Nhambita carbon crediting technical note 1.

Objective

To estimate the potential carbon sequestration associated with each land use system and the number of credits generated for sale from activities of the Miombo Community Land Use and Carbon Management Project – Nhambita Pilot Phase.

Project activity - Land use systems

Six land use systems have so far been considered. Potential carbon sequestration for each one of these systems has been calculated assuming the following proportions of tree species planted (Table 1).

Reference (technical specification)	Land use system	Objective	Tree species	Proportion of planting(%)	No. of trees (per 100m or ha.)
MOZ-TS-BP[1]	Boundary planting	Plant tree species typical of Miombo woodland around the perimeter of mashamba for timber, fuel wood, fruit and shade.	Albizia[2]	36	25 / 100m
			Umbila	20	
			Red mahogany	25	
			Amarula	10	
			Panga panga	10	
			Tamarind	20	
			Zisiphus	15	
MOZ-TS-DIP	Dispersed interplanting	Soil improvement to extend expected productivity of food production from mashamba. Pruning and thinnings can be used for fuel wood.	Gliricidia	100	200 / ha
MOZ-TS-FO-Cashew	Fruit orchard, var. cashew	Commercial cashew nut production.	Cashew	100	625 / ha
MOZ-TS-FO-Mango	Fruit orchard, var. mango	Commercial mango fruit production	Mango	100	666 / ha
MOZ-TS-HP	Homestead planting	Fruit and fuel wood for domestic use and shade around the house	Cashew	40	666 / ha
			Mango	40	
			Tamarind	10	
			Zisiphus	10	

[1] Calculations for boundary planting are per 100 m planted (as opposed to per hectare for all other systems). ECCM has assumed that 100m planted is equivalent to 5% of a hectare.

[2] 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 Boundary and Woodlot systems overall stocking densities of 625 and 1,100 trees have been assumed respectively. The calculations for carbon sequestration potential by timber species are based on assumed stocking densities 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 and 625 trees / ha (i.e. 36% of planting using the boundary system) and the difference between 400 and 1,100 trees / ha using the woodlot system (i.e. 64%).

MOZ-TS-WL	Woodlot	Sustainable timber and fuel wood production. Establishment of Miombo woodland.	Albizzia	64	1100 / ha
			Red mahogany	30	
			Amarula	20	
			Panga panga	25	
			Mbila	15	
			Muhimbie	10	

Table 1. Land use systems and tree species

In practice (2006) more species are being grown in the nursery than those listed in Table 1 which might be planted as part of these systems (in particular for boundary, homestead and woodlot planting where a greater range of tree species will be planted). However the trees listed above are considered to be representative and provide the most reliable growth data to date.

Additionally, further land use systems might be considered in the future, such as dispersed interplanting with Faidherbia albida.

Methods

The standard approach for estimating the long-term carbon benefit of afforestation for Plan Vivo VERs is based on average net increase of carbon storage in biomass and forest products over a 100 year period relative to the baseline. Carbon storage for each of the technical specifications was estimated in a two-staged approach. The carbon uptake of each species was calculated using the CO2FIX-V3 model (Mohren et al 2004). These model outputs were then used to build the result for the technical specification based on the numbers of species in each system and the length of rotations

Baseline

The '**baseline**' refers to carbon sequestered and stored in any existing vegetation (not including food crops) on a site at the time of planting. When calculating the number of tradable emission reductions that a farmer has for a site, the baseline carbon stock is subtracted from the carbon sequestration achieved by the project activity. The baseline for areas within the Nhambita project area varies according to how many years a site has been fallow. In general, the longer a site has been left fallow the higher the baseline will be. The carbon baseline (in biomass) is derived from a report prepared by Sambane (2005) This report is based on a sample of 28 mashambas in the Nhambita project area. An average accumulation rate of 1.1 t biomass / ha / yr was found in fallow sites. This corresponds to 0.55 tC / ha / yr.

