* (Photo: Naturalista site)

5.1.5 *Encephalartos ferox*

The species is classified as Near Threatened (NT) and it is endemic of Southern Africa, occurring from northern KwaZulu Natal extending from Sodwana Bay to Kosi Bay and then further north along the Mozambique coastline to Vilanculos (Turner, 2002). The cycad either stemless or with a short stem up to c. 1 m high and 25-30 cm in diameter. It occurs in coastal forest and scrub often behind sand dunes (Hyde et al. 2020). The fleshy seeds are relished by many animals (baboons, vervet monkeys, dassies, fruit-eating bats) and birds (a particular favourite of the Trumpeter and Crowned Hornbills). They are attracted by the brightly coloured fleshy covering of the seed and are important agents of seed dispersal, spitting out the poisonous kernels once they have eaten the fleshy covering (Turner, 2002).

Figure 7. *Encephalartos ferox* (Photos: Ann Bouckaert – left; Sune Holt – right)

5.1.6 *Polygala francisci*

The species is classified as Vulnerable (VU), it is a range restricted species of the northern MCE known only in southern Mozambique (Matimele et al. 2019). It is a perennial herb or shrub with slender stems. Occurs in open bush on white sand on the edges of dense, mixed woodland (Plant of World Online, 2020) and has also been recorded from Acacia woodland on more clay-rich soils. Because of it occurrence on the edges of woodlands, it is probably prone to edge effects induced by deforestation, different land uses, burning and expansion of human habitation. At Licuáti, there are severe threats to the thicket from charcoal production and wood removal. The building of the bridge linking Maputo Bay and Catembe is resulting in easier access to the southern locations for this species and likely increased human disturbance (Matimele et al. 2019).

Figure 8. Genus *Polygala* (Photos: Wikipedia – left; iNaturalist – right)

5.1.7 *Psydrax fragrantissima*

The species is classified as Near Threatened (NT) and it is endemic of MCE where it is locally abundant in thicket. It is characterized as shrub or small tree 2.5–6 m tall (Plant of World Online, 2020). Although well-conserved in South Africa the main part of the population known records are from the Maputaland Coastal Plain with the largest recorded subpopulation occurring at LFR (Matimele et al. 2020). Since 1943, the LFR has been under habitat loss due to timber and agriculture concessions which is suspected to have resulted in 20% loss to the overall population. As the LFR is one of the closest sources of charcoal for Maputo, it is under severe ongoing pressure (Sitoe et al. 2013 in Matimele, 2016).

Figure 9. *Psydrax fragrantissima* (Photos: GBIF).

5.1.8 *Sclerochiton apiculatus*

The species is classified as Vulnerable (VU) and it is endemic to MCE. It is erect or scandent shrub to 3-4.5 m tall. Occurs in dry semi-deciduous coastal forest (sand forest) and thicket, riverine forest (Plant World Flora Online, 2020). The ongoing development and habitat degradation in both Mozambique and South Africa, is increasingly reducing suitable habitat of this species. Development includes expansion of urban areas, increase in land allocation for food production, human settlement, and building of new infrastructures. Habitat degradation in the form of deforestation for fuel and charcoal production is causing rapid and ongoing loss of this species habitat particularly in Mozambique (Matimele, 2016).

Figure 10. *Sclerochiton apiculatus* (Photos: Naseeba Sidat/WCS-left; Denise Nicolau/BIOFUND –right)

5.1.9 *Warneckea parvifolia*

The species is classified as Endangered (EN), is an evergreen shrub or small tree, 2.5–6 m tall (Hyde, 2020) endemic to the MCE. It is known from two locations, one in Tembe Elephant Park, KwaZulu-Natal South Africa and the other at the LFR in Maputo province, southern Mozambique. Despite being a reserve, the LFR is under severe ongoing degradation which may have resulted in 20% loss of the species. If the degradation continues at the current observed rate, it is suspected that about 80% of the species in this area will be lost by 2040. The 80% loss of the LFR's subpopulation, relates to an overall loss of 50% to the entire known population (Matimele, 2016).

Figure 11. *Warneckea parvifolia* (Photos: Naturalista).

5.1.10 *Xylopia torrei*

The species is classified as Endangered (EN) and endemic to MCE. The shrub, up to 2 m high (Plants of the World Online, 2020) is a rare and localized species of undisturbed lowland thicket on sand. This habitat type is threatened at its known localities including at LFR, which appears to be the most important location for this species. The threats here are severe and regeneration of thicket is unlikely to occur after charcoal production (Matimele et al. 2019).

Figure 12. *Xylopia torrei* (Photo: Hermenegildo Matimele)

5.2 Fauna

Additionally, five fauna species have been compiled, namely:

5.2.1 *Cinnyris neergaardi*

The Neergaard's Sunbird (*Cinnyris neergardi*) is a bird species in the Nectariniidae family classified as Near Threatened (NT) and endemic to South Africa and Mozambique. It occurs from just south of Richard's Bay in northern KwaZulu-Natal, South Africa, to Inhambane, southern Mozambique (Harrison et al. 1997). It is restricted to the coastal belt, but atlas data do not suggest any range retraction. In Mozambique, it has two widely separated populations; one south of Maputo and the other north of the Limpopo River (Cheke and Mann 2001 in BirdLife International, 2020).

This species is a sometimes common, but nomadic, species of woodland, especially dry, dense forest on sandy soil. It also inhabits coastal scrubland and has been recorded in isolated trees in clearings and villages (Cheke and Mann 2001). It is found only at low elevations and apparently avoids fragmented coastal forest (Clancey 1985). It consumes nectar, small insects and spiders (Cheke and Mann 2001 in BirdLife International, 2020).

In southern Mozambique, the species' coastal forest habitat is highly threatened, particularly by commercial logging and afforestation with non-native tree species (Parker 1999). In Reserves such as Tembe Elephant Park, habitat modification by elephants may also prove to be a threat (Brown and Peacock 2015 in BirdLife International, 2020).

Figure 13. Neergaard's Sunbird *Cinnyris neergardi* (Photo: Marcel Holyoak)

5.2.2 *Hypargos margaritatus*

The Pink-throated Twinspot (*Hypargos margaritatus*) is classified as Least Concern (LC) and it is endemic of southern Africa. It inhabits dry savanna and moist, subtropical/tropical (lowland) shrubland habitats near the southeast African coast in Mozambique, South Africa and Swaziland. It has a large range, with an estimated global extent of occurrence of 160,000 km² (Avibase, 2020). The population is suspected to be stable in the absence of evidence for any declines or substantial threats (BirdLife International, 2020).

Figure 14. Pink-throated Twinspot - *Hypargos margaritatus* (Photo: Dave Irving)

5.2.3 *Crithagra citrinipectus*

The Lemon-Breasted Canary (*Crithagra citrinipectus*), also known as the Lemon-breasted Seedeater, is a species of finch in the Fringillidae family (Avibase, 2020). This species is classified as Least Concern (LC) and endemic to southern Africa being found in southern Malawi, south-east Zimbabwe, and southern Mozambique to Zululand and northern Natal, South Africa. It has also been recorded in Zambia (BirdLife International, 2020).

