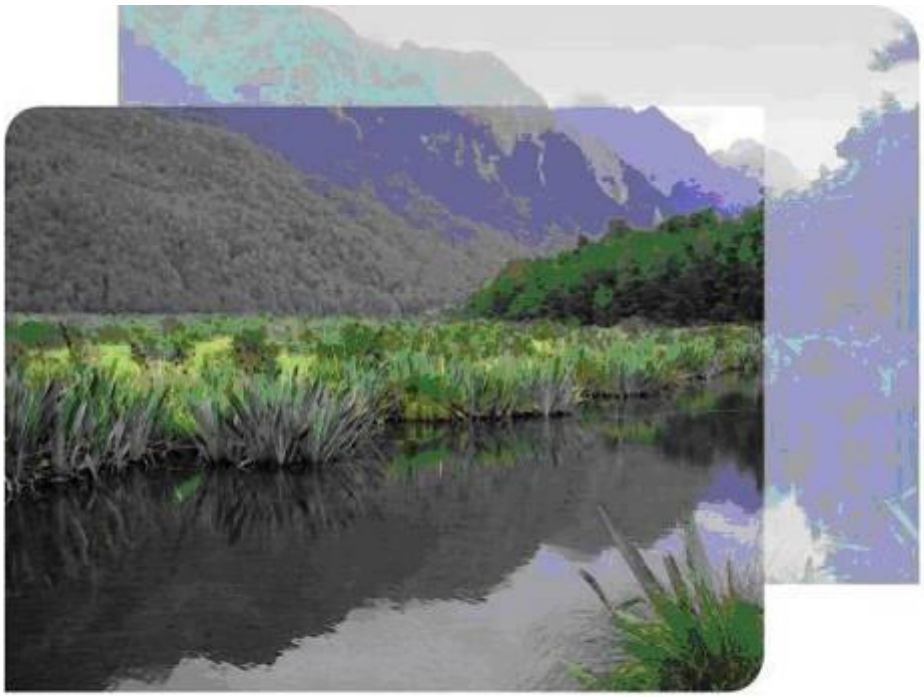
Emiti Nibwo Bulora fruit orchard technical specification

Report presented to : SCC-Vi Agroforestry

By : Geoffrey Onyango, Emmanuel Ekakoro and Joan Sang

Reference : P01901



May 2010

Final Version

Document type:	Technical Specification
Client:	SCC-Vi Agroforestry
Contact:	Bo Lager

Report:	2.0
Draft	May 2010

Author:	Geoffrey Onyango, Emmanuel Ekakoro and Joan Sang
Signature	
Date:	

QA:	William Garrett
Signature	
Date:	May 2010

Author contact details: joan.sang@camcoglobal.com

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SUMMARY

This ñtechnical specificationò has been developed for use by Plan Vivo projects involving communities participating in the Kagera Region of Tanzania. The activities described in this technical specification are only eligible for establishment on smallholders or community land which is either currently cultivated or neglected. This land management system may not be applied on land that already supports natural forest cover.

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 over a 25 year crediting period from planting and managing fruit trees on small holding farms in Kagera, Tanzania. 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 Kagera Region in Tanzania. Other valuable contributions to the development of this system have been received from SCC-Vi Agroforestry 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 May 2008 and December 2008.

The objective of the fruit orchard is to produce fruits for domestic consumption and commercial fruit production. Additional benefits will include soil conservation, improved water quality, and enhanced biodiversity. The carbon finance will make a critical difference in allowing for the implementation of this system by helping to finance the purchase of tree seedlings, increasing capacity in managing this land use system and putting in place frequent monitoring to ensure compliance with the technical specification that will create the carbon sink. This system should allow for widespread participation of small holding farmers in carbon markets. Fruit orchards may be widely adopted by individual farmers with small areas of landholding whilst contributing to enhanced food production. 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. This system may also be suitable for use along roadsides, in schools and in military barracks.

The net carbon benefit and tradable carbon offset for the fruit orchard land use system is shown in this table:

Technical Specification	Sink (tC/ha)	Baseline (tC/ha)	Net benefit (tC/ha)	Buffer (%)	Tradeable (tC/ha)	Tradeable (tCO_2/ha)
Homestead fruit orchard	8	2	6	20	4.8	17

ACKNOWLEDGEMENTS

This work has been undertaken by ESD/Camco as part of the Plan Vivo pilot project implementation in the Kagera Region of Tanzania. It has only been possible because of the financial support received from SCC-Vi Agroforestry. ESD/Camco wish to acknowledge the contribution made by all the staff of SCC-Vi Agroforestry Kagera, and all the other stakeholders engaged during the participatory planning process used to design and collect data for this technical specification.