The baseline for dispersed interplanting, boundary planting and homestead planting is zero. It is assumed that dispersed interplanting and boundary planting will primarily be used on cropped land (where the baseline is considered to be negligible) and homestead planting which will largely be on bare ground surrounding the house.

The baseline for the fruit orchard systems (cashew and mango) is 2.8 tonnes of carbon per hectare. This calculation is based on the average accumulation of biomass in sites which have been fallow for between 0 to 10 years.

The baseline for the woodlot system is 11.3 tonnes of carbon per hectare. This calculation is based on the average accumulation of biomass at sites which have been fallow for between 11 to 30 years.

Technical specification – Land use system	Baseline (tonnes of carbon / ha)
Dispersed interplanting	0.0
Boundary planting	0.0
Fruit orchard (cashew)	2.8
Fruit orchard (mango)	2.8
Homestead	0.0
Woodlot	11.3

Table 2. Nhambita carbon baseline

The baseline might be reveiwed and updated in the future as more data becomes available. It might also be appropiate in the future to consider a projected, regional level baseline. The baseline has been included in the Mozambique Carbon Calculator (ECCM, 2006)

Stem volume and current annual increment

A primary input to the CO2FIX model is current annual increment (CAI). This is a measure of annual stem volume increment (m^3/ha/year). No CAI data (or any other growth data) is currently available for any of the species listed in Table 1 in Mozambique.

ECCM measured the diameter at breast height (dbh) and height of a sample of trees of a known age within the Nhambita community to calculate stem volume using the following formula (Australian Government):

$$\text{Stem volume} = \frac{\pi \times (\text{dbh}/200)^2 \times \text{height}}{\text{form factor}}$$

- $\pi = 3.14$
- Stem volume is in cubic meters (m^3);
- dbh = diameter at breast height overbark (in centimetres)
- Height = total height in meters; and
- Form factor = 3

Approximately 400 trees of various tree species of known ages were measured to calculate stem volume.

Standing volume (m^3) was calculated by multiplying the individual tree volume by the number of trees that will be planted per hectare. The results were plotted using a linear regression. CAI is obtained by dividing the standing volume by the number of years. The results obtained are shown in Table 3.

Year	CAI										
	Albizia	*Amarula*	*Cashew*	*Gliricidia*	*Mango*	*Mbila*	*Muhimbie*	*Panga panga*	*Red Mahogany*	*Tamarind*	*Massanica*
5	12.0	0.5	4.1	1.6	0.7	0.6	2.4	1.7	2.3	0.3	3.9
10		0.5	4.1		4.6	0.1	2.4	3.5	2.3	0.3	6.4
15		1.0	5.0		4.5	1.3	1.1	6.9	4.6	0.7	
20		1.9	5.0		4.4	2.6	1.1	6.2	9.1	1.4	
25		4.9	4.9		4.3	3.8	1.1	5.4	23.0	2.7	
30		5.5	4.9		4.2	5.1	1.1	4.6	24.0	2.6	
35		6.1	4.8		4.0	6.3	1.1	3.9	20.8	4.5	
40		6.8	4.8		3.9	7.6		3.1	13.2	5.8	
45		7.4	4.7		3.8	8.9		2.3		6.4	
50					3.7	10.1		1.6		6.5	
55						11.4		0.8		5.9	
60						12.6				4.7	
	MAI										
	12.0	5.8	4.7	1.6	3.8	5.9	1.5	4.6	11.2	3.5	5.4

Table 3. Current annual increment and mean annual increment

Dry wood density

The dry wood densities for the tree species listed in Table 1, were obtained from three sources. Please refer to Table 4 for full details.

Species	Kg/m^3		
	Sandra Brown, 1997	Goldsmith & Carter, 1981	University of Edinburgh, 2005
Albizia	550-660		
Amarula		590	
Cashew			520
Gliricidia			620
Mango	520		
Mbila		640	
Muhimbie	780		
Panga panga	720		
Red mahogany		590	
Tamarind	750		
Ziziphus	760		

Table 4. Dry wood density

The carbon content is assumed to be 50% of dry weight of all biomass.

