Technical Specification: **MOZ-TS-WL**

System: Woodlot
Variation: Timber / Fuelwood

Main tree species

Miombo spp.		
Cordia africana	Mutondo	Wild mango
Afzelia quanzensis	Chamfuta	Pod mahogany
Sclerocarya birrea	Amarula	Marula
Tamarindus indica	Tamalinoninho	Tamarind
Zisiphus mauritania	Massanica	Zisiphus
Pterocarpus angolensis	Umbila	Wild teak
Millettia stuhlmanii	Panga panga	Panga panga
Strychnos innocua	Mutemo	
Kigelia africana	Muvunguti	Sausage tree
Swartzia madagascariensis	Pau rosa	Rosewood
Julbernadia globiflora	Muhimbie	Muhimbe
Brachystegia boehmii	Mfuti	Mufuti
Timber spp.		
Khaya nyasica	Umbaua	Red mahogany
Fuelwood and poles spp		
Albizia lebbeck	Albizia	

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Summary

This system will be used to re-establish Miombo woodland. In the long term these areas will be managed for the sustainable production of native hard wood timbers. In the short term (where appropriate) these areas will help to meet local demand for fuelwood and building materials. This system can be used to restore degraded areas of forest. This system is the most appropriate to use on old mashambas (i.e. that have been abandoned for many years).

Ecology

Altitudinal range. These species will grow mostly at low to medium altitudes (up to 1,000 m above sea level). Most will grow up to 1,500 – 2,000 m. Amarula will only grow up to 800 m.
Climatic factors – Typically Miombo species are very drought tolerant and frost sensitive. Typically annual precipitation in the range 700 – 2000 mm is required. Amarula, tamarind, ziziphus and mutemo will tolerate drier conditions (as low as 200 mm per year).
Habitat requirements – Typically Miombo species prefer well drained soils. Most of these species are very drought tolerant but will thrive on moist sites.

Growth habit

Most Miombo species are relatively slow growing. Many of these species are deciduous loosing their leaves during the long dry spell. Red mahogany is best planted in moist areas where very fast growth rates may be achieved.

Timber products

Cordia africana	Fruit, timber and a good tree for apiculture
Afzelia quanzensis	Hard timber, easy to work, durable and resistant to termites. Used for construction, boat building, furniture, flooring and

	turning
Sclerocarya birrea	Light, soft timber suitable for crafts and furniture
Tamarindus indica	Very hard durable timber. Will take a fine polish and can be used for general carpentry.
Zisiphus mauritania	Medium weight hardwood which is durable but will split easily. Can be used for construction and furniture. Excellent fuelwood
Pterocarpus angolensis	High value, very durable timber. Also useful for medicine, apiculture, fodder and tannins.
Millettia stuhlmanii	Useful for bee hives and apiculture
Strychnos innocua	Use for fuel wood, fodder, food timber and medicine
Kigelia africana	
Swartzia madagascariensis	Very hard wood
Julbernardia globiflora	
Brachystegia boehmii	
Albizia lebbeck	Fuel wood and poles
Khaya nyasica	Furniture, timber frames, veneer and dugout canoes

Classification of climate/ site productivity

Climate is classed as optimal and sub-optimal based on available ecological information and experiences within the project. (The use of this system in areas classified as sub-optimal for climatic conditions is not recommended.)

Optimal	Description of climate Range - 0 – 1,000 masl Range - 700 – 1,500mm/yr
Sub-optimal	Description of climate Range - 1,000 – 2,000masl Range - 350 – 2,500 mm/yr

Site productivity is inferred from locally reported soil conditions for the site

	High	**Medium**	**Low**
Soil type	Deep (>30cm), well drained, brown-black, few stones	20-30cm depth, heavy clays or sandy	Thin (<20cm), stoney, compacted soils or oxidised clays

Management objectives

Main management objectives. Re-establishment of native woodland species which can be managed in the future for sustainable fuelwood and timber production.

