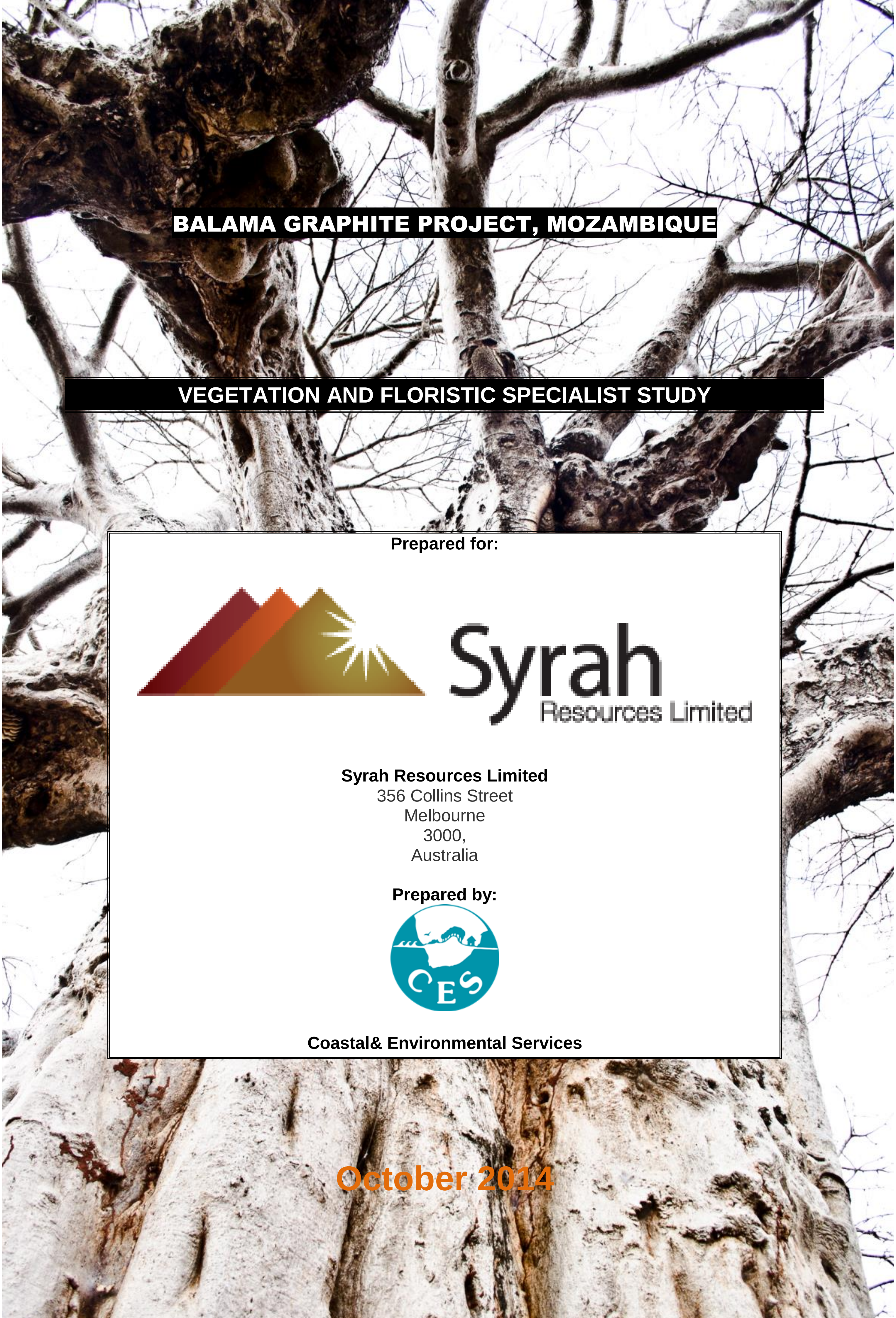

# BALAMA GRAPHITE PROJECT, MOZAMBIQUE

## VEGETATION AND FLORISTIC SPECIALIST STUDY

**Prepared for:**


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# EXECUTIVE SUMMARY


**Project Overview**

Syrah Resources Limited is an Australian resource company with its head office located in Melbourne, Australia. In December 2011 it acquired ownership of the Balama Graphite Project located in northern Mozambique, 7 km from the town of Balama, Cabo Delgado Province, Mozambique. Syrah's local subsidiary, Twigg Exploration & Mining Ltd, has subsequently received a license for the prospecting and exploration of graphite, base and precious metals in the Balama district.

Syrah Resources Limited plans to mine graphite in the project area using open pit mining to extract the ore. Conventional flotation processing will be used to extract the graphite using water from the Chipembe dam located approximately 12 km north-west of the project site.

The ore will be processed at the processing plant located on the mine site and the final concentrate transported by road to Pemba, where a deep water port is located. The product will be exported internationally from Pemba Port.

The Balama site is anticipated to have a large graphite deposit. Consequently, a minimum mine life of 50 years (minimum of 25 years with an option to extend with another 25 years), is anticipated although the site layout anticipates 100 years of operation. The plant will operate 365 days per year.

**Methods**

A wet season site survey was conducted from the 28th February 2013 – 10th March 2013 and a dry season survey from the 15-22 July 2013. An initial drive through of the project area was undertaken in order to establish habitat diversity and overall state.

Sampling was undertaken at the proposed locations of the west and east pit, the tailings storage facility, the rock waste dump, the processing plant and in areas within the project boundary that were potentially sensitive. No haul road options were assessed.

The vegetation types were characterised using TWINSPAN and DECORANA analyses. Simpson's index was used to calculate alpha biodiversity within each habitat. This index was used as it is relatively simple to use by the layman, whilst providing a meaningful interpretation of the habitat biodiversity. This can be easily repeated during future monitoring events.

**Biophysical Environment**

Cabo Delgado Province has a tropical climate with two distinct seasons. The wet season occurs from November to March and the dry season from April to November. Specific weather data for the project area is not available. Climate data for Montepuez, the nearest town to the project site (93km away), was therefore used. Montepuez has a tropical climate and is also a winter rainfall region. The average annual rainfall is approximately 942.3 mm. The driest month is August/September with 0 mm - 2 mm. Most precipitation falls in January, with an average of approximately 246.4 mm (http://www.weatherbase.com). Potential flooding in the area is likely to occur between December and February.

The average annual temperature in Montepuez is 24.2 °C. The warmest month of the year is November with an average temperature of 26.7 °C. In July, the average temperature is 21.1 °C making it the coolest month in the year. The average temperatures vary during the year by 5.6 °C. The highest recoded temperature was a maximum of 50 °C, recorded in November, while the lowest recoded temperature was a minimum of 5 °C, recorded in May (http://www.weatherbase.com).

North-eastern Mozambique is predominantly underlain by Proterzoic rocks that form a number of gneiss complexes that range from Palaeo to Neoproterozoic in age. The project site is underlain by metamorphic rocks of the Neoproterozoic Lurio Group that are included within the Xixano Complex.

The study area is relatively flat to gently undulating with sporadic inselbergs (Mount Nassilala and Mount Coronge) rising from the flat plains. The altitudinal range varies from 480 to 830 m above sea level (asl) with the highest point occurring on Mount Nassilala.

The Mehucua River flows through the southern section of the project site in a South-west to North-east direction. A few small wetlands occur in the project area, the most notable being a swampland located approximately 2 km south west of the proposed site and a wetland located approximately 7 km east south-east. The largest water body in the area, but outside of the project area, is the Chipembe Dam which is located 12 km northwest of the site.

Compared with other countries in the region, Mozambique has a rich natural resource base including untransformed indigenous forests, savannah woodlands and coastal habitats. About 25% of the land has commercial forestry potential, 12.5% constitutes state-protected areas and a further 22% comprises potential wildlife habitat.

Land use in the area is primarily for subsistence agriculture. Crops such as maize, cotton, beans and cassava are grown on the flat areas which are cleared using slash and burn techniques. Some small livestock is reared in the area although these animals were only noted near the villages and are not abundant in the project site.

Almost all households are heavily reliant on the natural resources for their livelihoods. Natural resources are used for construction, medicinal consumption and to supplement their food. Small scale charcoal production was also evident in the project site.

**Vegetation Types**

Little detailed, published information is available on the vegetation of Mozambique, especially information concerning vegetation found in Cabo Delgado Province or the project area in particular. The most reliable sources of information are a vegetation map and descriptions by Wild and Barbosa (1967) and a bio geographical survey by White (1983). The above literature largely describes plant formations on a broad landscape level, but provides very little information on the communities found within the major vegetation types.

Eight broad vegetation types have been described and mapped for Mozambique. Miombo Woodland (listed as Vulnerbale by WWF) is the most widespread, dominating in the north and centre of the country followed by Mopane Woodland which occurs in the southern and northern parts of the country. The third most widespread vegetation type is the Undifferentiated Woodland which covers extensive parts of the south, central and northern portions of the country. The remaining vegetation types includes smaller areas of Afromontane Elements, Coastal Mosaics, Halophytic Vegetation, Mangroves and Swamp Vegetation.

Two main vegetation types occur within the project site; *Riparian Woodland and Miombo Woodland*. The *Miombo Woodland* is further split into three varieties:

- *Miombo Woodland: Graphite*
- *Miombo Woodland: Granite*
- *Miombo Woodland: Plains (intact and degraded)*

The highest biodiversity was observed in the *Riparian Woodland* which had an alpha biodiversity index score of 21.7. This was followed by the intact *Miombo Woodlands: Plains*. The *Miombo Woodlands: Graphite* and degraded *Miombo Woodlands: Plains* had the lowest alpha biodiversity score. This is possibly due to anthropogenic disturbances such as harvesting for building materials and firewood.

**Floral Biodiversity**

It is estimated that over 5 500 plant species have been recorded in Mozambique, although the actual number of species is likely to be much higher. Of these 5 500 species, 177 species are endemic and 300 occur on the Mozambique Red Data List.

No species of special concern appear on the IUCN (2012) list. One exotic species is listed as data deficient and 25 species are likely to be classified as Least Concern since no species within their family occur on the list. There is no information available for the remaining 46 species.

According to the Mozambique Red Data List (2002), one species (*Sterculia appendiculata*) is considered ***Vulnerable*** as a result of over exploitation for firewood, timber and local construction.

One CITES species, from the Orchidaceae family, appears in Appendix II. This species is not necessarily threatened, but is controlled in terms of international trade whereby CITES controls international trade of certain species i.e. all import, export and re-export of CITES species has to be authorised through a licensing system. So while this species is not formally protected by the IUCN red data list or the Mozambique Red Datat list, unauthorised trade in this species is prohibited.

**Exotic and Invasive Species**

Mango trees were prevalent in the flat plains near the villages, in amongst the cultivated lands. Bamboo (*Oxytenanthera abyssinica)* was also noted to occur in the woodlands, particularly the degraded woodlands at the foot and on the slopes of Mount Nassilala. Although this bamboo is indigenous to the region, it could become invasive, especially in disturbed areas they regenerate and disperse rapidly from seeds and form inpenetrable stands that prevent other species from establishing in. It was noted that local communities avoided planting in areas previously covered by bamboo, possibly due to the extensive root system which is difficult to remove without machinery.

**Sensitivity**

A large portion of the project area has been cleared for agricultural purposes. These areas were rated as having a low ecological sensitivity as they have been transformed through anthropogenic activities and are therefore highly impacted and provide limited value to ecosystem functioning.

Areas of natural vegetation, such as the degraded *Miombo Woodland: Plains,* were assigned a medium ecological sensitivity. Despite these areas being degraded as a result of local pressures on the environment, they still have a relatively high species richness and form important ecological process areas for small mammals and birds that occur in the area.

Areas of high sensitivity were assigned to the *Miombo Woodland: Granite* and *Miombo Woodland: Graphite*, the intact *Miombo Woodland: Plains* and the *Riparian Woodland*. These areas are all relatively intact and have a high species diversity. Although highly degraded in most parts, the *Riparian zone* was assigned a high sensitivity score as it is an important process area for ecosystem functioning.

Where feasible, development should be restricted to those areas that have a low ecological sensitivity, and exclude those areas with a high or medium ecological sensitivity. The TSF, mine camp, waste dump and production plant should therefore be located in an area of medium to low sensitivity. Where this is not feasible (for example the location of the east and west mine pits), alternative mitigation measures such as conservation areas and biodiversity offsets should be investigated.

Five issues were identified for the project site:

- Loss of vegetation communities
- Loss of Biodiversity
- Loss of Species of Special Concern
- Disruption of Ecosystem Function and Process
- Loss of Ecosystem Services.

Eleven impacts were identified and assessed for the Construction and Operational Phases (Table 9-1). The majority of the impacts will occur during the construction phase of the project.Three impacts were classified as HIGH NEGATIVE and six impacts were classified as MODERATE NEGATIVE. With mitigation, two of the HIGH impacts can be reduced to LOW NEGATIVE and three MODERATE impacts can be reduced to LOW NEGATIVE.

Three impacts were identified for the operational phase. The two HIGH impacts can both be reduced to LOW and MODERATE NEGATIVE respectively.

**Conclusions and Recommendations**

- The highest number of *HIGH* impacts were noted to occur during the Construction phase. This phase will have the highest impact on the vegetation communities and floral biodiversity. It is imperative that mitigation measures to reduce the impact of this phase are implemented and should include the reduction in the number of bridge crossings through the riparian woodland, the use of existing river crossings, locating bridges in areas that have already been impacted, aligning roads and pipelines along a single corridor, avoiding the placemant of infrastructure in areas of high sensitivity, avoiding additional habitat fragmentation by locating linear infrastructure away from areas of high sensitivity, setting aside key representative portions of each vegetation type as conservation areas, preventing employees from harvesting plants for firewood, charcoal or their personal use.
- Inselberg's, which are islands of natural habitat, form important linkage corridors between fragmented vegetation and have been documented as important features for the conservation and dispersal of various species. It is therefore important that a portion of the inselberg Mount Nassilala, where the graphite deposit has been identified, is conserved so that this process can continue and that infrastructure such as the TSF, waste dump, mine camp and processing plant are located outside of these sensitive areas.
- Current land use is having a large impact on the natural vegetation in the area. Large tracts of land have been cleared and planted with crops such as cotton, maize and cassava leaving small "islands" of biodiversity on the inselberg's in the area. The inselbergs provide natural refugia since their slopes are not arable and therefore have no agricultural value to the local communities.
- The highest biodiversity was recorded in the *Riparian Woodland.* Although these exist as thin shreds of indigenous vegetation surrounded by a sea of agriculture, they currently form important natural ecological corridors and should therefore be conserved and protected. Mining activities and infrastructure must be kept to a minimum in these areas.
- The intact *Miombo Woodlands: Plains* that occurs near Nquide village has the second highest species diversity after the *Riparian Woodlands* and contains important species such *Habenaria sp.* (Orchidaceae). Mining activities must not occur in this area. Additionally, this area should be investigated as a possible conservation area.

To reduce the impact of the mining activities and associated infrastructure, the following mitigation measures have been recommended:

- A 50 metre "Restricted-Go" buffer on either side of water bodies (rivers, streams, wetlands and tributaries) should be implemented. In addition, drainage lines should be rehabilitated and re-vegetated. Where feasible, infrastructure occurring in these areas should be moved to less sensitive zones. Infrastructure that can't be moved, such as bridges, must be designed and located to ensure the minimum impact on these areas.
- Ecological corridors, designated as "No-Go", areas should be set aside within the project site to facilitate the movement of faunal species, seed dispersal and the expansion of existing vegetation types. It is recommended that a portion of Mount Nassilala is left intact and conserved so that it may continue to function as a "stepping stone" for the dispersal of animal and plant species. Rehabilitation of the project site should include restoration of the inselberg where feasible.

- It is recommended that a botanist/ecologist be on site during construction to determine if any of the species of special concern or protected species occur where the mine and associated infrastructure are positioned. Plants can be removed and placed in a nursery for rehabilitation purposes. If a species is identified for relocation, individuals of the species will need to be located within the proposed site, before vegetation clearing commences, and carefully uprooted and removed by a skilled horticulturist. Prior to removal, however, suitable relocation areas need to be identified, either within the site or in other disturbed areas on the property. Individual plants that cannot be relocated at the time of removal should be moved to the nursery.
- It is recommended that the following management and monitoring plans are implemented:
    - A Rehabilitation and Restoration Plan
    - Alien Management and Monitoring Plan
    - Conservation and Terrestrial Monitoring Plan

# TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

# PLATES

# LIST OF ACRONYMS

| | |
|---|---|
| asl | Above sea level |
| CES | Coastal & Environmental Services |
| CITES | Convention on International Trade in Endangered Species |
| DECORANA | detrended correspondence analysis |
| EIA | Environmental Impact Assessment |
| EN | Endangered |
| GIS | Global Information System |
| GPS | Global Positioning System |
| IUCN | International Union for the Conservation of Nature |
| NT | near-threatened |
| QDS | Quarter Degree Squares |
| SA | South Africa |
| SSC | Species of Special Concern |
| TWINSPAN | Two-way indicator species analysis |
| VU | Vulnerable |

# 1 INTRODUCTION AND PROJECT DESCRIPTION

## 1.1 Project description

Syrah Resources Limited is an Australian resource company with its head office located in Melbourne, Australia. In December 2011 it acquired ownership of the Balama Graphite Project located in northern Mozambique, 7 km from the town of Balama, Cabo Delgado Province, Mozambique. Syrah's local subsidiary, Twigg Exploration & Mining Ltd, has subsequently received a license for the prospecting and exploration of graphite, base and precious metals in the Balama district.

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The ore will be processed at the processing plant located on the mine site and the final concentrate transported by road to Pemba, where a deep water port is located. The product will be exported internationally from Pemba Port.

It is anticipated that the mine will have a minimum mine life of 50 years (minimum of 25 years with an option to extend with another 25 years), although the site layout anticipates 100 years of operation. The plant will operate 365 days per year.

## 1.2 Terms of Reference

For sound planning and environmental management of the area an ecological survey and biodiversity assessment of the Project Area has been done for the wet and dry season. The aim of this study is to establish baseline conditions prior to mining activities and provide an assessment of the potential impacts.

The following terms of reference apply to this assessment:

- Describe and map different vegetation units and ecosystems (e.g. grassland, savannah, riverine etc.) in the mining area.
- Describe the floral biodiversity and record the plant species that occur in each vegetation type.
- Determine habitat units that perform critical ecosystem functions (e.g. erosion control, hydrological service etc.).
- Utilise stratified random approach for plot based botanical surveys in order to describe biodiversity and the ecological state of each vegetation unit.
- Describe and map rare, endangered or threatened ecosystems.
- Establish and map sensitive vegetation areas.
- Identify species of special concern (IUCN Red Data list).
- Identify alien plant species, assess the invasive potential and recommend management procedures.
- Identify and assess the impacts of the mining activities and associated infrastructure on the natural vegetation in terms of habitat loss and fragmentation and degradation of key ecosystems.

# 2 LEGISLATION, POLICY AND GUIDELINES

## 2.1 International Finance Corporation (IFC) Performance Standards relevant to the Vegetation and Floristic Specialist Study

The following Performance Standards (PS) apply to the impact assessment of Floral Biodiversity:

1. **PS 1: Assessment and Management of Environmental and Social Risks and Impacts**
    - Identify and assess environmental impacts, risks and opportunities in the project's area of influence
    - To avoid, or where avoidance is not possible, minimize, mitigate or compensate/offset for adverse impacts on the natural environment
    - To promote improved environmental performance of companies through the effective use of management systems

2. **PS 6: Biodiversity Conservation & Sustainable Management of Living Natural Resources**
    - Objectives and requirements to avoid, minimise or compensate/offset risks and impacts
    - Protect and conserve biodiversity
    - Maintain the benefits of ecosystem services
    - Promote the sustainable management and use of living natural resources through the adoption of practices that integrate conservation needs and development priorities

PS 6 applies to modified, natural and critical habitats.

**<u>Specifically, PS 6 applies to the following habitats observed in the study areas:</u>**

1. Modified habitats that may contain significant biodiversity value as determined in this report
2. Natural habitats which should not be significantly converted or degraded by project activities, but if no available alternative is provided, can be mitigated by:
    - Avoiding impacts on biodiversity through protection of set-asides,
    - Implementing biological corridors
    - Restoring habitats during operations
    - Implementing biodiversity offsets
3. Critical Habitats are areas considered as high biodiversity areas which should remain in a natural state, failing which, should comply with conditions set out in Section 17 of PS6 and a Biodiversity Action Plan aimed at achieving net gains of biodiversity values for the habitat, is implemented.

Although the project area occurs in modified and natural habitats three factors need to be taken into account when considering the above:

1. The project area occurs in the Eastern Miombo Woodlands. While fairly extensive this vegetation type is under threat (clearing for agriculture, harvesting wood for construction and charcoaling etc) and consequently listed as **VULNERABLE** by the World Wildlife Fund (WWF) (http://worldwildlife.org/ecoregions/at0725, Accessed: 20 April 2013)
2. Natural habitats such as rivers may be indirectly (i.e. beyond the project area) affected by the mining activities and associated infrastructure. As such, set-aside areas and habitat restoration may need to be considered as biodiversity offsets.
3. No critical habitats associated with high biodiversity were identified at the project site.