In general, this species' natural habitats are dry savanna, subtropical or tropical dry shrubland, and rural gardens (Avibase, 2020). More specifically it can be found in lowland palm savannas, clearings in dry woodland, *Brachystegia* scrub, grassland, gardens, road verges and edges of cultivation, invariably below 750 m. It is gregarious and often forms flocks with Yellow-fronted Canary *S. mozambicus*, and in the non-breeding season nomadic flocks move at random in search of feeding areas of flowering grasses. It is strongly associated with Ilala palms *Hyphaene natalensis* over most of its range. At least 2,000 individuals are exported from the population in south Mozambique annually (Parker 1999). The Ilala palms *Hyphaene natalensis*, with which the species is associated, are commonly used in furniture manufacture, at least in Zimbabwe (Fry and Keith 2004 in BirdLife International, 2020).

Figure 15. Lemon-Breasted Canary - *Serinus citrinipectus* (Photo: Stephen Daly)

5.2.4 *Apalis ruddi*

The Rudd's Apalis (*Apalis ruddi*) is a species of bird in the Cisticolidae family, classified as Least Concern (LC) and endemic to Malawi, Mozambique, and South Africa. Its natural habitats are subtropical or tropical dry forests and subtropical or tropical moist shrubland (Avibase, 2020).

The populations of this species are crudely estimated to number more than 10,000 individuals in southern Mozambique, 1,000 in Swaziland, in excess of 7,000 in KwaZulu-Natal and 4,750 in the north-eastern Kruger National Park, South Africa. The population is suspected to be stable in the absence of evidence for any declines or substantial threats (BirdLife International, 2020).

Figure 16. Rudd's Apalis - *Apalis ruddi* (Photo: Marcel Holyoak)

5.2.5 *Gyps coprotheres*

The Cape Griffon or Cape Vulture (*Gyps coprotheres*), also known as Kolbe's Vulture, is an Old World vulture in the family Accipitridae, classified as Endangered (EN). It is endemic to southern Africa, and is found mainly in South Africa, Lesotho, Botswana and in some parts of northern Namibia. It nests on cliffs and lays one egg per year (Avibase, 2020).

It is a long-lived (Oatley et al. 1998) carrion-feeder specialising on large carcasses, it flies long distances over open country, although usually found near steep terrain, where it breeds and roosts on cliffs (Mundy et al. 1992 in BirdLife International, 2020).

The species is assumed to be declining throughout much of its range in the face of a multitude of threats (Boshoff and Anderson 2007). The primary threats are currently thought to be contamination of their food supply and possibly a shortage in food supply, negative interactions with human infrastructure and hunting for use in the traditional health industry (Allan 2015). Further threats include disturbance at colonies, bush encroachment and drowning (Anderson 1999, Borello and Borello 2002, Bamford et al. 2007). In southern Africa, vultures are caught and consumed for perceived medicinal and psychological benefits (McKean and Botha 2007, Anon. 2008). The species suffers mortality from the ingestion of poison left for pests (not vultures) (Diekmann and Strachan 2006) and potentially diclofenac, a non-steroidal anti-inflammatory drug often used for livestock, and which is fatal to Gyps spp. when ingested at livestock carcasses

(Komen 2006, BirdLife International news www.birdlife.org/news 2007). A single poisoning incident can kill 50-500 birds, making the species susceptible to sudden local declines (M. Diekmann in litt. 2006 in BirdLife International, 2020).

Poor grassland management in some areas has promoted bush encroachment, making finding carcasses more difficult for vultures (Schultz 2007, Bamford et al. 2009). There are records of at least 120 individuals (21 incidents) of this species drowning in small farm reservoirs in southern Africa between the early 1970s and late 1990s (Anderson et al. 1999), although modifications to many reservoirs have now been made (Boshoff et al. 2009 in BirdLife International, 2020).

Figure 17. Cape Vulture - *Gyps coprotheres* (Photo: Annette Fallin)

6 Main threats to biodiversity in Licuáti Forest Reserve

As explained before there are several pressures in LFR posed by local communities, with focus on deforestation for charcoal production, something that needs site confirmation. According with Population Cense of 2017 (FNDS, 2021), there are at least fourteen population settlements around LFR within a buffer of 5 km (see Figure 18).

A study developed by Matimele (2016) showed that there are several areas that have being lost inside the reserve. A story map on Charcoal Mound Search was developed by Peace Parks Foundation to identify and quantify charcoal mounds that usually are hidden, in the way to reduce the impact of charcoal production in Maputo Special Reserve (MSR) and LFR.

This story map shows Charcoal Mounds Hotspots in the western area of LFR, eastern part of MSR and in Catembe district. These mounds tend to generally be away from human activity, have paths leadings to them, are in close proximity to trees, and often have piles of white bags next to the mounds (the bags in which the end product, charcoal, is stored and commercialized), as illustrated in Figure 19.

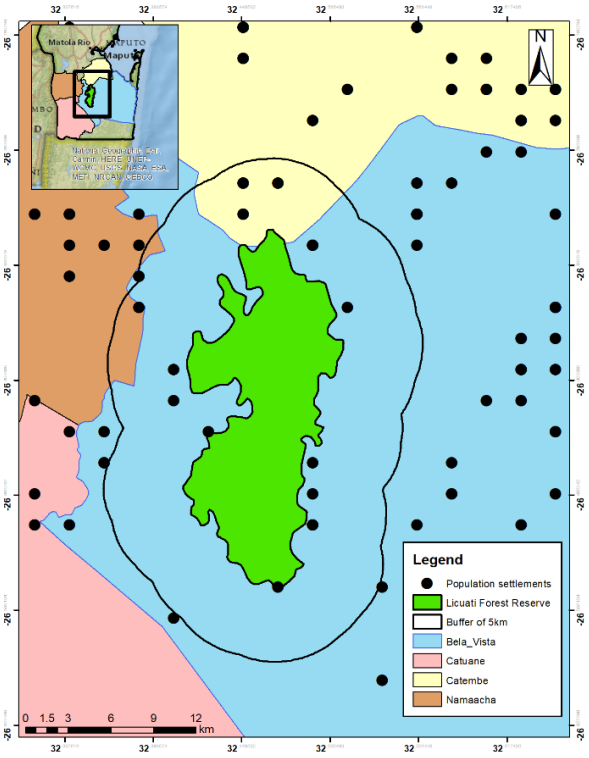

Figure 18. Population settlements from four Administrative Posts: Bela Vista, Catuane, Catembe and Namaacha, in LFR landscape. (Data Source: FNDS, 2021)

