STUDY ON LAND CLEARING IN RELATION TO LARGE SCALE PLANTATIONS AND FOREST CERTIFICATION

Executive Summary

The government of Mozambique has since the late 1990s been seeking to attract foreign and national investors to establish commercial forestry plantations in order to create economic activity in remote areas of the country. The establishment of these plantations will require the replacement of the existing vegetation cover with exotic fast growing species.

The investors in these plantations have stated that they wish to become FSC certified in order to demonstrate that they are following established social and environmental best practices.

The conversion of natural vegetation to exotic plantations may conflict with both the Mozambican governments' commitment to biodiversity protection under the Convention on Biodiversity and the Principles and Criteria of the FSC.

Land use allocation in Mozambique is governed by the land act under which both customary title and registered title in the form of DUATs are recognised. Most land use in rural areas is under shifting agriculture of the swidden variety. Increasing population densities mean that in many case the fallow periods have become too short to support agricultural production in the long term. A change of production system to a more intensive conservation based practice is necessary to support the growing population. Land use planning is poorly developed in Mozambique so that the use of land is generally arbitrary.

The conversion of natural forest to other land uses is not specifically prohibited by Mozambican law however the issue is covered by a number of different laws including land law, environmental law and provincial regulations. Protected areas exist along coasts, water bodies roads and frontiers in which plantations may not be established. Since forest conversion is not expressly dealt with under the law a formal definition of forest is not strictly relevant however Mozambique is required under the convention on biodiversity to report quinquenielly on the state of the forests and for this purpose it has a national definition based on canopy cover, height and a minimum area.

The development of forest definitions is reviewed and the definitions used in all African countries (68) have been summarised and analysed. Where definitions are based on the vegetation cover the median values are a canopy cover of at least 30% at a height of at least 4.5m and a minimum area of 0.5ha.

The FSC uses a more restrictive definition of forest using a modified UN/FAO figure of at least 10% canopy cover at a height of 4m and above. No minimum area is specified. The issue of conversion is one that is considered controversial by many FSC stakeholders. Working groups that have dealt with the issue since 2004 have been unable to achieve the consensus needed in order to progress the issue. The final report of these working groups is reviewed. Their recommendations to look at conversion in terms of sustained increases in biodiversity and social values at the level of the forest management unit (upwards conversion) have not been included in the revised principles and criteria of 2011.

The potential positive and negative impacts of plantation establishment are briefly reviewed. It is vital that plantation establishment is properly planned at the provincial, regional and local level and that these plans are subjected to environmental impact assessments.

Miombo woodlands in many parts of Mozambique are under a variety of negative pressures of both human and natural origin. This includes fires of both natural and human origin, excessive grazing by natural and domestic animals and swidden agriculture of a diminishing return period. Under the present scenario very large areas of miombo will disappear in the short term. Only changes in land use practices accompanied by active protection and management can prevent this loss. On the other hand we believe that miombo properly managed has the potential to contribute significantly to rural incomes through the use of biomass fuel and timber products.

The paper proposes that forest conversion is seen in the context of properly planned land management according to the agroforestry village concept. This concept brings together plantation forestry, miombo management and intensified agriculture as a sustainable land use system (in land use units of approximately 30,000ha) capable of supporting rural populations. At the same time the concentration of the plantation resource in smaller areas will serve to lower the logistics costs of plantation companies.

Forest conversion may be necessary in order to establish the plantations necessary for agroforestry villages. However the identification of sites that may need to be considered for conversion should come at the end of a comprehensive planning process in which land that should not be converted for other reasons (protected areas, biodiversity set asides, local community forest needs, corridors etc) is identified.

We offer a decision making framework which is based on both the existing vegetation at the site and the current pressures on the site as well as the potential of the site for future biodiversity. This framework should be applied as the last step in the planning process and must be based on field identification and delimitation of the site. It is not possible to obtain the necessary site level information purely by remote sensing.

In the final part of the document we consider what should be done with the biomass that will become available as a by-product of forest management. This biomass will become available from conversion of natural woodland, from management of natural woodland and from management of plantations.

Some of this material will be of use for local consumption as fuel and as servicewood or sawtimber. However the potential production is very large and other uses must also be considered.

We believe that at least in the short term the costs of transport to port and shipping to markets rules out the possibility of export either in the form of chips or pellets. The most rational form of use is likely to be the use of the biomass to generate heat and electricity for local consumption. Currently electricity for large areas of Mozambique is transported over many hundreds of kilometres. Local generation should have the dual advantage of lowering prices and stabilising the supply. Small generators with a capacity of 3MW are suitable for the use of biomass produced by one or two agroforestry villages. In addition to wood biomass it is also possible to generate electricity from domestic refuse collected in larger towns.

1. Background

In recent years the government of Mozambique has been attracting investors to establish forestry plantations in a number of regions. This is in addition to older plantations previously established. The proposed extent of these plantations is in excess of 2 million ha. The plantations will be established in areas where the current land use is extensive and shifting agriculture as well as land used for subsistence resources and hunting.

The present vegetation cover in the areas where plantations will be developed is a type of Savanna known generically as Miombo woodland. Miombo woodland is a fire adapted vegetation type which includes areas of closed canopy woodland, open woodlands, open grasslands and seasonal wetlands known as Dambos.

All investors in forestry activities in Mozambique have declared that they are aiming at FSC forest certification. The current FSC standard prohibits the conversion of natural forest to plantations after 1994. This means that if certification is desired then it is only possible to establish plantations on areas that have already been converted from forest to other vegetation types or to other uses.

The conversion of natural forest to plantations of exotic species may also conflict with the Mozambican government's commitment to biodiversity protection under the Convention on Biodiversity of which Mozambique is a signatory.

The purpose of this study is principally to develop criteria for determining when the vegetation of an area has been so changed that it no longer fulfils the definition of a forest. These areas can then be planted. However it is important to recognise that there are other factors which must also be considered when planting land if the desire is to become certified. These include both environmental and social concerns.

Mozambique forest law also prohibits the conversion of forest to other uses??? but it lacks an adequate definition of forest that can be used to determine if the area concerned is actually a forest. It similarly lacks a definition of conversion. Short term conversion is a vital component of the swidden system where forest is cleared, cultivated for a short period and then abandoned and allowed to recover to forest cover. Thus the current study will also prepare for the adoption of a definition of forest and of conversion for in the land use and forestry regulations.

In addition there is a component of the study that concerns the use of any woody biomass that is produced as the result of the clearing of miombo for the establishment of plantations.

2. Land use allocation

The Government of Mozambique has decided to allocate large areas of land in several provinces to the development of plantations of fast growing exotic species. The objective of this is to develop an industrial complex based on the resource created. It is expected that this industrial activity will lead to an increase in employment and in economic activity in general in the targetted areas.

Current land use in the area is principally a mixture of intensive agriculture in small areas, generally close to permanent or seasonal streams and extensive rain-fed agriculture, most often practiced in the form of swidden or shifting cultivation. This type of cultivation is usually located within distances of up to 5 km from villages. When the land is 'worked out' in the immediate region of the village then the site is abandoned and the community seeks better land to occupy. The life of such an agricultural village before it is forced to move is usually in the region of 5 to 7 years.

Other areas have been set aside for biodiversity conservation purposes in some cases associated with the development of ecotourism activities including hunting.

The remainder of the land is used at lower intensity by local people as a subsistence resource. This comprises the collection of a variety of subsistence products including medicinal plants, vegetable foods, game meat and fish, firewood, service wood and construction wood. There is also small scale production of charcoal.

Land ownership in Mozambique is vested in the government. In rural areas at a local level land tenure rights have been allocated to individuals under a quasi traditional system by local regulos (chiefs). Recent land tenure reform (1997) has enabled land occupiers to claim long term land use rights for up to 98 years under a system of DUAT (Rights of Land Use). However the process for acquiring these rights is somewhat complicated and has legal costs which often cannot be afforded by small land holders.

Foreign investors seeking to develop forestry plantations must first obtain a permit from the CPI (Centre for Investment Promotion) which will give them an allocation of the maximum area of plantation they can develop in the region. They must then go out to seek suitable land for planting and having identified this they must then negotiate with the local community in order to obtain the necessary DUAT. As of October 2011it is understood that the CPI has issued permits for 815,000ha of plantation and that a little below 40,000ha of plantations have been established. It is not known how many hectares exist in DUATs granted to companies. In most cases the plantable land inside a DUAT is less than 50% with the remainder being unsuitable due to the presence of unsuitable soils and riparian set aside zones amongst other factors, which includes the presence of Miombo woodland in good condition.

3. Land use planning

3.1 Land use planning processes

Land use planning is an essential precursor to the introduction of large scale changes of land use such as the establishment of commercial forestry plantations. A land use plan is essentially an agreement amongst the stakeholders in civil society about the purpose for which particular units of land should be used. This decision will be based on the social, economic and environmental objectives for the land in question. The choices of land use will be limited by the capability of the land to fulfil the requirements for a particular use as well as on the availability of human and financial resources.

The development of a local land use plan is usually preceded by a Strategic Environmental Assessment (SEA) at the regional level. This SEA will be used to identify the range of land use options possible in the region based on an analysis of the social, physical and biotic environment. The assessment will also take into account scale related issues in relation to the development of new activities as well as the expected markets from the products of these activities.

3.2 Land use planning considerations in relation forestry and agriculture.

It is understood that the development of a plantation sector in Mozambique is being carried out to supply export markets with in the first place pulp and paper products and in the second place timber products to local and regional markets. In order to satisfy the minimum demands of a viable pulp industry this will require a minimum of 150,000ha of plantations in full production in a relatively small area of the country (1,000,000ha). In this area the plantations would occupy approximately 15% of the landscape with higher local concentrations of up to 50% of the land in specific forest management areas. It is expected that between 10 and 15 of these forest management areas would be developed at distances of up to 60km from a processing plant.

Under current agricultural land use in the region, land, once it has been temporarily exhausted is returned to the general pool of unmanaged land for rehabilitation by a natural fallow period. This will not occur in forestry plantations where stands will be replanted at the end of rotation.

According to Chidumayo (1994) swidden agriculture in miombo has the capacity to support 2-4 people per km2. Current population densities in the Niassa plateau greatly exceed this carrying capacity so that the miombo is degraded when the return frequency to previously used sites becomes too high. This can be clearly seen along all the major road axes out of the provincial capital, Lichinga, where good quality miombo woodland is absent within 30km of the city. The only solution to this increasing problem is a transformation of the agricultural practices from the current swidden system to a settled pattern based on conservation agriculture principles.

The location of forestry plantations in relation to population centres is an important consideration. Where plantations are close to villages they inevitably compete for agricultural land. Where they are further from villages it is more difficult for community members to access plantation work and the miombo areas to be planted are likely to be in a better condition. It is necessary to seek a compromise mosaic of planted areas that achieves an optimal balance in relation to the social and biodiversity values that may be affected.

4. Analysis of issues related to conversion of natural habitats to industrial plantations

4.1. Objectives of Stakeholders in relation to plantation development

4.1.1. National Government

The Government of Mozambique has established a policy in favour of the establishment of plantations according to the Forest and Wildlife Act 10/99 of 7/7/1999. The objective of this act is to establish tree cover by the plantation of either native or exotic species. In addition the government resolution 8/97 of 1/4/1997 defines forest resources as a capital resource for the country with the potential of earning revenue. Together these instruments establish forest management, including plantations as a means for achieving conservation, business development, industrial development and energy supply.

Seven million ha of land have been identified as having a high potential for reforestation in order to meet these objectives. Approximately 50,000 ha have been established to plantations during the last five years. This has been possible due to a favourable investment climate and it is expected that the rate of establishment will increase in the short term. Plantations may be established by companies, individuals or communities either at a large or small scale. The output from plantations is expected to be processed locally in order to maximise the value added locally or within the country before sale either on the internal or export market.

4.1.2. Landholding communities

Communities and individuals establish land tenure rights on the basis of formalising customary tenure. This can be achieved by registering a DUAT for the land. Customary tenure is recognised after ten years unopposed occupation or use

of the land by a Mozambican citizen or a community.
Communities and individuals may make direct use of the forest resources on the land for their own benefit and the resources may be freely transported within the administrative district where the community is located.

Communities and individuals who have established a DUAT by customary occupation may formally register their rights themselves or they may negotiate the allocation of all or part of their rights to third parties. This is the manner in which DUATs are allocated to foreign investors. It is expected that the communities will be in a position to negotiate a fair deal in terms of the benefits that they will receive in exchange for making the land available to the investors. Communities may seek benefits in terms of employment, development support, rents or any other appropriate benefit. Where communities are allocating land to third parties it is expected that there is a meaningful consensus within the community about the terms of the agreements.

The formalities for the allocation of DUATs varies according to the area to be allocated. For areas less than 1000ha the provincial governor is the competent authority. For areas over 1000ha and less than 10,000ha the minister of agriculture is the competent authority and for areas larger than 10,000ha the allocation must be referred to the council of ministers.