## 2.2 International Union for Conservation of Nature (IUCN): Statutes and Regulations

The objective of the IUCN is to "*influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable*." (IUCN, Accessed: 20/04/2013)

In order to achieve this objective the IUCN implements programmes, administered by the World Conservation Congress, in the form of number of activities such as:

- Research species and ecosystem function and ensure sustainable, equitable and ecological utilisation of natural resources;
- Determine biological diversity, identify threats and priority conservation areas;
- Develop sound practices for the conservation and sustainable use of species and ecosystems; and
- Develop tools for effective rehabilitation, mitigation or offsets.

Performance standard 6 requires that the IUCN Red Data List and the countries Red Data List are consulted as part of the baseline survey to determine the conservation status of species found within the project site. It must be kept in mind that information contained in a Red Data List depends on the submission of data by botanical specialists and may therefore not contain a comprehensive list of all species present, especially in Mozambique where biodiversity research is lacking. For this reason, it may be pertinent to compare the Red Data List classification of plant species of surrounding countries to help inform the conservation status of plant species.

## 2.3 Convention on Biological Diversity (CBD)

The objectives of the CBD is to address issues of conservation, sustainable use and fair/equitable sharing of the benefits of natural resources. The CBD encourages the use of the "Ecosystem approach" which is based on the application of scientific methodologies focused on levels of biological organisation including process, functions and interactions between organisms and the environment (Convention on Biological Diversity, Accessed: 20/04/2013). The levels are extended to refer to any functional ecological unit at any scale.

The CBD emphasizes that adaptive management is necessary for complex and dynamic ecosystems. Impact responses of ecosystems are non-linear and often delayed, resulting in unpredictable reactive events. Management must be adaptive in order to respond to these events by incorporating a "lessons-learnt" approach and frequent considerations of "cause-and-effect".

The United Nations Framework Convention on Climate Change (UNFCCC), to which Mozambique is a signatory, recognises the CBD and its objectives.

The objectives and principles outlined in the CBD should be used to assess impacts and develop management and monitoring plans.

## 2.4 Equator principles relevant to the Ecological Study

The Equator principles were derived as a set of requirements which must be fulfilled in order for lenders to finance capital ventures (http://www.equator-principles.com/). These principles ensure that social and environmental issues are addressed, all considerations are taken into account, policies and standards are upheld and that all these elements are thoroughly addressed. This includes the identification and mitigation of all negative impacts. The principles relevant to the Vegetation and Floristic Specialist Report include:

- **Principal 1:** Review and categorisation: This involves a desktop study to determine potential impacts and risks to the environment using screening criteria based on the environmental and social categorisation process of the International Finance Corporation (IFC).

- **Principal 2:** Environmental and Social Assessment: An assessment process that addresses the relevant environmental and social risks and impacts of the proposed project. This study is in partial fulfilment of this principal.

- **Principal 3:** Applicable Environmental and Social Standards: Compare with IFC Performance Standards and World Bank Environment, Health and Safety standards and determine compliance or justify deviation.

- **Principal 4:** Environmental and Social Management System and Equator Principles Action Plan: An Environmental and Social Management System (ESMS) will be developed and maintained by the client and an Environmental and Social Management Plan (ESMP) will be developed based on the EIR and specialist studies which will include all mitigation measures suggested by the Environmental and Social Impact Assessment.

- **Principal 9:** Independent Monitoring and Reporting: The assessment should be conducted by an Independent Environmental and Social Consultant. This assessment is in complete fulfilment of this principle.

# 3 METHODOLOGY

## 3.1 Literature for review

A review of the existing literature pertaining to the natural vegetation and plant biodiversity, the presence and status of alien/invasive plant species and the effects mining may have on the surrounding vegetation ecology, was undertaken.

### *3.1.1 Current information and existing data*

A number of reference sources on the ecology and biodiversity of Miombo Woodland's were used for background information.

### *3.1.2 Findings of impacts of Alien plant species on surrounding environment*

As there appears to be no repository for information on the alien and invasive plant species of Mozambique, information sourced from the IUCN repository and Malawi has been used for inference of potential scenarios and impacts associated with the Balama Graphite project.

## 3.2 Site survey

A wet season site survey was conducted from the 28 February 2013 – 10 March 2013 and a dry season survey from the 15-22 July 2013. An initial drive through of the project area was undertaken on the 1 and 2 March in order to establish habitat diversity and overall ecological state.

Based on the initial drive through, a random stratified sampling approach was taken, where plot survey's were undertaken in specific habitat types within potentially affected areas. Sampling was undertaken at both the west and east pit, at the tailings storage facility, the rock waste dump, the processing plant and in areas within the project boundary that were potentially sensitive (Figure 3-1).

## 3.3 Vegetation mapping

Vegetation was mapped from aerial images and related to data gathered on the ground and geological and topographical maps.

## 3.4 Floral survey and Biodiversity calculations

### *3.4.1 Floral Survey approach*

During the site survey, selected sites which represented natural habitats were sampled for species richness and abundance and vegetation structure. This was carried out by identifying the species, counting the number of individuals within a predetermined area and placing their height into estimated size classes. The methodology applied varied between habitats and is summarised in Table 3.1 below.

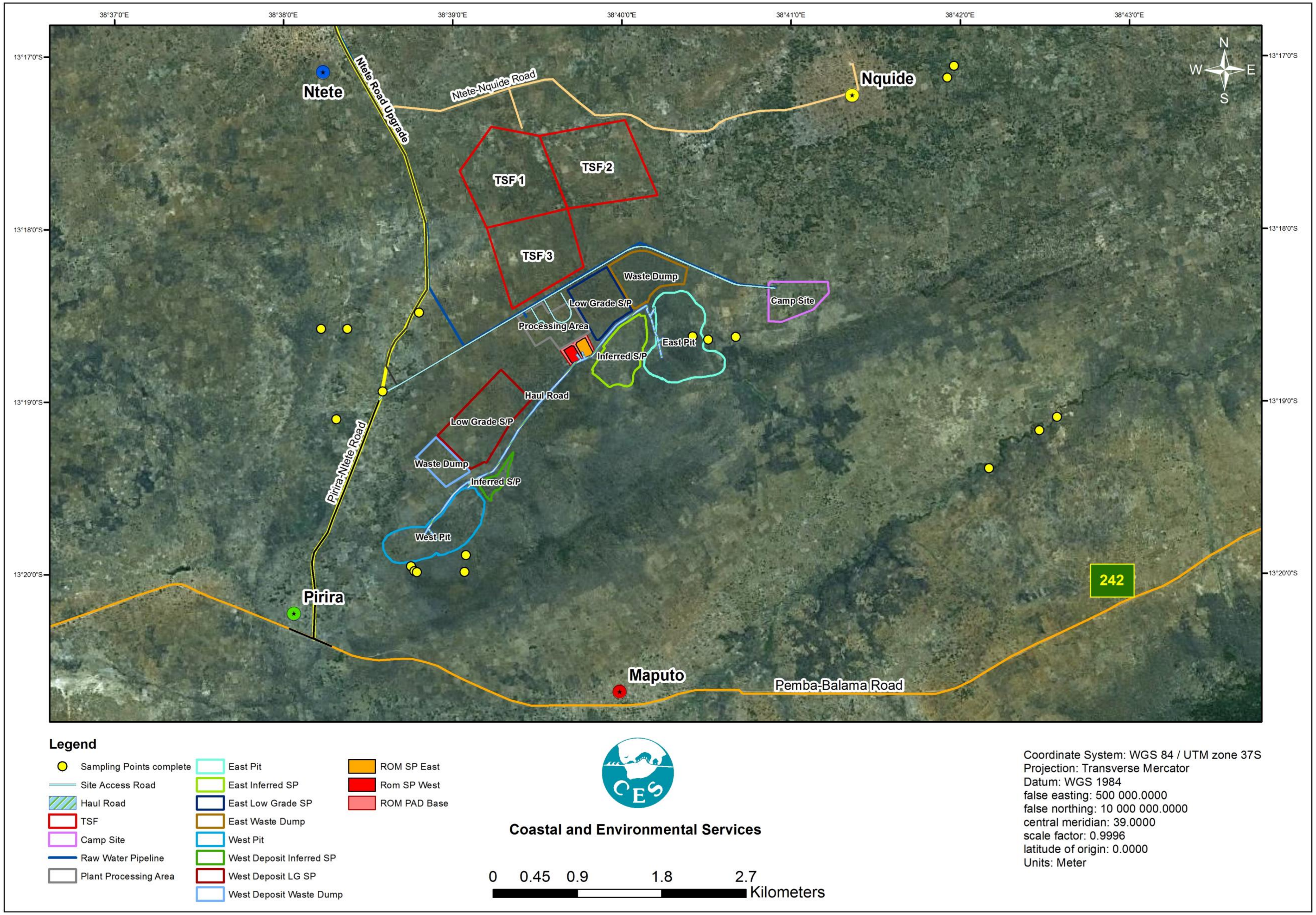


**Figure 3-1: Sampling points within the project site**

Habitat areas were selected (non-randomly), and sampling sites selected randomly within the habitat. Sites were based on habitat integrity for biodiversity sampling. The most pristine and established habitat representations were selected for as these would reflect the highest possible species diversity within the project area.

**Table 3.1 Methodology used for floral survey sampling**

| Habitats sampled | Biodiversity-Abundance Methodology | Total area per sample | No. of samples per habitat |
|---|---|---|---|
| Riparian Woodland | Stratified random sampling: Site pre-selected, start point of transect randomly selected.<br><br>50 metre transect along the length of the water course bank. All plant species were noted and abundance recorded. | 500m$^2$ | 3 |
| Miombo Woodland: Graphite | Stratified random sampling: Site pre-selected, start point of transect randomly selected.<br><br>10x10 metre plots alternating along the length of a 50 metre transects. All plant species within plots were noted and abundance and height recorded | 500m$^2$ | 6 |
| Miombo Woodland: Granite | Stratified random sampling: Site pre-selected, start point of transect randomly selected.<br><br>10x10 metre plots alternating along the length of a 50 metre transects. All plant species within plots were noted and abundance and height recorded | 500m$^2$ | 2 |
| Miombo Woodland: Plains – intact and disturbed | Stratified random sampling: Site pre-selected, start point of transect randomly selected.<br><br>10x10 metre plots alternating along the length of a 50 metre transects. All plant species within plots were noted and abundance and height recorded | 500m$^2$ | 9 |

### *3.4.2 Vegetation Characterisation*

**TWINSPAN:** TWINSPAN (Two-way indicator species analysis) provides a hierarchical clustering of sample site data (Hill, 1979). The method provides an estimation of the similarity between sample sites by comparing the characteristics of each in terms of species composition and the importance of each species as a component at each site. In addition to providing a quantitative analysis of the composition of the vegetation for each sample site within the study area, the use of TWINSPAN facilitates the grouping together of floristically similar sites which may represent specific plant communities, and assists the researcher to distinguish between different communities. TWINSPAN has been widely employed in vegetation analysis in many ecosystems, and generates a "two-way" (site-by-species) table. This is similar to a conventional "Blaun-Blanquet Table", and is used to generate a dendrogram representing the hierarchical relationship between the data for each sample site. TWINSPAN also facilitates the detection of differential and other diagnostic species, that is respectively, species whose occurrence at the sample sites corresponds exactly with the clusters of sample sites generated by the analysis at a particular hierarchical level, and species that are only present at most but not all sample sites within a particular cluster. Such species may be useful indicators of the specific plant communities recognised.

***DECORANA:*** DECORANA (detrended correspondence analysis: Hill, 1979) provides a means of ordinating sample sites and species on a scatter diagram against axes obtained from an iterative process derived from reciprocal averaging (Gauch, 1982). Like TWINSPAN, DECORANA has been widely employed in quantitative vegetation studies and serves to assess the extent of clustering of sites in term of species composition and importance. It is expected that the relative position of site clusters along the principle axis (x) would correspond to trends between the different sites. These trends may relate to environmental gradients, succession relationships or other factors. Plotting the corresponding ordination for the individual species on equivalent axes provides a means of detecting species with corresponding ordination values. Correlation between clusters of species and clusters of sample sites on the plotted graphs is used to determine characteristic species for each vegetation type. These species are those that tend to correspond to particular clusters of sites, but which are less strongly indicative of a particular site cluster than the differential and diagnostic species revealed by TWINSPAN. DECORANA is usually performed in conjunction with TWINSPAN, and further assists in recognising and distinguishing and characterising distinct plant communities.

The results from the TWINSPAN and DECORANA analyses were used to determine vegetation communities (and sub-communities), described in terms of the data recorded at each sample site and in terms of the plant species that characterise each community. The diagnostic species that are confined to, or largely confined to, a particular community have been highlighted.

### *3.4.3 Biodiversity calculation*

The Simpson’s index (Simpson, 1949) was used for the calculation of alpha biodiversity within each habitat. The Simpson’s index measures the probability that two individuals, randomly selected from a sample, will belong to the same species. The calculation considers a dominance index because it weights towards the abundance of the most common species. It is also relatively simple to use by the layman, whilst providing a meaningful interpretation of the habitat biodiversity. This can be easily repeated during future monitoring events.

The equation for the Simpson’s index is given below:

$$D = \Sigma(n1(n1 -1)/N(N-1))$$

Where:
D = Simpson Index
n1 = number of individuals of sp 1
N = Total number of spp in community

As biodiversity increases, the Simpson’s index value will get smaller. By inverting this value (1/D), a positive correlation is achieved making interpretation of the value easier to apply. This study has used the inverse format of the Simpsons Index.

## 3.5 IUCN, Mozambique Red Data List and CITES assessment

Compiled plant species checklists were reviewed for the presence of Species of Special Concern (SSC), as defined by IUCN Red List 2012. For the purposes of this report:

- Threatened species are defined as:
  a) species listed in the Critically endangered, Endangered or Vulnerable categories;
  b) possible threatened species (i.e. taxa currently un-assessed in the IUCN Red List 2009 whose conservation status has been highlighted subsequently);
- Species of conservation concern are defined as those species listed as Near Threatened on the IUCN Red List 2012

Additionally, the plant species list was reviewed in terms of the Mozambique Red Data List (2002). These lists are based on accurate assessments of species distributions. Since northern

Mozambique has not been sampled extensively, the Mozambique Red Data List is used with a low level of confidence. For this reason, the Zimbabwean, Malawian, Zambian and Tanzanian Red Data Lists have been used as a supplement, as these countries also have extensive areas of Miombo Woodlands.

Appendix 1 and 2 of the Convention of International Trade in Endangered Species (CITES) were also consulted.

## 3.6 Impact Assessment

The **environmental significance** scale evaluates the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both. The evaluation of the significance of an impact relies heavily on the values of the assessor/s making the judgement. Four factors need to be considered when assessing the significance of impacts, namely:

1. Relationship of the impact to **temporal** scales - the temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.
2. Relationship of the impact to **spatial** scales - the spatial scale defines the physical extent of the impact.
3. The severity of the impact - the **severity/beneficial** scale is used in order to scientifically evaluate how severe negative impacts would be, or how beneficial positive impacts would be on a particular affected system (for ecological impacts) or a particular affected party. The severity of impacts can be evaluated with and without mitigation in order to demonstrate how serious the impact is when nothing is done about it. The word 'mitigation' means not just 'compensation', but also the ideas of containment and remedy. For beneficial impacts, optimization means anything that can enhance the benefits. However, mitigation or optimization must be practical, technically feasible and economically viable.
4. The **likelihood** of the impact occurring - the likelihood of impacts taking place as a result of project actions differs between potential impacts. There is no doubt that some impacts would occur (e.g. loss or clearance of vegetation), but other impacts are not as likely to occur (e.g. vehicle accidents), and may or may not result from the project operations. Although some impacts may have a severe effect, the likelihood of them occurring may affect their overall significance.

Table 3.2 below summarises the above described factors' categorical limits and criteria.

**Table 3.2: Impact Significance Rating Criteria**

| | | |
|---|---|---|
| **Effect** | **Temporal scale** | |
| | Short term | Less than 5 years |
| | Medium term | Between 5 and 20 years |
| | Long term | Between 20 and 40 years (a generation) and from a human perspective almost permanent. |
| | Permanent | Over 40 years and resulting in a permanent and lasting change that will always be there |
| | **Spatial Scale** | |
| | Localised | At localised scale and a few hectares in extent |
| | Study area | The proposed site and its immediate environs |
| | Regional | District and provincial level |
| | National | Country |
| | International | Internationally |

| | **Severity** | | **Benefit** |
|---|---|---|---|
| | Slight / Slightly Beneficial | Slight impacts on the affected system(s) or party(ies) | Slightly beneficial to the affected system(s) or party(ies) |
| | Moderate / Moderately Beneficial | Moderate impacts on the affected system(s) or party(ies) | An impact of real benefit to the affected system(s) or party(ies) |
| | Severe / Beneficial | Severe impacts on the affected system(s) or party(ies) | A substantial benefit to the affected system(s) or party(ies) |
| | Very Severe / Very Beneficial | Very severe change to the affected system(s) or party(ies) | A very substantial benefit to the affected system(s) or party(ies) |
| **Likelihood** | **Temporal scale** | | |
| | Unlikely | The likelihood of these impacts occurring is slight | |
| | May Occur | The likelihood of these impacts occurring is possible | |
| | Probable | The likelihood of these impacts occurring is probable | |
| | Definite | The likelihood is that this impact will definitely occur | |

A four-point impact significance scale is then applied to the project impacts (Table 3.3 below).

**Table 3.3: Environmental Significance Rating Scale**

| Significance rating | Description |
|---|---|
| Very High | VERY HIGH impacts would constitute a major and usually permanent change to the (natural and/or social) environment, and usually result in severe or very severe effects, or beneficial or very beneficial effects. |
| High | These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as HIGH will need to be considered by the project decision makers as constituting an important and usually long term change to the (natural and/or social) environment. These would have to be viewed in a serious light. |
| Moderate | These impacts will usually result in medium to long term effects on the social and/or natural environment. Impacts rated as MODERATE will need to be considered by the project decision makers as constituting a fairly important and usually medium term change to the (natural and/or social) environment. These impacts are real but not substantial. |
| Low | These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as LOW are generally fairly unimportant and usually constitute a short term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect. |

# 4 BIOPHYSICAL DESCRIPTION

Mozambique is located along the eastern coast of southern Africa between 10$^o$27' and 26$^o$52'' South and 30$^o$12' and 40$^o$51'East. It covers a surface area of 799 380 km$^2$ and is bordered by South Africa, Swaziland, Zimbabwe, Zambia, Malawi and Tanzania (Ribeiro and Chauque; 2010).

The country is divided into eleven provinces; the study site occurs within the Cabo Delgado Province in the district of Namuno in northern Mozambique. The project site is located near the town of Balama and is approximately 260 km west of the port town of Pemba.

## 4.1 Climate

Cabo Delgado Province has a tropical climate with two distinct seasons. The wet season occurs from November to March and the dry season from April to November. Specific weather data for the project area is not available. Climate data for Montepuez, the nearest town to the project site (93km away), was therefore used. Montepuez has a tropical climate and is also a winter rainfall region. The average annual rainfall is approximately 942.3 mm. The driest month is August/September with 0 mm - 2 mm. Most precipitation falls in January, with an average of approximately 246.4 mm (http://www.weatherbase.com).

The average annual temperature in Montepuez is 24.2 °C. The warmest month of the year is November with an average temperature of 26.7 °C. In July, the average temperature is 21.1 °C making it the coolest month in the year. The average temperatures vary during the year by 5.6 °C. The highest recoded temperature was a maximum of 50 °C, recorded in November, while the lowest recoded temperature was a minimum of 5 °C, recorded in May (http://www.weatherbase.com).

## 4.2 Geology

North-eastern Mozambique is predominantly underlain by Proterzoic rocks that form a number of gneiss complexes that range from Palaeo to Neoproterozoic in age (Boyd *et.al.,* 2010). The project site is underlain by metamorphic rocks of the Neoproterozoic Lurio Group that are included within the Xixano Complex (Brice, 2012).

The graphite layer is comprised of a sequence of metamorphosed carbonaceous politic and psammitic sediments within the Proterozoic Mozambique Belt (Brice, 2012). The sediments have been metamorphosed to graphitic schists (pelites) and graphitic sandstones (psammites).

In addition to the graphite, the prospect site has granite outcrops in the northeast. It appears that these are intrusive into the schists.

## 4.3 Topography and Hydrology

The study area is relatively flat to gently undulating with sporadic inselbergs (Mount Nassilala and Mount Coronge) rising from the flat plains (Figure 4-1). The altitudinal range varies from 480 to 830 m above sea level (asl) with the highest point occurring on Mount Nassilala.

The Mehucua River flows through the southern section of the project site in a South-west to North-east direction (Figure 4-2). A few small wetlands occur in the project area, the most notable being a swampland located approximately 2 km south west of the proposed site and a wetland located approximately 7 km east south-east. The largest water body in the area, but outside of the project area, is the Chipembe Dam which is located 12 km northwest of the site (Figure 4-2).

