MANGO (*Mangifera indica*) ORCHARD TECHNICAL SPECIFICATIONS

Prepared by

Energy for Sustainable Development (ESD)

For and reviewed/edited by

TREES OF HOPE PROJECT

(A Plan Vivo Carbon Sequestration Project)

Clinton Hunter Development Initiative

Off Mphonongo Road

Plot No. 43/2/82

Lilongwe

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SUMMARY

This ñtechnical specificationò has been developed for use by Plan Vivo projects involving communities participating in Malawi.

Through the Plan Vivo system communities may be able to access carbon finance by land use change activities that involve afforestation and reforestation.

This technical specification sets out the methods that should be used to estimate the carbon benefits from planting and managing mango orchards on small holding farms in Malawi. This technical specification also details the management requirements for this system over a long period of time, and the indicators to be used for monitoring the delivery of the carbon benefit.

The technical specification aims to summarise the best available evidence about the environmental benefits associated with the sustainable management of this land use system. Further information and research is welcome and will be incorporated periodically.

This land use system has been developed in consultation with communities and individual farmers in the following districts in Malawi: Neno, Mwanza and Dowa. Other valuable contributions to the development of this system have been received from CHDI staff, national and district government officials and forestry and agricultural extension workers. The inputs have been received through a structured process of meetings and interviews with these key stakeholders between September 2007 and October 2008.

The objective of the fruit orchard (mango) system is to provide an alternative / additional source of income from other agricultural activities. Additional benefits will include soil conservation, improved water quality, enhanced biodiversity etc. The carbon finance will make a critical difference in allowing for the implementation of this system by providing tree seedlings, increasing capacity in managing fruit orchards and putting in place frequent monitoring to ensure compliance with the technical specification that will create the carbon sink. The most suitable areas for this system are neglected / degraded lands. This system may be more widely adopted on community land and amongst individuals with slightly larger landholdings (>1 hectare) i.e. those farmers that

have sufficient land not to jeopardise their food security by introducing a land use system that cannot be combined with growing other food crops in the long term.

The net carbon benefit of this system above the baseline (with 20% set aside as risk buffer) is calculated to be 24.28 tonnes of carbon per hectare. This is equivalent to 89 tonnes of carbon dioxide per hectare.

ACKNOWLEDGEMENTS:

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1.0 DESCRIPTION OF LAND USE SYSTEM

This system involves the planting of mango trees for commercial fruit production (as well as providing a source of additional nutrition to those households that use this system). The preferred varieties of mango for planting are Kent, Erwin, Zill, Keitt and Tommy Atkins because of observed demand from foreign and local markets due to their low fibre content.

1.1 Main tree species

Botanical name	Common name (English)
Mangifera indica	Mango

2.0 ECOLOGY

2.1 Altitudinal range.

Mango will grow well from sea level up to 1,200 m above sea level, however, fruit production decreases at higher altitudes.

2.1 Climatic factors

Mango is tolerant of a wide range of conditions from hot and humid to cool and dry. However, the climatic conditions will determine whether mangoes can be grown commercially and which cultivars should be selected. The optimum temperature range is 12ºC - 37ºC. Mango has no frost tolerance. A distinct dry season (more than 3 months) is required to assist with fruit production. Low rainfall (<500 mm/yr) will restrict fruit yields whilst high rainfall (>2,000 mm/yr) can also impact negatively on yields as vigorous vegetative growth will replace reproductive growth.

2.2 Habitat requirements.

Mango trees are tolerant of both drought and occasional flooding. For good growth deep soils are required to accommodate the large root system which can extend up to 6 meters deep.

2.3 Growth habit.

Mango trees will grow up to 40m high with a broad spreading crown but many cultivars may be much smaller.

3.0 MANAGEMENT OBJECTIVES OF MANGO ORCHARD SYSTEM

The main management objectives of establishing mango orchards include:

- Commercial production of mango fruits with potential of value addition through processing.
- Improvement of house holdôs nutritional status trough consumption of mango fruit products.
- Production of fuelwood in form of offcuts from pruning.
- Production of timber from mature trees at the end of rotation cycle.
- Mango trees will also be used for hanging beehives for apiculture besides providing excellent nectar for the bees.