4.1.3. Investors

Investors are seeking to optimise the return on their investments within the social and environmental constraints that exist in the region. It is clear from discussions with the managers that they clearly understand that they have environmental and social responsibilities and that they cannot achieve investment returns if they do not take this into account. Thus the investors have social and environmental goals integrated both implicitly and often explicitly in their objectives.

4.1.4. FSC and other NGOs

The objectives of NGO stakeholders with interests in plantation issues are varied. They include NGOs who work directly with communities to establish village level woodlots in order to provide a supply of timber to the community for all purposes. These woodlots are supposed to satisfy local needs for wood products while relieving the pressure on natural woodlands. Other NGOs seek to improve working conditions of those employed by plantation forestry companies and may also be interested in assuring that communities receive benefits from plantation management. The Forest Stewardship Council recognises the potential of plantation management to relieve the pressure on natural forests but also requires that plantation managers explicitly act to restore and protect natural forests. The overall objectives of the FSC are to ensure that all forests (including plantations) are responsibly managed but with the explicit objective to conserve (sensu 'to use wisely') natural forests. Natural forest management is therefore the preferred land use of the FSC.

4.2. Conversion of natural habitats under Mozambican Law

The issue of conversion of natural habitats does not appear to be directly dealt with under Mozambican law. In many countries there are legally established limitations for conversion of forests (in particular natural forests) to other land uses.
In Mozambique the issues is dealt with under four different fields of legislation.

The first of these is the land law which requires that anyone who will be carrying out any type of land management must have established a DUAT over the land either by customary occupation or by registration.
Under the environmental law there is a requirement for a formal environmental impact assessment before any type of activity which will result in a change of land cover type over an area in excess of 100ha reduced to 50ha in the case of an activity causing deforestation and increased to 250ha in cases of reforestation whether with native or exotic species.
In addition the environmental law prohibits activities which are detrimental to rare and endangered species or their resource needs.
The land law establishes protection zones of complete and partial protection designed to protect both national and community resources and interests. These include protection for biodiversity, natural resources, cultural resources and water amongst others.

These protection zones include the following:-
1) Riparian zones along rivers and lakes for a width of 50m from the upper limit of the waters edge.
2) Riparian Zones for a distance of 100m from a spring.
3) A zone of 100m inland from the highest tide level at the coast.
4) A zone of 250m width surrounding dams and lagoons.
5) A zone of 2km width along the terrestrial national frontier.
6) A zone of 50m on either side of a railway line, major road or airstrip, and a zone of 30m on each side of a secondary road and 15m each side of a tertiary road.

It is forbidden to establish forestry plantations in either partial or total protection zones.

Finally the act of conversion is seen as a harvest of the native trees at the site and permission for this harvest must be obtained from the provincial forest and wildlife authorities (SPFFB). A request for conversion must be supported by at least a provisional land use title issued by the provincial surveyor (SPGC). On the basis of this the SPFFB will carry out a survey to determine the quantities of timber for which stumpages will need to be paid at the site of the conversion. Once permission for this conversion harvest is given it must be completed in 90 days. Certain protected species may not be felled during a conversion.

Under certain circumstances District business development authorities may give permits to fell natural vegetation if this is necessary for the prevention or fighting of fires.

4.3. Conversion of natural habitats under FSC certification

4.3.1. Current situation

The issue of conversion of natural habitats under FSC certification is dependent on the type of habitat concerned and the conservation value of the habitat. It should be noted that the FSC is currently in the final stage of revising its Principles and Criteria for forest management. If these new P&C are as is expected accepted by the FSC membership then there will be a change in the situation.

The FSC does not at present have its own definition of forest but uses the FAO definition: an area of land of more than 0.25ha with a canopy cover of at least 10%

of woody species at a height of 4m. The new P&C include a definition for forest which is similar to the FAO definition in terms of canopy cover of trees but makes no mention of a minimum height. It should be noted that there is no definition of tree in the P&C so that it is not immediately clear if a bamboo forest is to be included.

> New FSC definitions of forest.
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> Forest (new): An area of land with a tree canopy cover of more than 10%, or of young trees able to reach 10% cover in situ. It does not include land used primarily for agriculture or urban use.
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> Natural forest (revised): An area of land with a tree canopy cover of more than 10%, or with young trees able to reach 10% cover in situ, in which all or almost all trees and other plants are indigenous species, and not classified as a plantation. This includes stands of any ages and sizes.
>
> Clarification: For FSC purposes, it includes areas in which natural forests have been affected by harvesting or other disturbances, and in which the trees are being or have been regenerated naturally or by planting or sowing with species typical of natural forests in that site. This clarification covers the situation in some temperate forests dominated by one or few species (often conifers) in which the regeneration of forest with a similar species composition after logging is often carried out by a combination of natural and artificial regeneration, and is not considered as Conversion (Source: Based on FAO (2007) and other international organizations).
>
> Plantation (revised): An area of land with a tree canopy cover of more than 10%, or of young trees able to reach 10% cover in situ, including all areas established by planting or seeding with alien (exotic) tree species, as well as areas newly established by planting or seeding with native (indigenous) tree species which are characterized by few species and even spacing and/or even-ages. (Source: Based on FAO (2007) definitions for Planted Forest and Forest Plantation)

Although the definition of forest appears to be unequivocal there are some doubts relating to the use of the word 'able'. In many fire maintained grasslands there are hundreds or thousands of tree seedlings per ha, however they are unable to form a tree canopy due to the incidence of fire. Some of this fire is of natural origin but some is undoubtedly caused by humans. Often fire setting by humans is a behaviour that has been practiced for hundreds or thousands of years. Are these areas to be considered forest? In addition there are enormous areas of woodland or forest where the primary land use is swidden agriculture, are these forests to be included or excluded from the definition? What types of agroforestry system are to be considered as forests for the purpose of certification and what types are to be considered as forests for the purpose of the criterion dealing with forest conversion to plantations? The situation remains unclear.

The issue of forest conversion remains a highly controversial one amongst FSC stakeholders with a very wide range of views of what would be classed as forest conversion. As part of the preparation for the development of revised Principles and Criteria the FSC in 2004 commissioned a Policy working group to examine all issues related to plantations and later a Technical working group (2007) to examine in detail the issues relating to conversion. This technical team produced its final report in 2009 (FSC 2009). The report highlighted a variety of important issues relating to the conversion question. This included technical considerations but also a number of policy issues that would need to be addressed by the FSC before technical solutions could be developed.

These policy issues include a number of widely held beliefs or preferences which have not been properly tested in relation to their consistency or impacts. The issues include the following:

a) There is a lack of clarity in relation to the conversion of non forest ecosystems to a forested state. In the case of non forest systems of high conservation value there is protection. However in all other cases there is an underlying assumption that any type of forest carries greater benefits.
b) Natural forest is 'more desirable' than all other vegetation communities and is automatically preferred as the 'ideal' vegetation type. This can be applied in two ways firstly as a tool for preventing conversion of natural forest to other vegetation types, but also, more controversially as an argument for replacing all non forest vegetation types with natural forest.
c) FSC should consider social justice issues when considering land that has been acquired for large scale industrial plantations, when the previous land occupiers were smallholders and communities who have not been properly compensated. In this case proper compensation is not to be determined by the legal requirement but by the ability of the displaced people to carry on with an acceptable lifestyle of at least equivalent quality. In effect the certified organisation is being asked to compensate for the lack of integrated land use planning. This issue is related to a further concern where it has been suggested that for indigenous peoples the rights to self determination should carry more weight than other FSC criteria.
d) Conversion to plantations must reduce the pressure on natural forests. This type of conversion rests on an unproven assumption that plantations due to their higher production rates will reduce the demand for timber from natural forests. The evidence for this is at present contradictory and it is difficult to prove. If the conversion of natural forest to plantations does not reduce the pressure on forests then it may be necessary to reformulate a number of the existing Principles and Criteria.

The issue of forest conversion needs to be seen in relation to forest dynamics and forest management. Forest management necessarily changes forests either by design or by default. Whenever a tree is removed then the forest will change. How can we determine if such a change is acceptable. The report considers six indicators that could be used to demonstrate if changes were generally positive in their effect.

a. Species (alpha) biodiversity – increase in the number of animal species which are pollinators or seed dispersers of preferred trees; increase in the number of plant species associated with older woodlands; increase in the species characteristic of locally-defined HCVs.
b. Habitat (beta) diversity – increase in the number of distinct types of floristic associations in the vegetation; recovery of riverine fringes and wetlands; decrease in the areas of ephemeral vegetation and replacement by more stable associations.
c. Structural complexity of the vegetation – increase in the variety of dimensions and the range of sizes in growth habits of plants; more layers in vegetation; greater variety in ground layers of vegetation, with persistent seedlings, saplings and poles; presence of mosses and liverworts and lichens; dynamic layering of humus.
d. Ecosystem functionality – a increase in the number and species of animals high in the food chain (trophic structure) such as woodpeckers, raptor birds or carnivorous mammals; increase

in the number of species of beetles, especially those associated with old decaying wood; increase in the number of springs and perennial water courses with clean water.
e. Economic productivity – a greater variety and volume of year-round products from the converted vegetation with stable or increasing markets and stable or increasing unit values, harvested on sustainable schedules.
f. Social significance – greater local importance of the converted vegetation for livelihoods of local people, as a source of employment, tangible products or cultural significance including physical recreation and spiritual renewal or social cohesion.

The report goes on to suggest an argument for upward conversion of vegetation. This could be permitted where it can be demonstrated that there is at least an increase in time in one or more of the above indicators and no reduction in the others. It is not however clear if this refers to the situation in the forest management unit as a whole or in each specific vegetation formation, although some of these indicators clearly consider more than one vegetation formation.

The conclusions of the team appear to provide a way forward to a more flexible approach to conversion. Unfortunately the recommendations were still considered too controversial to be included in the revised Principles and Criteria so that the status quo has been preserved in relation to conversion.

5. Part 2 Considerations for the development of forest legislation and forest certification standards to meet objectives of forest management
   5.1. Towards a definition of a sustainable natural forest landscape

There are very many definitions of a forest in existence. Gyde-Lund (1998-2011) has provided a continuously updated review of these definitions since 1998. The most recent updating has been in November 2011. These definitions have a wide variety of backgrounds and intents. They may relate to the type of vegetation of an area or to the legal classification of the area. These definitions have been developed by a range of actors to be applied at multilateral, regional, national, or sub-national levels.

Gyde-Lund (2011) has so far catalogued more than 1100 definitions categorised by him as in the following table.

Table 2 - Summary of number of published definitions of 'forest' found as of 11 November 2011

Definition Type	Scope				Total
	General	International	National	Local	
Administrative	18	0	63	17	98
Cover	195	62	288	100	645
Use	57	37	166	108	368
Ecological/Miscellaneous	15	0	16	15	46
Total	285	99	533	240	1157

It can be seen that almost 60% of these definitions are based on the characteristics of the vegetation cover, while almost 35% are based on the land use at the site. 9% of the definitions relate to the administrative classification of the area.

In many of these definitions it is clear that the 'forest' includes areas of vegetation that are not necessarily dominated by trees. In effect the forest is seen as an area of land containing areas of trees as part of a 'forest' landscape. Most forests around the world include larger or smaller areas that are either temporarily or permanently without tree cover. This variation can be the result of anthropogenic effects such as shifting agriculture or use of fire, or they may be due to natural causes. The rise and fall of the water table commonly causes changes in vegetation cover as in the Amboseli National Park in Kenya where two complete 'natural' forest-grassland cycles have been documented. In other areas episodic drought or the impact of elephants have caused similar changes. In many miombo areas open grassy dambos of large extent occur where the ground is seasonally waterlogged.

A sustainable natural forest landscape is an area where land use, including areas covered by trees, is able to supply the needs of local populations without long term degradation of the environment or of social conditions.

5.1.1. Common Forest Definitions

The English word forest derives from the Latin word foris. This simply means 'outside' and was used to refer to the area outside of the village or homestead fence. It is closely related to the term foreigner, meaning an outsider. Thus originally the word simply referred to any wild place regardless of the vegetation cover. In Europe in the period from 1100 to 1600 the term forest became used to describe any area of land that was set aside legally for the use of the king. These forests were used for hunting by the nobility. The areas set aside as forests were not specifically characterised by a tree cover since many open areas such as heathlands were included. Forests as land use types where no cultivation was allowed were also placed under a separate legal system with their own system of courts. In England this situation persists with the Verderer's courts administering forest law in some ancient royal forests. It is only relatively recently that the word forest has come to be generally accepted as being related to the presence of trees. Prior to this it was purely a legal classification based on land use and this situation persists in a number of legal definitions.