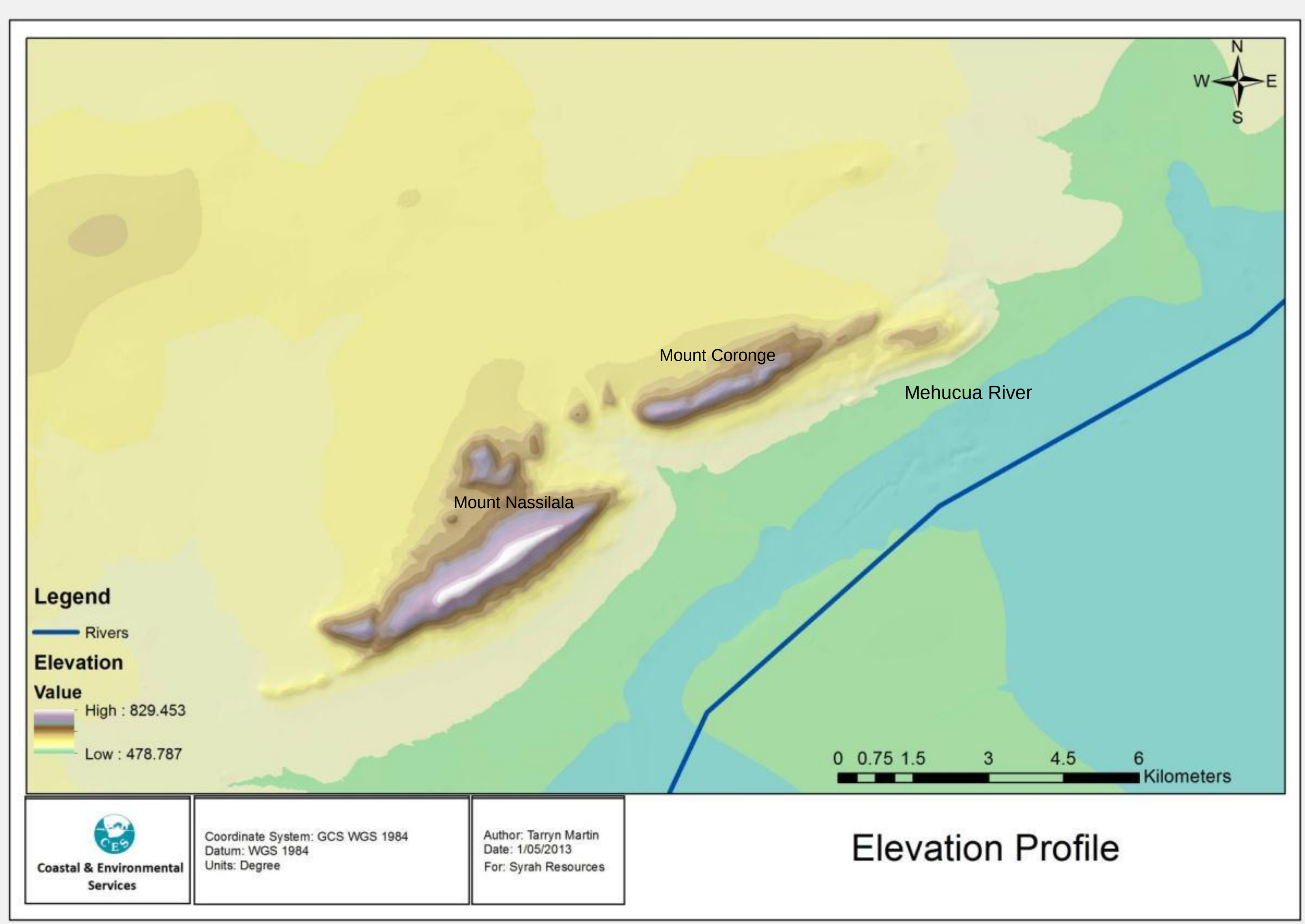


**Figure 4-1: Elevation Profile of the project area**

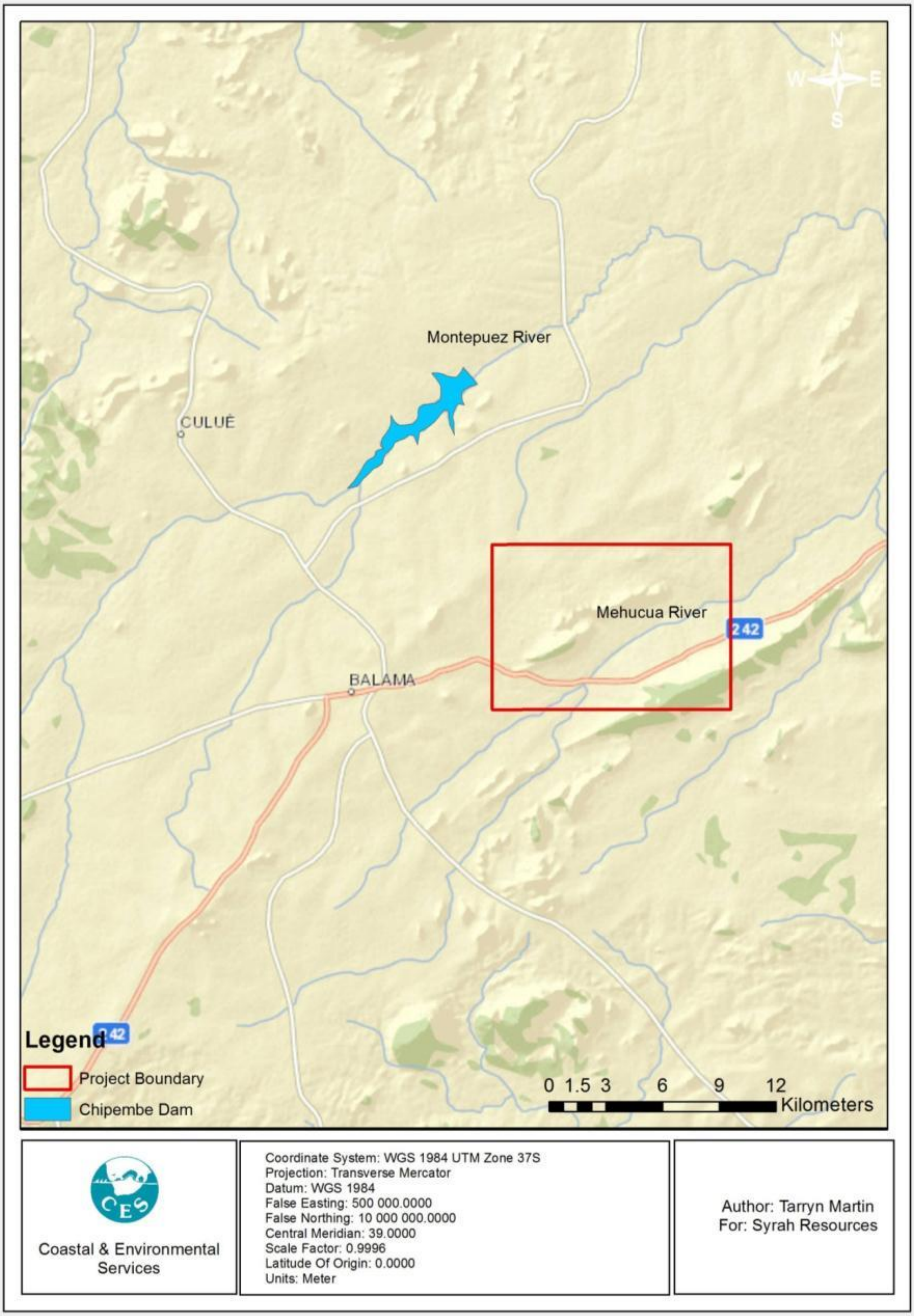


**Figure 4-2: Important rivers and dams located in the project area**

## 4.4 Protected Areas

Current conservation legislation was drawn up by the colonial administration prior to 1977 and is in the process of being rewritten. The existing legislation makes provision for the creation of protected areas under six categories: National Park, Game Reserve, Partial Reserve, Faunal Reserve, Hunting and Photographic Safari Area and Forest Reserve. Management of protected areas petered out during the civil war. By 1992, all designated protected areas were unstaffed, without infrastructure and effectively unprotected.

However, rehabilitation of the protected areas is gradually being implemented. For example, between 1995 and 2008 protected area coverage increased from 11% to 16% with new conservation areas being created (MICOA, 2009).

Examination of these protected areas in relation to the project site revealed that no National Parks occur in close proximity to the project area (Figure 4-3). The closest protected area (Quirimbas), designated as a National Park, occurs 85 km north-east of the project site.

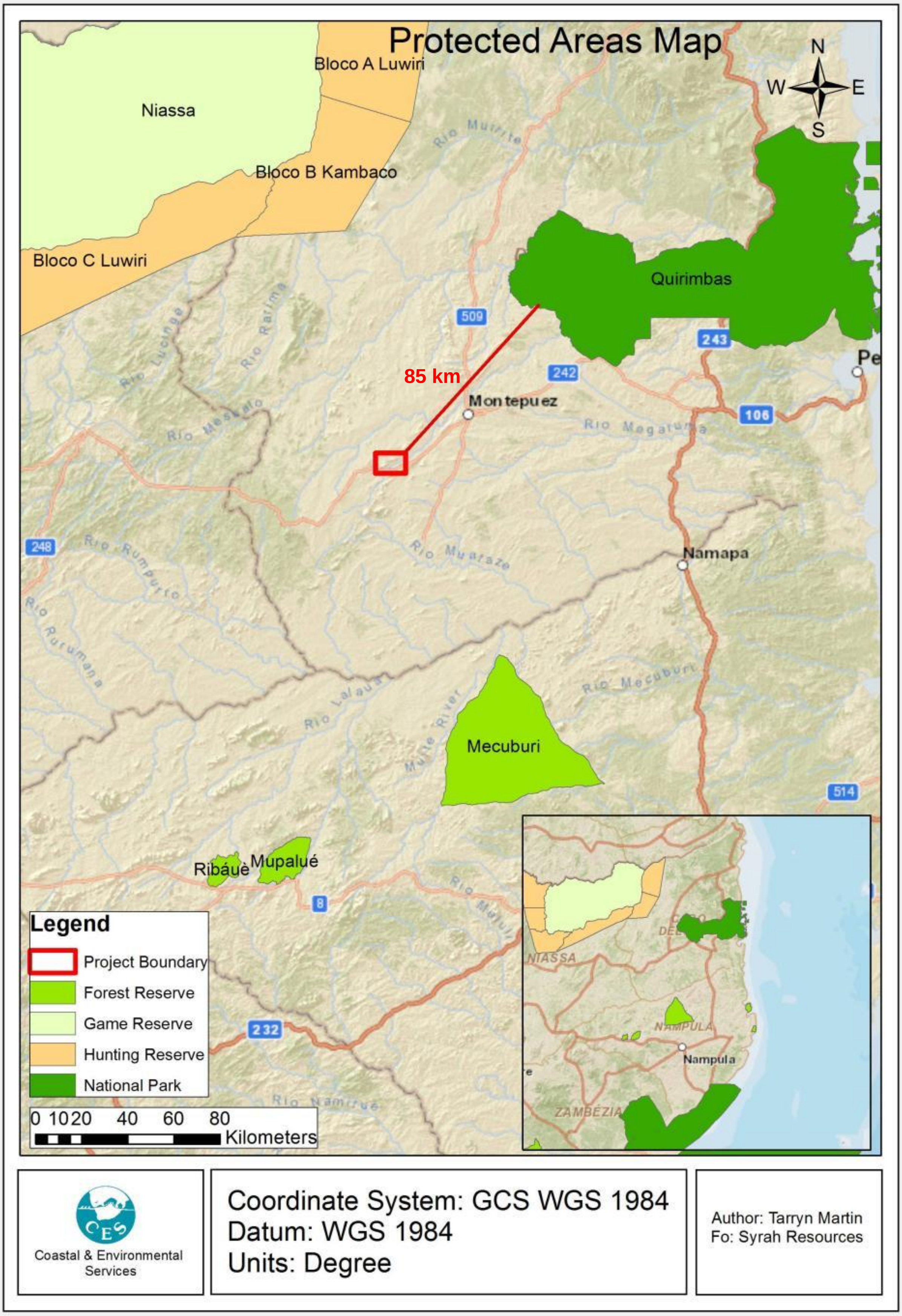


**Figure 4-3: Protected areas surrounding the project site**

## 4.5 Current Land Use

Compared with other countries in the region, Mozambique has a rich natural resource base including untransformed indigenous forests, savannah woodlands and coastal habitats. About 25% of the land has commercial forestry potential, 12.5% constitutes state-protected areas and a further 22% comprises potential wildlife habitat (GPZ, 2003).

Land use in the project area is primarily for subsistence agriculture. Crops such as maize, cotton and cassava are grown on the flat areas which are cleared using slash and burn techniques (Plate 4-1). Some small livestock is reared in the area although these animals were only noted near the villages and are not abundant in the project site.

Almost all households are heavily reliant on the natural resources for their livelihoods. Natural resources are used for construction, medicinal consumption and to supplement their food. Small scale charcoal production was also evident in the project site, but only where active woodland clearing was taking place.

**Plate 4-1: Recently burnt field at the project site**

# 5 LITERATURE REVIEW AND SPATIAL PLANNING

## 5.1 Ecological Zones of International Importance

Seventy-nine percent of Mozambique is covered in natural vegetation. Although several research projects have recently aimed at documenting Mozambique's diversity, the current conservation status of the country's flora still remains fairly unknown (Dudley and Stolton, 2012). Despite this, analyses of existing data show that the biodiversity in the country is high (USAID, 2008) and that globally, Mozambique boasts 7 ecological zones of international importance. These include the:

- Agulhas Current,
- East African Coast,
- Lakes of the Rift Valley,
- East African Mangroves,
- Forests of the South Rift Valley,
- East and Central Miombo, and the
- Savannas of the Zambezi Floodplains.

Other sites of high importance for biodiversity include Lake Niassa, Gorongosa Mountain, the Archipelago of Quirimbas, and the Chimanimani Massif (Dudley and Stolton, 2012; USAID, 2008).

Despite 16% of the country being declared as protected, these areas still face many challenges such as being understaffed, underfunded and without qualified personnel (USAID, 2008). Consequently, some of these areas are only protected on paper.

Mozambique has significant mineral resources and prospecting for oil, gas, diamonds, uranium, iron and coal is occurring at a rapid rate. If not managed effectively, this "rush" for mineral resources is likely to conflict with conservation in the country and have large impacts on important and sensitive ecosystems.

## 5.2 Vegetation Types in Mozambique

There is a lack of detailed, published information available on the vegetation of Mozambique, especially information concerning vegetation found in Cabo Delgado Province or the project area in particular. The most reliable sources of information are a vegetation map and descriptions by Wild and Barbosa (1967) and a biogeographical survey by White (1983). The above literature largely describes plant formations on a broad landscape level, but provides very little information on the communities found within the major vegetation types.

Eight broad vegetation types have been described and mapped for Mozambique (MICOA, 2009). Miombo Woodland is the most widespread, dominating in the north and centre of the country followed by Mopane Woodland which occurs in the southern and northern parts of the country. The third most widespread vegetation type is the Undifferentiated Woodland which covers extensive parts of the south, centre and northern portions of the country. The remaining vegetation types include Afromontane Elements, Coastal Mosaics, Halophytic Vegetation, Mangroves and Swamp Vegetation.

According to the broad vegetation map of Mozambique (After White, 1983 in MICOA, 2009) the project site occurs in Miombo Woodland (Figure 5-1). Miombo Woodland covers almost three million square kilometres in southern, central and east Africa (Smith 2000). Despite this broad and extensive range, the World Wildlife Fund (WWF) have listed this vegetation type as **VULNERABLE.**

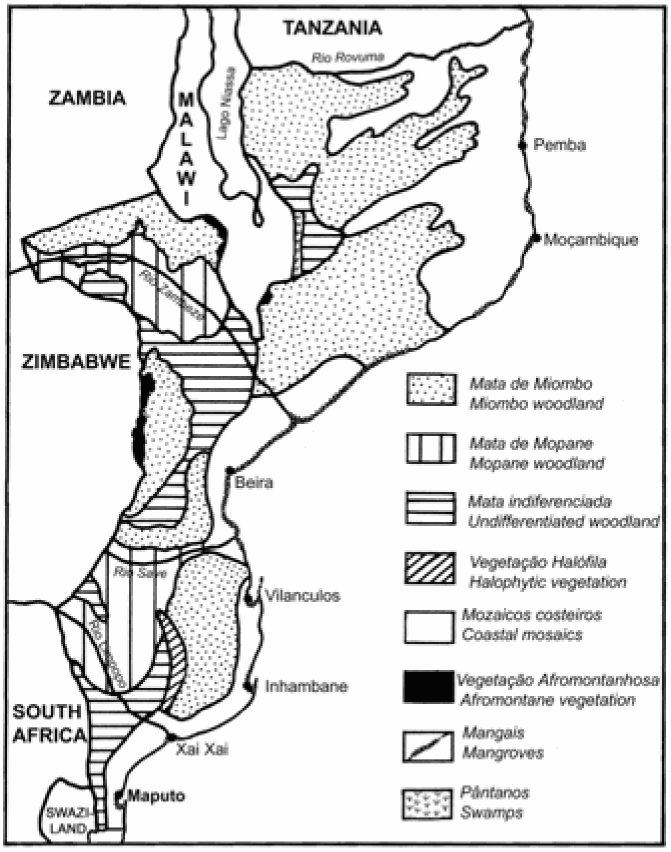


**Figure 5-1: Broad vegetation types found in Mozambique (After White 1983 in MICOA, 2009)**

WWF have defined global eco regions based on geographically distinct assemblages of species, natural communities and environmental conditions. Information on each eco region and its conservation status are provided to assist with the continued conservation of these areas.

According to this dataset, the project area falls into the *Central and Eastern Miombo Woodlands Eco region* as defined by WWF (Figure 5-2). This is a widespread eco region covering much of central and southern Africa. It is characterised by a high species diversity and is dominated by a woody component whose dynamics can be attributed to three interacting disturbances: people, fire and wildlife. Anthropogenic activities such as clearing for agriculture, harvesting and burning have resulted in the modification or transformation of this ecosystem in many areas. Population growth therefore poses a threat to this Eco Region, which is why it has been listed as **VULNERABLE.**

Dominant species in miombo woodland include nineteen species of *Brachystegia* and three other species namely: *Julberbernadia globiflora, Julbernadia paniculata* and *Isoberlinia angloensis* (White, 1983). Miombo woodlands range from completely deciduous to almost evergreen but are mostly semi-deciduous in nature (White, 1983). Miombo tends to show resistance to fire, but cannot survive repeated fire events (White 1983). Natural stress and drought are important factors in the growth of miombo (Chidumayo 1991) as well as its fruiting potential (Chidumayo, 1997). There are a few other species that occur within miombo but tend not to reach canopy height, these include: *Afzelia quanzensis, Anisophyllea pomifera, Erythrophleum africanum, Faurea saligna, Marquesia macroura, Parinari curatellifolia, Pericopsis angolensis* and *Pterocarpus angolensis*. Included are a few species of *Uapaca* and *Monotes*, which tend to be about 10m tall (White, 1983).

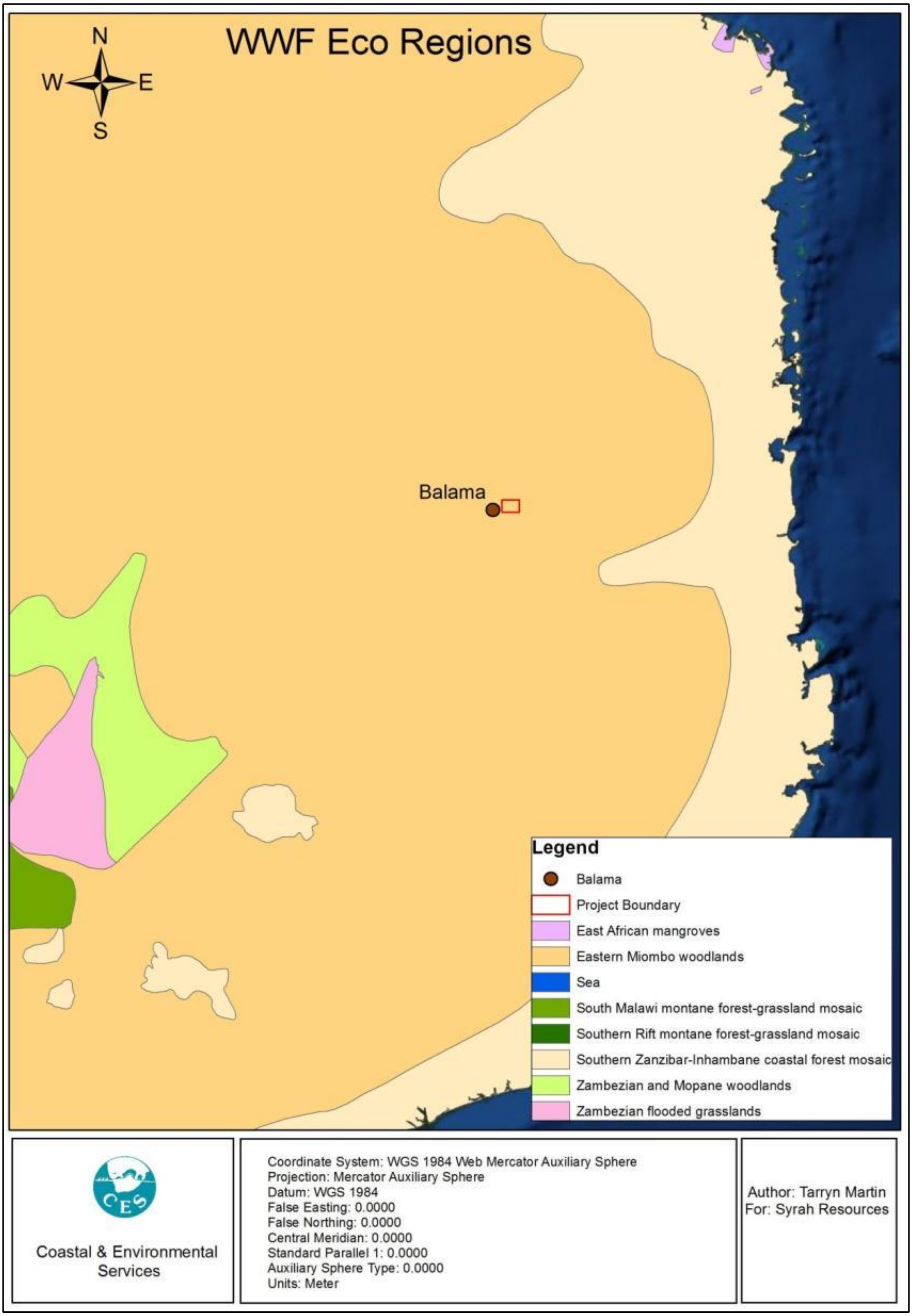


**Figure 5-2: WWF Eco Regions surrounding the project site**

Miombo Woodland is usually divided into two types: wetter and drier miombo, which are separated by the 1100mm mean rainfall isohyet (Chidumayo 1987). The project area occurs within the drier miombo type which can be defined by the following characteristics:

- Rainfall is less than 1000mm.
- Canopy height usually less than 15m.
- Floristically poor.
- *Brachystegia floribunda* etc. absent or very local.
- *Brachystegia spiciformis, Brachystegia boehmii* and *Julbernardia globiflora* are often the only dominants present.
- Associates in rocky places include many species which otherwise occur in deciduous forest and thicket or other dry types.
- Associated vegetation includes dry deciduous forest and thicket, deciduous riparian forest, and dry dambos.