4.0 COSTS OF IMPLEMENTATION

4.1 Nursery costs

The activities and costs for establishing 200 seedlings during the setting up of the nursery are

- Cost of seeds
- Digging, transporting and mixing of the soil
- Pot filling, transfer, and topping
- Seed sowing and bed management
- Pricking out and selection/transfer
- Watering and sanitation
- Procurement of media (sand, topsoil and manure).
- Purchase of scions and mango stones for rootstock development.
- Green house sheeting materials.

- Cost of one wheelbarrow, hoes, spades, machete, shade netting, poles, water, and fuel costs

The total nursery cost is estimated at $ 600

4.2 Establishment cost

The activities in the establishment phase would include

- Demarcation and soil test
- Bush clearing
- Chaining/marking
- Pitting
- Planting

The total cost for this phase for per hectare would be $50

4.3 Maintenance cost

Operations for year one are grass slashing, spot weeding, firebreaks, uprooting shrubs. The cost per hectare will be $40 while Year two operations that include grass slashing, spot weeding, firebreaks maintenance, and uprooting shrubs will cost an estimated $20. Operations for years 3, 4, and 5 that include fire protection and basic agronomy will cost $20 per hectare / year while other costs would go to buying equipments such as one slasher, one hoe, one machete, a pair of boots, and one overall estimated at $50. The full nursery profile is summarized in the table below:

Activity	Cost (per hectare for mango fruit orchard)
Nursery costs	$600
Establishment	$50
Maintenance year 1	$40
Maintenance year 2	$20

Maintenance year 3	$20
Maintenance year 4	$20
Maintenance year 5	$20
Equipment cost	$50
Total	**$820**

5.0 POTENTIAL INCOME

There will be a total of 400 mango fruit trees per hectare from a spacing of 5m by 5m. The average yield per hectare of a mango orchard is estimated at 80kg per year for an estimated productive life of 10 years giving a cumulative total production of 320000kg. At an estimated price of MK100 per kg, the yield would have a value of MK32000000 over ten years, however, it should be noted that this is a conservative estimate since the productive life of mango orchards can reach 20 years under good management and optimal climatic conditions.

6.0 MANAGEMENT OPERATIONS

6.1 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 in holes dug 60cm wide and 60cm deep at least a month before planting. It is best to plant at the beginning of the wet season to minimize the requirement to water the seedlings. Mulch (rock or organic mulching instead of grass due to termite invasion in case organic green material is used from 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. At planting, the following actions need to be considered:

- Water seedlings before planting to hold nursery soil together and to assist establishment in case it fails to rain on the day of planting
- Plant at the beginning of the rainy season
- 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 nursery 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

6.2 Maintenance

Particular attention should be paid to weeding and uprooting of competing shrubs where grafted mango has been planted. The orchard should also be protected from livestock browsing and bush fires. Recommended procedures for pest and disease management and crop nutrition largely through manuring will be followed in management of the orchard.

6.3 Pruning and harvest

Pruning of unwanted branches should be done carefully to leave smooth scars to minimise infection. This activity is necessary to allow better penetration of photosynthetic active radiation vital for fruit set. As the orchard ages, its productivity will decrease hence pollarding should be considered or complete re-establishment at approximately year 25.

7.0 DESCRIPTION OF THE ENVIRONMENTAL AND SOCIO-ECONOMIC BENEFITS.

The establishment of this land use system will bring about the following environmental and socio-economic benefits:

- Soil conservation - particularly the prevention of soil erosion associated with heavy rainfall events and siltation of water courses (climate change adaptation benefit)

- Hydrological benefit ï harvesting of incidental moisture and encouragement of water infiltration which will help to reduce flooding (climate change adaptation benefit)
- Biodiversity benefit ï through the protection of wildlife habitat for a diverse plant and animal life.
- Provision of potential bee keeping habitat as beehives could be hung in the trees.
- Shading for humans and livestock.
- Pruning material may be used as firewood.