Potential income Fuelwood Poles Timber
Costs of implementation Estimated costs per **ha**: Establishment (year 1):25,000 Meticais ($1,100) Maintenance (year 2 – 5): 10,000 Meticais ($430) Opportunity cost (lost production from land): N/A N.B. The above costs include values for the purchase of seedlings and for time that the farmer would spend on establishment and maintenance of the trees. However, in the first years of the project (during the Pilot Phase) seedlings are supplied at no cost to the farmer and most farmers will plant and maintain their own trees so this is not actually a cost that will be incurred.

Management operations

Establishment Competing vegetation (**other than trees**) should be cut and the foliage left on site to act as an organic fertilizer, and to conserve soil moisture. Miombo and timber trees should be planted in rows 3 meters apart (1,100 trees / ha). Trees planted for fuel wood, poles and soil improvement (such as albizia) should be planted between timber trees. These trees will be coppiced and thinned out over time. Any trees that already exist on the site should be left. Plant around these trees. It is best to plant at the beginning of the wet season to minimize the requirement to water the seedlings. Mulch should be placed around the base of the seedlings to help retain soil moisture whilst also reducing the growth of competing vegetation and adding fertility to the soil. When planting: • Care should be taken handling plants not to cause damage to shoots, buds or bark • Only remove plastic from around root-ball at the time of planting. Care should be taken to remove all the plastic • Prune back roots (especially any circular roots) at the time of planting to stimulate new root growth once in the ground • Plant to depth of root collar (i.e., for bagged plants, to level of existing soil). Never plant deeper than in nursery leaving no roots exposed. • Ensure that soil is replaced firmly around trees (i.e., well heeled in). Put top soil back in planting hole first Plant at the beginning of the rainy season to avoid the need for irrigation.
Maintenance The removal of all competing vegetation will be required twice a year for the first three years after planting, or until the trees have reached a height of 1.5 - 2 m. Weeding intensity can be reduced to once per year after the third year until approximately the sixth year (or once the trees are no longer in competition with weeds). Prune side branches of timber trees to create clear boles of high value. Offcuts can be used for fuel wood. No burning is allowed at any time. Any foliage should be left on site. Fire breaks should also be maintained between mashambas. All seedlings will require protection from goats.
Thinning and harvest Coppice albizia on 3 – 10 year cycle for fuel wood and poles to be used in construction.

Red mahogany, mbila, amarula and panga panga should be harvested on a 60 cycle. Other species including muhimbie should be harvested on a 100 year cycle.
Re-establishment Fuelwood and pole wood species (e.g. albizia) are to be coppiced on a three to ten year rotation for up to 25 years after which no re-establishment will be possible because of excessive shading from other trees. Miombo and timber tree species should be replaced when felled.

Carbon sequestration potential
Carbon sequestration potential over ***100*** years on an average quality site with optimal climatic conditions is **50** tC/ha above an initial vegetation carbon baseline of **11.3** tC/ha (Sambane, 2005). The Nhambita carbon calculator (ECCM, 2005) should be used to calculate the number of saleable carbon credits based on the land use system and area planted.

Carbon sequestration potential is based on average net carbon storage in biomass and forest products. Carbon storage is calculated using the CO2FIX-V3 model (Mohren et al 2004). Details of the parameters used (basic wood carbon content; timber production; total tree increment relative to timber production; turnover rate; product allocation for thinnings and expected lifetime of products) are given below.

The carbon sequestration potential of this system has been calculated using the species composition and assumed annual timber production shown in the table below:

Tree species	Proportion of planting (%)	Mean annual increment (m^3/ha)	Dry wood density (kg/m^3)	Rotation (no. of years)
Albizzia[1]	64	12.0	600	25
Red mahogany	20	11.2	590	60
Amarula	25	5.8	590	60
Panga panga	25	4.6	720	60
Mbila	15	5.9	640	60
Muhimbie	15	1.5	780	100

This species composition is likely to be representative of actual planting and growth data (MAI and CAI) has been obtained for these species which can be used to model carbon sequestration. Pole wood and fuelwood species such as acacia and albizia should be planted throughout where possible and appropriate.

N.B. Stem increment (MAI & CAI) was calculated on the basis of trees measured within the project area. The number of trees measured so far is relatively small. As the project expands and more data becomes available these calculations might be revised and updated.

N.B.B **50 tonnes of carbon** is equivalent to **183.3 tonnes of carbon dioxide**.