1 Description of Homestead/Fruit orchard Land use system

This system involves the planting of fruit tree species for domestic consumption and commercial fruit production Initial stocking density for fruit orchard will be 8mX8m for citrus, mango and (9m by 9m) avocado fruit trees.

1.1 Main tree species

Table 1: Tree species recommended for homestead fruit orchard technical specification

Botanical name	Common name (English)	Range
Mangifera indica	Mango	Naturalized
Citrus limon	Lemon	Naturalized
Persea americana	Avocado	Naturalized
Artocarpus heterophyllus	Jack fruit	Naturalized

1.2 Ecology

Table 2: Ecological requirements of species recommended for homestead fruit orchard land use system

Species	Ecology
Mangifera indica	-The mango thrives in both the subtropics and the tropics and are drought tolerant
Citrus limon	- Will require high temperatures to fruit - High humidity increases the growth of pests and diseases
Persea americana	Requires a well-drained aerated soil because the roots are intolerant of anaerobic conditions; waterlogging for more than 24 hours can kill trees. A pH of 5-5.8 is optimal for growth and fruit yield time before flowering
Artocarpus heterophyllus	It grows in tropical, near tropical and subtropical regions.

1.3 Altitudinal range

Table 3: Altitudinal range of species recommended for homestead fruit orchard land use system

Species	Altitudinal range and climatic factors
Mangifera indica	0-1200 m, Mean annual temperature: 19-35 deg. C, Mean annual rainfall: 500-2500 mm
Citrus limon	Grows up to 1800m or sometimes 2500m depending on environmental conditions
Persea americana	0-2 500 m, Mean annual temperature: -4 to 40 deg. C, Mean annual rainfall: 300-2 500 mm
Artocarpus heterophyllus	Up to 1600m. Can withstand cold temperatures and even some frost

1.4 Habitat requirements

Table 4: Habitat requirements of species recommended for homestead fruit orchard land use system

Species	Habitat requirements.
Mangifera indica	- Thrive in well-drained soils with pH ranging from 5.5 to 7.5 and are fairly tolerant of alkalinity. - Do not seem to suffer from occasional flooding.
Citrus limon	-More sensitive to cold than the orange and less able to recover from cold injury -Suited to sandy or loamy well-drained soils
Persea americana	Cold tolerant
Artocarpus heterophyllus	It will not tolerate drought or flooding, and for optimum production it requires a warm, humid climate and evenly distributed rainfall.

1.5 Growth habit

Table 5: Growth habits of species recommended for homestead fruit orchard land use system

Species	Growth habit.
Mangifera indica	- A prominent dry season lasting more than 3 months is necessary for fruit production. - Trees shade out grasses because of their thick crowns.
Citrus limon	- The lemon tree has the reputation of tolerating very infertile, very poor soil.
Persea americana	Evergreen, although some varieties lose their leaves for a short
Artocarpus heterophyllus	Straight stemmed and may grow to 8 ï 25 m.

1.6 Scope and applicability of this system

The project area (E31.07; S01.48) falls within the perennial banana/coffee agro-ecological zone with elevation of 1300-1600 meter. The annual precipitation is between 1000 and 1250 mm and mean annual temperature 20^{o}C. The agro-ecological zone of the project area as described above supports practicing the system, for example beside carbon revenues the system provides:

1. Small-scale fruit farming is a key economic activity in the area. Once demand for fruits in the community has been satisfied, fruit production may be developed as a source of income diversifying production at household.
2. Farmers adapting to climate change as a result of increased food, income, improved technologies and environmental services
3. Fruit orchards have a potential to increase food security and rural incomes and thereby reduce rural poverty.
4. Increased fruit consumption among farm families increases the nutritional security in the communities. Better nutrition among communities has a positive impact on HIV/AIDS. Fruits can improve household nutrition, which is especially important for individuals living with HIV/AIDS.