8.0 DESCRIPTION OF ADDITIONALITY

A key factor is that the emissions reductions from a project activity or intervention should be additional ï i.e. the intervention would not have occurred in the absence of the carbon-derived finance. Additionality, can be demonstrated through an analysis of the barriers to the implementation of activities in the absence of intervention. In this case the barriers to the permanent establishment of mango fruit orchards that are overcome through the project activity and receipt of carbon finance are include:

- Community mobilisation and participation in planning processes.
- Awareness of climate change issues, carbon trading and role of mango orchards in climate change management and livelihood improvement leading to renewed efforts in tree planting.
- Building of technical competence in development of grafted mango seedlings and their subsequent field establishment and management vital for sustainability.
- Access to high value mango planting materials.
- Access to tools and other nursery materials including polythene tubes, watering cans, seed etc to enable seedling production.
- Training to enable long term sustainability of programme through participatory monitoring and evaluation

As there are no formal means by which communities can access funding to cover these costs, the effect of Plan Vivo carbon finance is strongly additional.

9.0 LEAKAGE ASSESSMENT

Leakage is defined as unintended loss of carbon stocks outside the boundaries of a project resulting directly from the project activity. In the case of establishing mango orchards this is most likely to occur where farmers are establishing trees on cultivated land (these fruit trees are not suitable to be grown in combination with other cultivated food crops). If this were to occur it may result in displacement.

The Plan Vivo system requires that potential displacement of activities within the community should be considered and that activities should be planned to minimise the risk of any negative leakage. These actions should include:

- All farmers establishing mango orchards should be assessed individually to demonstrate that they retain sufficient land to provide food for themselves and their families.
- Signatories to Plan Vivo activities will be contractually obliged not to displace their activities as a result of the tree planting.
- In many instances it may be most appropriate to establish fruit orchards on degraded bush / scrub land which is not currently being used for producing other food crops. In this case any leakage resulting from displaced grazing or firewood collecting activities should also be assessed.
- A plan to monitor leakage on specific other woodland areas to ensure leakage is not occurring.
- Formation of community based ópolicingô to ensure that leakage resulting from displaced activities does not occur.

Where communities have a satisfactory plan for managing leakage risk resulting from the establishment of fruit orchards, there should be no assumption of leakage.

10.0 BASELINE CARBON EMISSIONS

The ó**baseline**ô 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 Voluntary Emission Reductions (VERôs) that a farmer has generated, the baseline carbon stock is subtracted from the carbon sink achieved by the project activity. The procedure used to quantify the ñbaselineò carbon emissions that would be associated with land management expected in the absence of the establishment of fruit orchards is set out in ó*Assesment of Net Carbon Benefit of CHDI Land Use Activities' (ESD, 2008)*. It is assumed that this system will be used only on cultivated land with an estimated carbon baseline of 0.42 tonnes of carbon per hectare in the absence of project activities.

11.0 QUANTIFICATION OF THE CARBON SINK

The approach used for estimating the long-term carbon benefit of afforestation for Plan Vivo VERs is based on average net increase of carbon storage (sink) in biomass and forest products over a 100 year period relative to the baseline. The carbon sink is calculated separately for each of the technical specifications. A three-staged approach is used:

- Calculate tree growth rates based on tree measurement data captured within the project area
- 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.

The procedure used to calculate the potential carbon sink created by mango fruit orchards is set out in ó*Assesment of Net Carbon Benefit of CHDI Land Use Activities' (ESD, 2008)*. The potential carbon sink created by this land use system (based on long term average carbon storage over 100 years) is calculated to be 30.78 tonnes of carbon per hectare.

12.0 BUFFER

Twenty percent (20%) of all VERôs generated by the project activities are 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 these VERôs will return to the farmer.

13.0 CALCULATION OF CREDITS

For the purposes of quantifying Plan Vivo certificates (carbon offset), the net carbon benefit of each tree planting system in addition to the baseline has been calculated. In accordance with Plan Vivo standards (http://www.planvivo.org/) 20% of all the carbon offset (i.e. net carbon benefit) is set aside to be kept as a risk buffer (i.e. non tradable carbon asset). Records of all buffer stock should be maintained in the database. The net carbon benefit, buffer stock and tradable carbon offset (Plan Vivo certificates) generated by the mango fruit orchard land use system (technical specifications) is presented in the table below:

Table 13.1: The net carbon benefit and tradable carbon offset for the mango fruit orchard land use system

Technical Specification	Sink (tC/ha)	Baseline (tC/ha)	Net benefit (tC/ha)	Buffer (%)	Tradeable (tC/ha)	Tradeable (tCO_2/ha)
Fruit orchard (Mango)	30.78	0.42	30.36	20%	24.28	89

The figure below shows the long-term average carbon sink over the simulation period (100 years).