5.1.2. Legal, NGO and Multilateral Agency Forest Definitions

TABLE 1 FOREST DEFINITIONS IN USE IN AFRICAN COUNTRIES (AFTER GYDE LUND 2011)

Country	Definition Type	Area (ha)	Crown Cover (%)	Tree Height (m)	Strip Width (m)	Notes
Angola	Unknown					
Benin	Cover					
Botswana	Declared					"Tree" includes palms- shrubs- bushes- climbers- seedlings- saplings and regrowth of all ages and of all kinds- and any part thereof.
Burkina Faso	Use					
Burundi	Use					
Cameroon	Cover					
Central African Republic	Declared		10	5		
Chad	Unknown					
Comoros	Use					
Congo (Zaire)	Cover		10			
Congo- Republic of	Cover					
Côte d'Ivoire	Cover					

Côte d'Ivoire UNFCCC		0.1	30	5		Excludes palms and bamboos
Democratic Republic Congo UNFCCC		0.5	30	3		
Egypt	Unknown					
Equatorial Guinea	Unknown					
Eritrea	Cover		10			
Ethiopia	Cover		68	7		
Ethiopia UNFCCC		0.05	20	2		
Gabon	Declared					
Gambia	Cover		10	3		
Ghana	Cover					
Ghana UNFCCC	Potential	0.1	15	2		
Guinea	Unknown					
Guinea Bissau	Cover		10			
Kenya	Cover		40	2		
Kenya UNFCCC		0.1	30	2		
Lesotho	Use					Tree includes any seedlings- sapling- transplant or coppice shoot of any age.
Liberia	Unknown					
Libya Arab Jamahiriya	Unknown					
Madagascar	Use					
Madagascar UNFCCC		1	30	5		
Malawi	Cover	100	80			
Mali	Use		20			
Mali UNFCCC		1	30	2		
Mauritania	Cover					
Morocco	Cover	3	30	7		
Morocco UNFCCC		1	25	2		
Mozambique	Cover		25	7		
Namibia	Cover		20	5		
Niger	Use					
Niger UNFCCC		1	30	4		
Nigeria	Unknown					
Reunion	Unknown					
Rwanda	Unknown					
Rwanda UNFCCC		0.05	10	3		
Senegal	Unknown					
Senegal UNFCCC		0.5	30	2		
Seychelles	International			10		Reportedly has no national or legal definition but uses international conventions. Which conventions were notspecified. Shrubs > 10 m.
Sierra Leone	Declared					"Tree" includes any woody vegetation.
Somalia	Cover		20	5		
South Africa	Cover		75	3		
South Africa UNFCCC		0.05	30	2		
St. Helena	Unknown					

Sudan	Cover		40	10		
Swaziland	Unknown					"Tree" means the whole or any part of any tree as ordinarily understood or of shrub- bush- seedling- transplant- sapling- reshoot- underbrush or regrowth.
Tanzania	Cover		60	8		"Tree" includes palms- bamboos- canes- shrubs- bushes -plants- poles- climbers- seedlings- saplings and regrowth thereof- all ages and all kinds and part.
Togo	Use					
Togo UNFCCC		0.5	10	5		Includes palms and bamboo
Tunisia	Cover					
Uganda	Declared			4		"Tree" includes palms- bamboo- canes shrubs bushes- climbers- seedlings- and re-growth of all ages and of all kinds- and any part thereof.
Uganda UNFCCC		1	30	5		
Western Sahara	Unknown					
Zambia	Declared					
Zimbabwe	Cover		80	15		"Tree" includes bushes- climbers- coppice- palms- reshoots- saplings- seedlings and shrubs of all ages and of all kinds and nay part thereof.
SADC	Cover		70	5		Excludes planted forests

In summary African countries use 68 separate definitions of forest where the basis of the definition is summarised in Table X below. 16 countries have more than 1 definition of forest since there is a secondary definition used for reporting in terms of the UNFCC. Of the UNFCC definitions 15 are reported as being based on the characteristics of the vegetation cover while Ghana uses forest potential as its basis. No forest definition could be found for 14 countries. SADC of which Mozambique is a member has a definition for natural forests based on canopy cover and height.

TABLE 2 BASIS FOR DEFINITION OF FOREST IN AFRICAN COUNTRIES

Basis for Definition	Number of Countries
Cover	23
Declared	6
Unknown	14
Use	8
International	1
UNFCC	16
Total	68

Where definitions in use in Africa have been based on the vegetation cover the characteristics are given in Table X below. Most of the definitions are based on crown cover and tree height while half of them also have a minimum area requirement. No definition in use in Africa has a requirement for a minimum strip width for shelterbelt forests. Malawi stands out in relation to its minimum area requirement for a forest of 100ha with the next highest being Morocco with a requirement for 3ha. Malawi also tops the table with its requirement of an 80% canopy cover. The median figures for Africa are a minimum area of 0.5ha with a canopy cover in excess of 30% and a canopy height of at least 4.5m. The definition given for Mozambique has no minimum area specified but requires a minimum cover of 25% at a height of at least 7m.

TABLE 3 MINIMUM CHARACTERISTICS FOR COVER BASED FOREST DEFINTIONS IN AFRICA

	Area (ha)	Crown Cover (%)	Tree Height (m)	Strip Width (m)
Number of Definitions	16	32	29	0
Max	100	80	15	0
Min	0.05	10	2	0
Average	6.9	35	4.7	0
Median	0.5	30	4.5	0

5.1.3. Forest Conversion

The multiplicity of forest definitions leads to a similar multiplicity of definitions of deforestation and afforestation. In cases where the definition depends on the land use, the removal of the tree canopy does not count as deforestation. Where the definition depends on the vegetation cover a change in land use or a change in legal status does not constitute deforestation. In areas where the declared land use is agriculture under the swidden system there will be extensive changes in vegetation cover which may or may not result in the permanent removal of a woody vegetation canopy.

5.1.4. Social, Economic and Environmental impacts of forestry activities

Forestry activities have a wide range of environmental, social and economic impacts which can be felt at the local, regional and national level. These impacts can be considered as either negative or positive depending on the viewpoint of the particular stakeholder concerned. For example a reduction in runoff may reduce the flood risk for one stakeholder while reducing the water availability for another. The most important changes that may be caused by the establishment of plantation forests in a region can be considered as follows (This list is not intended to be exhaustive):

Environmental impacts.

Changes in hydrological regime commonly resulting in a reduction in streamflow. Elimination of most native biodiversity at the site. Introduction of invasive species of trees into native vegetation. Chemical pollution by pesticides and fertilisers. Changes in biodiversity in natural vegetation due to effects on landscape connectivity. Changes in biodiversity due to changes in access to or elimination of critical resources. Changes in local weather patterns due to changes in evapotranspiration and temperature of the vegetation surface. Reduction in land availability for agriculture leading to land degradation. Change in fire regime in natural vegetation.

Social impacts.

Provision of employment for local populations. Loss of access to or reduction in amount of subsistence resources. Large scale immigration leading to population increase in areas where employment is available. Changes in demand for health and education services. Changes in pattern of health problems including introduction of new diseases. Changes in demand on infrastructure. Changes in gender roles as a result of employment of women. Reduction in land availability for agriculture leading to competition for land.

Economic impacts

Changes in formal employment opportunities (can be an increase or decrease depending on previous land use). Changes in cash income. Changes in informal employment. Changes in services demanded of local service providers. Change in the balance between subsistence income and employment income. Increase in employment in the timber processing sector. Changes in national foreign exchange earnings depending on the market for which forest products are intended.

It is vital that these and other potential impacts are considered prior to the commencement of plantation activities and that measures are taken to maximise the positive impacts and to mitigate as far as possible the negative impacts. Before proceeding on to a discussion of criteria and processes for deciding whether the natural vegetation at a particular site can be removed we must make it clear that we believe that a range of higher level planning issues must be completed first. Thus it is necessary to have a land use agreement with local communities concerning the general layout of the plantation system which is understood by them. This understanding must be based on full information about the changes that are likely to be caused by the plantation activities.

It is also necessary to identify all natural resources that must be protected from the impacts of plantation establishment. In particular areas of high conservation value (sensu FSC) must be identified and a landscape plan must ensure that there is connectivity of natural vegetation in the landscape which includes and maintains natural processes at sites of high conservation value.

5.2. The situation of Miombo woodlands in Mozambique.

Miombo woodlands are the most widespread vegetation formation in Mozambique covering between 60 and 70% of the country. Evergreen forests have a relatively limited occurrence in the west and north of the country. Miombo woodlands occur in areas where the rainfall is between 500 and 1500mm per year and where there is strong seasonality of the rainfall with an extended dry season. Rainfall intensity is generally high so that there is commonly a great deal of overland water flow as a result of storms with a much reduced soil penetration of water. Effective rainfall is therefore significantly lower than recorded rainfall. Miombo woodlands are dominated by members of 3 genera, *Brachystegia, Julbernardia and Isoberlinia*, but include a wide range of inmix species in the company including a variety of species that provide high value timber such as *Dalbergia melanoxylon, Burkea africana, Milletia stuhlmani, Afzelia quanzensis and Pterocarpus angolensis.* These latter species are an important component in the international trade in tropical timber species.

Where miombo vegetation is removed there is a successional process for reestablishment. Early succession species such as light demanding *Uapaca* sp. form dense stands that are able to exclude fire by suppressing the field layer grasses and thereby reducing the fuel load.. Trees of late succession shade tolerant miombo species are then able to regenerate from coppice sprouts and seedlings. Eventually these late succession species suppress the *Uapaca* by competition for light. The late succession species allow the canopy to open and grasses can regrow which allows for more intense fires. However these trees have thick barks and are fire tolerant. In areas with sufficient rain the succession continues beyond this stage when evergreen species enter the stands and once again suppress grass growth leading to an evergreen forest with infrequent fire.

Driving forces in Miombo woodlands

Farming
In many areas of miombo woodland human densities have historically been quite low. Traditional agriculture of the swidden type is able to support 2-4 persons/km2. In many areas this density has been greatly exceeded. This has resulted in large areas where the fallow period has been shortened to such an extent that miombo regeneration is not possible. In the areas of most intense farming this has resulted in an open scrubland. In other areas the succession never proceeds past the Uapaca dominated stage.

FIGURE 1 AREA DEGRADED TO OPEN SCRUBLAND BY OVERUSE

Fire
Miombo systems evolved in the presence of fire and are adapted to them. Most late succession miombo species are capable of surviving fires of low to moderate intensity. Early succession species are generally fire intolerant but their dense canopy suppresses grasses so that there is insufficient fuel for fires to carry. Most fire in miombo is of human origin. Natural fires would have been less frequent but probably covered larger areas. Present fire regimes are in many cases of a frequency that is capable of preventing miombo regeneration. It is necessary for there to be a gap of 3 to 4 years between fires in order to allow the late succession miombo species to develop past the

fire tender sapling stage to the fire resistant pole stage.

Weather
Miombo systems occur in areas where there is a large interannual variation in rainfall. During dry years there is little growth of grasses but trees which are deeper rooted are able to grow more strongly. In drought conditions the fuel load decreases since the few grasses that grow are consumed by animals, mainly termites. Thus episodic droughts favour miombo tree regeneration.

Animals
In systems where large animals are still present at somewhere close to natural densities they are able to have a significant impact on miombo systems. In addition domestic livestock can also strongly affect miombo successions. Large grazing animals act to reduce the grasses and thereby reduce fire intensity. This favours tree regeneration. On the other hand large browsing animals can prevent tree regeneration by pruning seedlings and keeping their height below the level at which flames are able to kill off the above ground growth. Elephants are capable of pushing over and killing large miombo trees and in this way opening up the forest and returning it to a grassland system.

Humans
In addition to the influence of swidden agriculture which can be considered a more or less 'natural' influence on the miombo there are more recent direct impacts on woodlands. Woodcutting for fuel and/or for the semi commercial production of charcoal is capable of having a very large influence. In some areas many thousands of hectares are completely cleared each year and the fuel is removed. This pattern of use not only removes the fuel but also prevents the recycling of the nutrients that is a characteristic of swidden agriculture. As a result miombo regeneration may be further retarded due to a lack of nutrients. The cutting of poles for servicewood also acts to reduce recruitment of adult trees.

FIGURE 2 SOUTHWEST OF LICHINGA LANDSCAPE DEFORESTED BY OVERUSE

Current situation

In many areas of Mozambique, there exists a situation where at least three of these factors are causing a large scale rapid degradation of the miombo resource. Swidden agriculture at high return frequency is depleting soils and reducing the returns from farming. Wood cutting for charcoal and fuel is opening canopies and allowing grasses to grow, this in turn allows for greater fuel loads. Wood cutting for servicewood uses also acts to reduce the recruitment rate to adult trees. People are burning the miombo with a very high frequency, sometimes more than once a year. Close to villages goats can also have an effect on regeneration by consuming all saplings. The result is a large scale failure of the miombo woodlands to recover from disturbances (Figure 2).

Along roads where access to the miombo is easy and close to villages the miombo degradation is almost complete in many areas. For example leaving Lichinga in any direction it is more than 40km before any areas having a more or less normal miombo structure can be observed from the road.