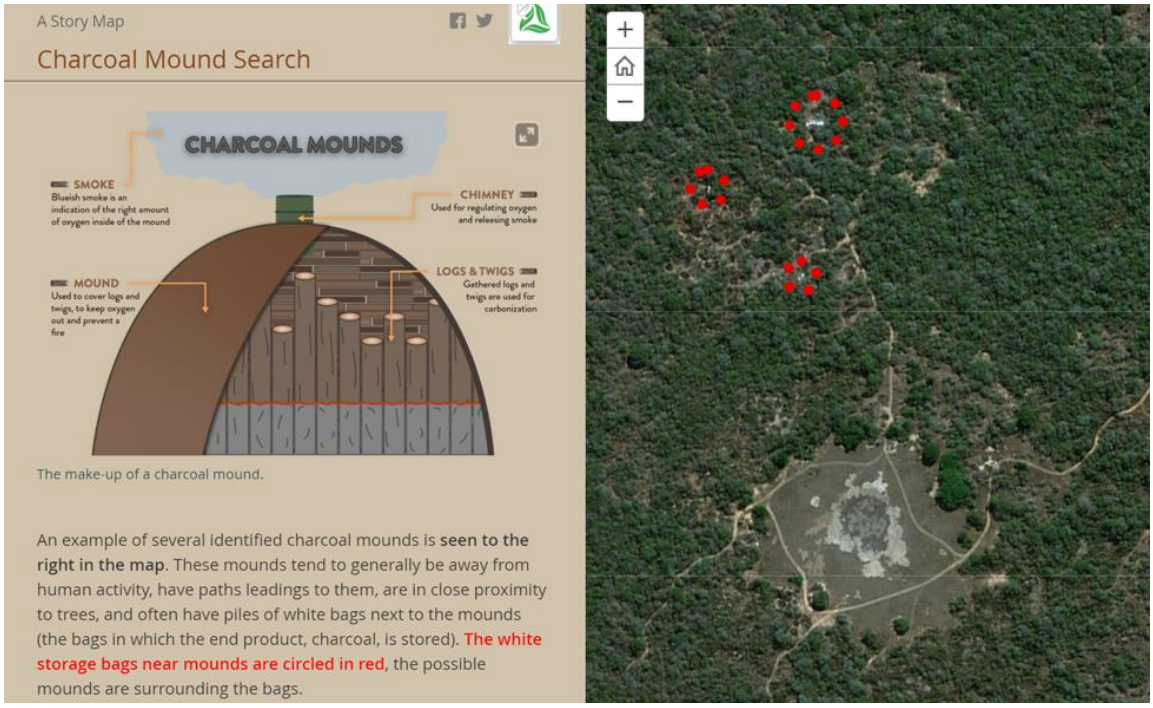

Figure 19. Localization of charcoal bags near mounds.

A preliminary visit by our team to the site in 2018 shows that at least close to the road Boane-Ponta do Ouro/N200 there are several areas that are being used for charcoal production and it was common to see charcoal bags for selling along the way to LFR and Maputo Special Reserve, as shown in Figure 20.

Figure 20.Charcoal bags for sell, in the surround areas of Licuáti Forest Reserve and Maputo Special Reserve. Source: Naseeba Sidat (WCS) and Fabien Quetier (Biotope).

A preliminary analysis done by our team using remote sensing shows significant areas of deforestation. Figure 21**Error! Reference source not found.** illustrates NDVI calculations using two different sources of satellite imagery where red shows the areas which have likely been cleared, and green color indicate forest or vegetation.

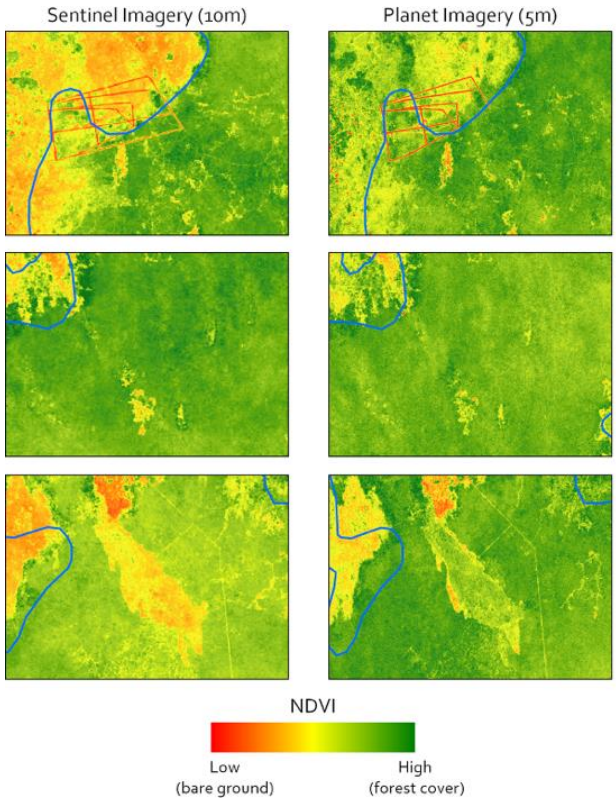

Figure 21. NDVI calculated using sentinel (10m resolution) and planet (5m resolution).

Local interventions are required, however, any action plan would probably need to include landscape conservation actions within the Matutíne district or at least inside Maputo Environmental Protected Area.

7 Site visit to Licuáti Forest Reserve: key findings

A field visit[8] was carried out between 1 and 6 March 2021 to assess the current conditions of Licuáti Forest Reserve and its surrounding area. The visit was led by IIAM with the intention of visiting some sites in Djabula community and LFR area, validating vegetation cover, collecting information on flora species and interacting with communities and their community leaders. WCS and BIOFUND team joined IIAM, FNDS/MozBio2 and DINAF, with the main objective to verify the occurrence of priority species identified in the section above, and also to identify potential restoration areas within LFR.

According to the results from the field visit and discussion with flora experts, the team pre-selected eight (8) flora species important for the improvement of the ecosystem of the LFR, based on their endemicity, importance for Licuáti ecosystems and threats to their local populations. These are:

1. *Balanites maughamii*
2. *Empogona maputensis*
3. *Newtonia hildebrandtii*
4. *Polygala francisi*
5. *Psydrax fragrantissima*
6. *Spirostachys africana*
7. *Warneckea parvifolia*
8. *Xylopia torrei*

Three arboreal species like *Balanites maughamii*, *Newtonia hildebrandtii* and *Spirostachys Africana* was selected due to the threats to their local populations. The other five species were not recorded during the field visit in March, however, they have been selected because of their endemicity, importance for the Licuati ecosystems and impacts to their local populations.

Table 1 presents some insights from the field visit regarding characterization and occurrence at site; socio-economic value; anthropogenic disturbances and their impacts:

[8] Field visit report to Licuáti Forest Reserve and Djabula, Matutuíne, Maputo, available here

Table 1. Relevant information about the five flora species recorded during the field visit as being important for the improvement of the LFR ecosystem.