## 5.3 Floristic Diversity

Historically, vegetation surveys in Mozambique have been limited. However, there has been an increase in the last 20 years with specific areas of interest being targeted. These include protected areas (such as national parks and reserves), centres of endemism and suspected biological hotspots.

From these surveys, it is estimated that over 5 500 plant species have been recorded in Mozambique although the actual number of species is likely to be much higher (MICOA, 1997 and 2009). Of these 5 500 species, 177 species are endemic and 300 occur on the Mozambique Red Data List (MICOA, 2002).

Based on habitat distribution it is possible that nine vulnerable species listed on the Mozambique Red Data List could occur in the project site. These are listed below (Table 4-1).

**Table 4-1: Vulnerable Plant Species that could occur in the project site**

| Species | Status | Endemism | Encountered on Site |
|---|---|---|---|
| *Adenia mossambicensis* | Vulnerable | Endemic | No |
| *Cassipourea obovata* | Vulnerable | Endemic | No |
| *Combretum stocksii* | Vulnerable | Endemic | No |
| *Dichapetalum zambesianum* | Vulnerable | Endemic | No |
| *Grevea eggelingii* | Vulnerable | Near-Endemic | No |
| *Hexalobus mossambicensis* | Vulnerable | Possible Endemic | No |
| *Homalium mossambicensis* | Vulnerable | Endemic | No |
| *Maerua andradae* | Vulnerable | Endemic | No |
| *Viscum littoreum* | Vulnerable | Endemic | No |

## 5.4 Inselbergs: Islands of Biodiversity

The project area is characterised by the presence of Inselberg's. Inselberg's are defined as rock outcrops that rise suddenly above a plain and form isolated islands of biodiversity similar to islands in an ocean (van der Maesen *et a.l,* 1996). They are generally restricted to tropical and sub-tropical climates and are generally the last intact patches of natural habitat within agricultural landscapes. Previous studies have shown that although these features may appear isolated, they in fact form linkage corridors between other such features and mainland sources of vegetation (Burke, 2002). They are therefore important for the conservation and dispersal of taxa, particularly those with short dispersal ranges.

In Mozambique, many of the identified endemic species and rare and threatened habitats are associated with isolated inselberg's such as the Chiperone and Namule hills, Mecula and

Gorongosa Mountains and Chimanimani massive. While these areas are recognised as areas of floristic endemism, many more inselberg's are yet to be documented in the country (MICOA, 2007). These areas, which in many cases provide refugia for taxa amongst a sea of agricultural land, are under threat from vegetation clearing, slash and burn agriculture, human settlements and uncontrolled fires. Degradation or removal of these inselberg's could result in breaks in ecological corridors, created by these "stepping stones" of biodiversity, resulting in habitat fragmentation.

Although the project site was characterised by the presence of two inselbergs that are relatively intact compared to the surrounding vegetation and provide refugia for plant species, neither of these features can be described as critical habitats, as defined by the IFC Performance Standard 6, from a floral perspective since they do not contain critically endangered and/or endangered species, neither of them are habitats of significant importance to endemic and/or restricted/range species, neither of these inselbergs can be classified as highly threatened or unique ecosystems and they are not associated with key evolutionary processes. While these habitats are not classified as critical habitats they have been classified as natural habitats using the IFC definition *"areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."* (IFC, 2012).

## 5.5 Ecosystem services

From a biological perspective, ecosystems support all life and are responsible for regulating natural systems. From a socio-economic perspective they provide resources required for material welfare and livelihoods and they provide health and cultural benefits to the people who use them. These functions are considered to be ecosystem services which the IFC (PS6, 2012) defines as *"the benefits that people, including businesses, obtain from ecosystems"*

These services have been divided into four categories (IFC PS6, 2012):

- **Provisioning services** – This includes products or goods such as water for drinking, wild foods, ethnobotanical plants and timber;
- **Regulating services** – This includes ecosystem functions such as flood control and climate regulation;
- **Cultural services** – This includes non-material benefits such as recreational purposes (sport, hunting, fishing), aesthetic, and spiritual benefits; and
- **Supporting services** – This includes fundamental processes such as nutrient cycling and photosynthesis that support the above three categories.

The International Institute for Sustainable Development (IISD) has identified 10 broad ecosystem services that are under threat in Mozambique (UNEP, 2005). These include maintenance of biodiversity, food production, water supply, energy resources, flood regulation, adequate nourishment, clean water, energy for warmth and cooking, ability to earn a livelihood and vulnerability to flood and drought. In Cabo Delgado, the province where the project is located, biodiversity, food provision, water supply and fuel have been identified as stressed ecosystem services. These are discussed in further detail below:

**Biodiversity**
**Issue: Loss of biodiversity.** Loss of biological variability is occurring as a result of habitat fragmentation due to logging, slash-and-burn, the conversion of habitat to agricultural systems and the exploitation of mineral resources (UNEP, 2005).

**Food Production**
**Issue: Loss of Crops.** Variation in rainfall in Mozambique makes the country vulnerable to droughts and floods which directly impact on food production, specifically impacting small subsistence farmers who are the most vulnerable to these fluctuations (UNEP, 2005).

### Water Resources

**Issue: Degradation of clean water sources.** Pollution of surface, coastal and domestic water is an emerging problem in Mozambique as a result of industry and poor sewage treatment (UNEP, 2005). Wetlands that provide purification and regulation are under threat from expansions in agricultural areas and an increasing population size. As a result, clean water required for domestic use such as drinking and cooking, especially in un-serviced rural areas, is under threat.

### Fuel

**Issue: Loss of forest fuel resources.** The high concentration of people in some areas, as a result of internal migration and displacement, is resulting in the over-exploitation of forests and woodlands for agricultural needs and fuel (UNEP, 2005). In addition, forest fuel resources are lost to logging and profit driven timber exportation.

# 6 VEGETATION TYPES AND SITE DESCRIPTION

## 6.1 Vegetation Characterisation

### *6.1.1 TWINSPAN*

TWINSPAN is a program that is used to classify species and samples using a hierarchical classification process. Firstly, samples are successively divided into categories and then the species are divided into categories based on the sample classification.

The TWINSPAN analysis resulted in a dendrogram (or tree diagram) that defined different plant communities (Figure 6-1). The reason for the separations of these vegetation types lies primarily with the species composition. Transects that share many species in common will appear closer to one another than to those that have very different species. The analysis also identifies indicator species, whose presence can be used to separate the classes.

The plant names shown at every node or division on the dendrogram are the species that TWINSPAN determined to be the most reliable "indicator species" for every pair of groups. These species are fairly consistently present [+] or absent [-]. For example, the highest order division on the tree, which splits Groups A from B, gives the presence of *Dichrostachys cinerea* as the best indicator species of Group A.

The results show a clear split into two groups – see the blue highlights in Figure 6-1. The split defines two major vegetation groups. These comprise Group A *Miombo Woodland* and Group B *Riparian Woodland.*

The *Miombo Woodland* was further divided into three main categories:

- *Miombo Woodlands* associated with the graphite deposit
- *Miombo Woodlands* associated with the granite intrusions
- *Miombo Woodlands* associated with the flat areas

A DECORANA plot was also done for this data, allowing for a more comprehensive grouping of the transects.

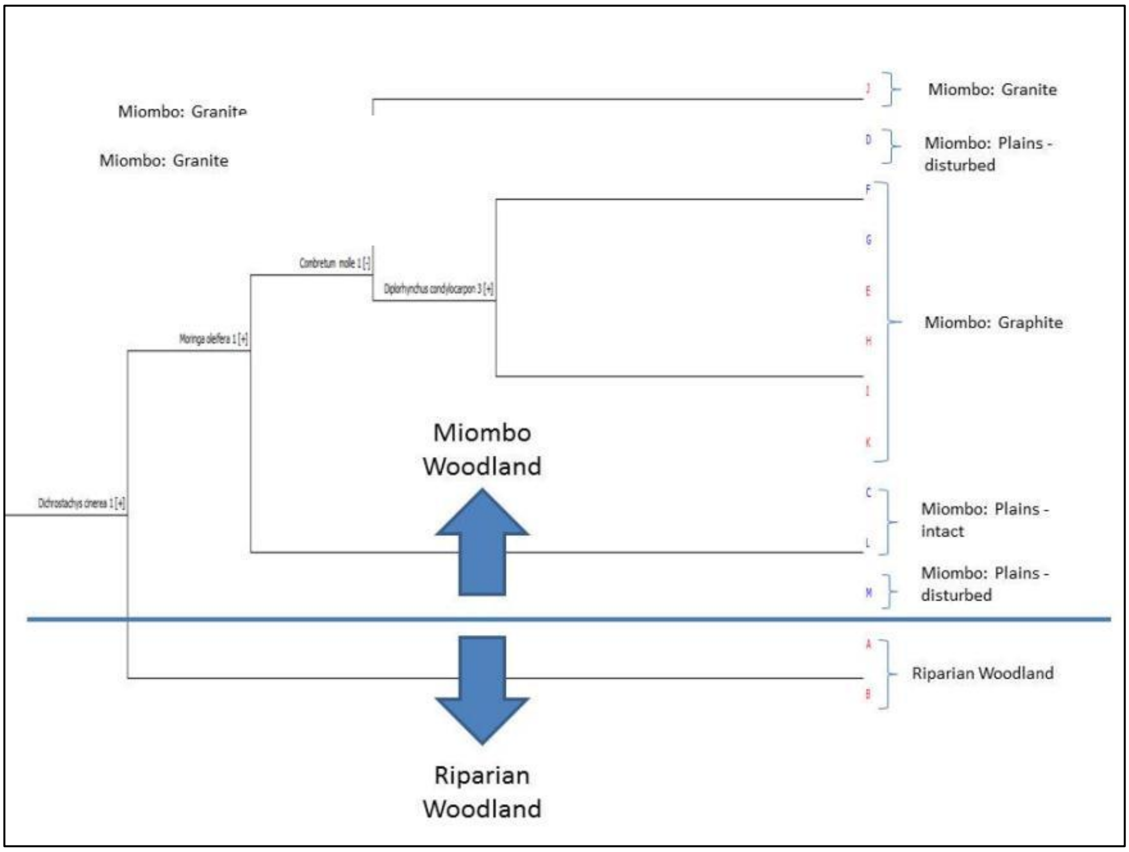


**Figure 6-1: Dendrogram produced by TWINSPAN showing groupings defined for the 13 transects sampled in March 2013**

### *6.1.2 DECORANA*

The DECORANA analysis resulted in a scatter plot representing the 13 transects. This analysis provides a clearer representation of the different communities than the TWINSPAN analysis. Figure 6-2 illustrates the combination of all of the data for the entire project area and shows a clustering of Community A (*Miombo Woodland*) and B (*Riparian Woodland*) as distinctly separate. It also shows that the Miombo Woodland associated with the granite has a different species composition to the *Miombo Woodland* associated with the graphite deposit and to that found on the plains. In addition, the *Miombo Woodland* found on the flat plains has been split into two distinct groups which can be explained by the level of disturbance along the road (*Miombo Woodlands: Plains – degraded)* compared to the fairly intact vegetation found near Nquide village.

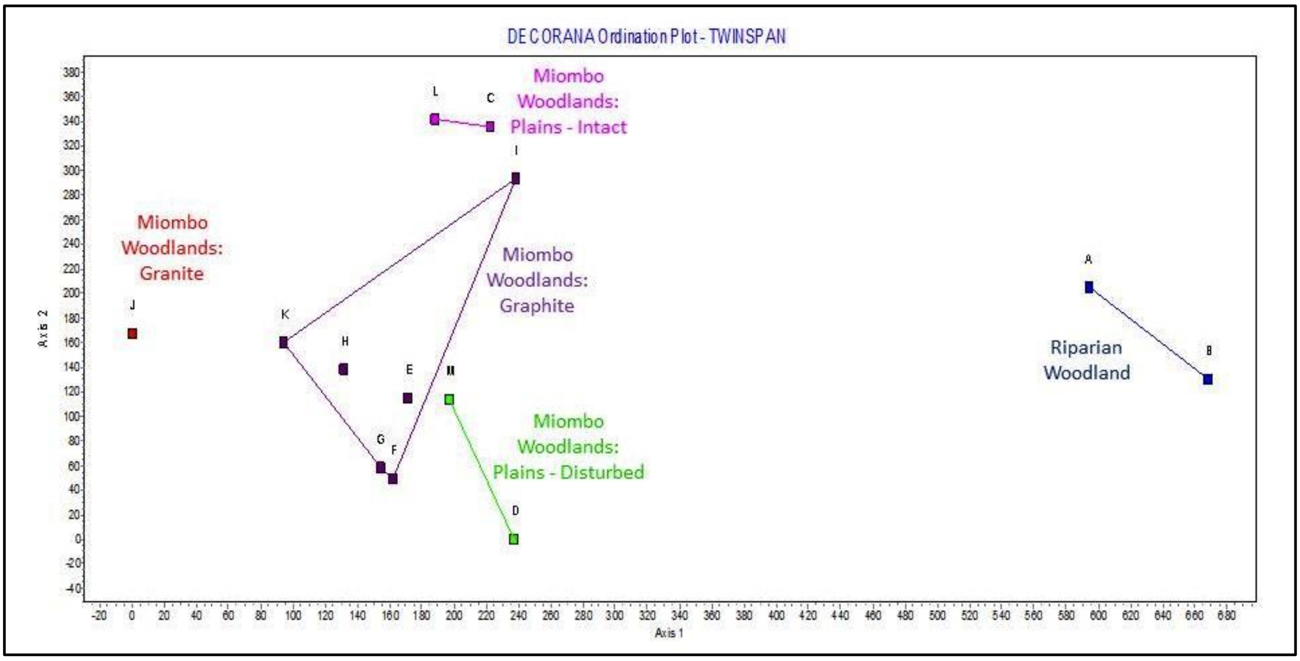


**Figure 6-2: Detrended Correspondence Analysis scatter plot of 68 samples taken in March 2013, showing the clear division of the 3 major community types, A-C. The clusters in this figure may be compared with the groups shown on the TWINSPAN dendrogram (Figure 6-1).**

## 6.2 General description of vegetation types

Based on the TWINSPAN and DECORANA analyses, two main vegetation types occur within the project site; *Riparian Woodland and Miombo woodland*. The *Miombo Woodland* is further split into three types which are illustrated in Figure 6-3 and described in further detail below.

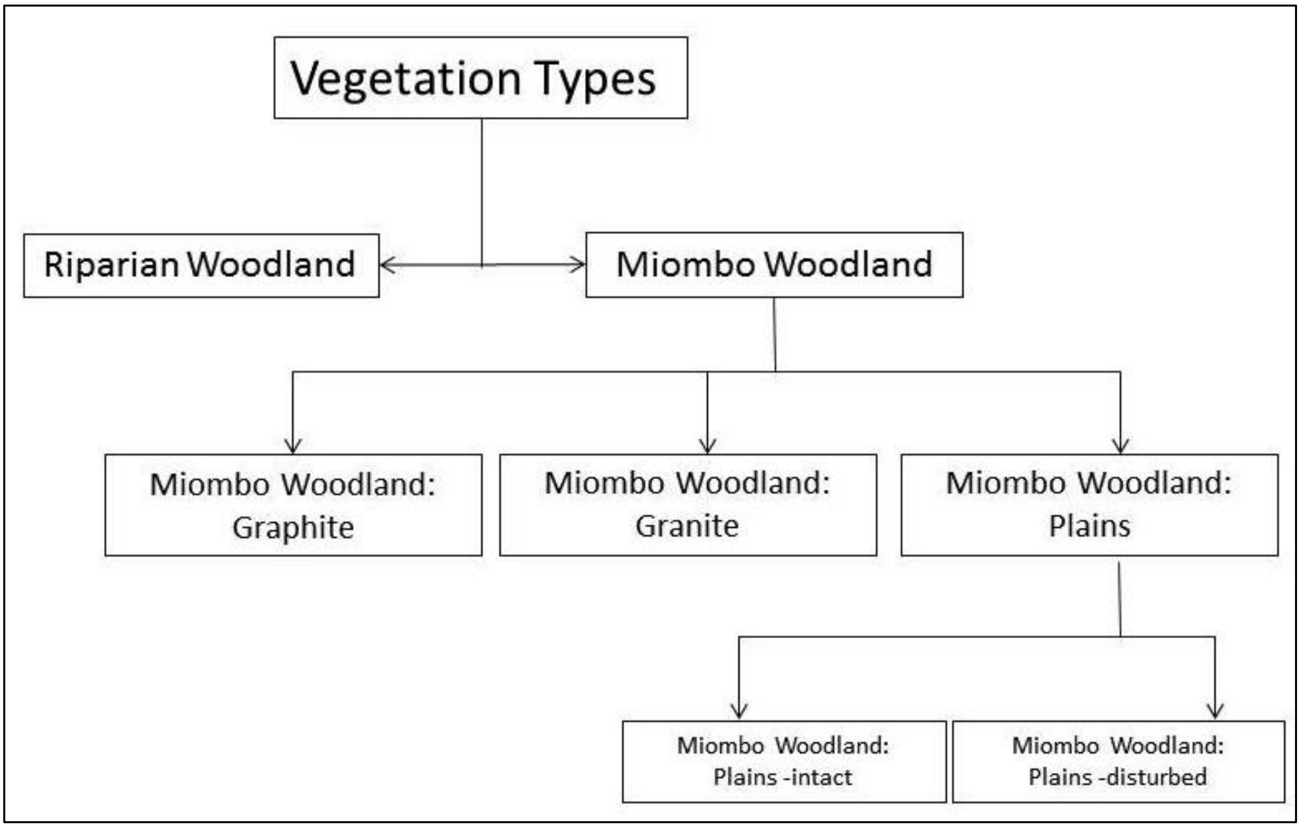


**Figure 6-3: Organogram illustrating the various types of Miombo Woodlands found in the project site.**

For the purpose of this study the definition of woodlands, as described by Palgrave *et al.* (2007), has been adopted: Woodlands are open stands of trees at least 5 m tall with crowns that cover at least 20% of the surface and are not interlocking. Grass cover is usually present.

### *6.2.1 Riparian Woodland*

The Riparian Woodland is entirely restricted to a few metres, adjacent to the rivers and streams, throughout the Balama Graphite project area. In most cases, the riparian woodland is absent or highly degraded (Figure 6-4; Plate 6-1). The narrow strips of riparian trees were difficult to detect on the aerial imagery, limiting accurate mapping of this vegetation type. The dominant species in the intact areas are *Brachystegia boehmii, Albizia adianthifolia., Grewia forbsii, Combretum sp., Tabernaemontana elegans* and *Xylotheca kraussiana* (Plate 6-2) (see Appendix A for all species found in this habitat).