The way ahead for Miombo

If miombo woodlands are to be preserved in many areas of Mozambique there is a requirement for interventions to reduce the pressure on the forest. This will require changes in agricultural practices which reduce the amount of land required per person. In addition it will be necessary for land use planning procedures to ensure that land allocation agreements are reached that make space for natural miombo. This miombo will need to be managed in such a way that sustained benefits can be derived from it for local populations. Plantation companies potentially have an important role in this since they have the capacity and the knowledge of their professional foresters to manage and protect miombo in the required way.

An interesting and potentially successful way of achieving is the agroforestry village concept promoted by Technoserve. It will be necessary to expand the basic concept by including miombo management in the mixture of activities. It must be recognised that in order to achieve this, space will need to be made in the landscape for the establishment of plantations.

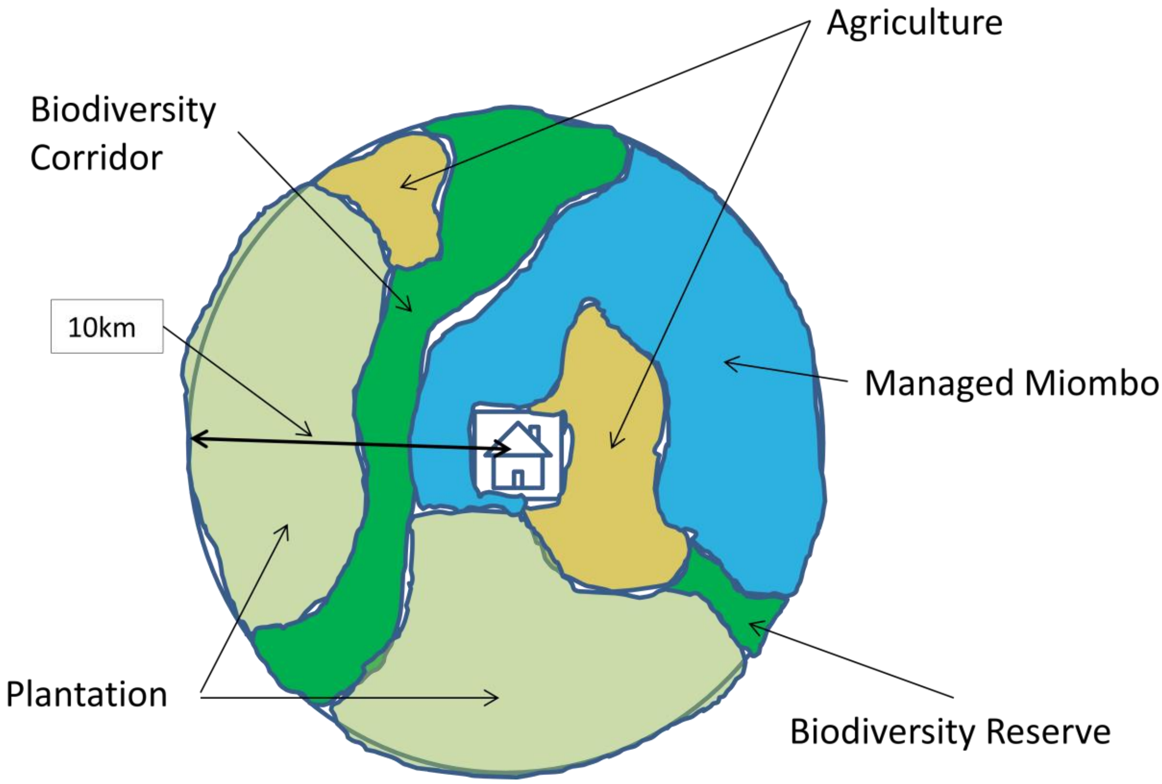


FIGURE 3 AGROFORESTRY VILLAGE OVER AN AREA OF RADIUS 10KM = 31,400HA

The potential for miombo woodlands to contribute to community welfare is potentially much bigger than currently realised. For most communities miombo is a source of firewood, non timber forest products, servicewood, medicinal plants and bushmeat. The potential for managed miombo to contribute to local economies through timber production is underestimated. Unmanaged miombo is capable of yielding 2 tonnes of firewood per ha per year. If this is commercially managed this should provide a yield of USD50-80 per ha/year. High value timber species as well as the core miombo species also provide potential resources for the timber trade at local and international levels. It is therefore important that miombo which is set aside from agriculture and plantations is managed in order to yield real benefits for landholding communities.

5.3. Space requirements for plantation forestry.

Forestry plantations in remote areas such as northern and western Mozambique will be highly dependant on distant markets for their products. Local and even national markets have only a limited demand and capacity to pay for timber products. The products that will be produced for export markets will be dominated by commodity timber and pulp. Economies of scale dictate that in order to be competitive processing plants will need to be very large. There is a minimum input requirement below which timber processing is not financially sustainable. This minimum input requirement is significantly larger for pulp than it is for timber. For a minimum viable pulp industry the annual input to a plant will need to be in the range of 1-2million tonnes per year. In order to provide this it will be necessary to have a plantation area of at least 120,000ha of fast growing species. Timber transport to the processing site is a major cost so that

plantations will need to be as close to the mill as reasonable possible. The most distant plantations supplying a mill should be less than 60 road km from the mill. If we assume this can be achieved in a radius of 50km then in this area 15% of the land will need to be allocated to plantations.
There is an additional consideration that relates to the distribution of plantation stands within this zone. Where stands are small and scattered there are very high logistic and management costs involved in their management. These arise as a result of the need to travel between stands in order to carry out management interventions, In addition smaller stands require a much higher investment in their protection. They have longer edges over which fire prevention needs to be carried out, longer transport distances mean that fire fighting crews need to be present in many more areas in order to make a timeous attack on the fire, many more fire towers also need to be manned in order to cover the area. In order to reduce these costs it is necessary to concentrate stands in such a way that management is cost effective. We suggest that this can be achieved under the agroforestry village concept if each village has control of an area of 30,000ha and is able to allocate 10,000ha of this to plantations. Then the plantations of 12 agroforestry villages plantations can supply the needs of a large mill.

The need for miombo conversion
It is clear that this type of land use arrangement cannot be achieved using only land where the miombo has been completely destroyed. Much of this type of land is concentrated close to existing population centres and it is socially undesirable to plant all of this land since it will in future be an important resource for more settled agriculture. Significant land areas that currently have some form of tree cover will need to be converted to plantations if the industry in Mozambique is to be viable and become a driver of development.

It is necessary to ensure that this conversion is carried out in such a way as to minimise the negative social and environmental impacts while maximising their benefits. The conversion of natural woodlands to plantations should be seen as an action of last resort so that all other possibilities are considered first by means of a strong planning process which takes full account of social and environmental impacts. We present in the next section a decision making procedure for selection of land for plantation establishment but emphasise that this can only be considered as the last step in a thorough planning process.

5.4. A procedure and decision making criteria for selecting areas for plantation establishment.

5.4.1. Planning procedures for plantation establishment.

The establishment of plantations must be preceded by a comprehensive planning process that takes into account all significant social and environmental issues. This planning should commence before negotiations are started for the transfer of DUATs to plantation companies. At a landscape level this procedure will be used to eliminate from consideration all lands that for some reason fail to qualify as suitable for planting. The procedure should be applied in a hierarchical fashion in order to finally achieve a potentially plantable area. The following aspects need to be considered and areas affected should be eliminated from consideration:

Soils: Areas where soils are not suitable should be eliminated.

Intact forest landscapes: Contiguous blocks of miombo woodland where the canopy is composed of late succession miombo species of an area in excess of 2000ha should be preserved.

Biodiversity corridors: Corridors or potential corridors joining areas to be preserved for biodiversity must be identified and preserved .

High conservation value: Areas having a high conservation value on account of high biodiversity, importance for environmental processes, concentrations of critical resources for wildlife, concentrations of rare and endangered species, concentrations of resources for local communities or having high religious or cultural significance for local populations should be managed in order to maintain these values and not be planted..

Alternative land uses: Areas that are required for agriculture or other land use should be eliminated from consideration.

It is also likely that a comprehensive EIA would identify other areas that cannot be planted for a variety of reasons, for example travel routes used by local populations or small evergreen forest patches, etc.

The remaining areas which will form a mixture of sites ranging from recently abandoned agricultural land to miombo woodlands in good condition can then be evaluated to determine where it would be permissible to establish plantations.

5.4.2. Considerations for permitted conversion of sites originally carrying intact miombo woodland.

Areas currently carrying intact miombo dominated by late succession species should not be converted to plantations. Only areas that are already heavily degraded or areas where the degradation pressures are so great that they will not be able to recover to a fully functional miombo should be considered for conversion to plantations.

Since miombo is a dynamic system and periods in which there is no forest canopy present are common the absence of trees in an area is not of itself a sufficient indicator that the area could be converted to plantations.

We have developed a decision making framework to be applied at the site level for considering if a particular site can be converted to plantation. It is necessary to visit a particular site on the ground in order to determine if the site will meet the criteria for conversion to plantation. Aerial photography or satellite imagery may be a useful first step in identifying potentially plantable land but it can never be the final tool on which decisions are based.

The decision making framework should be applied initially at the feasibility survey for an area when it should be applied at the same level of intensity as a typical soil reconnaissance survey of 200m spacing between sampling sites. Prior to plantation establishment the framework should again be applied for the delimitation of the boundaries of individual stands.

We use the following indicators of degradation and forces driving degradation in order to identify plantable land and land that must be managed for miombo.

a) Canopy cover.
A canopy cover of over 10% is an indication of a forest that may have the potential to achieve a late succession status. However for this purpose we consider only the canopy cover of late succession species. We do not consider *Uapaca* to be a significant part of the mature miombo system. Where the canopy cover of late succession miombo trees exceeds 30%

b) Basal area (area at breast height)
A basal area in excess of 15m2/ha can be an indicator of a forest having a sufficiently well developed structure to resist some of the degrading forces.

c) Presence of Regeneration
Most miombo stands have a greater or lesser number of small plants of late succession miombo species. These plants are either new seedlings or post fire coppice resprouts. Where fire frequency is high these will not be able to become trees. Evidence for regeneration of late miombo succession species is in the form of pole sized trees with a dbh of more than 5cm and a height above 4m. Where regeneration takes place under an existing canopy of early succession species 50 pole stage trees/ha will have the potential to achieve a canopy cover of 10% if each crown is assumed to have a diameter between 4 and 6m. Where early succession species are absent we believe that at least 100 pole stage trees/ha will be required to achieve a future canopy of 10% since there is significant mortality risk due to fire in open stands.

d) High level of woodcutting.
In many areas regeneration is prevented by a high degree of woodcutting for, firewood, charcoal and servicewood. Where this happens at a high frequency pole sized trees are never able to reach the canopy stage. It is easy to determine the extent of this woodcutting from the cut stumps of pole sized and larger trees which often resprout. Where this cutting affects more than 30% of the pole sized trees in a year it is unlikely that the stand will ever regenerate even though pole sized trees are present.

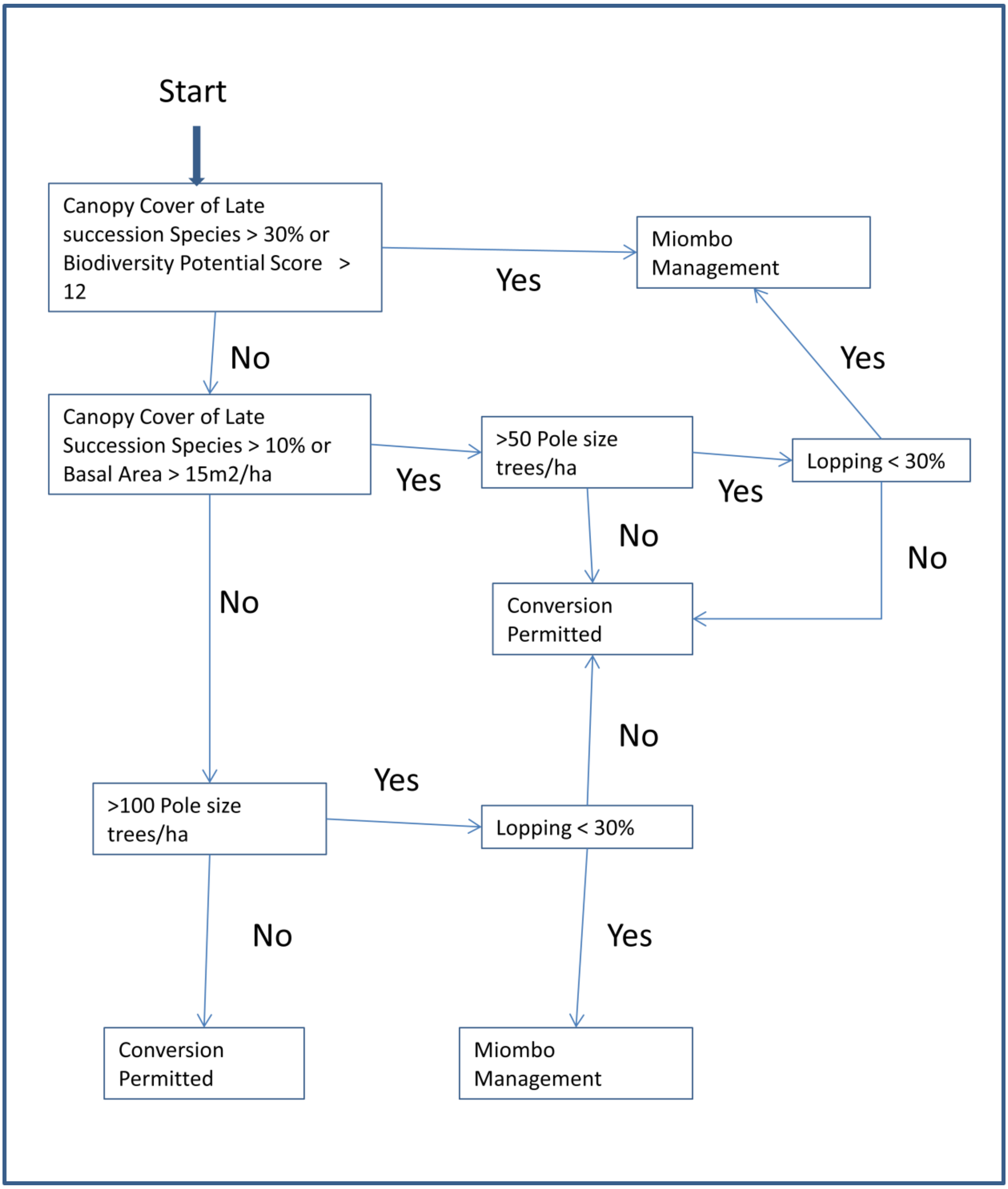
e) Presence of high commercial value trees.
In many miombo areas selective harvesting of high value trees has resulted in a significant decrease in their population. Where they are present they have the potential to provide a high value to local communities if they are properly managed. The presence of these species e.g. Afzelia, Dalbergia, Khaya, Pterocarpus, Milletia, Burkea, Milicia etc, (essentially those occurring in the category 1 species definiton in Mozambique) is a strong argument for retaining a stand.