Other carbon pools

Foliage. All tree species were assumed to have a foliage growth rate of 0.7 relative to stem growth with a 100% turnover per year.

Branches. The growth rate of branches for all species has been assumed to be 0.2 relative to stem growth with a 5% turnover per year.

Roots. The growth rate of roots for all species has been assumed to be 0.25 relative to stem growth with a 7% turnover per year.

A shortcoming observed by ECCM with the CO2 FIX model is that carbon storage in tree roots and stumps is not accounted for where more than one rotation is expected during the crediting period. This means that our estimates are conservative.

Calculating the carbon sequestration potential of foliage, branches and roots might be refined over time and become more species specific as more data becomes available as a result of ongoing project activities.

Timber products

It has been assumed that wood products would either be used for energy (wood fuel / charcoal) or construction. The average residence time of carbon in energy products is assumed to be 1 year and 25 years for products used in construction.

The assumed proportions of wood destined for use either as energy or for construction from thinnings and final harvest are shown in Table 5.

It has been assumed that all branches and slash will be used as fire wood.

Species	Thinnings		Final harvest	
	Energy	Construction	Energy	Construction
Albizia	0.80	0.20	0.80	0.20
Amarula			0.30	0.70
Cashew	0.75	0.25	0.75	0.25
Gliricidia	0.80	0.20	0.80	0.20
Mango	0.75	0.25	0.75	0.25
Mbila			0.30	0.70
Muhimbie			0.30	0.70
Panga panga			0.30	0.70
Red mahogany			0.30	0.70
Tamarind			0.30	0.70
Ziziphus			0.30	0.70

Table 5. Proportion of wood destined for energy products and construction products

Buffer

It has been recommended by ECCM that 15% of all carbon sequestration achieved by project activities is maintained as a risk buffer. Records of all buffer stock should be maintained in the database. It has yet to be decided at what stage the right to trade this carbon will return to the farmer.

The following formula should be used to calculate the number of carbon credits (emission reductions) that each farmer has to sell.

No. of carbon credits to sell =
((project activity carbon sequestration
– baseline) - buffer) x area in hectares

Results

Land use system	*Project activity (tonnes of carbon)*	*Baseline (tonnes of carbon)*	*Buffer (tonnes of carbon)*	*Tradable carbon credits (tonnes of carbon)*	*Tradable carbon credits (tonnes of carbon dioxide)*
Boundary planting	3.23 / 100m	0.0 / 100m	0.48 / 100m	2.75 / 100m	10.03 / 100m
Dispersed interplanting	10.00 / ha.	0.0 / ha.	1.50 / ha.	8.50 / ha.	31.16 / ha.
Fruit orchard var. cashew	40.14 / ha.	2.8 / ha.	5.60 / ha.	31.74 / ha.	116.38 / ha.
Fruit orchard var. mango	34.00 / ha.	2.8 / ha.	4.68 / ha.	26.52 / ha.	97.24 / ha.
Homestead planting	42.05 / ha.	0.0 / ha.	6.30 / ha.	35.75 / ha.	131.08 / ha.
Woodlot	61.30 / ha.	11.3 / ha.	7.50 / ha	42.50 / ha.	155.83 / ha.

Table 6. Calculation of tradable carbon credits

Reference:

http://www.greenhouse.gov.au/nrm/fieldmeasurement/part02/section4two.html. Australian Government, Department of the Environment and Heritage Australian Greenhouse Office.

Brown, S (1997) Estimating Biomass and Biomass Change of Tropical Forests: a Primer. (FAO Forestry Paper - 134)

Goldsmith, B and Carter, D. (1981) The Zimbabwe Bulletin of Forestry Research. No. 9. The Indigenous Timbers of Zimbabwe. Zimbabwe Forestry Commission.

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