Specie	Conservation status	Characterization and occurrence at site	Socio-economic value	Anthropogenic disturbances and their impacts
Balanites maughamii	The species is classified as Least Concern (LC) in the IUCN Red List of Threatened Species.	Woody species, medium to high in size, which can reach 15m in height. It occurs in thickets and semi-deciduous forests.	It is used to make benches for sitting.	It was once used extensively for charcoal production, so very few individuals of this species are found today.
Spirostachys africana	The species is classified as Least Concern (LC) in the IUCN Red List of Threatened Species.	Woody species, medium to high in size, which can reach up to 18m in height. It occurs in deciduous woodland, often on brackish flats and sandy soils.	Known as *African Sandalwood*, it is used for wood, stumps and firewood production.	Habitat degradation of this species is mostly caused by habitat fragmentation, and deforestation for logging. It was overexploited in the past, and afterwards a project had been developed in 2004 to restore their population. This plantation was found with trees of 2 to 3 m of height, and, another area was found with adult individuals. Stumps were found in some degraded areas inside the LFR.
Newtonia hildebrandtii	Species classified as Least Concern (LC) in the IUCN Red List of Threatened Species.	A large woody species that can reach over 10 - 25m in height. It has been recorded in degraded areas and deciduous forests.	Target species for charcoal production, and is overexploited.	Habitat degradation of this species is mostly caused by habitat fragmentation, and deforestation for charcoal production and/or logging. Very few trees were observed. Charcoal production areas were found with adult trees cut down.

Regarding avifauna, no targeted survey was carried out. However, the team recorded the occurrence of birds in the sampling plots as shown in Table 2.

Table 2. Registration of bird species in the LFR and its surrounding area.

Date	Point/ ref.	Time	Duration	Species name	Conservation status and population trend	<50m	50 to 100m	>100m	Cloud cover	Rain	Visibility	Temperature	Observations
1-5/03/21	26°33'21.7"S 32°23'06.2"E	7h00 - 08h00	1 hour	Crowned Hornbill *Lophoceros alboterminatus*	Least Concern (LC) Population decreasing	x			20%	No	Good	30C	4 birds on the canopy of a *Newtonia* tree, in Djabula, at VIDA facilities
2/3/2021	26°26'07.9"S 32°21'59.4"E	11h30	30min	Red Bishop *Euplectes orix*	Least Concern (LC) Population stable		x		40%	No	Good	29C	Cropland close to Tembe River, in Djabula
2/3/2021	26°26'07.9"S 32°21'59.4"E	11h30	30min	Yellow wrumped Widow *Euplectes capensis*	Least Concern (LC) Population stable		x		40%	No	Good	29C	Cropland close to Tembe River, in Djabula
2/3/2021	26°26'07.9"S 32°21'59.4"E	11h30	30min	Little Bee-eater *Merops pusillus*	Least Concern (LC) Population decreasing		x		40%	No	Good	29C	Cropland close to Tembe River, in Djabula
4/3/2021	26°27'52.3"S 32°36'07.5"E	15h00	15min	Little Bee-eater *Merops pusillus*	Least Concern (LC) Population decreasing			x	20%	No	Moderate	30C	Wetland at Tinonganine
4/3/2021	26°27'52.3"S 32°36'07.5"E	15h00	15min	Woollynecked Stork *Ciconia episcopus*	Near Threatened (NT) Population decreasing			x	20%	No	Moderate	30C	Wetland at Tinonganine
4/3/2021	26°23'43.1"S 32°24'49.9"E	16h30	1 hour	Blackeyed Bulbul *Pycnotus barbatus*	Least Concern (LC) Population increasing		x		40%	No	Moderate	28C	Point H, degraded area, LFR
4/04/2021	26°29'26.82"S 32°21'16.38"E	17h40	10min	European Roller *Coracias garrulus*	Least Concern (LC) Population decreasing	x			10%	No	Good	30C	Open woodland, with many cut trees, near a low area
5/3/2021	26°32'53.8"S 32°23'02.9"E	19h30	10min	Spotted Eagle *Owl Bubo africanus*	Least Concern (LC) Population stable	x			0%	No	Low	25C	Sighted on the way back to the VIDA facilities, on at least 3 consecutive days, in Djabula
6/3/2021	26°19'40.6"S 32°26'36.7"E	11h00	15min	Emeraldspotted Dove *Turtur chalcospilos*	Least Concern (LC) Population stable	x			60%	No	Very good	30C	Point A, LFR
6/3/2021	26°19'40.6"S 32°26'36.7"E	11h00	15min	Bluecheeked Bee-Eater *Merops persicus*	Least Concern (LC) Population stable	x			60%	No	Very good	30C	Point A, LFR
6/3/2021	26°19'40.6"S 32°26'36.7"E	11h30	30min	Lizard Buzzard *Kaupifalco monogrammicus*	Least Concern (LC) Population stable	x			40%	No	Very good	30C	The bird was on top of a power pole, along the national road and very close to point A

8 Mapping restoration priorities in the Licuáti Forest Reserve and surrounding areas: testing the ROAM tool

To support the application of the new regulation developed for the implementation of Biodiversity Offsets[9], a series of tools and technical guidelines need to be developed, such as a framework to identify potential restoration sites to be used as future offset receiving areas.

There is a need to therefore identify strategic areas that maximize the potential benefit of enhancement/restoration activities for targeted biodiversity. This includes understanding the current degradation of ecosystems and identifying strategic areas for restoration. While final site choice will always require field verification, GIS based assessments can provide useful first-pass filters to identify potential target areas.

There have been previous attempts to identify ecosystem restoration priorities in Mozambique using the IUCN ROAM – Restoration Opportunities Assessment Methodology approach (MICAIA et al., 2018; MITADER, 2018). While this approach was primarily focused on functional ecosystem restoration, such objectives are not directly applicable to restoration for biodiversity offsets, which should be related to specific biodiversity enhancement. Therefore, WCS in partnership with BIOFUND has been adapting the ROAM to update the assessment of restoration priorities in Mozambique, with a focus on identifying potential offset receiving sites.

The ROAM tool allows the identification and mapping of the potential restoration areas, at different scales, and thus target the field validation study to these areas to determine which are the most suitable for restoration of a particular type of biodiversity, where metrics for determining the ecological condition of that ecosystem can be applied later on. This approach will complement existing ROAM assessments and use similar analytical techniques but will be focused on identifying restoration areas to achieve the objectives of Mozambique's biodiversity offset regulations.

To demonstrate how restoration priorities can be identified at a macro-scale using the ROAM, we conducted an example assessment for the Matutuíne region. While in this case LFR had already been identified as a potential restoration site for the type of forest ecosystem that occurs in the region, in other regions this will not be the case, and our example assessment demonstrates how restoration priorities can be identified for any given area of interest.