f) Sites having a high biodiversity potential.
It is not practicable to determine the biodiversity at a site in a cost effective manner. However it is possible to identify habitat features that are frequently correlated with higher biodiversity such as rocky outcrops, old trees carrying epiphytes, watercourses etc. A system developed in Sweden and in wide use there to identify high value habitats has been adapted for use in miombo systems in

Tanzania. We have further adapted it for use in dry miombo in the Lichinga area. It requires some further validation by local experts however we believe that already in its present form it is a useful tool for identifying areas that should be retained as miombo. We have also include the presence of high value species as a component of this tool so that it encompasses the issues in both sections e and f of this discussion. Where a stand scores more than 12 on this tool it should be retained for miombo management regardless of any other conditions.

The flow chart on the following page should be used for decision making at the stand level where the stand is to be considered as an area of no greater than 4ha. Experienced operators will quickly be able to recognise areas that may or may not be converted on the basis of this decision making tool and it will become possible to delineate the proposed conversion area on the basis of the rules set out in it.

FIGURE 4 FLOW CHART FOR DECISION MAKING ABOUT CONVERSION



6. Part 3 Options for use of biomass from land clearing activities

Land clearing will yield significant amounts of biomass. The majority of this biomass will be in the form of woody biomass since leaves in general make up only 4% of biomass in miombo. At present this biomass is probably largely unused, although if close enough to a settlement there is likely to be some consumption for a variety of purposes. This biomass source however is only available at the moment of plantation establishment and when no further conversion is taking place in an area there will be no further production. The management of miombo for biomass production is however another potential source of material and studies have shown that the production in unmanaged miombo is likely to be in the order of 2 tonnes/ha/yr. On the other hand the plantation system itself will provide large quantities of biomass in the form of thinning waste and if there is local processing then this is likely to be increased by the bark material and the processing wastes.

Clearly in order for any organised activity to be carried out with this available biomass it is necessary that there is a sufficient and reliable source of the biomass to justify the investments in organisation and in infrastructure that will be necessary to make efficient use of it. For this reason we have assumed that the target landscape is a community (agroforestry village) area of 30,000ha where 10,000ha will be established to plantations, 10,000ha will be managed miombo woodland, 3,000ha for biodiversity and environmental protection and 7000ha for agriculture. The number of people who could be supported under this scenario is estimated in the table below. The community size would be in the range of 1500-1800 persons. It has been estimated that both subsistence work and employed work enables a person to generate sufficient resource to support 1.5 people at an acceptable level.

TABLE 4 POPULATION SUPPORTED BY VARIOUS LAND USE ACTIVITIES IN A 30,000HA COMMUNITY

	Land Use			
	Swidden Agriculture	Miombo Management	Biodiversity Management	Plantation
Area	7000	10000	3000	10000
Ha/Employed Person	20	100	500	15
No Employed	350	100	6	667
No Supported	525	150	9	1000

6.1. Biomass yield

6.1.1. Expected biomass yield as fruit of conversion

Above ground biomass in different types of miombo in Zambia have been estimated by Chidamayo 1994 and range from 90 dry tonnes/ha in moist sites to

50 tonnes/ha in dry miombo. It is assumed that these estimates are taken from areas of intact miombo with typical canopy cover in the range of 50 to 80%. Areas of degraded miombo are therefore likely to have significantly lower biomass and it is expected that the average in sites that are degraded enough to be considered for clearing are likely to be in the range of 10-20 dry tonnes/ha.

6.1.2. Expected biomass from sustainable management of natural forests

There is little experience of the sustainable management of miombo woodlands. We have been unable to find information about the sustainable yields of commercial species under management. There is some information (Chidamayo 1994 and Cunningham 2003) on the diameter increments of trees in unmanaged stands which suggest an annual growth of between 1 and 2 mm. There is information on the regrowth of coppiced miombo without management suggesting that yields of between 1.5 and 3 tonnes/ha/yr could be sustained.

6.1.3. Expected biomass yield as by product of plantation forestry activities

Plantations produce biomass which cannot be used commercially as timber at several occasions during the production cycle. This biomass can be generated as a result of both thinning and pruning activities. It is unlikely that the pruning biomass will be sufficient to warrant its collection and it is therefore discounted from further consideration. There is therefore the potential to use this biomass for a variety of purposes (described in the next section) but a high proportion can only be used for the generation of heat by burning. It is important to recognise that the removal of this material from the site instead of leaving it to decompose can have important impacts. In general there is a higher concentration of important nutrients in the fine material and the leaves and the removal of this may need to be balanced with fertilisation. The lying trash protects the soil surface from wind, rain and sun during the period when there is no tree canopy and its removal may have important consequences in relation to erosion and to the soil biota.

It should be noted that an investment in a large scale processing facility will only be made once there is a guarantee of sufficient timber to satisfy its needs. This means that during the early years of the system development there will be a large scale production of biomass for which there is no processing option. The only use for this biomass which will include all of the material from thinnings including the pulp logs and some sawlogs will be available as biomass. This source will disappear the moment a large scale processing facility opens its gates which is likely to be towards the end of the first rotation of eucalyptus trees in about 12 years time.

Residue from thinnings
Silviculture of pine plantations requires a variety of thinning activities depending on the desired product of the stand. Where high quality saw wood is required the thinning is designed to obtain an optimised growth with annual growth rings of uniform thickness throughout the life cycle. Where stands are managed for the production of fibre for pulping thinning is aimed at achieving the most economically efficient fibre production with less emphasis on the wood properties. Planting densities and thinning regimes therefore vary according to the purpose of the stand and therefore different amounts and frequencies of biomass production

will be generated by different types of stand. In some cases a proportion of the product generated by silvicultural thinning will be of commercial use but there will always be some material which is of no other use and can be extracted as biomass fuel.

Residue from Harvest

When harvesting takes place there is always a certain amount of branch and top material which cannot be used commercially. This amount will vary strongly according to the silvicultural regime followed during production and the capacity of the processing system to deal with small diameter logs. In many countries this has become an important source of biomass fuel. In some cases the tree stumps are also removed after harvest for biomass.

Residue from Processing Activities

It is usual only to transport the commercially useful parts of a tree to the processing site. Where biomass from the plantation is used for other purposes it is often taken to a separate site.

Where the final product is pulp the residue from processing activities is largely confined to the bark and a few small branches which are removed before chipping takes place. This accounts for a small percentage of the total biomass in the range of 3-7% depending on the species and the log dimensions. For some species the bark may be removed in field and left at the site further reducing this source of residue from processing.

On the other hand where sawn timber is the main product then there is likely to be a much higher volume of sawmill residue. Sawmill recovery rates to finished products from plantation grown trees are usually in the range of 40-70% of the original volume depending on the log dimensions, properties and the effort that is made to recover small waste pieces by for example finger jointing of short pieces. Depending on the types of machines used for processing the waste material will consist of a mixture of slabs with excessive wane, short pieces, pieces with unsound knots, woodchips and coarse and fine sawdusts. These can all be used as biomass for generating heat and power.

Where there is a pulping facility within economic range it sometimes makes economic sense to send some of this waste material to be incorporated into the pulp production. However with increasing energy prices it is often the case that the generation of heat and power is the better option provided the capital cost can be achieved.

In many cases these wastes are used on site to generate heat for use in the kiln drying of the sawn boards. Wherever sufficient heat is generated there is likely to be a capacity to convert some or all of that heat to electrical power.

Therefore the amount of biomass that becomes available from processing sites is highly variable depending on the specific details of the individual site. However it is probably safe to assume that 30% of the material could be used to supply biomass for off site heat and power generation.

6.1.4. Total Biomass from all forestry sources

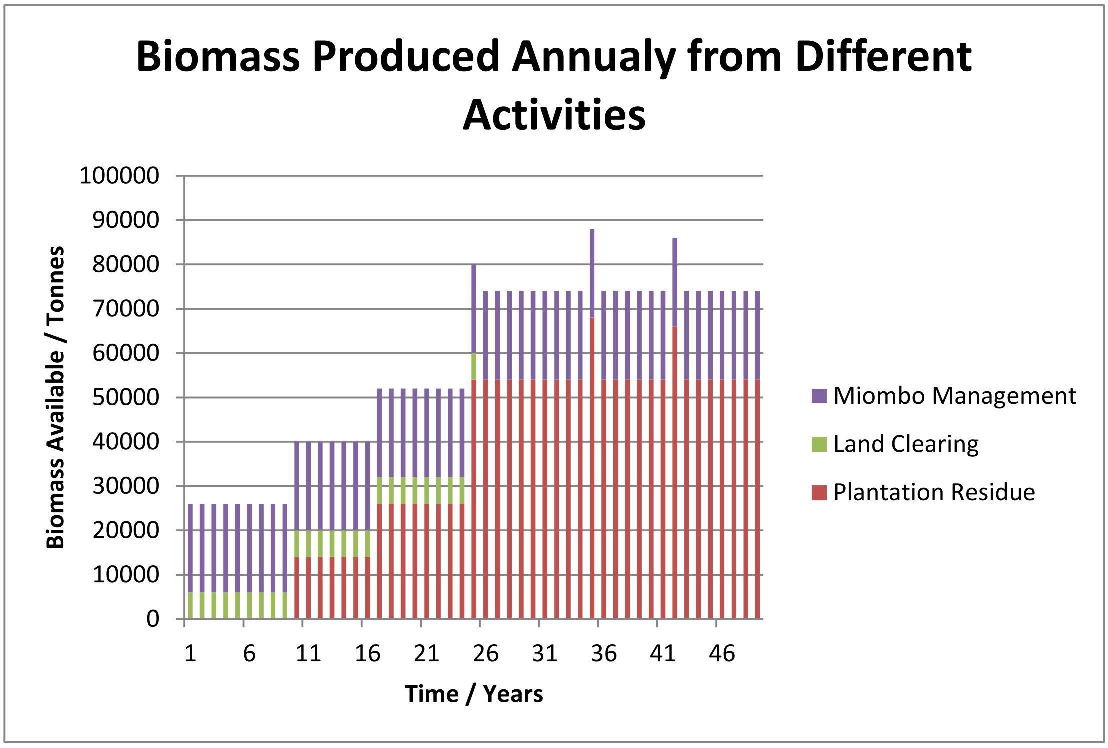
The flow of biomass availability from the managed environment is show in the graph (figure x) below. This biomass is generated from the original land clearing activity, the management of miombo and from the plantation waste. The biomass from land clearing is a once only input and in the model below we have assumed that the plantation will be fully established after a twenty five year period and that this source will cease. The flow of material from managed miombo will remain more or less constant. The plantation waste occurs at each silvicultural intervention. In our model we have assumed that there will be a first commercial thinning after ten years, a second commercial thinning after 17 years and final felling at 25 years in pine stands. The biomass generated by each of these activities increases with time so that the final felling will generate the greatest amount. For the system as a whole there is no biomass generated from plantations during the first ten years, a small amount is generated as a result of the first commercial pine thinning in year ten and then increasing amounts as the result of the commercial thinnings, reaching a plateau after 25 years when the system is in normal rotation. At this stage there will be thinnings or final fellings over an area of 1200ha each year.