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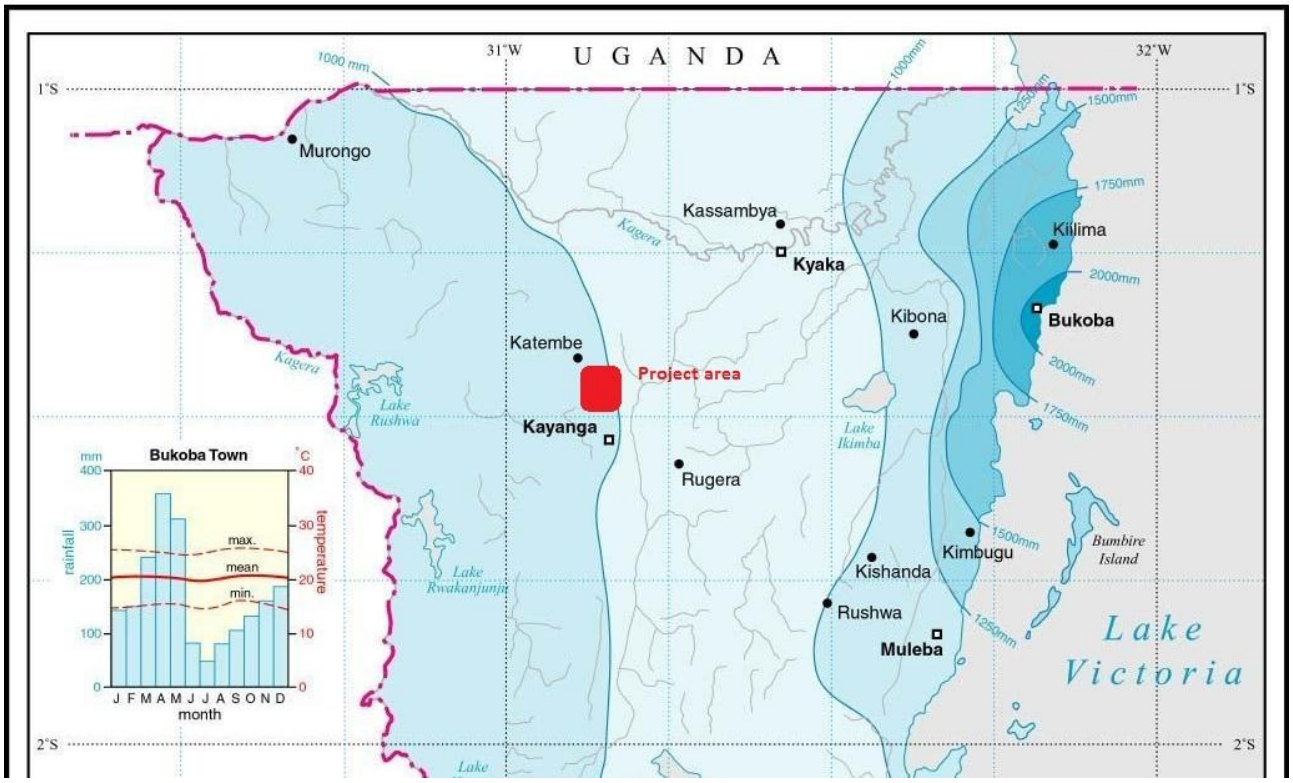

2 Managing this land use system

2.1 Management objectives

The main objective of this system is to produce fruits for household consumption and as alternative livelihood system as well as provide other environmental services. The primary management objectives for each species are shown in the table below:

Table 5: Management objectives for species recommended for homestead fruit orchard land use system

Species	Management objective
Mangifera indica	Fruit production. Apiculture (the tree secretes large quantities of nectar), fuel (excellent for charcoal and firewood), timber, carpentry, shade/shelter
Citrus limon	Fruit production. The lemon tree will tolerate very infertile, poor soil.
Persea americana	Avocado fruit production
Artocarpus heterophyllus	Fruit, fodder and valuable timber

2.2 Costs of implementation

These costs of implementation are based on planting 150 trees. All costs are merely indicative.

2.2.1 Nursery costs

The activities and costs for establishing 150 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
- Grafting
- Green house sheeting
- Cost of one wheelbarrow, 3 hoes, 2 spades, 1 machete, shade netting, poles, water, and fuel costs

The total nursery cost is estimated to be $ 520

2.2.2 Establishment cost

The activities in the establishment phase would include

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

The total cost for this phase for per hectare is estimated to be $ 35

2.2.3 Maintenance cost

Calculations are based on planting 150 trees per hectare. The tree stocking number is derived in line with proportions listed (Table 10) for carbon sequestration models)

Operations for year one are grass slashing, spot weeding, firebreaks, uprooting and shrubs. The cost per hectare is estimated to be $25

From year 2 to year 5 operations include grass slashing, spot weeding, firebreaks maintenance, and uprooting shrubs. The total cost is estimated to be $50

Other costs would go to buying equipments such as one slasher, one hoe, one machete, a pair of boots, and one overall coat. This is estimated to cost $ 50. In total, the maintenance cost is estimated to be $ 110

