Technical Specification: MOZ-NHA-FO-MANGO
Last modified: 8 May 2009

System: Fruit orchard
Variation: Mango

Main tree species

Mangifera Indica	Mango	Mangueira

.

Minor tree species

Citrus sinensis	Orange	
Carica papaya	Papaya	
Morus alba	Mulberry	
Psidium guajava	Guava	
Zisiphus mauritania	Zisiphus	

.

Summary

Under this land use system more than 80% of the area is planted with mango trees which will be managed in the future for commercial production of mango fruit. Any remaining area can be planted with other fruit and / or fuelwood species for domestic consumption.

Ecology

Altitudinal range. Mango will grow from sea level up to 1,200 m above sea level. For successful fruit production (especially from cultivars) mango should only be grown up to 600 m above sea level.
Climatic factors – Mean temperature of 20℃ to 37℃. The optimum temperature range is 24℃ – 27℃. No frost tolerance. A distinct dry season (more than 3 months) is required for fruit production.
Habitat requirements. There are no major limiting factors. Mango trees are tolerant of both drought and occasional flooding. For good growth deep soils are required to accommodate large root system.
Growth habit. Mango trees will grow up to 20m high with a broad spreading crown. It is an evergreen tree whose dense canopy will shade out all other vegetation.

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 - 600masl Range - 1000 – 2500 mm/yr
Sub-optimal	Description of climate Range - 600 – 1200 masl No. 500 – 3500 mm/yr

<u>Site productivity</u> 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
The main management objective is the commercial production of mango fruit. Other fruits produced can either be sold or used domestically. Any offcuts / pruning material can be used as fuelwood. The timber is quite hard and has many uses including indoor construction, furniture, flooring and boat building (this timber will be harvested in approximately year 50 after planting). Mango also makes an important tree for apiculture, as the flower nectar provides excellent fodder for bees.

Potential income
Up to a maximum of 70 kg of mango fruit can be produced per tree / year. The current market value for mango fruit is 5,000 mts per kg.
Costs of implementation Estimated costs per ha: Establishment (year 1): 12,000 meticais ($520) Maintenance (year 2 – 5): 5,000 meticais ($200) 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
All competing vegetation should be removed and the foliage left on site to act as an organic fertilizer, and to conserve soil moisture. Trees should be planted in rows at a distance of 4m x 4m (625 tree/ha). Intercropping with other fruits and vegetables will be possible until canopy closure. It is best to plant at the beginning of the wet season to minimize the requirement to water the seedlings. Mulch (in the form of organic green material from e.g. competing vegetation or interplanting) 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. • 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 Regular watering especially in the first year will help trees survive
Maintenance The removal of all competing vegetation will be required twice a year for at least the first three years after planting, or until the seedlings have reached a height of 1.5 – 2 m.. Weeding frequency can be reduced to once per year after the third year until canopy closure. No burning is allowed at any time. Any foliage should be left on site to be incorporated naturally into the soil rather than being burnt. To ensure balanced and productive growth, the mango seedlings should be pruned. The main stem of the hardy trees should be allowed to grow to 1 m

before being topped[1] to give well-distributed branches. In fruiting trees, pruning is confined to the removal of dead wood and branches broken or weakened by pests and diseases. When the trees are big enough to produce a substantial crop, irrigation should be stopped, or at least interrupted long enough (up to 3 months) to impose dormancy leading to flower initiation. All seedlings will require protection from goats.
<u>Thinning and harvest</u> No thinning required. Trees should be replaced when fruit production begins to decrease at approximately year 50.
<u>Re-establishment</u> The whole site should re-planted at year 50.

[1] Topping involves the pruning back of the leading stem to remove apical dominance and stimulate increased growth of side branches.