In the case of the Mozambican regulation, the selection of a potential offset site depends on the previous determination of the type of biodiversity that needs to be offset. This is a mandatory step, because the biodiversity to be improved by the offset needs to be equivalent to the one that will be impacted by the development project.

The current exercise is focused on identifying potential restoration within the Licuáti Forest that can be used as future offset receiving areas. Therefore, an approach has been developed to identify strategic areas that maximize the potential benefit of enhancement/restoration activities for targeted biodiversity. This includes understanding the current degradation of ecosystems, and identifying strategic areas for restoration. While final site choice will always require field verification, GIS based assessments can provide useful first-pass filters to identify

[9] Instrument under development by the National Directorate of Environment (DINAB) in collaboration with WCS and BIOFUND – the Foundation for Conservation of Biodiversity.

potential target areas. The methodology and rationale of this approach is described in detail in another report (WCS & BIOFUND, 2021), so here we provide only a brief description of how the methodology was applied.

8.1 Define area of interest

In order to map potential ecosystem restoration sites, a key first step is to identify the area of interest (AOI) in which to search. Focusing on a specific region of interest, rather than conducting analysis at a broader scale, helps streamline further analysis and allows for the best available datasets to be used in subsequent steps. Here we define the AOI as forest ecosystems within the Matutuíne district, using Mozambique's updated historical ecosystem map to include only Forest Ecosystems (Figure 22).

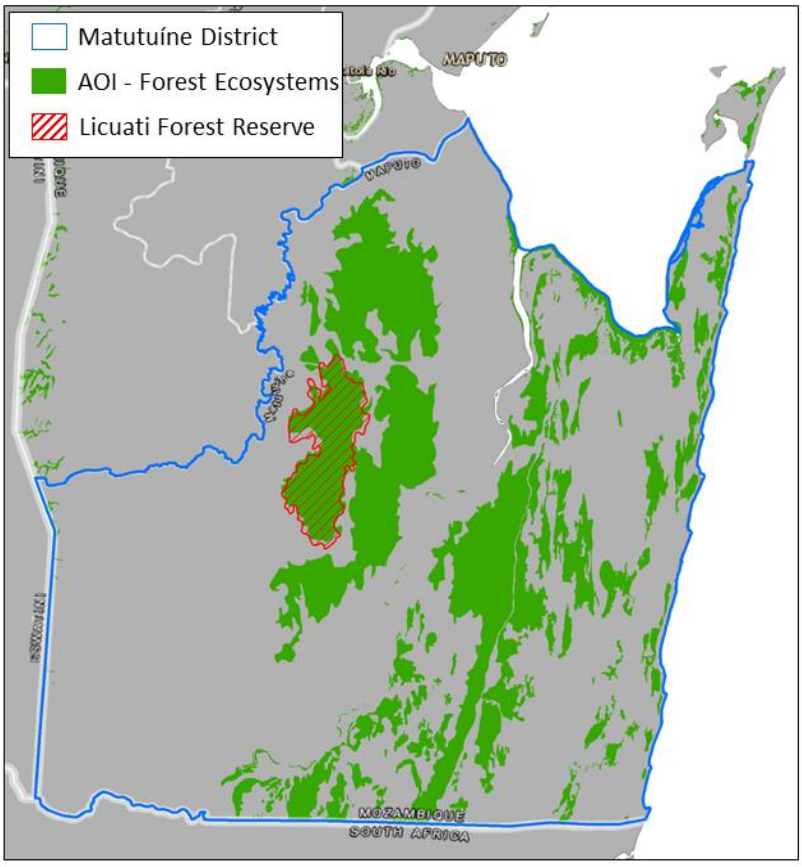

Figure 22.Forest ecosystems within Matutuíne district, used as AOI in this example.

8.2 Exclude unsuitable areas

After defining an AOI, a key next step is to identify areas that are unsuitable for offset activities (e.g. cities, roads, intensive agriculture). This can help focus further analysis to areas that may potentially receive offsets, and avoid wasting time and effort assessing the restoration potential

of unsuitable areas. In this example, we mapped areas within 200 m of roads and areas of high population density and excluded these areas as they are likely to be unsuitable for offsets. We used a buffer of 200m around roads because these places often face substantial threat due to the ease by which they can be accessed, which may lead to future impacts negating the benefit of any restoration activities.

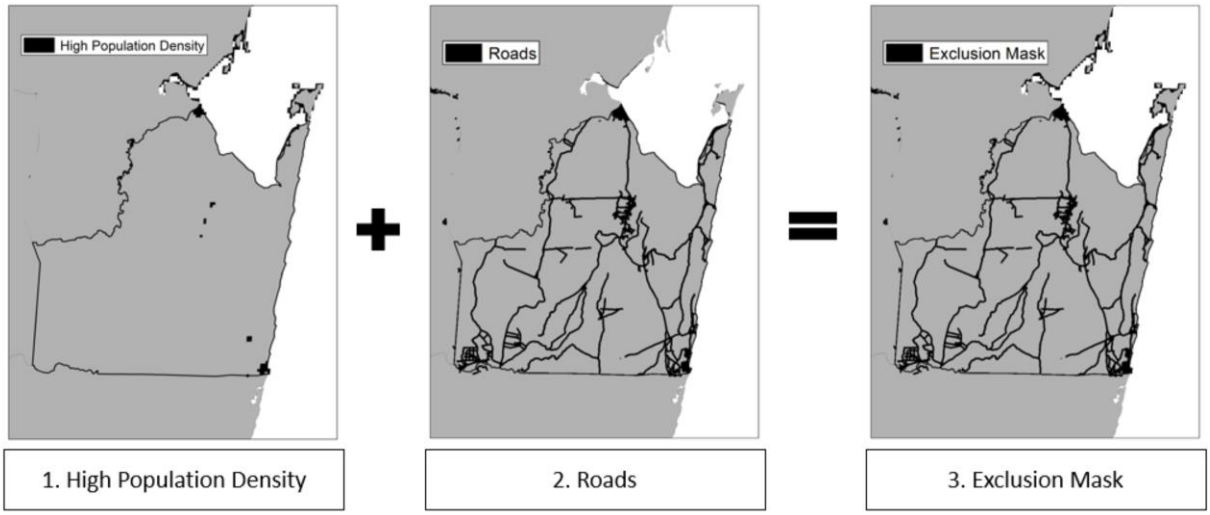

Figure 23.Exclusion map, used to remove unsuitable areas from further analysis.

8.3 Degradation Assessment

The third step in identifying restoration priorities is to assess the current state of the environment within the AOI, in order to identify converted or degraded areas where restoration may be beneficial (in healthy, good condition areas there is no need for restoration). Importantly, this step does not involve deciding on restoration priorities or ranking areas based on restoration importance or environmental value. Instead, this step simply produces an assessment of the state of the environment within the AOI, by using indicators of human pressure to map ecological degradation across the AOI.