[1] Albizia has been modelled as if coppiced on a five year rotation and assumed not to re-establish after year 25 because of excessive shading from other trees. For the purposes of the calculation of carbon sequestration potential by the Woodlot system an overall stocking density of 1,100 trees has been assumed. The calculations for carbon sequestration potential by timber species (red mahogany, amarula, panga panga, mbila and muhimbie) are based on an assumed stocking density of 400 trees / ha. The calculation for fuel wood species (albizzia) assumes a stocking density of 1,100 trees / ha. For the purposes of these calculations we assume that although 400 timber tree species are planted per ha this is equivalent to 100% of the required stocking density. Planting of fuel wood species in between the timber tree species will make up the difference between 400 trees and 1,100 (i.e. 64%)

Monitoring

Monitoring targets for the first 4 years are based on establishment; the whole plot must be established by the third year with at least 85% survival of seedlings. Thereafter monitoring targets are based on DBH, the expected DBH at the time of monitoring is based on a predicted mean annual diameter increment on which carbon sequestration estimates are based.

Year	**Indicator**
1	At least 35% plot established
2	At least 70% plot established
3	Whole plot established, 85% survival (at least **935** stems /ha)
4	Whole plot established
5	Average DBH not less than 6cm
6	Average DBH not less than 7cm
7	Average DBH not less than 9cm
10	Average DBH not less than 13cm

Additional information

Amarula
Psyllid mites, aphids and wood susceptible to termite and wood borer attack.

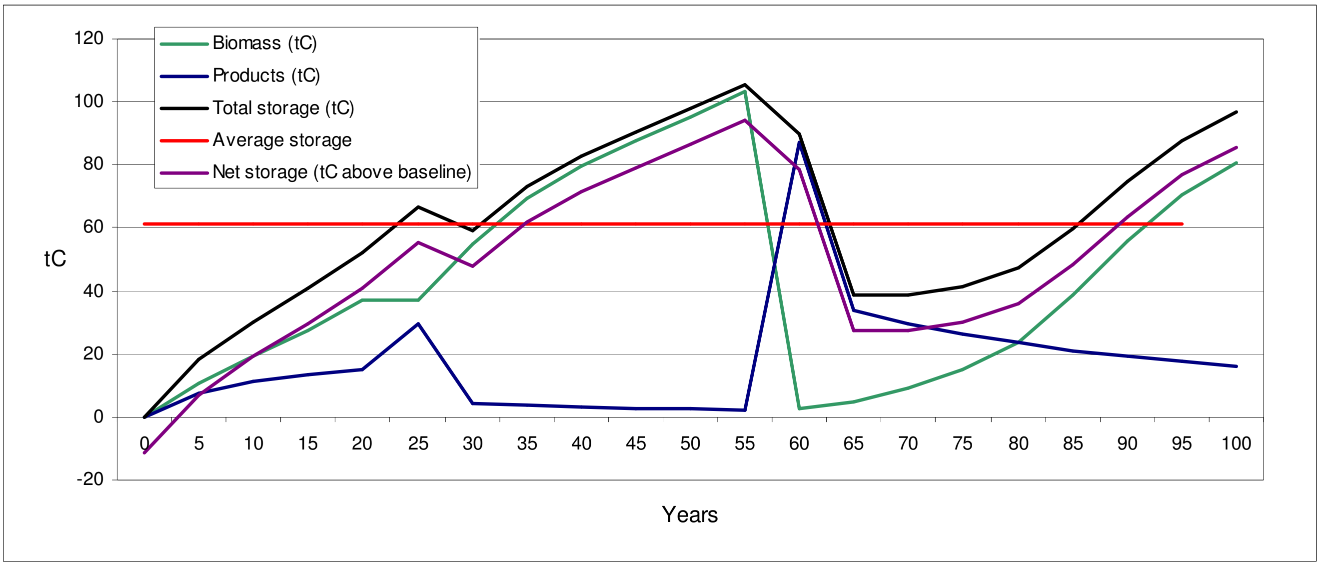
Tamarind
Scale insects, mealy bugs and borers

Ziziphus
Fruit flies can be a major cause of crop loss

Red mahogany
Shoot borer (will damage leading stem and reduce timber quality)