The waste volumes from typical Finnish conifer stands are given in the table below. We assume that the yields in Mozambique will be 35 m3/ha from the first commercial thinning, 30 m3/ha from the second commercial thinning and 70 m3/ha from the final felling of pines.

Treatment	**Stand age**	**Yield of timber**	**Biomass residues**		
	years	m^3/ha	m^3/ha	toe/ha	GJ/ha
Pre-commercial thinning	10-20	-	15-50	3-9	125-375
1st commercial thinning	25-40	30-80	30-50	6-9	250-375
2nd commercial thinning	40-60	50-90	20-40	4-8	165-335
3rd commercial thinning	50-70	60-100	20-40	4-8	165-335
Final harvest	70-100	220-330	70-130	13-24	545-1005
Total during rotation	**-**	**360-600**	**155-310**	**30-58**	**1255-2430**

Source: VTT, Wood Energy Technology Programme, Finland (ex EBIA 2011).

For eucalypts the cycle is shorter but there are no thinnings all biomass available will be derived from the pantation trash at final felling after 10 to 12 years. This will account for about 20-30% of the total stand volume. Probably approximately 30 tonnes/ha. The model below is based only on pine plantations since they currently dominate in many of the development areas in Mozambique. However we are aware of increasing plantings of eucalypts and these will bring in significant volumes of harvesting trash earlier on due to the short rotations. We can assume that at final felling there would be 70m3/ha available. No thinnings are planned for eucalyptus stands.



It can be seen that the system will generate about 25000 tonnes during the first few years largely from miombo management but that the plantation residues will increase in importance and become dominant after25 years when they will generate over 60% of the waste biomass.

6.2. Options for biomass usage

6.2.1. Local consumption

Sawtimber

The better logs from suitable species could and should ideally be used for sawing for both the local market and where possible for export. It is likely that these will be a small component of the total biomass yielded from both the land clearing and the miombo management activities.

Carving

Logs that are not suitable for sawing may be suitable for carving where there is the local capacity to engage in this. However the volumes used by carvers are in general not large. In Kenya for example each carver consumes about 0.1 m3 of timber per year. These volumes are likely to be easily available from managed miombo and the total volumes produced by land clearing are expected to be greater than the local demand. However not all timbers are equally suitable for carving either in terms of their workability or in terms of the price achieved for objects carved from them. Where carving is specialised in certain rare timbers then the local supply is often unable to cope with the demand. This is particularly the case when the utilisation is wasteful and where carvers specialise in large objects.

Servicewood

Servicewood is wood that can be used for a wide variety of purposes by communities. It includes poles that may be used for the construction of buildings and for fencing. Servicewood is also used for the making of furniture for home use. Other uses include the manufacture of farming implements and domestic tools.

Servicewood often uses similar dimensions of timber as fuelwood. Poles are typically in the diameter range of 3 to 10cm and have a length of 2-3m. Different timbers are used for different purposes depending on the nature of the use and the properties of the timber. In some cases carpenters especially skilled in the manufacture of particular products may use servicewood on a more commercial basis. However in most cases the total volumes consumed are small compared with the volumes used as fuelwood. Due to the need to match the right species to the product it is possible that in some cases the demand for servicewood can have a significant impact on the population or regeneration of a species locally.

Fuelwood

In rural locations the dependence on fuel wood for cooking and for space heating is very high. Firewood collection is an activity carried out on almost a daily basis for many people. Fuelwood consumption varies with the local situation and the family size and ranges from 200kg to 1000kg per person per year over a wide range of situations. In some regions the supply of fuelwood to cities is highly organised while in other cases the supply is based on a free market taken from a commonly held resource. In the case of supply to communities the situation is almost exclusively based on informal extraction from a common resource. Logistics is the most common limiting factor for fuelwood collection. There is a limit to the distance over which people are prepared to travel, on foot or by bicycle in order to collect the wood. Effectively this means that sources more than 3km from the homestead will not be exploited unless there is other transport available. This means that much of the wood available from the land clearing activities will not be accessible.

Charcoal

Where wood is available but transport costs or logistics are too high or too complex it is often better to convert wood to charcoal at or close to the forest site. This can be done for all wood of sufficient dimension and this generally means branches in excess of approximately 2cm in diameter. Where conversion of wood to charcoal is done at the site there are a variety of means for doing this. The key aspect is to maintain a strong control of the oxygen flow to the wood in order to avoid complete combustion. Traditionally this was achieved using earth covered stacks but now specially designed portable metal kilns are often used. These have a capacity of between 1 and 10m3. The conversion efficiency of field systems if properly used is generally between 7:1 and 11:1 for traditional earth kilns, and between 5:1 and 8:1 for purpose built metal kilns.

Where the wood is brought to a permanent large scale facility outside the forest there are two types of process that may be used, in both cases these are heated by an external source. The first consists of large sealed retorts that are heated until carbonisation takes place and the waste gases are expelled. The second type is of a continuous flow system where the carbonisation takes place as the material passes along the conveyor. For both of these systems it is possible to achieve conversion efficiencies in the range of 3:1 - 4:1. However in order for this to be economically viable there is a need to have an assured supply of large timber volumes in order to justify the capital expense of both the processing and logistic systems.

Charcoal has the advantage of being light and therefore easily transported and charcoals made from the right woods have very good burning properties and are in high demand in the export market for barbecuing. In the export market there is in general some premium for certified charcoal. There is also strong demand in most African markets since charcoal is easier to handle and to control than wood.

There is an existing charcoal production and distribution system in the Lichinga district. Production is by use of traditional earth kilns. Longer range transport is by truck to a depot approximately 25km from Lichinga. From this point into lichinga transport is carried out on bicycles and in small cars. This pattern is used to avoid licencing and revenue requirements since private production and transport for personal use is permitted. In town price of charcoal is approximately five times the price paid to producers. The market is said to be dominated by a single individual or small cartel.

Combined Heat and Power

Where large amounts of biomass are available combined heat and power plants are an attractive use for the material. These powerplants burn the wood in a furnace and use it to heat water to create steam and then use the steam to drive an engine for the production of electricity. There is considerable waste heat from this process and this waste heat can be used for a variety of purposes including refrigeration. There are large economies of scale in this process which relate principally to the characteristics of the water boilers that are used to generate the steam and to the properties of the engines themselves. Where there are very large amounts of material and the capacity of the system is more than 10MW then steam turbines have some efficiency advantages. Where the amounts of material available cost effectively at a site are less, then high pressure steam piston engines have efficiency advantages and also have the advantage of maintaining their efficiency over a wide range of power production. Turbines are only efficient at or very close to their designed operating capacity. Steam piston based systems can be used most economically where the power production is greater than 3MW. The limiting factor is the design of the burner and the flame height required. Thus a burner designed for 1MW electricity will be able to produce enough heat for 3MW. Generators can be produced with outputs of 0.5MW so that 3MW will require six generators. However the burner accounts for a very high proportion of the overall cost of the system.

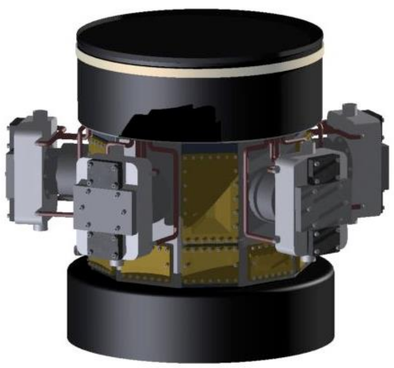


FIGURE 5 HIGH PRESSURE 5 CYLINDER RADIAL STEAM PISTON ENGINE

The energy content of all woods is very similar on a weight for weight basis. The main cause of differences in the energy released in different situations is the need to drive off the water that is contained in the wood. Fresh wet wood may have moisture contents in excess of 60% while wood from which all the free water has been removed has a moisture content of approximately thirty percent. Dried waste wood from a sawmill is likely to have a moisture content of approximately 10%. To generate 1MW of power using wet wood requires much more wood than generating the same power from dry wood.

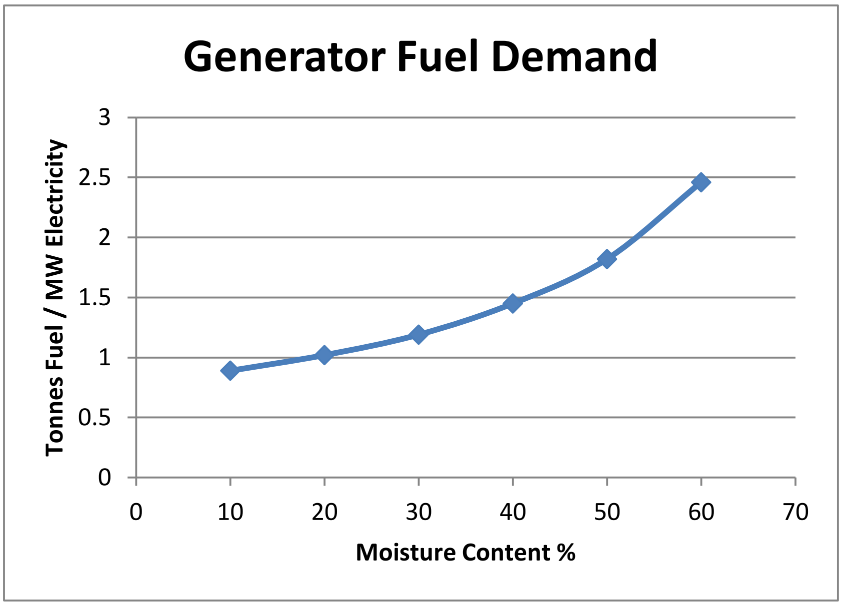


FIGURE 6FUEL CONSUMPTION REQUIRED PER MW OF ELECTRICITY AT DIFFERENT MOISTURE CONTENTS.

Running on fuel at a moisture content of 30% the annual requirement for biomass will be approximately 10,000 tonnes per MW per year. Un-dried wood collected from the field at 60% moisture content would require an input of 22,000 tonnes per MW per year. Combined heat and power plants are able to accept a mixture of fuel inputs so that fuel from the forests can be supplemented with domestic refuse collected from towns and villages. In addition agricultural wastes such as straw can also be used in the burners.

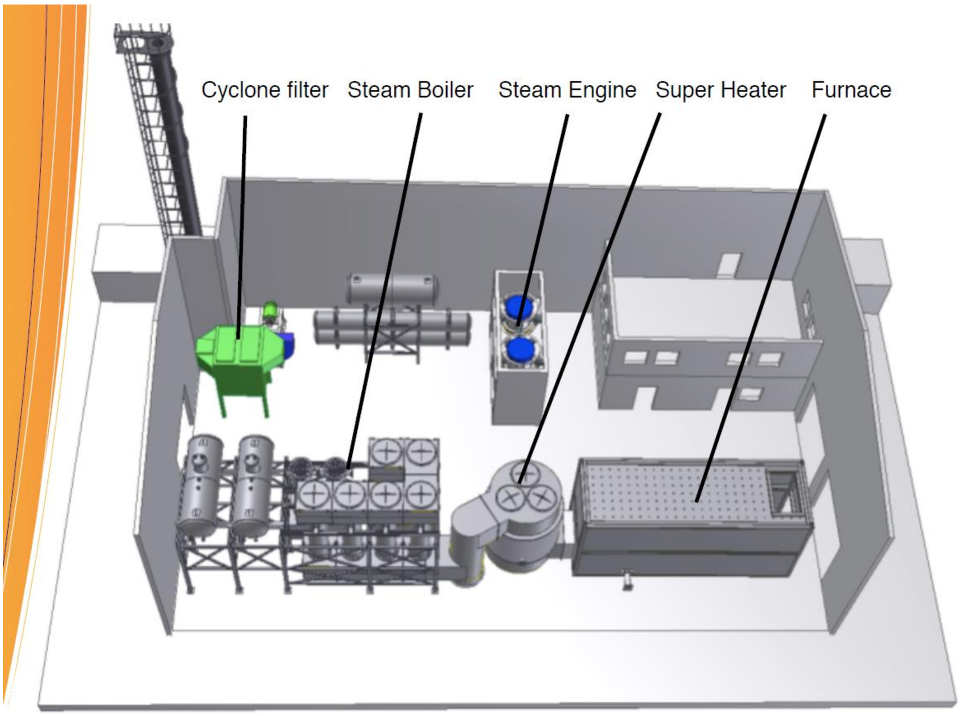


FIGURE 7 LAYOUT OF COMBINED HEAT AND POWER STATION (2MW)

The profitability of combined heat and power plants is dependent on the costs of fuel and the infeed price paid by utilities for electricity supplied to them. Where the infeed price exceeds 100USD/MWhr then delivered biomass prices below USD70/tonne at 30% moisture content provide a viable business for electricity sales. Where the heat can be sold as well then there is the potential for a rapid return on the investment.