**Plate 6-1: Riparian Woodland**

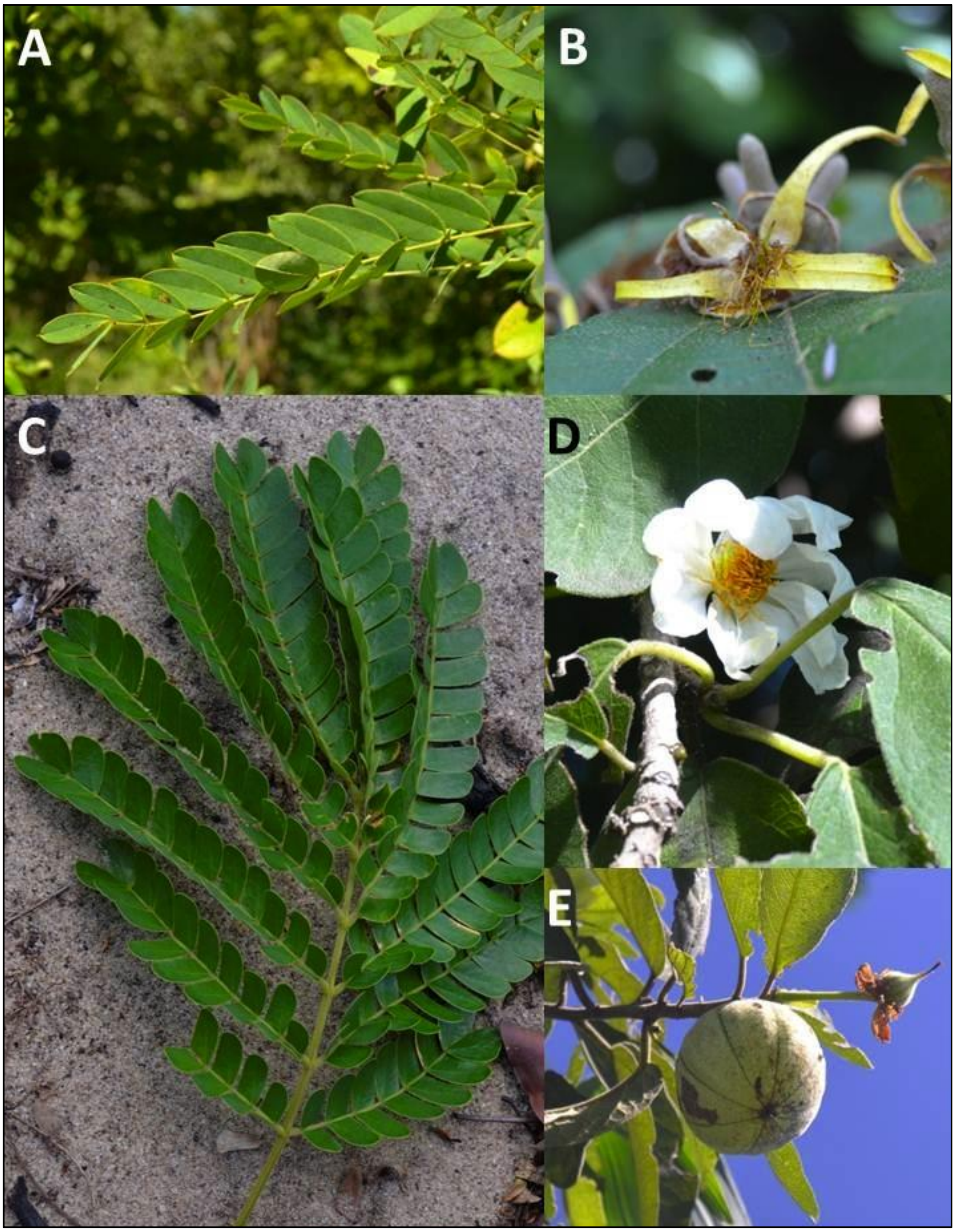


**Plate 6-2: Dominant species found in the Riparian Woodland. A) *Brachystegia boehmii.* B) *Grewia forbsii,* C) *Albizia adianthifolia* D) *Xylotheca kraussiana* flower and D) *Xylotheca kraussiana* fruit.**

### *6.2.2 Miombo Woodland*

*Miombo Woodland* is found throughout the project site in varying states of degradation and transformation. Further analysis of the survey data indicates that this vegetation type can be further divided into three distinct vegetation types based on their species composition. These are described in detail below and their distribution illustrated in Figure 6-4.

**Miombo Woodland: Graphite**

This vegetation type is found on the slopes of the inselberg Mount Nassilala and is strongly associated with the underlying graphite. It is characterised by a closed canopy with a distinct grass layer beneath (Plate 6-3). It is interspersed with fairly large patches of bamboo (*Oxytenanthera* *abyssinica)* which appear to be invasive and may become a problem if left unchecked. Dominant species include *Securidaca longipedunculata, Bauhinia galpinii, Milletia stuhlmannii and Cussonia arborea. Diplorhynchus condylocarpon* was dominant in areas that had been recently disturbed by harvesting. During the dry season it was noted that large trees were being harvested on Mount Nassilala for construction materials. The vegetation on this inselberg therefore provides an important ecosystem service to the surrounding villages.

**Plate 6-3: Miombo Woodland (on the hill slopes) associated with the graphite deposit**

**Miombo Woodland: Granite**

This vegetation type predominates on the granite intrusion Mount Coronge (Plate 6-4). The dominant species include *Cussonia cf arborea*, *Sterculia appendiculata* and *Milletia stuhlmannii.* Other species include *Combretum molle* and *Steganotaenia araliaceae.*

**Plate 6-4: Miombo Woodland (on the hill slopes) associated with the granite intrusions**

**Miombo Woodlands: Plains**

This vegetation type predominates in the flat areas surrounding the inselbergs. It is largely secondary woodland, having been transformed by agricultural practices. Patches of degraded woodland occur along the road from Pirira village to Chipembe dam and within the project site (Figure 6-3).

However, a significant patch of intact woodland was found to occur east of Nquide village (Plate 6-4). It is unclear why this woodland has not been transformed and planted by the local community but it is highly probable that this is a sacred site.

Dominant species in the intact areas include *Gardenia resiniflua, Ficus sp. Antidesma vernosum, Brachystegia boehmii, Brachystegia bussei* and *Strychnos madagascariensis.*

Dominant species in the degraded areas include *Securidaca longipedunculata, Bauhinia galpinni, cf Dovyalis sp., Pseudolachnostylis maprouneifolia, MIlletia stuhlmannii* and *Antidesma vernosum*.

**Plate 6-5: Intact woodland found in the flat plains near the Nquide village**

**Plate 6-6: *Habenaria* sp. (Family: Orchidaceae) found to occur in the intact *Miombo Woodlands: Plains***

### *6.2.3 Agricultural Land:*

Large sections of the plains have been cleared for the cultivation of crops such as maize, cassava, beans and cotton. Despite the majority of tree species being cleared it was noted that there were numerous Baobab trees (*Adansonia digitata*) and Tall Star Chestnut trees (*Sterculia appendiculata)* that had not been removed (Plate 6-6). These trees are either too large to remove or they serve a functional purpose such as a source of shade or in the case of the baobab trees, as a source of food. They could also have spiritual significance to the local communities.

**Plate 6-7: Example of typical agricultural fields with a single Baobab tree**

## 6.3 Vegetation Distribution

Twenty percent of the project site is comprised of degraded *Miombo Woodlands: Plains* (Table 6-1 and Figure 6-3). *Agricultural areas* and *Settlement*s make up a further 65.8% of the project area. The Miombo Woodlands associated with the granite intrusions and graphite deposits (i.e. the vegetation that occurs on Mount Coronge and Mount Nassilala) collectively make up 12.4 percent of the vegetation in the project area.

Figure 6-3 illustrates the distribution of each vegetation type throughout the project area. The *Miombo: Graphite* vegetation is found on Mount Nassilala and the eastern portion of Mount Coronge. The *Miombo: Granite* vegetation can be found on the western portion of Mount Coronge. The *degraded Miombo Woodlands: Plains* is found in patches throughout the flat, low-lying areas and is surrounded by agricultural land. There was only one small patch of *intact Miombo Woodlands: Plains*. This occurs to the east of Nquide village.

The vegetation type that will be most heavily impacted by the proposed mining infrastructure (excluding roads) is the *Miombo Woodland: Graphite.* 7.8% of the total area of this vegetation type will be lost during the mining process. The second most impacted vegetation type is the degraded *Miombo Woodlands: Plains* with a loss of 1.4% of this vegetation type. 1% of the *Miombo Woodlands: Granite* will be lost. The intact *Miombo Woodlands: Plains* will not be directly impacted by the mining operation. Although not included here, riparian vegetation will be impacted by infrastructure such as roads. Although not a "vegetation type" it is worth noting that 13.0% of agricultural land will be directly impacted.

**Table 6-1: Total Area of Each vegetation type and the area that will be directly impacted**

| Vegetation Type | Total Area (Ha) | % of Project Area | % of veg type Impacted |
|---|---|---|---|
| *Riparian Woodland* | 56 | 0.7 | 0 |
| *Miombo Woodland: Graphite* | 824 | 10.5 | 7.8 |
| *Miombo Woodland: Granite* | 149 | 1.9 | 1.0 |
| *Miombo Woodland: Plains – degraded* | 1561 | 19.9 | 1.4 |
| *Miombo Woodland: Plains - intact* | 91 | 1.2 | 0 |
| *Agriculture* | 4840 | 61.6 | 13.0 |
| *Settlements* | 332 | 4.2 | 0 |
| **TOTAL** | **7 853 (Mapped Area)** | **100** | **9.1** |

## 6.4 Ecosystem Services

The vegetation types identified at the project site all provide important ecosystem services to the local communities. A high level survey has identified the following ecosystem services in the project area (Table 6-2). A more in depth assessment is provided in the Land and Natural Resource Use Assessment.

**Maintain soil structure and stability**
Indigenous vegetation cover functions to prevent soil erosion and desertification and thus functions to maintain ecosystem integrity and function. All four ecosystems function to maintain soil structure and stability. This is particularly important in areas that are susceptible to erosion such as the steep slopes of the inselbergs and the riparian areas.

**Construction Materials**
All four vegetation types are a potential source of materials for the construction of furniture, houses, animal traps and fish traps. Non-timber products such as grass and reeds are used for thatching, constructing ropes and for household items such as sleeping mats and baskets (Plate 6-7).

**Medicinal and Food Plants**
Plants are used by the local communities as a source of food and for medicinal purposes. Wild foods are particularly important during times of stress such as drought. The vegetation assessment did not conduct focus groups with local communities to identify important medicinal and food plants in the area. It is recommended that this is done prior to construction.

**Source of fuel wood**
All four vegetation types contain woody species that are collected and used as fuel wood.

**Charcoal Production**
Tree harvesting for small scale charcoal production is evident in the area, but only associated with newly cleared woodland around and directly associated with the graphite deposit (plate 6-7).

**Table 6-2: Ecosystem services supplied by each vegetation type**

| **Ecosystem Services** | **Vegetation Types** | | | |
|---|---|---|---|---|
| | **Riparian Woodland** | **Miombo Woodland: Graphite** | **Miombo Woodland: Granite** | **Miombo Woodland: Plains** |
| Construction Materials | | X | X | X |
| Medicinal Plants | X | X | X | X |
| Food Source | X | X | X | X |
| Soil Structure and Stability | X | X | X | X |
| Source of Fuel Wood | | X | X | X |
| Charcoal Production | | X | X | X |


**Plate 6-8: Example's of natural resources providing ecosystem services to the local communities. A) trees being cut for construction, B) plant materials used for constructing fish traps, C) trees and shrubs being used for charcoal production; D) grasses used for sleeping mats.**

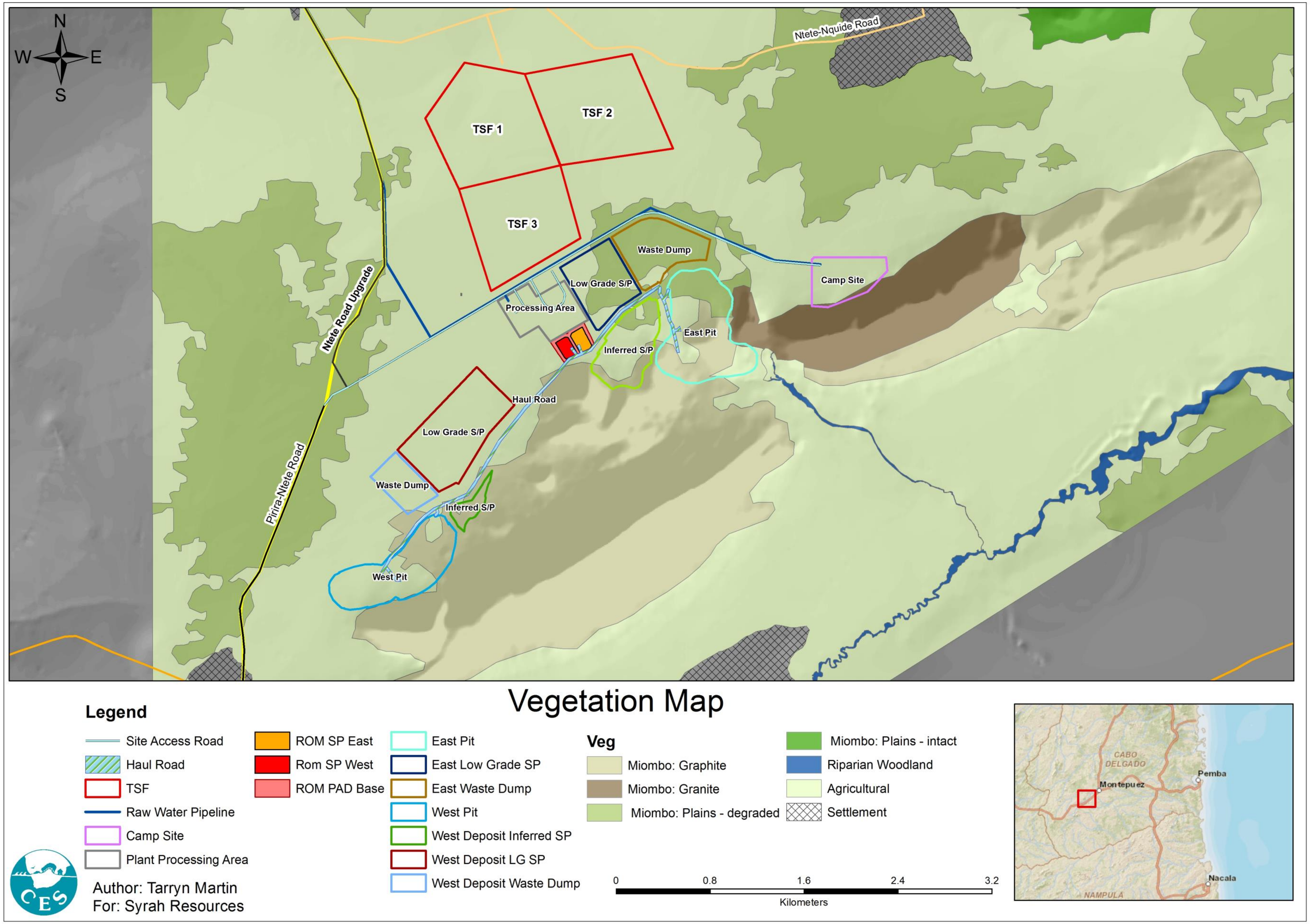


**Figure 6-4: Vegetation Map of the Balama Graphite Project Site**

# 7 FLORAL BIODIVERSITY AND CONSERVATION STATUS

## 7.1 Floral Biodiversity

Two plant survey's was undertaken; a wet season survey in March 2013 (late summer) and a dry season survey in July 2013. As such, early flowering species (species that flower in November/December) that had already dropped their flowers and fruit were in some cases difficult to confirm down to species level.

Species abundance (number of plants per unit area) data in *Riparian Woodland, Miombo Woodland: Graphite, Miombo Woodland: Granite* and *Miombo Woodland: Plains (intact and degraded)* have been used to calculate biodiversity.

For future monitoring, alpha biodiversity calculations within each habitat will be useful management tools. Alpha Biodiversity considers species richness *and* relative abundance with the habitat. This report has utilised the Simpsons Index to calculate the alpha biodiversity for three reasons:

1. It is a relatively simple calculation which can be utilised for monitoring
2. It is fairly robust and does NOT rely on large datasets
3. It is abundance-weighted, which allows for a better reflection of biodiversity in habitats that are dominated by a few species

**Table 7.1 Floral Survey and Biodiversity calculations (2013)**

| **Habitat** | **Alpha Biodiversity** (Simpsons Index 1/D; value range 0.0 < 1/D < 10+) | **Ecologically important (key stone) taxa or indicator species** | **Pioneer species (indicative of disturbance) or Edge species** |
|---|---|---|---|
| **Riparian Woodland** | 21.7 | *Brachystegia boehmii, Combretum sp. 3, Azelia quanzensis, Grewia forbsii, Xylotheca kraussiana, Brachystegia spiciformis* | *Securidaca longipedunculata, Bauhinia galpinni* |
| **Miombo Woodland: Graphite** | 5.24 | *Securidaca longipedunculata, Diplorhynchus condylocarpon, Bauhinia galpinni, Annona senegalensis, Cussonia cf arborea, Albizia sp.* | *Securidaca longipedunculata, Diplorhynchus condylocarpon* |
| **Miombo Woodland: Granite** | 10 | *Cussonia cf arborea, Albizia sp., Steganotaenia araliaceae, Combretum molle, Sterculia appendiculata* | *Albizia sp, Combretum molle* |
| **Miombo Woodland: Plains – intact** | 13.7 | *Albizia sp., Gardenia resinflua, Ficus sp., Antidesma vernosum, Diplorhynchus condylocarpon, Brachystegia species* | *Albizia sp., Diplorhynchus condylocarpon* |
| **Miombo Woodland: Plains – degraded** | 6.5 | *Securidaca longipedunculata, Securidaca longipedunculata, Antidesma vernosum, Annona senegalensis, Pseudolachnostylis maprouneifolia* | *Securidaca longipedunculata* |

The highest biodiversity was observed in the *Riparian Woodland* which had an alpha biodiversity index score of 21.7. Considering that riparian zones are highly impacted and severely limited, pristine or rehabilitated riparian woodland is likely to be significantly more diverse. The intact *Miombo Woodlands: Plains* had the second highest biodiversity index. The *Miombo Woodlands: Graphite* and degraded *Miombo Woodlands: Plains* had the lowest alpha biodiversity score. This is possibly due to anthropogenic disturbances such as harvesting building materials and firewood.

## 7.2 Conservation Status of plant species: Rare, Endangered or Threatened species

Of the 5 500 recorded species in Mozambique, 300 occur on the red data list and 122 of these are threatened (MICOA, 2003). Clearing of vegetation, slash and burn agriculture, human settlements and uncontrolled fires have been identified as the main threats to Mozambique's flora.

The total species list from the site visit was assessed against the International Union for Conservation of Nature (IUCN) Red Data list, the Mozambique, Malawi, Zimbabwean, Tanzanian and Zambian Red Data Lists and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The results are summarised in Table 7-2 and the full species list appears in Appendix A.

**Table 7-2: Species of Special Concern**

| Status | Number of Species |
|---|---|
| **IUCN Red Data List (international)** | |
| Likely least Concern* | 25 |
| Unknown (no information available) | 46 |
| **Mozambique Red Data List** | |
| Vulnerable | 1 (*Sterculia appendiculata)* |
| **CITES** | |
| Appendix I | 0 |
| Appendix II | 1 (*Habenaria sp.)* |

* *Not present in IUCN list, but no other species in family identified as endangered, vulnerable or near threatened*

No species of special concern appear on the IUCN (2012) list. One exotic species is listed as data deficient and 25 species are likely to be classified as Least Concern since no species within their family occur on the list. There is no information available for the remaining 46 species.

According to the Mozambique Red Data List (2002), one species (*Sterculia appendiculata)* is considered "vulnerable" as a result of over exploitation for firewood, timber and local construction (Plate 7-1 A).

One CITES species, from the Orchidaceae family, appears in Appendix II. This species is not necessarily threatened, but is controlled in terms of international trade whereby CITES controls international trade of certain species i.e. all import, export and re-export of CITES species has to be authorised through a licensing system (Plate 7-1 C).

No species appear on the Tanzanian, Zimbabwean, Zambian or Malawian Red Data Lists.