There are a multitude of indicators that can be used to measure human impact on the environment and identify degraded areas. The most appropriate indicators for use will depend on the AOI being assessed, and the types of ecosystems occurring in that AOI. For our example of Matutuíne district, we used general indicators of degradation that will be appropriate for all ecosystems: proximity to agriculture, distance to roads, and human population density. For more information on the rationale for inclusion of these indicators, see WCS & BIOFUND (2021). All indicators are place on a 0-1 scale and summed to generate an overall degradation map (Figure 24).

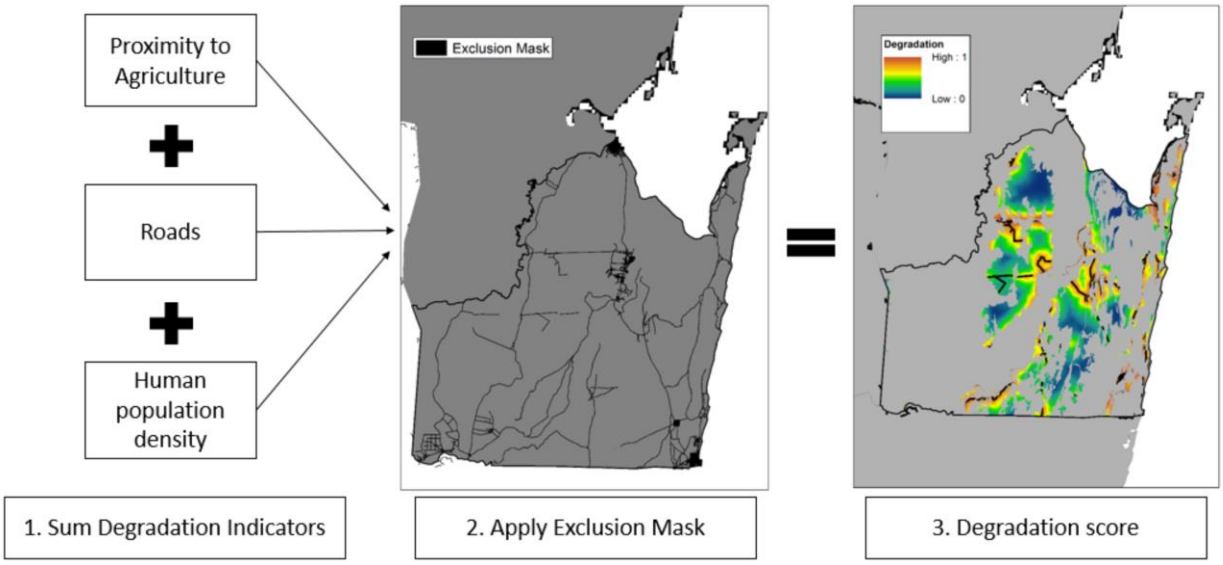

Figure 24. Combining degradation indicators to generate an overall degradation score for Matutuíne. Black areas in the AOI are likely unsuitable for restoration offsets, and were removed using the exclusion mask described in section 8.2.

8.4 Restoration priority assessment

After identifying degraded areas, the next step is to use data on restoration priorities to help choose potential restoration areas. Restoration priority indicators will be used to develop a restoration priority index, which can be combined with the degradation index developed in section 8.3 to generate a map of potential restoration areas. These restoration priority indicators have a large influence on the final map of potential restoration sites, so it is important that they are carefully selected, and that they relate to the overall objective of restoration efforts (see WCS & Biofund 2021). In our Matutuíne example, we selected three restoration priority indicators, outlined below:

- **Protected Areas & KBAs** – included as these areas are priorities for restoration in Mozambique's offset legislation;
- **Climate Stability** – included to preferentially place offsets in areas where future climate change will be less severe;
- **Recent deforestation** – included as areas of recent deforestation may be easier to restore than areas deforested longer ago.

All indicators are place on a 0-1 scale and summed to generate an overall restoration priority map (Figure 25).

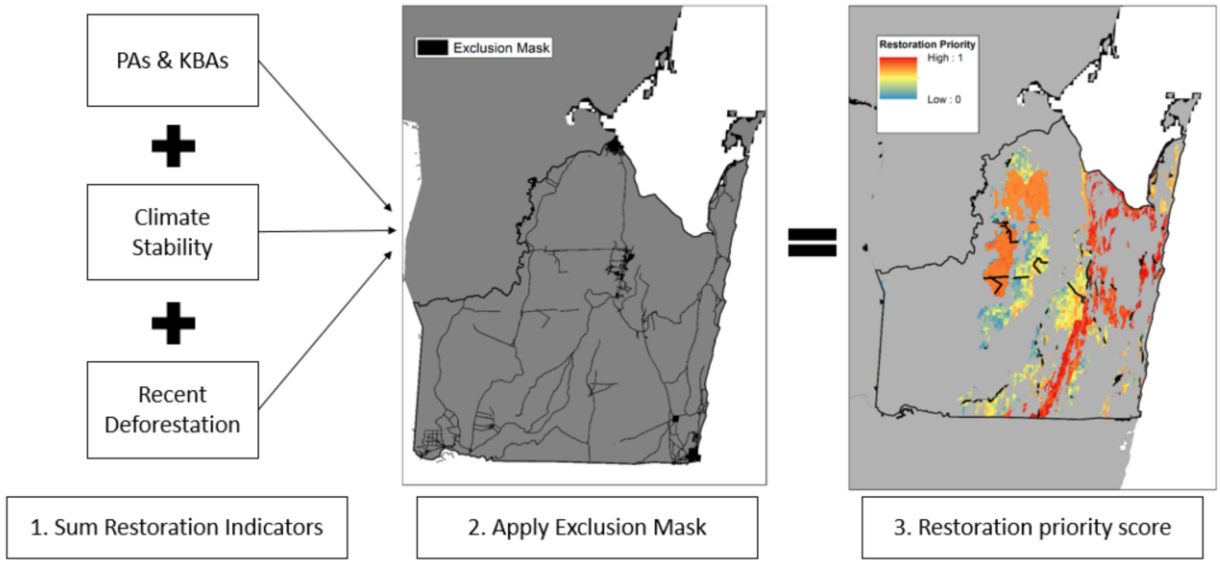

Figure 25. Combining indicators to generate an overall restoration priority score for Matutuíne. Black areas in the AOI are likely unsuitable for restoration offsets, and were removed using the exclusion mask described in section 8.2.

8.5 Identify potential restoration sites

To identify potential restoration sites across the AOI, the final step is to combine the degradation assessment (section 8.3) and restoration priority assessment (section 8.4) described above, to generate a final restoration suitability map (Figure 26). This generates an overall index of restoration suitability which can be used to identify potential sites for more detailed assessment and fieldwork.