Carbon sequestration potential
Carbon sequestration potential over ***100*** years with a crop rotation of ***60*** years on an average quality site with optimal climatic conditions is **31.2** tC/ha above an initial vegetation carbon baseline of **2.8** 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 (i.e. the living parts of the tree including the main stem, canopy and roots) and forest products (i.e. poles, timber used for furniture and construction etc.) 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; product allocation for thinnings and expected lifetime of products) are given below. The model uses current annual increment for planted trees (for details of model inputs see appendix 2). At this stage the carbon sequestration has been modelled as if 100% of the area is planted with mango (i.e. this does not include other species such as orange, mulberry, guava, zisiphus, papaya and albizia). As more data becomes available these species might be included in the calculation of the carbon sequestration potential of this system.

N.B. Stem increment (CAI) was calculated on the basis of trees measured within the project area. A relatively large number of trees (>80) of a known age were measured. The trees measured ranged in age from 7 to 50 years. However, as the project expands and more data becomes available these calculations could be revised and updated if required.

N.B.B **31.2 tonnes of carbon** is equivalent to **114.4 tonnes of carbon dioxide**.

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 ***530*** stems / ha surviving
4	Whole plot established
5	Average DBH not less than 7cm
6	Average DBH not less than 8.5cm
7	Average DBH not less than 10cm

10	Average DBH not less than 16cm

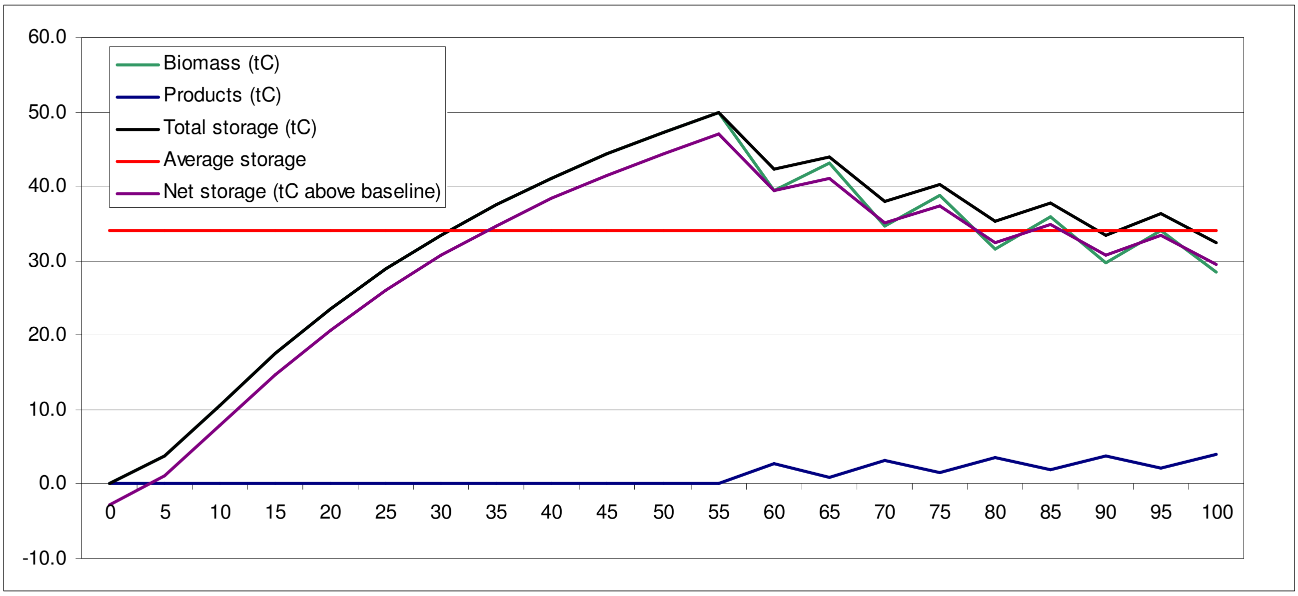
Information about pests
Anthracnose (*Glomerella cingulata*, conidial stage *Colletotrichum gloeosporioides*) distorts and turns developing leaves black and disfigures developing fruit. May be controlled by use of copper based fungicide.