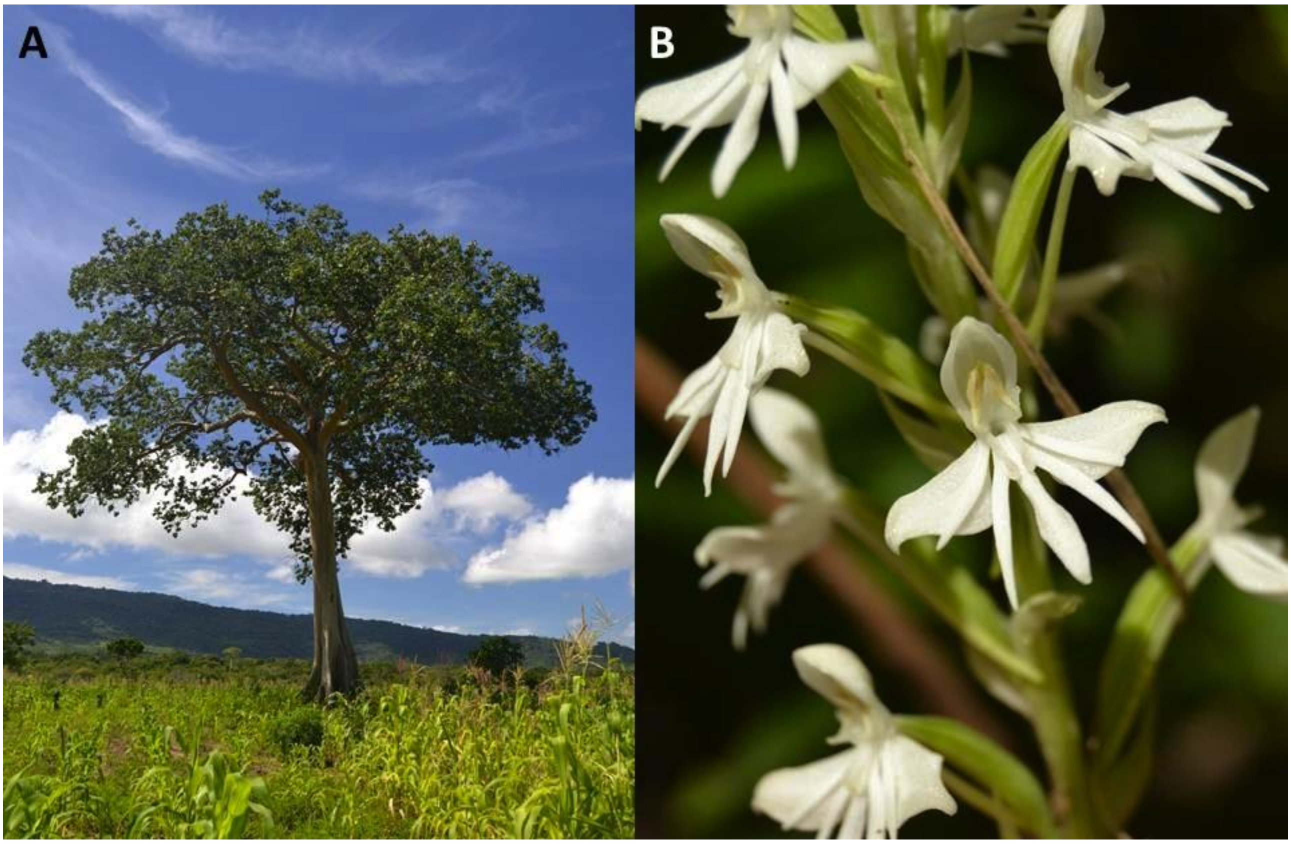


**Plate 7-1: Species of Special Concern identified at the project site. A) *Sterculia appendiculata* B) *Habenaria* sp**

## 7.3 Alien Species

According to the Global Invasive Species Database (http://www.issg.org) the species listed in Table 7-3 have been identified as problematic alien species in Mozambique:

**Table 7-3: Problematic alien species in Mozambique (Source: http://www.issg.org)**

| Name | Type | Status |
|---|---|---|
| *Leucaena leucocephala* | Tree/shrub | Alien Species |
| *Ligustrum lucidum* | Tree | Alien Species |
| *Ziziphus mauritiana* | Tree/shrub | Biostatus not specified |
| *Imperata cylindrica* | Grass | Alien Species |
| *Bidens pilosa* | Herb | Alien Species |
| *Verbena brasiliensis* | Herb | Alien Species |

None of these species were identified on site. However, mango trees were prevalent in the flat plains near the villages, in amongst the cultivated lands. Bamboo (*Oxytenanthera abyssinica)* was also noted to occur in the woodlands, particularly the degraded woodlands at the foot and on the slopes of Mount Nassilala. Although this bamboo is indigenous to the region, it could become invasive, especially in disturbed areas they regenerate and disperse rapidly from seeds and form inpenetrable stands that prevent other species from establishing in. It was noted that local communities avoided planting in areas previously covered by bamboo, possibly due to the extensive root system which is difficult to remove without machinery.

## 7.4 Sensitivity assessment of the project area

The sensitivity map was developed by identifying areas of high, medium and low sensitivity (Figure 7-1).

Areas of **high sensitivity** include:

- Process areas such as rivers, wetlands and streams that are important for ecosystem functioning, including surface and ground water as well as animal and plant dispersal;
- Areas that have a high species richness;
- Areas that are not significantly impacted, transformed or degraded by current land use; and
- Areas that contain the majority of species of special concern found in the area and may contain high numbers of globally important species, or comprise part of a globally important vegetation type.

Areas of **medium sensitivity** include:

- Areas that still provide a valuable contribution to biodiversity and ecosystem functioning despite being degraded;
- Degraded areas that still have a relatively high species richness; and
- Degraded areas that still contain species of special concern.

Areas of **low sensitivity** include:

- Areas that are highly impacted by current land use and provide little value to the ecosystem; and
- Highly degraded areas that are unlikely to harbour any species of special concern.

In the case of the project area, a large portion of the area had been cleared for agricultural crops such as cotton, maize and cassava. These areas were rated as having a **low ecological sensitivity** as they have been transformed through anthropogenic activities and are highly degraded (Figure 7-1).

Areas of natural vegetation, such as the degraded *Miombo Woodland: Plains,* were assigned a **medium ecological sensitivity**. Despite these areas being degraded as a result of local pressures on the environment, they still have a relatively high species richness and form important ecological process areas for small mammals and birds in the area. These areas can withstand a limited loss of, or disturbance to, natural areas.

Areas of **high sensitivity** were assigned to the *Miombo Woodland: Granite* and *Miombo Woodland: Graphite*, the intact *Miombo Woodland: Plains* and the *Riparian Woodland* (Figure 7-1). These vegetation types were assigned a high sensitivity score as these areas are all relatively intact and have a high species diversity. They also contain species of special concern such as *Sterculia appendiculata* (listed as Vulnerable on the Mozambique red Data Lists). A number of these species were noted to occur on the slopes of the Granite Inselberg (Mount Coronge).

Although highly degraded in most parts, the *Riparian zone* was assigned a high sensitivity score as it is an important process area for ecosystem functioning. It also scored a high biodiversity value.

Where feasible, development should be restricted to those areas that have a low to medium ecological sensitivity, and exclude those areas with a high ecological sensitivity. This is particularly important for infrastructure such as the TSF, mine camp and plant site which should be located in areas of low to moderate sensitivity. Areas of high sensitivity should be avoided. Where this is not feasible, such as the case of the mine pits, alternative mitigation measures such as biodiversity offsets and conservation areas must be investigated.

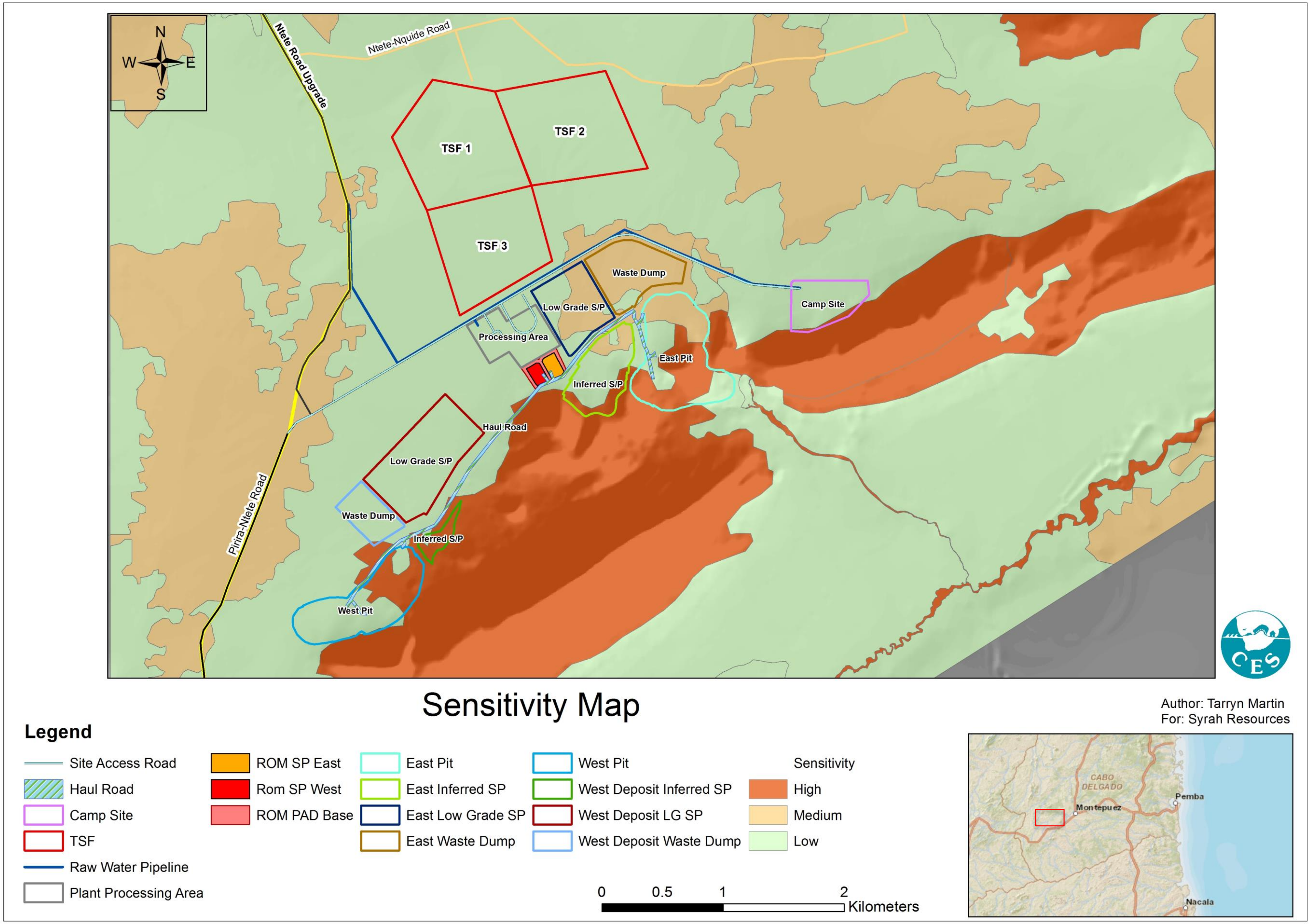


**Figure 7-1: Sensitivity Map of the project area**

# 8 ISSUES IDENTIFIED AND ASSESSED

The study that has been undertaken provides the necessary information to assess the preliminary impacts of the mining project on the vegetation and the flora at various relevant spatial and temporal scales.

The individual impacts have been grouped together as a series of key environmental issues. All of the issues relate to the removal of the existing vegetation cover on the eventual mined areas within the Project Area. At the spatial scale of the Project Area the impacts described below will definitely be considerable, but these need to be seen in the context of the project area as a whole or at a still larger spatial scale.

## 8.1 The current impacts: the “NO-GO” or “Without project scenario”

To contextualise the potential impacts of the mining activities and associated infrastructure proposed by the developer, the existing impacts (or status quo), associated with current ecological conditions, need to be described in terms of vegetation patterns, structure and composition. This baseline or status quo should be used as the comparison against which project impacts are assessed. The main issues identified with the existing impacts are discussed below:

### *8.1.1 ISSUE 1: Loss of Vegetation communities*

Natural plant communities are dynamic ecosystems that provide habitats that support all forms of life. Different types of plant communities (and habitats) exist in the project area, and these occur within and around the project area. The villages in the area are reliant on natural resources found within the different plant communities and actively clear tracts of land for agricultural purposes. The current vegetation conditions in the low lying regions of the project area can be described as mostly transformed by anthropogenic activities and are either of low or moderate ecological sensitivity. The current impact’s on each plant community are assessed below.

***Impact 1: Loss of Riparian Woodland***

**Cause and comment:**
This vegetation type occurs along the banks of the river’s and tributaries that occur in the project area. Direct impacts on this vegetation type include clearing of river banks by local inhabitants to plant sugar cane and harvesting of plant materials for construction purposes.

**Significance Statement:**
The loss of the *Riparian Woodland* is definitely occurring and is having a **severe**, permanent impact. The environmental significance of this unmitigated impact is HIGH NEGATIVE.

| **Current Impacts** | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Permanent | Study Area | Severe | Definite | HIGH- |

***Impact 2: Loss of Miombo Woodland: Graphite***

**Cause and comment:**
This vegetation type occurs on Mount Nassilala and Mount Coronge. This vegetation type is relatively intact despite existing evidence of harvesting plant materials for construction purposes.

**Significance Statement:**
The loss of the *Miombo Woodland: Graphite* is definitely occuring and is having a **low**, Medium Term impact. The environmental significance of this unmitigated impact is MODERATE

NEGATIVE.

| Current Impacts | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Medium Term | Study Area | Moderate | Definite | MODERATE- |

***Impact 3: Loss of Miombo Woodland: Granite***

**Cause and comment:**
This vegetation type occurs on Mount Coronge. This vegetation type has been cleared for agriculture on the lower slopes and there is evidence of harvesting large trees higher up. Despite this, the areas that remain intact provide important refugia for indigenous and threatened plant species.

**Significance Statement:**
The loss of the *Miombo Woodland: Granite* is definitely occuring and is having a **Severe**, Long Term impact. The environmental significance of this unmitigated impact is HIGH NEGATIVE.

| Current Impacts | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Long Term | Study Area | Severe | Definite | HIGH- |

***Impact 4: Loss of Intact Miombo Woodlands: Plains***

**Cause and comment:**
This vegetation type occurs to the east of Nquide village and has been assigned a high sensitivity. Despite its proximity to Nquide village, this area has been left intact.

**Significance Statement:**
The loss of the *Intact Miombo Woodland: Plains* is unlikely and is having a **slight**, Short Term impact. The environmental significance of this unmitigated impact is LOW NEGATIVE.

| Current Impacts | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Short Term | Study Area | Slight | Unlikely | LOW- |

***Impact 5: Loss of Degraded Miombo Woodlands: Plains***

**Cause and comment:**
This vegetation type occurs in the flat, low lying areas through much of the project site and is heavily harvested by villagers for construction timber, firewood and charcoal production. Consequently it has a low species diversity index.

**Significance Statement:**
The loss of the *Degraded Miombo Woodland: Plains* is unlikely and is having a **slight**, Short Term impact. The environmental significance of this unmitigated impact is HIGH NEGATIVE.

| **Current Impacts** | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Long Term | Study Area | Severe | Definite | HIGH- |

### *8.1.2 ISSUE 2: Loss of Biodiversity*

The Balama Graphite Mine concession area consists of a number of habitats which include inselbergs, the riparian zone, agricultural areas and surrounding natural vegetation. These habitats comprise of the following vegetation types: *Riparian woodland* in the Riparian zone; *Miombo Woodland: Granite* and *Miombo Woodland: Graphite* that occurs on the inselbergs and degraded and *intact Miombo Woodland: Plains* that occurs in the flat low lying areas interspersed between the agricultural land.

Unique habitats on the site have been shown to contain a high biodiversity, for example, the inselbergs that support the granite and graphite Miombo woodlands have a high biodiversity. The current land use is resulting in the clearance of these habitats, particularly in the low lying areas, reducing the areas potential to support biodiversity through habitat destruction and reduction.

***Impact 6: Loss of Biodiversity (general)***

**Cause and comment:**
The clearing of land for agriculture and harvesting of plant materials for construction and charcoaling is resulting in the loss of biodiversity in the area.

**Significance Statement:**
The loss of biodiversity is definitely occurring and is having a **moderate**, Long Term impact. The environmental significance of this unmitigated impact is MODERATE NEGATIVE.

| **Current Impacts** | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Long Term | Study Area | Moderate | Definite | MODERATE- |

### *8.1.3 ISSUE 3: Loss of Species of Special Concern*

Three species of special concern (*Habenaria sp., Sterculia appediculata* and *Afzelia quanzensis)* were identified at the Balama Graphite Project site and are being impacted on by the current activities.

***Impact 7: Loss of Species of Special Concern***

**Cause and comment:**
Current land use activities, such as clearing, harvesting and charcoaling are resulting in the loss of species of special concern, as well as other species that are important to ecosystem functioning.

**Significance Statement:**
The loss of species of special concern is definitely occuring and is having a **moderate**, Medium Term impact. The environmental significance of this unmitigated impact is MODERATE NEGATIVE.

| Current Impacts | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Medium Term | Study Area | Moderate | Definite | MODERATE- |

### *8.1.4 ISSUE 4: Disruption of Ecosystem Function and Process*

The habitats that exist in the project area, together with those of the surrounding area that are linked, form part of a functional ecosystem. An ecosystem provides more than simply a 'home' for a set of organisms, and is a functional system where biological and biophysical processes such as nutrient cycling, soil formation, reproduction, migration, competition, predation, succession, evolution and migration take place. Destruction or modification of habitats causes disruption of ecosystem function, and threatens the interplay of processes that ensure environmental health and the survival of individual species. This issue deals with a collection of complex ecological impacts that are almost impossible to predict with certainty, but which are nonetheless important.

***Impact 8: Fragmentation of vegetation and edge effects***

**Cause and comment:**
Fragmentation is one of the most important impacts on vegetation, especially when this creates breaks in previously continuous vegetation, causing a reduction in the gene pool and a decrease in species richness and diversity (See also Issue 2). This impact occurs when large areas are cleared for agriculture or burned to create green grass for grazing, or to establish crops. Fragmentation results in the isolation of functional ecosystems, and results in reduced biodiversity and reduced movement due to the absence of ecological corridors.

**Significance Statement:**
The fragmentation of vegetation is definitely occuring and is having a **severe**, Permanent impact. The environmental significance of this unmitigated impact is HIGH NEGATIVE.

| Current Impacts | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Permanent | Study Area | Severe | Definite | HIGH- |

## 8.2 Impacts of the Mine project: Construction Phase

### *8.2.1 ISSUE 1: Loss of Vegetation communities*

Natural plant communities are dynamic ecosystems that provide habitats that support all forms of life. Different types of communities (and habitats) exist in the project area, and these occur within and around the project area. The Balama Graphite mine and associated project infrastructure will result in the clearance of approximately 150 ha of natural vegetation, resulting in the loss of plant communities. The impact of the loss of portions of the different habitats will differ, and these will need to be considered separately.

***Impact 1: Loss of Riparian Woodland***

**Cause and comment:**
This vegetation type occurs along the banks of the river's and tributaries that occur in the project area. There are no planned project works that will directly impact on this vegetation type. Although degraded due to anthropogenic activities it is still considered to be an important ecological process area and activities in this area should be kept to a minimum.

**Mitigation and Management:**

The following mitigation actions are suggested:

- Detailed inventory in these areas to facilitate restoration;
- Restoration of this vegetation type after mining;
- Reducing the number of crossings through careful planning and design;
- Using bridge designs that afford the lowest impact on this vegetation;
- Locating project infrastructure away from sensitive areas where feasible;
- Locating bridges and river crossings at existing crossings and in areas that are already impacted;
- Designing and implement a Biodiversity Monitoring Plan during the operational phase to ensure that the project has no unnecessary negative impacts on this plant community; and
- Designing and implementing a Rehabilitation Management Plan.

**Significance Statement:**

The loss of the *Riparian Woodland* during the construction phase will probably occur and will have a **moderate**, permanent impact. The environmental significance of this unmitigated impact would be MODERATE NEGATIVE. With mitigation measures this will remain a MODERATE NEGATIVE.

| **Construction Phase** | | | | | |
|---|---|---|---|---|---|
| Without Mitigation | Permanent | Study Area | Moderate | Definite | MODERATE- |
| With Mitigation | Permanent | Localised | Slight | Definite | MODERATE - |

***Impact 2: Loss of Miombo Woodland: Graphite***

**Cause and comment:**

This vegetation type occurs on Mount Nassilala and will be most heavily and directly impacted by mining activities on the west and the east sections of the inselberg. Direct impacts are likely to be clearing of vegetation for the east and west pit as well as the plant site. Although there are large stands of bamboo, this vegetation type is fairly intact with a species composition unique to this inselberg. However, no locally endemic species were found to occur on the slopes of Mount Nassilala that did not occur elsewhere on the site. During the dry season it was noted that large trees were being harvested on this inselberg for construction purposes. This inselberg therefore provides an important ecosystem service to the surrounding communities.

**Mitigation and Management:**

The following mitigation actions are suggested:

- Detailed inventory in these areas to facilitate restoration;
- Areas impacted by construction activities and that are no longer required during the operation phase to be restored to their natural state;
- Restore impacted areas during the decommissioning phase;
- Creating no-go areas and ecological corridors on Mount Nassilala to preserve this area and facilitate the inselberg's continued function as a stepping stone and refugia for biodiversity (plants and animals);
- Demarcate and implement a 50 m buffer around this area;
- Avoid locating unnecessary infrastructure such as the TSF and mine plant within this 50 m buffer.
- Design and implement a Rehabilitation and Offset Strategy Management Plan.

**Significance Statement:**

The loss of the *Miombo Woodland: Graphite* during the construction phase will definitely occur and will have a **severe**, permanent impact. The environmental significance of this unmitigated impact would be HIGH NEGATIVE. With mitigation measures this will remain a HIGH NEGATIVE.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Permanent | Study Area | Severe | Definite | HIGH- |
| With Mitigation | Permanent | Study Area | Severe | Definite | HIGH- |

***Impact 3: Loss of Miombo Woodland: Granite***

**Cause and comment:**
This vegetation type occurs on Mount Coronge and may be directly impacted by mining activities on the western tail of the inselberg where the east pit. Direct impacts are likely to be clearing of vegetation when the pit is mined. This vegetation type has been cleared for agriculture on the lower slopes and there is evidence of harvesting large trees higher up. Despite this, the areas that remain intact have a species composition that appears to be unique to this area. No locally endemic species were found to occur on the slopes of this area. There are a number of large *Sterculia appendiculata* that occur on the slopes of Mount Coronge.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Restore this vegetation type to its natural state after mining;
- Areas impacted by construction activities and that are no longer required during the operation phase to be restored to their natural state;
- Avoid locating infrastructure in areas with large numbers of *Sterculia appendiculata;*
- Where feasible, design the mining pits to reduce the amount of vegetation that needs to be cleared;
- Create no-go areas and ecological corridors on Mount Coronge to preserve the areas that will not be mined. This will allow this inselberg to continue functioning as a stepping stone and refugia for biodiversity (plants and animals) and will continue to provide important ecosystem services to the local communities;
- Demarcate and implement a 50 m buffer around this area;
- Move infrastructure such as the new mine camp,outside of this 50 m buffer.; and
- Design and implement a Rehabilitation Management Plan.