6.2.2.Export

It has been suggested that there is a potential to export biomass from the plantations in Niassa. This could be in the form of woodchips which could either be burnt for power and heat generation or could be used for manufacture of pulp. It could also be pre-processed into briquettes or pellets in order to increase the density of the product and thereby to reduce the transport costs and increase the price. Prices paid for biomass in the European markets are increasing steadily since the 1990s. The increasing fuel costs however also increases the transport costs for long distance movement which may render an export business based on forest residues uneconomic. There is an increasing demand for biomass in order to fulfil developed countries targets for renewable energy sources. This is reflected in increasing prices paid for biomass both as a result of increasing demand and increasing oil prices. However in the UK there is still very little import of biomass since imported sources are not able to compete on price with locally produced material. Local production is either a waste by product or comes from specially grown short rotation energy crops.

Delivered bulk biomass prices for industrial use (Combined Heat and Power) in the UK range from USD50 to 80 per dry tonne while smaller consumers can expect to pay up to USD300 per dry tonne. At present the lower prices paid by industrial users are very competitive with oil and gas but the prices paid by individual consumers are much less competitive particularly with gas.

Chipping
The most common form of use of biomass is in the form of chips. Chipping can be done at a variety of sites using either chipping or crushing technology to produce the chips. The site of chipping affects both the costs and the logistics. Effectively four choices exist, chipping in field, chipping at landing, chipping at a dedicated terminal and chipping at the point of use. The purpose of chipping before transport is to reduce the volume of the material in order to make transport more efficient. Where chipping is carried out in field only lightweight chipping plant can be used, at a landing intermediate equipment can be used and at a fixed site (terminal or plant) heavyweight equipment which is more durable and more efficient can be used. In some cases it is possible to compress the forest waste in field in order to increase its density in order to reduce short-haul transport costs. Costs of chipping equipment are also very variable depending on the capacity and production of the system. Chippers for use in field and capable of producing a few tonnes per hour start at prices of USD 15-20000 while large chippers with capacities of 100 tonnes per hour will generally cost several million USD. The optimum system to be used will depend on the market demands and the Spatial distribution of the biomass sources.
Chips can be shipped as bulk freight in specially designed ships and there is an increasing market demand for biomass so that this capacity is likely to increase.

Pelletting or Briquetting
In order to increase the density and to reduce shipping costs chips or sawdusts from mills can be compressed into pellets or briquettes for specific types of burners. This can also add value to the biomass produced. Pellets used for heating

are approximately 3 times the price of chips in the UK market and fetch up to USD300 per oven dried tonne at retail, delivered in bulk to a consumer. However it must be recognised that this includes the margins and logistic costs of a number of middlemen who transport and store the material.

Logistics and Costs

Biomass material from the forest will need to be transported to a suitable port, probably Beira or Pemba for shipping to a final destination by sea. The distances involved are likely to be approximately 600km from Niassa to Pemba and approximately 300km for shipments from Manica to Beira. Road Transport costs in Africa are relatively high at 0.06USD per tonne/km. Resulting in a road cost of USD 36 per tonne from Niassa and USD 18 per tonne from Manica to the nearest suitable ports. Shipping costs for bulk delivery are likely to be in the range of USD30-50. Currently therefore the prices paid in overseas markets are unlikely to cover the costs of transporting the material to those markets.

6.3. Protecting the forest from the market

Where biomass usage projects are successful and profitable there is a strong risk of overexploitation of the forest in order to achieve short term returns. This is particularly likely to occur where biomass from natural stands is supplied by outsiders. In addition due to the transport costs involved it is always more profitable in the short run to harvest biomass close to the processing plant. There is therefore a risk of local depletion of the resource. In order to overcome this risk it is necessary to put in place strong control systems. Fortunately the volumes required by biomass processing facilities are very large (>100 tonnes/day) so that it is relatively easy to track and trace the transport systems used.

The biomass supply should be verified as coming from forest areas that are being managed under a sustainable harvesting and silviculture plan that is supervised by professional foresters.

7. Field observations

Six days were spent in the Lichinga district by the consultants van Hensbergen and Drakenberg, in addition X days were spent in the ???? district by the consultants Pechisso and Taquidir. During this time field observations were made in a variety of miombo sites in order to determine the condition of the woodlands and to identify possible criteria for evaluating their environmental and biodiversity value. These sites were principally in the land holding of the existing plantation forestry companies. For confidentiality reasons the sites visited are not identified as to ownership. Principal observations made at the site included the species composition, defined in terms of their position in the miombo succession. pioneer, mid or late succession. Evidence of recent fire. Canopy height taken as the height to the bottom of the canopy. Canopy closure estimated on a five point scale, Closed >80%, Partially Closed >50%, Open <50% >30%, Sparse <30% >10%, none < 10%. Basal area estimated using a relascope and based on a minimum of 4 readings taken in the stand. Stand volume calculated as basal area/2*canopy height. The amount of regeneration at the site was also estimated. Sites were sampled over an area of approximately half a hectare, approximately half an hour was spent at each site. In addition for some sites where quick inspection suggested a higher biodiversity potential, a version of the Swedish biodiversity potential estimation instrument, modified for use in miombo situations in Tanzania was applies at the site and a biodiversity potential score was calculated.

7.1. Site observations

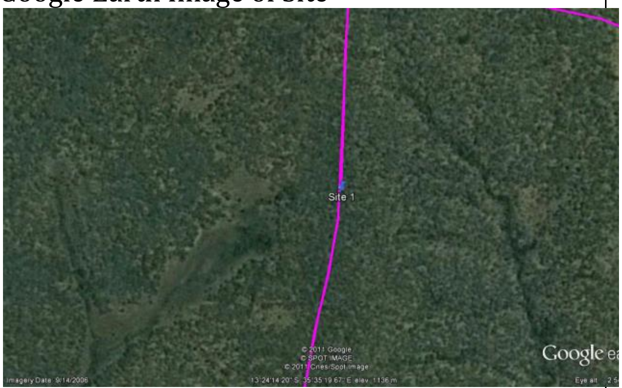
Site 1

Situation of site	This site adjoined a recently established plantation stand and was located on a ridgetop close to sites that were in use for swidden agriculture.
Species composition	The site was dominated by a single early succession miombo species (Uapaca sp.). This species accounted for 90% of the canopy and practically 100% of the understorey. Late succession miombo trees occurred at a density of approximately 10/ha
Canopy Closure	Partially closed. 50 > 80
Fire	Not burnt during previous fire season, protected by fire belt.
Stand height	7.5m
Stand basal area	11 m2
Stand Volume	41.25m3
Regeneration	Many specimens of Uapaca sp. of all sizes including pole size. Practical absence of regeneration of later succession species, no pole sized individuals of late succession.
Biodiversity Potential	1

Pole sized trees all Uapaca

Canopy cover > 90% Uapaca

Google Earth Image of Site



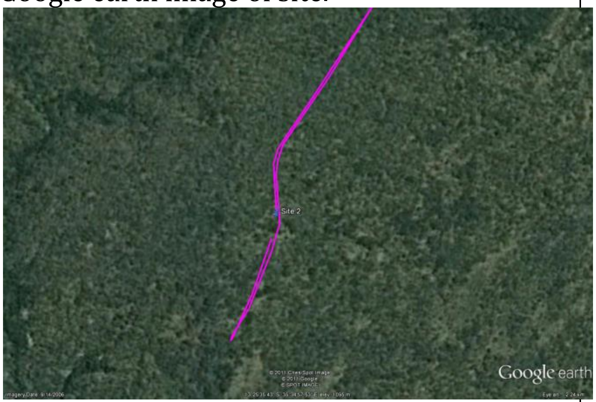
Site 2

Situation of site	On a rocky ridge close to site 1.
Species composition	Dominated by later succession species.
Canopy Closure	Open canopy. >30 <50%
Fire	No evidence of fire during last burning season.
Stand height	10m
Stand basal area	13m3
Stand Volume	55m3
Regeneration	Some small seedlings of late succession miombo species. Pole sized trees almost absent.
Biodiversity Potential	9

Pole sized trees almost absent. Canopy late succession.

Sparse cover of late miombo seedlings

Google earth image of site.



Site 3

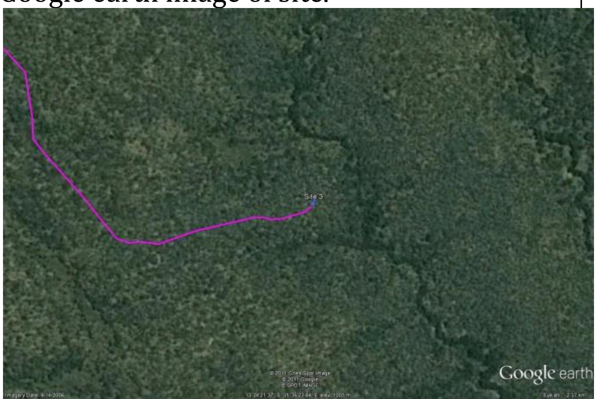
Situation of site	Riparian set aside zone. At least 100m wide along small stream, informed that stream becomes significant torrent during rainy period.
Species composition	Dominated by late succession miombo species. In some areas presence of lianas. Epiphytes absent. Some large trees over 60cm diameter present.
Canopy Closure	Open canopy >30 <50
Fire	No evidence of fire in last season
Stand height	8.7m
Stand basal area	16.3m2
Stand Volume	70.9m3
Regeneration	Abundant seedlings of late succession miombo trees. Abundant pole sized trees of late succession miombo species.
Biodiversity Potential	13

Looking into site. Showing good canopy of late succession miombo.

Abundant pole sized trees.

Abundant field layer regeneration

Google earth image of site.



Site 4

Situation of site	Adjacent to village. Sloping towards a drainage line. Very heavy lopping of all pole sized trees and remnant larger trees for firewood.
Species composition	Many small miombo trees generally resprouting from coppice. Few scattered late succession miombo trees.
Canopy Closure	None <10%
Fire	Site burned during present season.
Stand height	Dominant height 50cm, scattered large trees 4.5m
Stand basal area	2m2
Stand Volume	4.5m3
Regeneration	Resprouting from coppice, and resprouting from suffrutexes.
Biodiversity Potential	3

Very sparse canopy of late succession miombo species.

Abundant post fire suffrutex coppices. Absence of pole sized trees.

Pole sized trees all lopped.

Google Earth Image of Site

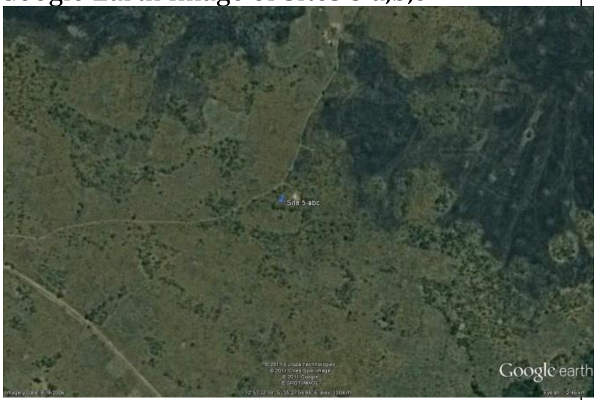
Site 5a

Situation of site	Approximately 1km from village. Adjacent to a government gravel pit. Heavy lopping for firewood. Scattered larger trees.
Species composition	Late succession miombo species
Canopy Closure	None < 10%
Fire	Burnt this season
Stand height	4m
Stand basal area	2m2
Stand Volume	2m3
Regeneration	Resprouting from coppice and suffrutex. Pole sized trees heavily lopped. No recruitment to adult population.
Biodiversity Potential	3

Pole sized trees heavily used.

No canopy above 4m

Google Earth Image of Sites 5 a,b,c



Site 5b

Situation of site	1km from village. Adjacent to gravel pit. Lightly disturbed by lopping.
Species composition	Late succession miombo species.
Canopy Closure	Sparse >10 <30%
Fire	Not burned this season.
Stand height	8m
Stand basal area	10m2
Stand Volume	40m3
Regeneration	Seedlings present. Pole sized trees present. Recruitment to adult size trees common.
Biodiversity Potential	8

Trees of all sizes present with obvious recruitment to adult stages.

Site 5c

Situation of site	1km from village. Close to government gravel pit. Area thought to have been used fro charcoal making in recent past. Scattered large trees
Species composition	Late succession miombo.
Canopy Closure	Sparse < 30%
Fire	Not burnt in last season.
Stand height	8m
Stand basal area	7m2
Stand Volume	28m3
Regeneration	Abundant coppicing. Few pole sized trees.
Biodiversity Potential	8

Area opened up by charcoal making. 	Stumps from larger trees cut for charcoal clearly visible. 