A mealybug, *Rastrococcus invadens*, can cause serious damage to mango and other crops. In the greenhouse, thrips often turn leaves rusty brown. Malathion is the conventional spray for insect pests; sulphur works on mites. A long-horn beetle (*Rhytidodera simulans*) bores into the trunk and thick branches; branches may be killed but the whole tree retains its viability. The larvae of the mango weevil (*Cryptorrhynchus mangiferae*) feed on the pulp and damage the fruit.

Other diseases include the flower malformation caused by *Fusarium moniliforme* and spread by mites, bacterial canker which is becoming a pressing disease problem and *Oidium mangiferae*, a powdery mildew that affects flowers, young fruit and leaves. Can be controlled by spraying powdered kelp, sodium bicarbonate and fungicide sprays (World Aforestry Centre, 2004)

Appendix 1 Carbon storage figures

Year	Biomass (tC)	Products (tC)	Total storage (tC)	Net storage (tC above baseline)
0	0.0	0.0	0.0	-2.8
5	3.9	0.0	3.9	1.1
10	10.6	0.0	10.6	7.8
15	17.5	0.0	17.5	14.7
20	23.6	0.0	23.6	20.8
25	28.8	0.0	28.8	26.0
30	33.5	0.0	33.5	30.7
35	37.6	0.0	37.6	34.8
40	41.2	0.0	41.2	38.4
45	44.4	0.0	44.4	41.6
50	47.2	0.0	47.2	44.4
55	49.9	0.0	49.9	47.1
60	39.4	2.9	42.2	39.4
65	43.0	0.9	43.9	41.1
70	34.7	3.3	38.0	35.2
75	38.7	1.5	40.2	37.4
80	31.7	3.6	35.2	32.4
85	35.9	1.9	37.8	35.0
90	29.7	3.8	33.5	30.7
95	34.1	2.2	36.2	33.4
100	28.4	4.0	32.4	29.6



Appendix 2 - CO2Fix Inputs

Stand parameters		
Rotation length (yr)		60
Number of rotations		2
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

* The initial biomass (baseline) was not included in CO2Fix but has been calculated separately based on research by Sambane (2005). The baseline for this technical specification is calculated to be a constant value of 2.8 tonnes per hectare per year throughout the crediting period of 100 years. The baseline carbon has been deducted in the calculation of net carbon benefit (see carbon sequestration potential above).

Tree Growth Table				
Age (yr)	Stem increment **CAI** (m3/ha/yr)	Dry weight increment relative to stem		
		foliage	branches	roots
5	0.7	0.35	0.2	0.25
10	4.6			
15	4.5			
20	4.4			
25	4.3			
30	4.2			
35	4.0			
40	3.9			
45	3.8			
50	3.7			

Tree species Parameters		
Basic density of stemwood (kg/m3)		520
Carbon content of dry matter		0.5
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	Fraction stem removed	Dead wood	Energy	Packing	Construction

60	0.25	0.0	0.75	0	0.25
70	0.25	0.0	0.75	0	0.25
80	0.25	0.0	0.75	0	0.25
90	0.25	0.0	0.75	0	0.25
100	0.25	0.0	0.75	0	0.25

References

ECCM (2005). Nhambita carbon calculator

Mohren, F., van Esch, P., Vodde, F., Knippers, T., Schelhaas, M., Nabuurs, G., Masera, O., de Jong, B., Pedroni, L., Vallejo, A.., Kanninen, M., Lindner, M., Karjalainen, T., Liski, J., Vilen, T., Palosuo, T. (2004). CO2FIX-V3

Sambane, E (2005). Above ground biomass accumulation in fallow fields at the Nhambita Community, Mozambique. A dissertation presented for the degree of Master of Science, University of Edinburgh, 2005.

World Agroforestry Centre (2004). Agroforestry tree database.

Acknowledgement

This work undertaken by ECCM as part of the Miombo Community Land Use and Carbon Project has only been possible because of the financial support received from the European Commission (Environment budget).