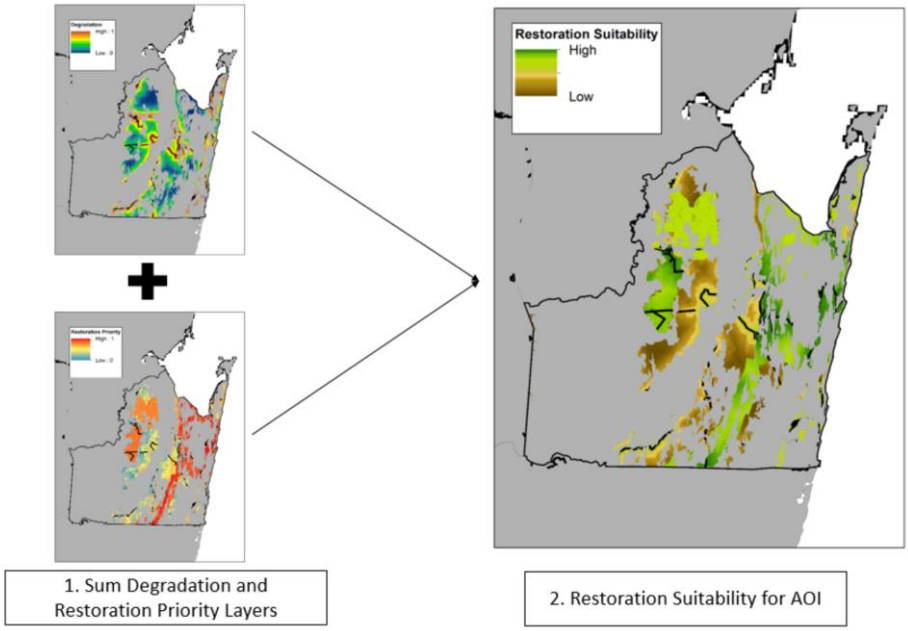

Figure 26. Generating overall restoration suitability map using degradation and restoration priority maps, and including only forest ecosystems.

Importantly, this approach is only useful for identifying restoration sites at a macro-level. For example, in the Matutuíne region we can see broad priority areas (dark green) (Figure 26). However, field work will always be required to assess site feasibility, social context, and ecosystem equivalence, among any other relevant factors to consider.

To demonstrate this, Figure 27 shows the location of field sites around Licuáti Forest Reserve which were visited in early 2021 to verify offset suitability.

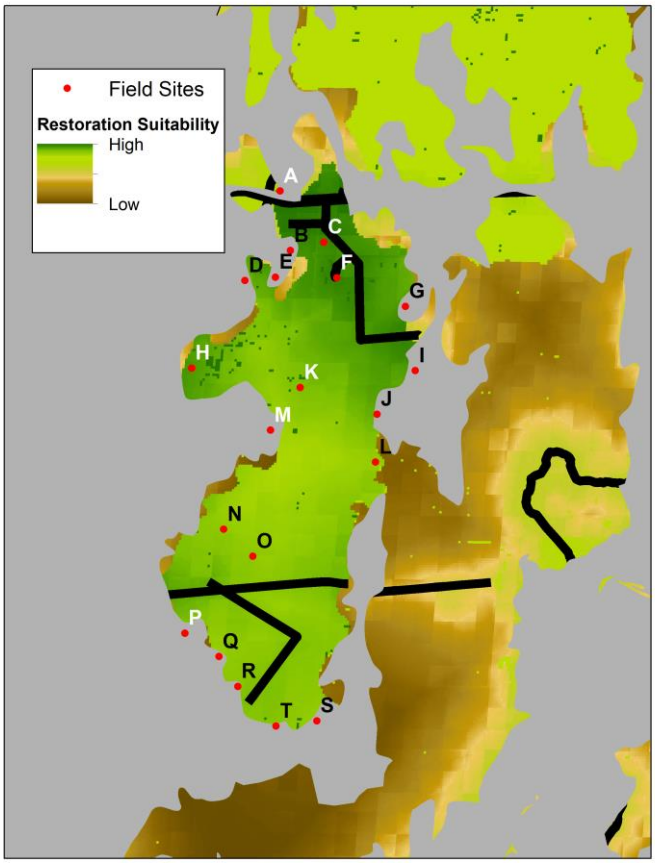

Figure 27. Twenty (20) sites marked for field verification, from which only 7 sites (white colour letters) were visited during the field visit conducted in March 2021.

Table 3 shows the description of the situation found on each site.

Table 3. Description of the 7 sites visited in LFR to assess the feasibility for restoration. Sites details described in Figure 27 above.

Site	Description
A	This site is on the other side of the EN200 national road, on the northern boundary of the LFR, where signs of urbanization have been detected. The area is degraded, there are croplands and a sawmill nearby. There are also traces that indicate that the area was used for charcoal production in the past. The occurrence of species such as

Site	Description
	Combretum sp., Sesamum alatum, Aspargus falcatus, Vitex sp., one and another *Afzelia quanzensis* trees, endemic species such as *Sclerochiton apiculatus* and *Acridocarpus natalitius var. Linearifolius*.
C	Habitat characterized as semi-closed thicket, with the occurrence of endemic species such as *Sclerochiton apiculatus* and *Acridocarpus natalitius var. Linearifolius*. The topsoil has organic matter, pteridophyte species and there are many signs of regeneration. However, there are wide clearings, many traces and charcoal kilns, Sandalwood stumps of medium-sized trees. As one enters into the forest, large tree stumps, charcoal kilns, extensive grass cover were found which indicates that the area has been heavily degraded on these sides and regeneration is slowing down. Since the area is accessible from the national road Boane-Ponta do Ouro, through a track which facilitates the charcoal flow, so this area has been under pressure.
F	Similar as site C
H	The habitat is degraded, with signs of succession to an open woodland, with the presence of some trees, and the shrub layer showing greater coverage. Shrub specimens reach about 2m, and in the same area was recorded the occurrence of two endemic species: *Sclerochiton apiculatus* and *Acridocarpus natalitius var. linearifolius.*
K	The habitat is degraded, with large trees cut and burned, and a large cover of grass. The area has active charcoal production, part of which has been turned into a cropland and cattle shed. There were cut trunks inside the shed and on the path, very large trees of *Newtonia hildebrandtii*, about 1m diameter at breast height (DBH) with cut trunks
M	The habitat is characterized in open scrubland with shrub extract of about 2m, occurrence of fruit trees such as, *Strychnos sp.* (monkey orange/massala), *Sclerocarya birrea* (marula/canhueiro), as well as large trees of *Afzelia quanzensis*, herbaceous species (*Dicerocaryum senecioides*) and endemic shrub (*Acridocarpus natalitius var. Linearifolius*). The occurrence of an invasive species known as Cacita was also recorded.
P	Open woodland, where the occurrence of the *Afzelia quanzensis* has been recorded, with an abundance of large trees. However, it is clear that the area has already been degraded as grass occupies most of the herbaceous substrate. In the 1990s, the area was used as a place of refuge during the civil war, and today it is considered a sacred area, as it is here that the tomb of the ancestor of Francisco Tembe, leader of Djabula, is located.