Table 7: Maintenance costs for species recommended for homestead fruit orchard land use system

Activity	Cost (per hectare for fruit orchard)
Nursery costs	$ 520
Establishment	$ 35
Maintenance year 1	$ 25
Maintenance year 2	$20
Maintenance year 3	$ 10
Maintenance year 4	$ 10
Maintenance year 5	$ 10
Equipment cost	$ 50

Total	$ 680

2.3 Potential income

The calculations are based on planting 150 trees. The potential income is merely indicative

2.3.1 Income from fruit trees

In the system, either one or two fruit species or a mixture of all the fruits can be planted.

There will be a total of 150 fruit trees per hectare with a spacing of 8X8 metres .Up to a maximum of 150 kg of Orange fruit can be produced per tree / year. The current market value for orange fruit is $0.40 per kg.

There will be a total of 156 mango, citrus and jack fruit (8x8m spacing) and 123 avocado fruit trees with a spacing of 9X9 metres. Up to a maximum of 70 kg of mango fruit can be produced per tree / year, whereas avocado tree can yield 250-300 kg of fruit per harvest season. The current market value for mango fruit is $2.00 per kg whereas the current market value for avocado fruit is $0.4 per kg

2.4 Management operations

Management operations suitable for this system is as follows

2.4.1 Preparation of site

Demarcate the planting area clear any unwanted undergrowth (competition) and mark where individual trees will be planted as follows:

1. All shrubs and unwanted trees should be removed from the planting area in order to remove undue competition with the young plants.
2. The litter should then be collected for burning
3. Uprooting of any stumps in the area.
4. Mark planting spots at (variable spacing for different tree species ï see Table below).
5. Opening of holes at 60cm x 60cm, which should be done before the onset of rains.
6. Planting should be done immediately 50 mm of rain is achieved during the onset of rains.

When planting nursery grown stock:

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

2.4.2 Establishment

Table 8: Establishment procedure for species recommended for homestead fruit orchard land use system

Species	Establishment

Mangifera indica	Planting density should be 8 x 8 meters (156 trees / hectare). The planting density may vary according to variety and management regime i.e. less vigorous varieties and pruning will allow for closer spacing. 8 x 8 is considered to be an average viable spacing for mango. - Propagated by seed but selected varieties may also be propagated vegetatively by grafting the rootstock of the same or other Mangifera species and by budding. - Irrigation in the 1st years after planting promotes faster growth and widens the scope for intercropping, for example, with papaya, banana, pineapple or vegetables, during the establishment phase
Citrus limon	Citrus fruit trees should be planted at 8X8 meters (156 trees per hectare)
Persea americana	Avocado trees should be planted at 9X9 meters (123 trees per ha). Different varieties should be mixed.
Artocarpus heterophyllus	Plant 8m x 8m