**Significance Statement:**
Based on the current layout, no infrastructure or project activities will impact this vegetation type. The loss of the *Miombo Woodland: Granite* is therefore unlikely to occur and and the severity of the impact is therefore rated as a **moderate**, short term impact. The environmental significance of this unmitigated impact would be MODERATE NEGATIVE. With mitigation measures this will be reduced to a LOW NEGATIVE. If the layout is to change then this impact will need to be reassessed.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Short Term | Study Area | Moderate | Unlikely | MODERATE- |
| With Mitigation | Short Term | Localised | Moderate | Unlikely | LOW- |

***Impact 4: Loss of Intact Miombo Woodlands: Plains***

**Cause and comment:**
This vegetation type occurs to the east of Nquide village and has been assigned a high sensitivity. Although not directly impacted by project infrastructure, the displacement of agricultural fields and access to natural resources by the mine may lead to the clearing of this area as it is within easy walking distance of the village. In migration from outside areas may place additional pressure on this area.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Employ members of the local community instead of outsiders. This will reduce the level of in migration from outside areas thereby reducing the pressure on the natural resources found in this vegetation type.
- Implement more efficient and intensive agricultural practices that reduces the amount of land cleared for agriculture. Possible irrigation systems using water from Chipembe dam may be a viable solution.
- Introduce cash crops that are more economically viable than the cotton industry and produce greater yields per hectare. This will reduce the amount of clearing of natural vegetation.

**Significance Statement:**

The loss of intact *Miombo Woodland: Plains* during the construction phase is probable if there is an influx of outsiders seeking work at the mine and will have a **severe**, permanent impact. The environmental significance of this unmitigated impact would be MODERATE NEGATIVE. With mitigation measures this will be reduced to a LOW NEGATIVE.

| | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Permanent | Study Area | Severe | Probable | MODERATE- |
| With Mitigation | Long-Term | Localised | Slight | Unlikely | LOW- |

***Impact 5: Loss of Degraded Miombo Woodlands: Plains***

**Cause and comment:**
This vegetation type occurs in the flat, low lying areas through much of the project site. This vegetation type is heavily harvested by villagers for construction timber, firewood and charcoal production. Consequently it has a low species diversity index. Despite this it is still considered an important ecological process area providing refuge to local wildlife such as birds, reptiles and amphibians.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Where feasible, reduce the footprint of the infrastructure to the minimal required area;
- Impacted areas during the construction phase to be rehabilitated if not required during operation; and
- It is possible that individuals who have had their agricultural land displaced by the mine will make up for this by clearing additional land within this vegetation type. Further clearing will result in induced secondary impacts which may be prevented through the introduction of more efficient agricultural practices as well as introducing cash crops that are more economically viable.

**Significance Statement:**

The loss of degraded *Miombo Woodland: Plains* during the construction phase will definitely occur and will have a **moderate**, permanent impact. The environmental significance of this unmitigated impact would be MODERATE NEGATIVE. With mitigation measures this will remain a MODERATE NEGATIVE.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Permanent | Study Area | Moderate | Definitely | MODERATE- |
| With Mitigation | Long Term | Study Area | Moderate | Definitely | MODERATE- |

### *8.2.2 ISSUE 2: Loss of Biodiversity*

The Balama Graphite Mine concession area consists of a number of habitats which include inselbergs, the riparian zone, agricultural areas and surrounding natural vegetation. These habitats comprise of the following vegetation types: *Riparian woodland* in the Riparian zone; *Miombo Woodland: Granite* and *Miombo Woodland: Graphite* that occurs on the inselbergs and degraded and *Intact Miombo Woodland: Plains* that occurs in the flat low lying areas interspersed between the agricultural land.

Unique habitats on the site have been shown to contain a high biodiversity, for example, the inselbergs that support the granite and graphite Miombo woodlands have a high biodiversity. The mine will result in the partial clearance of these habitats, particularly the Miombo Woodlands associated with the graphite deposits, reducing the areas potential to support biodiversity through habitat destruction and reduction.

***Impact 6: Loss of Biodiversity (general)***

**Cause and comment:**
Mining activities and the associated infrastructure will result in the removal of large areas of vegetation, resulting in the loss of biodiversity.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Set aside key representative portions of each vegetation type, as conservation areas within the mining area;
- Prevent mining employees from harvesting plants for personal use, firewood or charcoal within the mining area;
- Maintain ecological corridors within the mining area; and
- Design and implement a Rehabilitation and Biodiversity Offset Management Plan.

**Significance Statement:**

The mining activities will definitely result in the loss of biodiversity and this will have a **severe** permanent impact. The environmental significance of this unmitigated impact would be HIGH NEGATIVE. Mitigation measures will reduce this to a MODERATE NEGATIVE impact.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Permanent | Study Area | Severe | Definite | HIGH - |
| With Mitigation | Long Term | Study Area | Moderate | Definite | MODERATE- |

### *8.2.3 ISSUE 3: Loss of Species of Special Concern*

Three species of special concern (*Habenaria sp., Sterculia appendiculata* and *Afzelia quanzensis)* were identified at the Balama Graphite Project site and will be impacted on by the proposed mine. It is likely that additional species will be identified during the construction and operational phase of the project.

The impacts at a larger spatial scale will only be important in the case of species that have a globally restricted range, or are otherwise in need of protection. In these cases the mining process may significantly reduce the *area of occupancy* of the species. A reduction of the area of occupancy in turn may threaten the chances of survival for these plant species of concern. However, the significance of an impact differs depending on our knowledge of the distribution of these plant species.

***Impact 7: Loss of Species of Special Concern***

**Cause and comment:**
Mining activities and the associated infrastructure will result in the loss of species of special concern, as well as other species that are important to ecosystem functioning.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Set aside key representative portions of each vegetation type as conservation areas within the mining area;
- Maintain an ecological corridor within the mining area;
- Avoid locating infrastructure such as the mine camp and TSF in areas with high numbers of species of special concern such as on the southern slopes of Mount Coronge where a number of *Sterculia appendiculata* trees were noted; and
- Collect seeds from established trees and where feasible relocate samplings of species of special concern.

**Significance Statement:**
The mining activities will <u>probably</u> result in the loss of Species of Special Concern and will have a **moderate** impact in the <u>long term</u>. The environmental significance of this unmitigated impact would be MODERATE NEGATIVE. While mitigation measures could reduce the spatial and temporal scale of the impact, they are unlikely to be very effective and the impact will still remain MODERATE NEGATIVE.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Long Term | Study Area | Moderate | Probable | MODERATE- |
| With Mitigation | Medium Term | Localised | Moderate | Probable | MODERATE- |

### *8.2.4 ISSUE 4: Disruption of Ecosystem Function and Process*

The habitats that exist in the project area, together with those of the surrounding area that are linked, form part of a functional ecosystem. An ecosystem provides more than simply a 'home' for a set of organisms, and is a functional system where biological and biophysical processes such as nutrient cycling, soil formation, reproduction, migration, competition, predation, succession, evolution and migration take place. Destruction or modification of habitats causes disruption of ecosystem function, and threatens the interplay of processes that ensure environmental health and the survival of individual species. This issue deals with a collection of complex ecological impacts that are almost impossible to predict with certainty, but which are nonetheless important.

***Impact 8: Fragmentation of vegetation and edge effects***

**Cause and comment:**
Fragmentation is one of the most important impacts on vegetation, especially when this creates breaks in previously continuous vegetation, causing a reduction in the gene pool and a decrease in species richness and diversity (See also Issue 2). This impact occurs when large areas are cleared for agriculture or burned to create green grass for grazing, or to establish crops. Fragmentation results in the isolation of functional ecosystems, and results in reduced biodiversity and reduced movement due to the absence of ecological corridors. Although the project area already has large areas cleared for agriculture, mining processes and associated infrastructure such as roads and pipelines will severely increase fragmentation within the project area, and possibly remove an important "stepping stone" through the clearing of vegetation on Mount Nassilala.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Set aside an ecological corridor within the project area that encompasses all of the vegetation types defined in this report;
- Use existing access roads where feasible;
- Align roads and pipelines within a single corridor and keep this as narrow as feasible; and
- Avoid locating linear infrastructure (such as roads and pipelines) through areas of high and moderate sensitivity.

**Significance Statement:**
The mining activities will <u>definitely</u> result in habitat fragmentation and will have a **moderate,** <u>permanent</u> impact. The environmental significance of this unmitigated impact would be HIGH NEGATIVE. With mitigation, this will be reduced to a MODERATE NEGATIVE impact.

| | | | | | |
|---|---|---|---|---|---|
| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Construction Phase** | | | | | |
| Without Mitigation | Permanent | Study Area | Severe | Definite | HIGH- |
| With Mitigation | Long Term | Study Area | Moderate | Probable | MODERATE- |

***IMPACT 9: Disruption of ecological systems and functions***

**Cause and Comment:**
Some dust may be generated as a result of construction activities and, in particular, where there is exposed ground. Specific activities that may contribute to release of fugitive dust include offloading and stockpiling of building materials such as sand, excavation, demolition of existing structures, storage of excavated materials and movement of heavy vehicles. The generation of dust may be higher during windy, dry periods. Dust may result in the the smothering of vegetation located adjacent to these areas reducing light penetration and, subsequently stunting or inhibiting

development and growth.

**Mitigation and Management:**

- Employ dust suppression measures such as wetting of the project area during dry, windy periods.
- Limit the height of stockpiles
- Enforce speed limits for vehicles associated with the construction activities

**Significance Statement:**
The impact to terrestrial systems associated with any dust produced during construction will probably be a *short term*, **moderate impact**. The overall significance would be MODERATE NEGATIVE. This can be reduced to LOW NEGATIVE mitigation measures.

| **Impact** | Effect | | | **Risk or Likelihood** | **Overall Significance** |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| ***Construction Phase*** | | | | | |
| Without Mitigation | Short Term | Study Area | Moderate | Definite | MODERATE- |
| With Mitigation | Short Term | Localised | Low | Probable | LOW- |

## 8.3 Impacts of the Mine project: Operational Phase

### *8.3.1 ISSUE 4: Disruption of Ecosystem Function and Process*

***Impact 9: Invasion of alien species***

**Cause and comment:**
The removal of existing vegetation also creates ‘open’ habitats that will inevitably be colonised by pioneer plant species. While this is part of a natural process of regeneration, which would ultimately lead to the re-establishment of a secondary vegetation cover, it also favours the establishment of undesirable species in the area, such as the locally occurring species of Bamboo. These species are introduced along transport lines, and by human and animal movements in the area. Once established, these species are typically very difficult to eradicate and may then invade, posing a threat to the neighbouring ecosystem. This impact is likely to be exacerbated by careless management of the site and its facilities, e.g. seed dispersal via inappropriate organic waste disposal and inadequate monitoring.

**Mitigation and management:**

The following mitigation actions are suggested:

- Prepare an Alien Management Plan
- Eradicate alien plants as they appear;
- Put in place environmentally acceptable procedures for waste management;
- Do not use exotic species that are known to be invasive for rehabilitation purposes but rather use indigenous species and exotic species that are not invasive; and
- Monitor the project area for any new invasive plants.

**Significance Statement:**

Mining activities associated with the operational phase will probably result in the invasion of alien species into the project area and will have a **severe,** permanent effect. The environmental significance of this unmitigated impact would be HIGH NEGATIVE. Taking remedial action will reduce the impact to a LOW NEGATIVE.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Operation Phase** | | | | | |
| Without Mitigation | Permanent | Regional | Severe | Probably | HIGH- |
| With Mitigation | Short Term | Localised | Moderate | Probable | LOW- |

### *8.3.2 ISSUE 5: Loss of Ecosystem Services*

Ecosystem Services refers to the benefits derived by humans from ecosystems and biodiversity. Loss of ecosystem services through the removal of vegetation communities during the mining process will result in the potential loss of ecosystem services associated with each habitat and vegetation type. This is especially relevant since the local communities are reliant on these areas as a source of food and medication, for construction materials and fuel wood and as a source of income, on a small scale, through charcoal production.

**Impact 10: *Loss of ecosystem services provided by the plant communities identified in the project area***

**Cause and comment:**
Loss of ecosystems services through the removal of vegetation communities due to mining activities will result in the loss of ecosystem services associated with each habitat and vegetation type. This is especially relevant since the local communities are heavily reliant on these areas as a source of food and medication, for construction materials and fuel wood and as a source of income through activities such as charcoal production.

**Mitigation and Management:**
The following mitigation actions are suggested:

- Align with recommendations made in the Social Impact Assessment to determine alternatives such as improved health care, woodlots for charcoaling, construction materials and fuel wood to offset the loss of ecosystem service to the affected communities.
- Setting aside key representative portions of each vegetation type that will provide adequate ecosystem services to the communities within the project area (a Conservation Management Plan will be drawn up and these areas mapped in consultation with stakeholders).

**Significance Statement:**
The mining activities will definitely result in the loss of ecosystem services provided by the plant communities and will have a **severe,** permanent impact. The environmental significance of this unmitigated impact would be HIGH NEGATIVE. With mitigation, this will be reduced to a MODERATE NEGATIVE impact.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| **Operation Phase** | | | | | |
| Without Mitigation | Permanent | Study Area | Severe | Definite | HIGH- |
| With Mitigation | Long Term | Study Area | Moderate | Probable | MODERATE- |

***IMPACT 11: Disruption of ecological systems and functions***

**Cause and Comment:**
Some dust may be generated as a result of operational activities and, in particular, where there is exposed ground. Specific activities that may contribute to release of fugitive dust include excavation of the mine pit, blasting, movement of heavy vehicles. The generation of dust may be higher during windy, dry periods. Dust may result in the the smothering of vegetation located adjacent to these areas reducing light penetration and, subsequently stunting or inhibiting development and growth.

**Mitigation and Management:**

- Employ dust suppression measures such as wetting of the project area during dry, windy periods.
- Limit the height of stockpiles
- Enforce speed limits for vehicles associated with the operation activities.

Significance Statement:
The impact to terrestrial systems associated with any dust produced during the operation of the mine will probably be a long term, moderate impact. The overall significance would be HIGH negative. This can be reduced to LOW negative if mitigation measures are implemented.

| Impact | Effect | | | Risk or Likelihood | Overall Significance |
|---|---|---|---|---|---|
| | Temporal Scale | Spatial Scale | Severity of Impact | | |
| Without Mitigation | Long Term | Study Area | Severe | Probable | **HIGH** |
| With Mitigation | Long Term | Localised | Slight | May Occur | **LOW** |

## 8.4 Impacts of the Mine: Decommissioning Phase

The decommissioning of the project could have a high positive impact on the natural vegetation, if the areas of high sensitivity are restored to their natural state and areas of moderate and low sensitivity are appropriately rehabilitated to a near-natural state. However, detailed baseline monitoring will be required to refine the alpha diversity and indicator species, as well as to confirm and augment the list of SSCs (especially geophytes, the majority of which flower in the early wet season, and which may not have been identified during the late-wet season sampling), in order to more precisely characterise the pre-mining ecological conditions. It will also be necessary to establish nurseries to determine which of the naturally occurring plant species can be successfully propagated for rehabilitating areas disturbed by mining activities.

However, rehabilitating disturbed areas to a natural or near-natural condition may not meet the livelihood requirements of the project-affected communities, whose needs may be better served by reinstating the land to agriculture or woodlots. Accordingly, prior to commencing any rehabilitation activities it will be necessary to undertake a programme of stakeholder engagement to assess the needs of the communities. In this case the decommissioning phase will result in a net loss of biodiversity, inasmuch as natural vegetation will be replaced by species of direct economic value to the communities, and thus this will be considered to be a negative ecological impact.

As a Rehabilitation Plan has not yet been prepared for the proposed development, the decommissioning phase impacts cannot be realistically assessed at this stage.

Small residual impacts as a result of the decommissioning phase will be similar to those listed for the construction phase and will include:

- Increased dust levels
- Increased access (along the haul road)
- Loss of ecosystem services as a result of increased access

# 9 CONCLUSIONS OF THE IMPACT ASSESSMENT AND RECOMMENDATIONS

## 9.1 Current Status

The vegetation of the project area comprises a mosaic of agricultural land, degraded natural Miombo Woodland and patches of natural Miombo Woodland that are intact and in fairly good condition. The intact woodland is currently threatened by human related impacts such as clearing for agriculture. Anecdotal evidence suggests that local communities have been actively clearing woodlands at the foothills of Mount Nassilala since there was word that a large mining operation was prospecting in the area and there would be compensation for land and crops if mining went ahead.

There are very few invasive species in the area and they are not currently problematic. However, invasive species are likely to become a problem when large areas of intact vegetation are disturbed during the construction and operation phases of the mine. Unmitigated, this is likely to become an important impact and should therefore be managed effectively.

Where possible it is recommended that areas within the study site be set aside for conservation, allowing the vegetation to reach its natural state free from agricultural pressure and alien infestation.

## 9.2 Conclusions

### *9.2.1 Concluding remarks: Reporting on Terms of Reference*

The Terms of Reference provided are tabulated below (Table 9-1). A description of where each item is reported on, is provided

**Table 9-1: Terms of Reference and reporting response**

| Requirement | Report assessment/response |
|---|---|
| Describe and map different vegetation units and ecosystems (e.g. grassland, savannah, riverine etc.) in the mining area. | Chapters 6.2 and 6.3 |
| Describe the floral biodiversity and record the plant species that occur in each vegetation type. | Chapter 7.1 and Appendix A |
| Determine habitat units that perform critical ecosystem functions (e.g. erosion control, hydrological service etc.). | Chapter 6 |
| Utilise stratified random approach for plot based botanical surveys in order to describe biodiversity and ecological state of each vegetation unit. | Chapter 7 |
| Describe and map rare, endangered or threatened ecosystems. | Chapters 5.4.1 and 5.4.2 |
| Establish and map sensitive vegetation areas and species of special concern (IUCN Red Data list). | Chapters 7.2 and Section 7.4 |
| Identify alien plant species, assess the invasive potential and recommend management procedures. | Chapters 7.3 and 9.3 |
| Identify and assess the impacts of the mining prospects and associated infrastructure on the natural vegetation in terms of habitat loss and fragmentation and degradation of key ecosystems. | Chapter 8 |

### *9.2.2 Summary of impacts*

Eleven impacts were identified and assessed for all the Construction and Operational Phases (Table 9-2). The majority of the impacts will occur during the construction phase of the project.Three impacts were classified as HIGH NEGATIVE and six impacts were classified as MODERATE NEGATIVE. With mitigation, two of the HIGH impacts can be reduced to LOW NEGATIVE and three MODERATE impacts can be reduced to LOW NEGATIVE.

Three impacts were identified for the operational phase. The two HIGH impacts can both be reduced to LOW and MODERATE NEGATIVE respectively.

**Table 9-2: Summary of identified impacts with and without mitigation measures.**

| Impact | Without Mitigation | With Mitigation |
|---|---|---|
| **Construction Phase** | | |
| *Impact 1: Loss of Riparian Woodland* | MODERATE- | MODERATE- |
| *Impact 2: Loss of Miombo Woodland: Graphite* | HIGH- | HIGH- |
| *Impact 3: Loss of Miombo Woodland: Granite* | MODERATE- | LOW- |
| *Impact 4: Loss of Intact Miombo Woodlands: Plains* | MODERATE- | LOW- |
| *Impact 5: Loss of Degraded Miombo Woodlands: Plains* | MODERATE- | MODERATE- |
| *Impact 6: Loss of Biodiversity (general)* | HIGH- | MODERATE- |
| *Impact 7: Loss of Species of Special Concern* | MODERATE- | MODERATE- |
| *Impact 8: Fragmentation of vegetation and edge effects* | HIGH- | MODERATE- |
| *Impact 9: Disruption of ecological systems and processes* | MODERATE- | LOW- |
| **Operational Phase** | | |
| *Impact 10: Invasion of alien species* | HIGH- | LOW- |
| Impact 11: *Loss of ecosystem services provided by the plant communities identified in the project area* | HIGH- | MODERATE- |
| Impact 12: Disruption to ecological processes and functions | MODERATE- | MODERATE- |

### *9.2.3 Concluding remarks*

- Inselberg's form important "stepping stones" or linkage corridors between fragmented vegetation and have been documented as important features for the conservation and dispersal of different species. It is therefore important that a portion of the inselberg Mount Nassilala, where the graphite deposit has been identified, is conserved so that this process can continue.

- Infrastructure such as the tailings storage facility, mine camp and mine plant should be located in areas of low and moderate sensitivity. It is recommended that the position of the mine camp on Mount Coronge be shifted out of the area of high sensitivity.

- Current land use is having a large impact on the natural vegetation in the low lying areas. Large tracts of land have been cleared and planted with crops such as cotton, maize and cassava.

- The vegetation on the slopes of Mount Nassilala and Mount Coronge is relatively intact. The plant communities on these inselbergs are important refugia for plant and animal species and they provide important ecosystem services for local human communities.

- The highest biodiversity was recorded in the *Riparian Woodland.* Although these exist as thin strips surrounded by a sea of agriculture they currently form important, natural ecological corridors and should therefore be rehabilitated, conserved and protected.