The team was very close to site O, about 1.3 Km, which could not be accessed due to lack of access, but is considered an area of charcoal extraction according to the leader. It was possible to detect that this was a region where there were cuts, but also signs of natural regeneration of *Newtonia hildebrandtii*, and occurrence of endemic species such as *Sclerochiton apiculatus* and *Acridocarpus natalitius var. Linearifolius.* Due to poor access conditions, it would be useful to use advanced technologies for field surveys, such as drones, to allow access to areas without roads. In addition, this technology allows obtaining a complete and detailed image of the area under

study, maximizes time, and allows mapping areas of interest in 3D images. In addition, the use of cameras with more powerful lenses and GPS can help mapping these areas more efficiently, facilitate site analysis, capturing images at long distances with a level of detail that can support its identification.

While our restoration priority assessment exercise does show LFR to be a priority for restoration offsets at a macro-scale, field visits showed that some of the identified areas are unsuitable offset sites for a variety of reasons. We ranked the probability for successful restoration for each of the sites, according to three parameters:

- Presence of signs of regeneration;
- If the site was free of risk factors;
- Degree of modification in each site;

As shown in table 5, affirmative responses were ranked with 1, while the negative responses were ranked 0. For the question related to the degree of modification, the high/medium/low responses were ranked 0/1/2, respectively. Overall, the sum for each parameter was ranked as:

- 0: No probability for successful restoration
- 1: low probability for successful restoration
- 2: medium probability for successful restoration
- 3+: high probability for successful restoration

Table 5. Ranking of probability for successful restoration for each site visited during the field work

Sites	Are there any signs of regeneration?	What is the modification degree of the site?	Is the area currently free of risk factors?	Ranking	Probability for successful restoration
A	1	0	0	1	Low
C	1	2	0	3	High
F	1	1	0	2	Medium
H	1	0	0	1	Low
K	0	0	0	0	N/A
M	1	2	0	3	High
P	1	2	0	3	High

Based on the information obtained so far, it was concluded that the ROAM tool has ability to identify potential restoration sites. Although all sites checked in the field were not free of risk factors (proximity to community or to an agriculture area, proximity to a road, etc.), three sites showed high probability for successful restoration due to signs of regeneration and low degree of modification. One site presented medium degree of modification, so it has ranked with medium probability for successful restoration.

Two sites seem to have low probability for successful restoration mainly due to high modification degree resulted from anthropogenic impacts. Nevertheless, remote sensing combined with field verification is crucial for site validation and there is a need to assess other sites that were not possible to visit during the field work carried out in March.

9 Next steps to establish an ecological baseline for the implementation of a pilot-project in Licuáti Forest Reserve

The LFR is located near the Maputo city and is crossed by the national road EN200 Boane-Ponta do Ouro, increasing its vulnerability and pressure on its resources. However, despite having been declared a forest reserve in the 1950s, to date, the LFR has no administrative, technical, or enforcement structure to ensure the protection and conservation of the reserve.

The ecological and socio-economic relevance of LFR, the need to acknowledge the legal status and the growing support for reduction of forest degradation and its maintenance, assure that the implementation of a biodiversity offsets pilot project is an opportunity to create the conditions for conservation and protection of the LFR and surround areas.

To implement a biodiversity offsets pilot project, it is necessary to assess condition of targeted biodiversity components and identify and map potential restoration areas. Restoration actions should follow an ecosystem approach rather than interventions targeted at species. However, to improve the ecological condition of the ecosystem, it is necessary to target actions at specific species. This type of approach has to be combined with an integrated action plan that includes management measures and effective long-term protection.

According to the analysis presented above and the discussions made between WCS/COMBO, BIOFUND, DINAF, FNDS and IIAM, eight species seemed to have potential to be addressed through the biodiversity offsets pilot project, such as:

1. *Balanites maughamii*
2. *Empogona maputensis*
3. *Newtonia hildebrandtii*
4. *Polygala francisi*
5. *Psydrax fragrantissima*
6. *Spirostachys africana*
7. *Warneckea parvifolia*
8. *Xylopia torrei*

Based on the results from the initial desktop and site assessment, we propose to carry out a baseline study for the eight species mentioned above, due to the fact that they are important components of the LFR ecosystem and the fact that they are under pressure due to anthropogenic impacts.

The preliminary tests of the ROAM methodology showed that LFR does have land degraded sites and there are areas with restoration potential. Some examples of active and passive actions to be implemented can include: i) active tree planting; ii) awareness raising about the importance of the area and its biodiversity that includes endemic and near-endemic species; iii) effective protection of the site and law enforcement; vi) zone and regulate various community uses of the forest and its resources (charcoal, medicinal, agricultural, etc.).

9.1 Baseline study: ecological assessment

The baseline study will be done inside the LFR and surrounding areas since these also include important biodiversity according with the field visit conducted in March. It is important to note that according with the legal status, the LFR relevant biodiversity area goes beyond the "LFR thicket and forest" thus covering a wider area. The main activities will include:

- Identify and map the largest aggregations of the 8 selected species mentioned above, inside the LFR and surrounding areas;
- Assess the abundance and distribution of the 8 selected species;
- Identify the habitat requirements to improve its quality and increase local populations of the 8 selected species;
- Identify the main threats for the 8 selected species;
- Assess the ecological connectivity of LFR and surround areas based on the distribution of the 8 selected species;
- Identify effective measures for restoration and protection of some of the 8 selected species, according to the status of its current population;
- Assess the viability of propagation of selected flora species;
- Undertake an inventory of fauna, with focus on avifauna and mammals;
- Test the ROAM tool extensively and cover other sites that could not be accessed during the March visit. Expand it to include LFR surrounding areas;
- Analyze community use of different natural resources both inside and around the RFL, with a specific focus on charcoal production;
- Assess threats such as charcoal production and trade and assess effective actions to regulate the trade in collaboration with DINAF; this would include:
    - Determining forest ecological condition;
    - Determining forest diversity and biomass;
    - Estimating merchantable timber volume;
    - Determining the annual cycle of reproduction and exploration;
    - Identifying forest users and related value chain;
    - Determining how are these values divided amongst local community vs local elite vs outsider vs middlemen/transporters/officials etc.;
    - Identifying the vulnerable points along the value chain that can be controlled and what kind of interventions would be required;
- Assess the quality of the habitat and carry capacity of the area to receive mid-size fauna and megafauna for the purpose of establishing a game/wildlife farm, as Djabula community has interest in this idea;
- Propose recommendations for management of LFR and specific species.

Once the information above is gathered and analyzed it will be possible to define the specific actions and sites where the pilot offset project should occur.

We estimate that the detailed assessment described above will require at least 3 months of data collection, followed by 1-2 months of data analysis, to determine the area for the pilot offset and develop the complete pilot biodiversity offset management plan.

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