Site 6

Situation of site	A graveyard site of very dense forest. Set aside from the plantation. Close to a former settlement.
Species composition	Site dominated by uapaca of two species. Canopy approxiamtely 90% uapaca. Many small and pole sized brachystegia and julbernardia.
Canopy Closure	Closed >80%
Fire	Site not burned recently. Dense canopy ensures that there is no fuel growth at ground level.
Stand height	6m
Stand basal area	27m2
Stand Volume	81m3
Regeneration	Abundant regeneration of late succession species. Many pole sized trees.
Biodiversity Potential	3

Site seen from outside. 	Canopy dominated by Uapaca sp. 
Pole sized trees present in and outside patch. Late succession species common. 	Google Earth image of Site 

Site 7

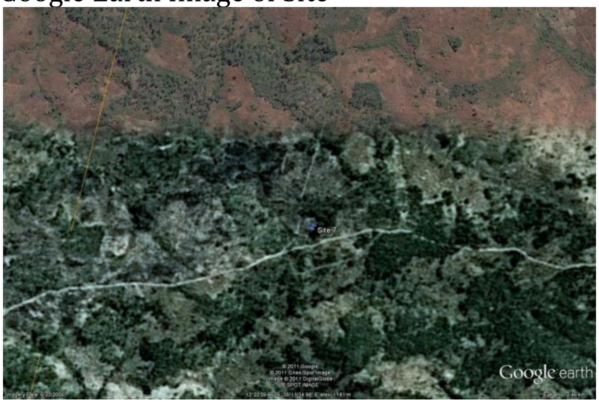
Situation of site	Close to village. Evidence of previous use for agriculture. No large trees. Majority of trees at pole stage up to 10cm diameter
Species composition	Mostly late succession miombo species.
Canopy Closure	Open >30 <50%
Fire	Burnt annually. Burnt in last season.
Stand height	6m
Stand basal area	6m2 but strong variation on site with patches in excess of 10m2 and remainder 4m2
Stand Volume	12m3 in less dense patches and 30m3 in denser patches.
Regeneration	Regeneration from coppice post fire. No intermediate sized saplings. Dominated by pole sized trees in diameter class 5-10cm
Biodiversity Potential	7

Large trees absent, variable density stand.

Extensive lopping for poles and firewood.

Strong coppice regeneration of late succession miombo species.

Google Earth Image of Site



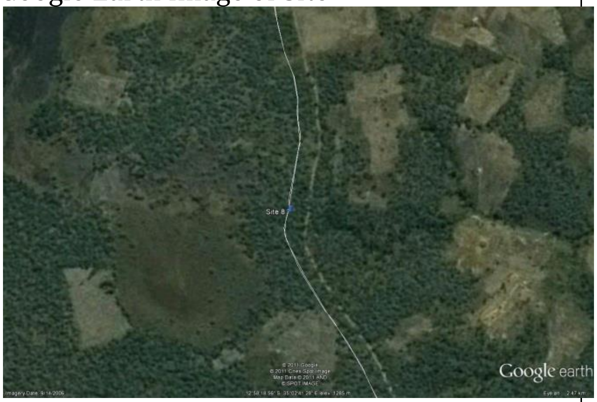
Site 8

Situation of site	Adjacent to similar area cleared recently for Shamba use during current year. Less than 500 metres from two dwellings.
Species composition	Dominated by Uapaca. Less than 10% of canopy formed of late succession tree species.
Canopy Closure	Partially closed >50 <80%
Fire	Burnt this year.
Stand height	8.5m
Stand basal area	11.3m2
Stand Volume	48m3
Regeneration	Brachystegia abundantly resprouting from suffrutex. No pole stage late succession species. Plentiful pole stage Uapaca.
Biodiversity Potential	4

All trees taller than 1m are Uapaca sp.

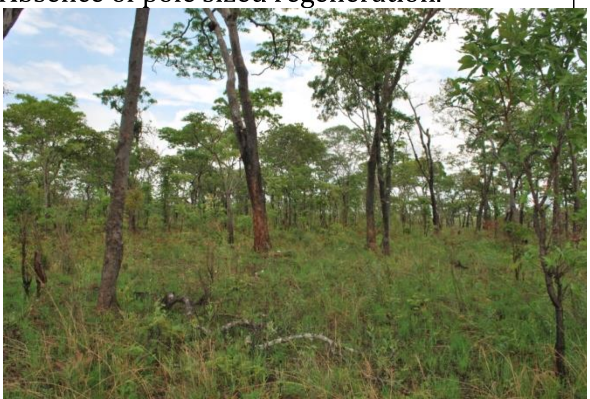
Adjacent area cleared for Shamba this season.

Google Earth Image of Site.



Site 9

Situation of site	Site situated about 100m from a dwelling and adjacent to an area cleared for Shamba.
Species composition	Canopy dominated by late succession miombo. Some taller miombo. Uapaca present in canopy at less than 10%
Canopy Closure	Open >30 <50%
Fire	Burnt this year.
Stand height	12m
Stand basal area	10m2
Stand Volume	60m3
Regeneration	Abundant late succession seedlings and suffrutex coppices. No pole stage trees present.
Biodiversity Potential	10

Open canopy of late succession miombo species. 	Heavy cutting for poles and firewood. 
Absence of pole sized regeneration. 	Google Earth Image of Site. 

Site 10

Situation of site	Site approximately 200m from main road. More than 2km from closest dwellings. Site selected for its appearance of being mature undisturbed miombo. Site on slope and rather stony. Stream adjacent to site. Baboons seen at site. Site lightly disturbed with several trees cut.
Species composition	Dominated by late succession miombo species. Some taller emergent trees of late succession species.
Canopy Closure	Open >30 <50%
Fire	Burned this year.
Stand height	10m (emergents to 20m)
Stand basal area	15m2
Stand Volume	75m3
Regeneration	Abundant pole stage trees of late succession species.
Biodiversity Potential	13

View of site canopy from outside 	Abundant pole sized trees. 
	Google Earth Image of site. 

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Appendix 1. Draft version of biodiversity assessment tool for use in miombo woodlands in Mozambique

Test version: ASSESSMENT OF LICHINGA MIOMBO FOREST BIODIVERSITY POTENTIAL

SITE	M	TREES	M
1. Conspicuously broken terrain / varied topography	◯	31. Substantial amounts of high bushes > 2 m other species than small canopy trees	◯
2. Vertical cliff / scree-slope > 10 m high	◯	32. Several Pterocarpus / Dalbergia / Afzelia / Milicia /Khaya / Pericopsis / ……..	◯
3. Forested gorge / ravine > 10 m deep	◯	33. Substantial amounts of Pterocarpus / Dalbergia / Afzelia / Milicia,,,,,,,, >10 cm	◯
4. Site characterised by slope steeper than 15% (3:20)	◯	34. Several Pterocarpus / Dalbergia / Afzelia / Milicia> 20 cm	◯
5. Site characterised by normally wet / very wet forest	◯	35. Substantial amounts of inmix tree species (Vitex, Sterculia, Parinari, Monetus, Albizzia)	◯
6. Riverine area with perennial stream in forested surroundings	◯	36. Substantial amounts of trees > 20 cm	◯
7. Site characterised by a conspicuous herb component	◯	37. More than 6 tree species > 20 cm	◯
8.	◯	38. Several trees > 40 cm	◯
9.	◯	39. Substantial amounts of trees > 40 cm	◯
10.		40. Several trees > 60 cm	◯
DYNAMICS		**STRUCTURE AND EPIPHYTIC VEGETATION**	
11. Several large >20 cm trees with basal scars from forest fires	◯	41. Trees > 10 cm characterised by a conspicuous girth / age variation	◯
12. Several large >20 cm trees with successive scars from different fires	◯	42. Several trees stand out as consp. older / larger than the stand in general	◯
13. Forest area > 0,1 ha unaffected by a recent fire	◯	43. Substantial amounts of trees as above	◯
14. Several canopy gaps less than 0,1 ha with natural saplings of main canopy tree	◯	44. Main canopy cover above 30%	◯
15. Substantial amounts of > 3 m saplings of main canopy tree species	◯	45. *Main canopy cover above 60%*	◯
16. Substantial amounts of basally single-stammed trees > 10 cm	◯	46. Several trees with occurrences of orchids / other epiphytes	◯
17. Non-native Acacias or other exotic trees absent / controlled	◯	47. Substantial amounts of trees with occurr. of orchids / other epiphytes(excl pendulous	◯
18. Seasonally inundated area >0,1 ha in forested surroundings	◯	48. Several trees with conspicuous occurrences of lianas	◯
	◯		◯
HABITATS		**DEAD WOOD**	
20. Area > 0,1 ha of normally wet / very wet forest	◯	50. Several erect dying / dead trees / > 2 m high stumps > 20 cm	◯
21. Permanent wetland area > 1 ha	◯	61. Substantial amounts of erect dying / dead trees / > 2 m high stumps > 20 cm	◯
22. Seasonal stream in forested surroundings	◯	62. Several rot-broken trees	◯
23. White-water / rapids / waterfall >2 m high in forested surroundings	◯	63. Several fallen logs > 20 cm.	◯
24. Forest in contact with / enclosing open Dambo > 0,1 ha	◯	64. Several fallen logs > 20 cm in various stages of decay	
25. Forest in contact with open grassland /grassland with scattered trees	◯	65. Substantial amounts of fallen logs > 20 cm	◯
26. Shaded > 2 m high vertical cliff with a mixed moss / fern / lichen cover	◯	66. Fallen logs > 40 cm	◯
27. Area > 0,1 ha of forested rocky outcrop / ground with very shallow soils	◯	67. Several trees / stumps / logs with conspicuous occurrences of fungi	◯
28. Boulder terrain > 0,1 ha / large boulders > 2 m high	◯	68. Substantial amount of dead wood with fungi	◯
29. Conspicuous hollow tree / nest of coarse twigs / several nesting holes	◯		◯
30. Hollow tree > 40 cm with a major cavity in the trunk	◯		
Lichinga test version **SITE SCORE**		**STAND SCORE**	

FOREST BIODIVERSITY ASSESSMENT

Stand no:	Area:

Description:

Site score + Stand score = Biodiversity potential score	
D – Drier, uphill Dense Miombo dominated by Brachystegia bussei "Male Miombo"	-
M- Mesic or wet flatland or small hill miombo dominated by open Brachystegia bohemii, "Female Miombo"	
E - Evergreen forests, normally rich with epiphytes like lianas and orchids	

Noted species and cultural remnants:
Management suggestions:
For enquiries contact authors: drakenb@algonet.se

Some brief comments on use and evaluation.

* Assessed sites may be from 0,5 ha up to several 10:s of ha but they should represent a fairly homogenous site type where canopy is similar. Smaller habitats like fens, rock outcrops, dambos and forest brows may be included.
* A feature scoring as several must be present at least 2 / ha on an average.
* A feature scoring as substantial amounts of must be present in such amounts that several of it can be seen anywhere in the stand without having to search specially for it.
* In some cases the assessment asks for the same feature as previous question but with a raised level (dimensions, amounts of). If the higher level is reached both questions score.
* Questions 1-30 score regardless of the size of the stand / site.
* Questions 31 - 60 only score if they reach the required amounts expressed as an average/ha.
* The dashes mean either / or, the asked features may appear singly or in combination.
* Conspicuous features (thick branches, hollow trees et.c.) must be conspicuous enough to be seen as locally more distinct than what is the normal case in the assessed area/province.
* Diameter refers to breast height, for downlogs it refers to the thickest part.
* Canopy tree species are Brachystegia, Isoberlinina, Julbernadia...............
* Inmix tree species include the following genera: Vitex spp, Annona spp, Combretum spp, Pseudolachnostylis ssp, Diospyros spp, Syzygium spp, Sterculia spp.Parinari spp., Monetus, Albizzia spp.

Interpretation and use.

* The sum of site and stand scores is a general figure that indicates the potential for biodiversity or in other words the suitability of the assessed site for rare or unusual species. It is important that this figure is not seen as an exacting figure on the presence of rare species.
* The score may not be interpreted as an exacting nature value assessment partly because some items are very rare and more important for biodiversity while others may be more common, partly because the methodology itself is based on some subjective judgements.
* The selection of sites / stands for protection, adapted management or conversion depends partly on the score, partly on a judgement on which site types, structures and features that are rare or underrepresented in the region. The position in the landscape is also important i.e. the possibilities of linking riverine habitats with similar sites.
* Sites with a very low site score may be seen as less valuable because they lack the basal character that is typical of natural, less degraded miombo, hence thay will not always carry a high biodiversity.
* Large sites with a high stand score have a markedly higher value than small sites with corresponding scoring because of the larger amounts evidently present.

Management

* Many of the asked questions refer to conditions that can be maintained or changed by dircect or indirect management towards an objective -which may be productive or purely conservation objectives. Characteristics of natural Miombo forests are reflected in the many questions and by analyzing which ones that do not score in a given stand one can get a view of what is missing from purely conservation standpoints. Stands with a high score are normally not in need for active management in the short term but stands with a low score where objectives are conservation can well be managed towards a higher level of potential for biodiversity. In a Miombo forest managed towards a production objective the same analysis can be applied as to ensure that the potential for biodiversity is not unecessarily lowered.