- The intact *Miombo Woodlands: Plains* that occurs near Nquide village has the next highest species diversity after the *Riparian Woodlands* and contains important species such as *Habenaria sp.* (Orchidaceae). This area should be conserved and protected.

### *9.2.4 IFC Performance Standard 6*

The Vegetation and Floristic Specialist Report needs to satisfy the requirements of the IFC standards with specific reference to Performance Standard 6. For ease of reference, these requirements are tabulated and annotated with comments (Table 9-3).

**Table 9-3: IFC PS6 requirements and comments**

| PS 6: requirement | Comments |
|---|---|
| Modified habitat (Natural or modified): further degradation should be minimised.<br><br>*"Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition."* (IFC Performance Standards, 2012) | *Degraded Miombo Woodland: Plains* and *Riparian Woodland* are considered as modified habitats as they are subjected to frequent and often severe disturbance. These systems, however, are capable of regenerating over long periods of succession.<br><br>Where possible, further degradation to the surrounding natural vegetation should be minimised through implementation of mitigation measures discussed in chapter 8. |
| Natural/Critical habitat: including habitats required for endangered species or maintenance of high biodiversity.<br><br>*"Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."* (IFC Performance Standards, 2012)<br><br>*"Critical habitats are areas with high biodiversity value, including … highly threatened and/or unique ecosystems; and/or areas associated with key evolutionary processes."* (IFC Performance Standards, 2012) | The mining project will have an impact on areas of natural habitat that contain a high biodiversity.<br><br>No critical floral habitat's were identified on site.<br><br>It is recommended that biodiversity offsets are investigated as a mitigation measure (see section 9.3.4) |
| Legally protected areas. | No legally protected areas occur within the study area. |
| Invasive Alien Species: introduction of new alien species. | No alien invasive species were identified within the project site and no alien species will be intentionally introduced to the project site. However, it is recognised that alien species can be accidentally introduced. This should therefore be monitored and an Alien Management Plan introduced. |

## 9.3 Recommendations

### *9.3.1 Construction and Operational Phases*

Impacts were identified and assessed for each phase of the mine's life i.e. Planning and Design Phase, Construction Phase, Operational Phase and the Decommissioning Phase. The largest number of *HIGH* impacts were noted to occur during the Construction phase. This phase will have the highest impact on the vegetation communities and floral biodiversity followed by the Operational Phase which will have the second highest impact. It is imperative that mitigation measures suggested for each identified impact are implemented to reduce the effects of the mine. Key impacts associated with the construction and operation phase are highlighted below:

- Reduce the number of crossing through the riparian woodland;
- Use bridge designs that afford the lowest impact on riparian vegetation;
- Locate birdges and river crossings at existing crossings and in areas that are already impacted;
- Rehabilitate all vegetation types that are impacted on during the construction phase but that are no longer required during the operation phase;
- In areas of high sensitivity, demarcate no-go areas and ecological corridors to facilitate their continued functioning;
- Avoid locating unnecessary infrastructure in areas of high sensitivity or areas demarcated as no-go areas;
- Set aside key representative portions of each vegetation type as conservation areas within the mining concession area;
- Prevent employees from harvesting plants for personal use, firewood or charcoal;
- Avoid locating infrastructure such as the TSF and mine camp in areas with high concentrations of species of special concern;
- Where feasible relocate samplings of species of special concern;
- Use existing roads where feasible;
- Align roads and pipelines along a single corridor and keep this as narrow as possible;
- Avoid locating linear infrastructure (such as roads and pipelines) through areas of high and moderate sensitivity; and
- Move infrastructure out of areas of high sensitivity.

### *9.3.2 Conservation*

- Wetlands and rivers are important ecological process areas, with a high sensitivity, that form corridors for plant and animal dispersal. Therefore, a 50 metre “Restricted-Go” buffer on either side of all water bodies (rivers, streams, wetlands and tributaries) should be implemented. In addition, drainage lines should be rehabilitated and re-vegetated. Where feasible, infrastructure occurring in these areas should be moved to less sensitive zones.

- Habitat fragmentation creates breaks in previously continuous vegetation, causing a reduction in the gene pool and a decrease in species richness and diversity for both flora and fauna. Ecological corridors, designated as “No-Go”, areas should therefore be set aside within the project site to facilitate the movement of faunal species, seed dispersal and the expansion of existing vegetation types. It is recommended that areas of Mount Nassilala unaffected by mining are left intact so that it may continue to function as a “stepping stone” for the dispersal of animal and plant species. Management intervention by the mine will be required to avoid community exploitation of the resources by local communities, and a cocommunity based natural resource management strategy should be developed. It is recommended that the Conservation Monitoring Plan is designed and implemented.

- Proposed corridors have been recommended and illustrated in Figure 9-1. Rehabilitation of the project site should include restoration of the inselberg where feasible. The conservation of these areas will be dependant on the co-operation “buy-in” of the local communities. Educating communities on the sustainable use of natural resources in these areas is imperative as well as why poaching shouldn’t occur in these areas. Additionally, improved agricultural practices that are more intensive as well as alternative sources of construction materials through the creation of woodlots will aid in conserving these areas.

- Unlike the graphite resources, which are located in an ecologically sensitive area and cannot be relocated, the mine camp need not be located in an ecologically sensitive area. It is therefore recommended that it be moved 400 metres north into less sensitive disturbed Miombo woodland.

- It is recommended that a botanist/ecologist be on site to determine if any of the species of special concern or protected species occur where the mine and associated infrastructure are positioned. Plants can be removed and placed in a nursery for use for rehabilitation purposes where appropriate. If a species is identified for relocation, individuals of the species will need to be located within the proposed site, before vegetation clearing commences, and carefully uprooted and removed by a skilled horticulturist. Prior to removal, however, suitable relocation areas need to be identified, either within the site or in other disturbed areas on the property, preferably in the ecological corridor and conservation areas. Individual plants that cannot be relocated at the time of removal should be moved to the nursery, although this is less preferable due to associated costs and low survival rates. It is recommended that a Plant Rescue and Protection plan is implemented.

  It should be noted that many critical species of special concern are plants that will not be able to be successfully uprooted and replanted at all, or at best may have a low survival rate. In all cases the species will require very careful treatment to give them the best chances of survival, and specialist horticultural knowledge will be needed.

- It is recommended that an Environmental Control Officer ( ECO) is employed to ensure that construction and operation activities are undertaken in accordancewith the recommendations contained in this report and the Environmental & Social Management Plan, and to monitor that no unauthorised activities are occurring.

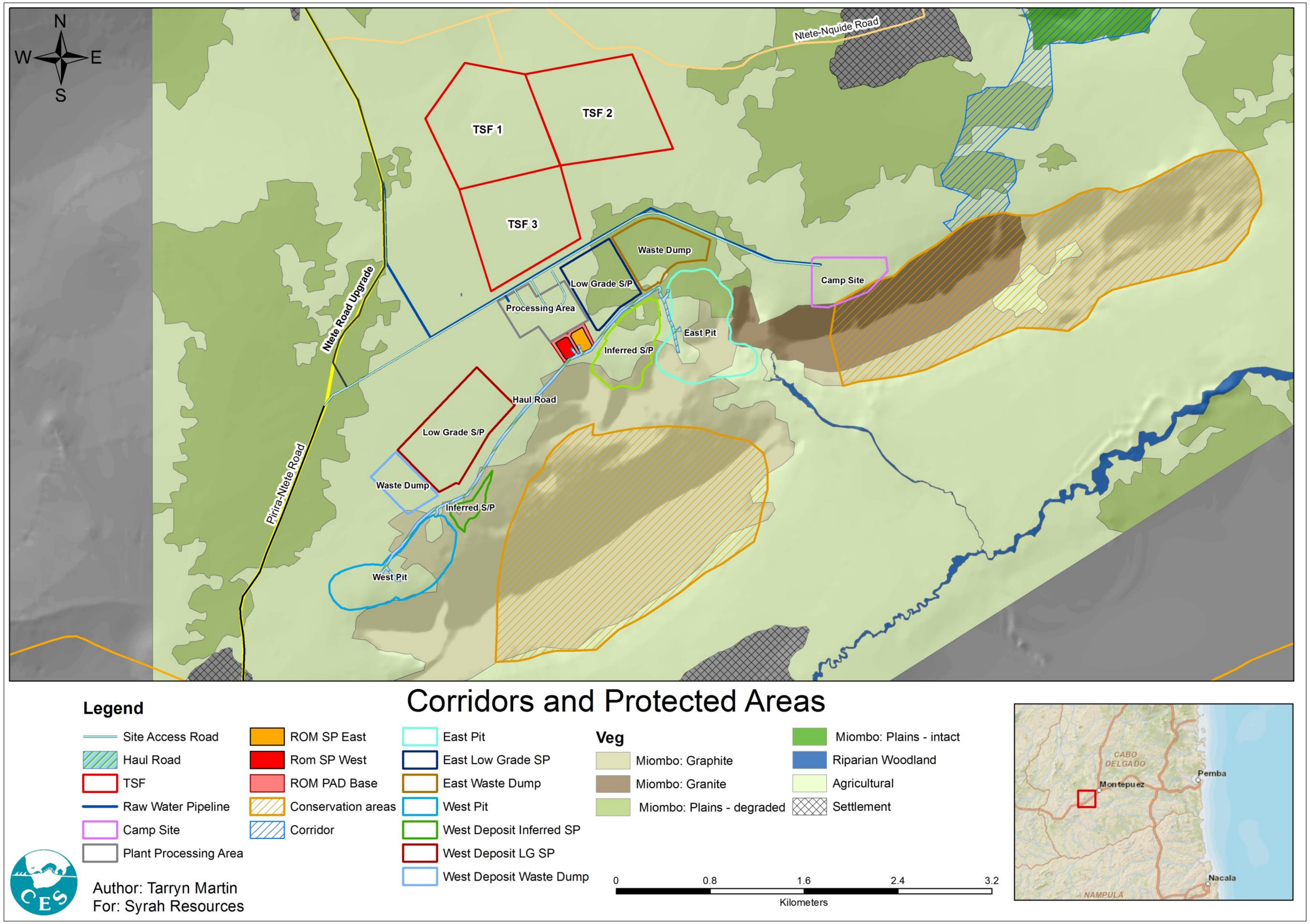


**Figure 9-1: Proposed corridors (blue stripes) conservation areas (orange stripes).**

### *9.3.3 Rehabilitation*

- Not only is rehabilitation considered "good practice" but it is important in the prevention of soil erosion and alien species invasion; and it returns the land to a functional state that can be used by future land owners. A Rehabilitation Management Plan for the mining site must therefore be created and implemented. This should include a rehabilitation plan for any extra land that was needed for the construction phase of the development but will not be used during the operation phase of the development, as well as suggestions on how best to rehabilitate the weaste rock dump, and other strategies to make the pits safe.

### *9.3.4 Invasion of alien species*

- Any form of disturbance to the natural vegetation provides a gateway for alien species to invade the site of disturbance. In this regard, it is recommended that a strict Alien Management and Monitoring Plan is implemented to prevent the spread of any alien species and to remove alien species already present at the site.
- The spread of the existing bamboo should be monitored and mitigation measure implemented where necessary.

### *9.3.5 Biodiversity offsets*

A recommendation that needs consideration is the concept of biodiversity offsets. As conservation and sustainability targets are increasingly difficult to attain due to competing land uses, biodiversity offsets aim to ensure that significant and unavoidable negative impacts from development are balanced by quantifiable, positive conservation actions (BBOP, 2012). This option is recommended since the project will impact on natural habitats with a high sensitivity.

Broadly defined, biodiversity offsets are conservation measures taken at one location to make up for biodiversity lost at another location. Biodiversity offsets are therefore seen to provide a mechanism to compensate for negative impacts on biodiversity after a project developer has proved that all feasible and practical alternatives have been investigated and considered and that all reasonable and responsible actions have been taken to avoid, minimise and repair/restore associated impacts (IFC, 2012).

A biodiversity offset should be designed and implemented to achieve measurable conservation outcomes that can reasonably be expected to result in no net loss[1]. The design of a biodiversity offset must adhere to the "like-for-like or better" principle and must be carried out in alignment with best available information and current practices.

Biodiversity offsets should meet the following criteria:

- Only be undertaken after all reasonable mitigation measures have been adopted.
- Should strive for no net-loss.
- Should compensate like-for-like or better.
- Should result in a net-gain in critical habitats.
- Should be flexible and case-specific.
- Should comply with all legal and policy requirements.
- Should be rigorous, transparent and consultative.
- Should ensure benefits from biodiversity offsets in the long term.

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[1] No net loss is defined as the point at which project-related impacts on biodiversity are balanced by measures taken to avoid and minimize the project's impacts, to undertake on-site restoration and finally to offset significant residual impacts, if any, on an appropriate geographic scale (e.g., local, landscape-level, regional, national).

It is important to note that biodiversity offsets have financial implications that need to be carefully considered before agreeing to using them as a mitigation measure.

## 9.4 Proposed management plans to be developed and implemented as part of the EMPr

In summary, the following plans need to be developed as part of the ESMPr, incorporating all the issues, conclusions and recommendations of this report:

1. Rehabilitation Implementation Plan
2. Alien Management and Monitoring Plan
3. Plant Rescue & Protection Plan
4. Conservation and Monitoring Plan
5. Biodiversity Offset Plan (this needs consideration)

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# APPENDIX A

| Family | Scientific Name | Riparian Woodland | Miombo Woodland: Graphite | Miombo Woodland: Granite | Miombo Woodland: Plains - intact | Miombo Woodland: Plains - degraded | IUCN | CITES | Mozambique Red Data List | Tanzanian Red Data List | Zambian Red Data List | Zimbabwean Red Data List | Malawi Red Data List |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mimosoideae | *Acacia galpinii* | | - | - | - | - | - | - | - | - | - | - | - |
| Mimosoideae | *Acacia polyacantha* | x | - | - | - | - | - | - | - | - | - | - | - |
| Mimosoideae | *Acacia senegalensis* | x | - | - | - | - | - | - | - | - | - | - | - |
| Malvaceae | *Adansonia digitata* | | - | - | - | - | - | - | - | - | - | - | - |
| Caesalpinioideae | *Afzelia quanzensis* | | x | - | - | - | - | - | - | - | - | - | - |
| Mimosoideae | *Albizia adianthifolia* | | x | - | - | - | - | - | - | - | - | - | - |
| Mimosoideae | *Albizia amara* | | x | - | - | - | - | - | - | - | - | - | - |
| Papilionoideae | *Millettia stuhlmannii* | | x | x | x | x | - | - | - | - | - | - | - |
| Mimosoideae | *Amblygonocarpus andongensis* | x | x | - | - | x | - | - | - | - | - | - | - |
| Annonaceae | *Annona senegalensis* | | x | - | - | x | - | - | - | - | - | - | - |
| Euphorbiaceae | *Antidesma vernosum* | | - | - | x | x | - | - | - | - | - | - | - |
| Malvaceae | *Azanza garckeae* | x | x | - | - | - | - | - | - | - | - | - | - |
| Balanitaceae | *Balanites maughamii* | | - | - | - | - | - | - | - | - | - | - | - |
| Gramineae | *Bambuseae* | | x | - | - | x | - | - | - | - | - | - | - |
| Caesalpinioideae | *Bauhinia galpinni* | x | x | - | x | x | - | - | - | - | - | - | - |
| Caesalpinioideae | *Bauhinia petersiana* | x | - | - | - | - | - | - | - | - | - | - | - |
| Bignoniaceae | *Begonia cf sonderiana* | | - | - | - | - | - | - | - | - | - | - | - |
| Caesalpinioideae | *Brachystegia allenii* | x | - | - | x | - | - | - | - | - | - | - | - |
| Caesalpinioideae | *Brachystegia boehmii* | x | - | - | x | - | - | - | - | - | - | - | - |
| Caesalpinioideae | *Brachystegia bussei* | | - | - | x | - | - | - | - | - | - | - | - |
| Caesalpinioideae | *Brachystegia spiciformis* | x | x | - | - | x | - | - | - | - | - | - | - |
| Apocynaceae | *Calotropis gigantea* | | - | - | - | - | - | - | - | - | - | - | - |
| Combretaceae | *cf Combretum sp. 2* | x | - | - | - | - | - | - | - | - | - | - | - |
| Salicaceae; | *cf Dovyalis* | | - | - | - | x | - | - | - | - | - | - | - |
| Asparagaceae | *cf Scilla sp.* | | - | - | - | - | - | - | - | - | - | - | - |
| Combretaceae | *cf Terminalia* | | x | - | - | - | - | - | - | - | - | - | - |
| Phyllanthaceae | *cf. Pseudolachnostylis maprouneifolia* | | - | - | - | x | - | - | - | - | - | - | - |
| Combretaceae | *Combretum molle* | | - | x | - | - | - | - | - | - | - | - | - |
| Combretaceae | *Combretum adenogonium* | x | x | - | - | x | - | - | - | - | - | - | - |
| Combretaceae | *Combretum collinum* | | - | - | - | - | - | - | - | - | - | - | - |
| Combretaceae | *Combretum erythrophylum* | | - | - | x | - | - | - | - | - | - | - | - |
| Combretaceae | *Combretum sp* | | x | - | - | - | - | - | - | - | - | - | - |
| Combretaceae | *Combretum sp. 2* | | - | - | x | - | - | - | - | - | - | - | - |
| Combretaceae | *Combretum sp.3* | x | - | - | - | - | - | - | - | - | - | - | - |
| Burseraceae | *Commiphora africana* | | - | - | x | - | - | - | - | - | - | - | - |
| Burseraceae | *Commiphora cf mollis* | | - | - | - | x | - | - | - | - | - | - | - |
| Burseraceae | *Commiphora mossambicensis* | x | - | - | - | - | - | - | - | - | - | - | - |
| Araliaceae | *Cussonia cf arborea* | | x | x | - | x | - | - | - | - | - | - | - |
| Mimosaceae | *Dichrostachys cinerea* | x | - | - | - | - | - | - | - | - | - | - | - |
| Ebenaceae | *Diospyros usambarensis* | | - | - | - | - | - | - | - | - | - | - | - |
| Apocynaceae | *Diplorhynchus condylocarpon* | | x | - | x | - | - | - | - | - | - | - | - |
| Moraceae | *Ficus sp.* | | x | - | x | x | - | - | - | - | - | - | - |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moraceae | *Ficus sp. 2* | x | - | - | - | - | - | - | - | - | - | - | - |
| Rubiaceae | *Gardenia resiniflua* | | - | - | x | - | - | - | - | - | - | - | - |
| Tiliaceae | *Grewia forbsii* | x | - | - | - | - | - | - | - | - | - | - | - |
| Tiliaceae | *Grewia sp. 2* | x | - | - | - | - | - | - | - | - | - | - | - |
| Orchidaceae | *Habenaria sp.* | | - | - | - | - | - | Appendix II | - | - | - | - | - |
| Rubiaceae | *Keetia venosa* | x | - | - | - | - | - | - | - | - | - | - | - |
| Bignoniaceae | *Kigelia africana* | | - | - | - | - | - | - | - | - | - | - | - |
| Anacardiaceae | *Mangifera indica* | | - | - | - | x | Data Deficient | - | - | - | - | - | - |
| Bignoniaceae | *Markhamia obtusifolia* | x | - | - | - | - | - | - | - | - | - | - | - |
| Celastraceae | *Maytenus undata* | | x | - | - | - | - | - | - | - | - | - | - |
| Moringaceae | *Moringa oleifera* | | - | - | x | x | - | - | - | - | - | - | - |
| Caesalpinioideae | *Piliostigma thonningii* | | - | - | - | x | - | - | - | - | - | - | - |
| Rubiaceae | *Psychotria sp.* | | - | - | x | - | - | - | - | - | - | - | - |
| Papilionoideae | *Pterocarpus angloensis* | | x | - | - | - | - | - | - | - | - | - | - |
| Polygalaceae | *Securidaca longipedunculata* | x | x | - | x | x | - | - | - | - | - | - | - |
| Smilacaceae | *Smilax sp. 1* | x | - | - | - | - | - | - | - | - | - | - | - |
| Apiaceae | *Steganotaenia araliaceae* | | x | x | x | x | - | - | - | - | - | - | - |
| Malvaceae | *Sterculia  appendiculata* | | - | x | - | - | - | - | Vulnerable | - | - | - | - |
| Scrophulariaceae | *Striaga asiatica* | | - | - | - | - | - | - | - | - | - | - | - |
| Loganiaceae | *Strychnos madagascariensis* | | - | - | x | x | - | - | - | - | - | - | - |
| Loganiaceae | *Strychnos sp.* | x | - | - | - | x | - | - | - | - | - | - | - |
| Loganiaceae | *Strychnos spinosa* | | - | - | - | x | - | - | - | - | - | - | - |
| Apocynaceae | *Tabernaemontana elegans* | x | - | - | - | - | - | - | - | - | - | - | - |
| Combretaceae | *Terminalia brachystemma* | | - | - | - | x | - | - | - | - | - | - | - |
| Lamiaceae | *Vitex cf payos* | x | x | - | x | x | - | - | - | - | - | - | - |
| Lamiaceae | *Vitex sp.2* | | - | - | x | - | - | - | - | - | - | - | - |
| Papilionoideae | *Xeroderis stuhlmannii* | | - | - | - | - | - | - | - | - | - | - | - |
| Flacourtiaceae | *Xylotheca kraussiana* | x | - | - | - | - | - | - | - | - | - | - | - |
| | 41 Unidentified | x | x | x | x | x | - | - | - | - | - | - | - |