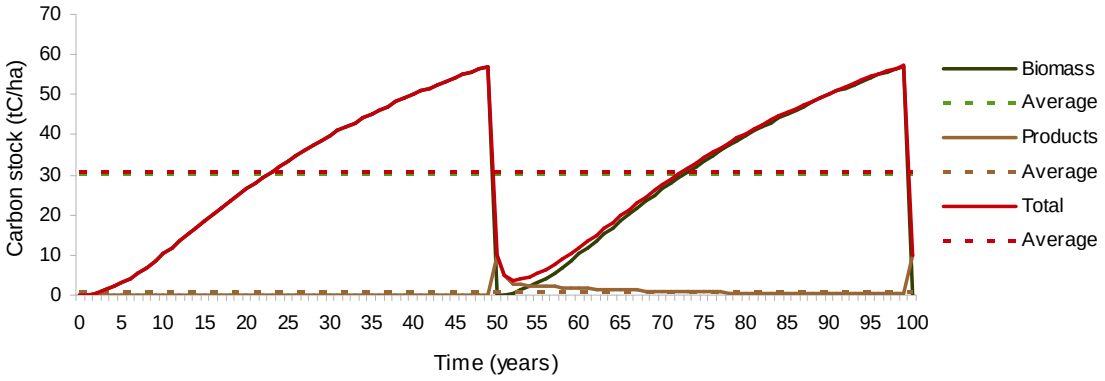

Figure 13.1: Mango fruit orchard technical specification carbon sequestration potential over 100 years

14.0 MONITORING

Monitoring targets for the first 3 years are based on establishment whereby the whole plot must be established by the third year with at least 100% 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. Monitoring field data collection templates for years 0 to 3 (establishment-based) and years 4, 7 and 10 (DBH-based) are presented in the appendix.

Year	Monitoring Indicator
0	At least 50% plot established
1	At least 75% plot established
2	Whole plot established with 85% survival.
3	Whole plot established with 100% survival
4	Average DBH not less than 8cm
7	Average DBH not less than 15cm
10	Average DBH not less than 20cm

NOTE: DBH refers to Diameter at Breast Height

15.0 REFERENCES

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ANNEXES

ANNEX 1: Monitoring field data collection template for Years 0 to 3 (establishment-based indicators)

MONITORING FIELD DATA COLLECTION TEMPLATE FOR YEARS 0 TO 3.

FOR TREES OF HOPE CARBON SEQUESTRATION PROJECT.

Identity of producer (name and village)	
Technical specification	
Area (ha) or perimeter (m) of registered plot	
No. of plan vivo	
Expected total number of trees on plot at full establishment	
Year/season of establishment	
Year of monitoring	
Expected min. number of trees on plot at this monitoring	
Number of surviving trees on plot at this monitoring	
General comments and recommendations	
Name of Local Program Monitor	
Date of Monitoring	
Name of approving CHDI Technician	
Date of approval	
Name & organization of approving partner	
Date of approval	

ANNEX 2: Monitoring field data collection template for Years 4, 7 and 10 (DBH- based indicators)

MONITORING FIELD DATA COLLECTION TEMPLATE FOR YEARS 4, 7 and 10. FOR TREES OF HOPE CARBON SEQUESTRATION PROJECT.

Identity of producer (name and village)	
Technical specification	
Area (ha) or perimeter (m) of registered plot	
No. of plan vivo	
Total number of trees on plot at full establishment	
Average DBH (cm) from 20% random sample	
Expected DBH (cm) from plot	
Year/season of establishment	
Year of monitoring	
Expected min. number of trees on plot at this monitoring	
Number of surviving trees on plot at this monitoring	
General comments and recommendations	
Name of Local Program Monitor	
Date of Monitoring	
Name of approving CHDI Technician	
Date of approval	
Name & organization of approving partner	
Date of approval	

NOTE: DBH refers to Diameter at Breast Height