Appendix 1 Carbon storage figures

Year	Biomass (tC)	Products (tC)	Total storage (tC)	Net storage (tC above baseline)	Accumulated tCyr
0	0	0	0	-11.3	
5	10.9592	7.264	18.2	6.9	58.4
10	19.1967	11.1488	30.3	19.0	177.0
15	27.5341	13.4912	41.0	29.7	346.0
20	37.229	15.0144	52.2	40.9	567.3
25	37.3225	29.44	66.8	55.5	854.6
30	54.743	4.4224	59.2	47.9	1118.6
35	69.555	3.6544	73.2	61.9	1457.8
40	79.6785	3.104	82.8	71.5	1854.7
45	87.6215	2.7072	90.3	79.0	2291.2
50	95.4055	2.4128	97.8	86.5	2765.4
55	103.3305	2.2016	105.5	94.2	3277.5
60	2.794	86.9297	89.7	78.4	3805.2
65	4.918	33.9372	38.9	27.6	4026.4
70	8.9675	29.6202	38.6	27.3	4218.4
75	15.1235	26.3045	41.4	30.1	4418.7
80	23.68	23.5146	47.2	35.9	4642.0
85	38.4495	21.157	59.6	48.3	4911.7
90	55.75	19.1518	74.9	63.6	5256.0
95	70.515	17.4395	88.0	76.7	5670.8
100	80.6125	15.9662	96.6	85.3	6138.6



Appendix 2 - CO2Fix Inputs

Stand parameters		
Rotation length (yr)		**Tree species** / **Rotation legnth**: Red mahogany 60; Amarula 60; Panga panga 60; Mbila 60; Muhimbie 100; Albizia 25
Number of rotations		2 (only 1 rotation for albizia)
Adjustment of assimilate to account for non-optimal site conditions	Foliage	1
	Branches	1
	roots	1
Initial biomass (Mg/ha)	Foliage	0
	Roots	0
	Litter	0
	Branches	0
	Stems	0
	Deadwood	0

Tree species	**Rotation legnth**
Red mahogany	60
Amarula	60
Panga panga	60
Mbila	60
Muhimbie	100
Albizia	25

Stem increment **CAI** (m3/ha/yr)							Dry weight increment relative to stem		
							foliage	branches	roots
Year	Albizia	Red mahogany	Amarula	Panga panga	Muhimbie	Mbila	0.35	0.2	0.25
5	12.0	2.3	0.5	1.7	2.4	0.6			
10		2.3	0.5	3.5	2.4				
15		4.6	1.0	6.9	1.1	1.3			
20		9.1	1.9	6.2		2.6			
25		23.0	4.9	5.4		3.8			
30		24.0	5.5	4.6		5.1			
35		20.8	6.1	3.9	1.1	6.3			
40		13.2	6.8	3.1		7.6			
45			7.4	2.3		8.9			
50				1.6		10.1			
55						11.4			
60						12.6			

Tree species Parameters	
Basic density of stemwood (kg/m^3)	see below
Carbon content of dry matter (proportion of dry weight)	0.5

Tree species	**Kg/m^3**
Red mahogany	590
Amarula	590
Panga panga	720
Mbila	640
Muhimbie	780
Albizia	600

Turnover of various biomass components (1/yr)	Foliage	1
	Branches	0.05
	Roots	0.07
Mortality as a fraction of trees per year (1/yr)		0.0
Average residence time of carbon in wood products (1/yr)	Dead wood	10
	Energy	1
	Packing	5
	Construction	25

Thinning and harvest table						
Thinning age (Yr)	Species	Fraction stem removed	Dead wood	Energy	Packing	Construction
5	Albizia	50	0.0	0.8	0	0.2
10	Albizia	50	0.0	0.8	0	0.2
15	Albizia	50	0.0	0.8	0	0.2
20	Albizia	50	0.0	0.8	0	0.2
25	Albizia	100	0.0	0.8	0	0.2
60	Red mahogany, amarula, mbila & panga panga	100	0.0	0.3	0	0.7
100	Muhimbie	100	0.0	0.3	0	0.7

References

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World Agroforestry Centre (2004). Agroforestry tree database.

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