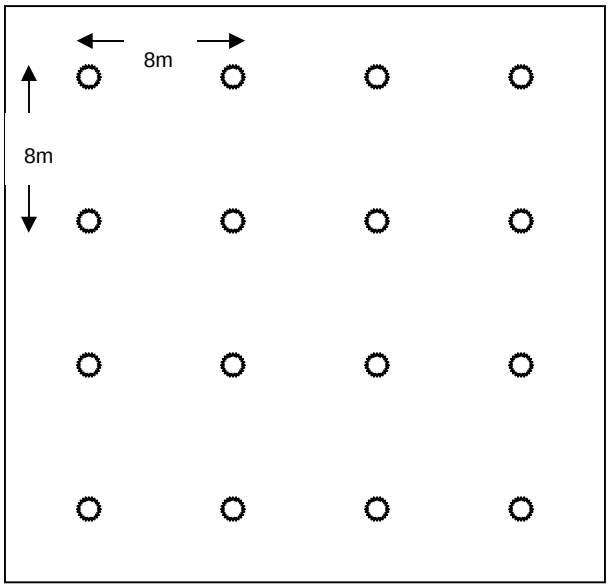

Figure 1 a: Pure mango orchard

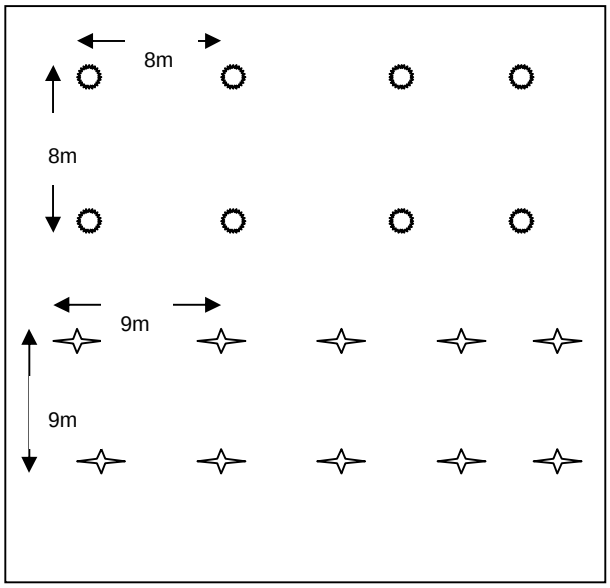

Figure 1 b: Mixed fruit orchard

2.4.3 Weeding

Weeding should be done twice in the first year and once in the subsequent years until dominance has been achieved by the planted trees. Weeding facilitates the achievement of maximum growth rate. Some grass slashing may also be required for the first three years and occasional uprooting of shrubs. Weeding reduces competition for nutrients and fire risk.

2.4.4 Protection from Hazards

The following measures are recommended to ensure the planted trees are not harmed:

1. Fencing off the planted area is recommended to stop grazing and reduce soil re-compaction by both animal and human activity. However, controlled foot paths should be designated to create access points across the planted area for humans.
2. Fire breaks need to be in place before the onset of the dry spell. Firebreaks are important in halting the spread of fire in case of such an eventuality
3. The boundary forest floor should be kept clean of any potential fire hazards.

4. The farmer should always be on the lookout for any fires.

2.4.5 Maintenance

Each species would require different management regimes as follows

Table 9: Maintenance operations for species recommended for homestead fruit orchard land use system

Species	Maintenance
Mangifera indica	- Mango seedlings should be pruned by removing dead wood and branches broken or weakened by pests and diseases. This ensure good, balanced and productive growth - A little weeding to keep the orchard floor clean
Citrus limon	The lemon must be pruned from time to time to promote an attractive shape
Persea americana	-Appropriate good practice will be required for all trees planted in terms of planting techniques, weeding, and replacement of dead trees, irrigation, and pruning. -Pruning during the first 2 years encourages lateral growth and multiple framework branching. Commercially, after several years of production it is desirable to occasionally reduce canopy width of the trees to 5-6 m, to reduce spraying and harvesting costs and reduce storm damage.
Artocarpus heterophyllus	Very little pruning required. Weeding around young trees. Irrigate during dry season Fertilising will improve fruit yields

2.4.6 Harvesting

The table below will act as a guide to rotation age of each species

Table 10: Rotations of species recommended for homestead fruit orchard land use system

Species	Harvesting
Mangifera indica	Tree to be harvested / re-established on a 50 year cycle.
Citrus limon	To be harvested/re-established between 25 to 50 years
Persea americana	>25 years
Artocarpus heterophyllus	>25 years

3 Description of the environmental and social benefits that may be derived from this land use system

- 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 improved water flows which will help to reduce catastrophic flooding (climate change adaptation benefit)
- Biodiversity benefit ï through the protection of wildlife habitat (birds, bees).

- NTFP ï beekeeping, medicines, fruits etc.
- Shading for humans and livestock
- Pruning material may be used as firewood

4 Description of additionality of community and individual on farm tree planting in Kagera Region, Tanzania

Prove of additionally in this system would be to demonstrate that fruit orchard planting would not have occurred in the absence of the carbon derived finance. The barriers which would be eliminated by this system would be:

- Community mobilisation and participation in planning processes
- Capacity (on improved land use management systems, agriculture and silviculture)
- Awareness (benefits that may be derived from tree planting)
- Raising seedlings
- Seedling distribution
- 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.

5 Leakage Assessment

Leakage is 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.

6 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 tradable 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 woodlots is set out in ó Assessment of Net Carbon Benefit of Emiti Nibwo Bulora project in Kagera, Tanzaniaô (Camco, 2010). Since there is no significant difference between the carbon baseline on cultivated land and that on neglected land a common baseline has been applied for all land use systems. The carbon baseline is estimated to be 2 tonnes of carbon per hectare in the absence of project activities. A slightly different approach from previous carbon sink calculations has been adopted. In this new approach, the baseline value (i.e. 2 tC/ha) was input into the CO_2Fix model, resulting in a marginal increase in the long term carbon sink.

7 Carbon sequestration potential

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 25 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 is calculated using the CO2FIX-V3 model (Mohren et al 2004).
- These model outputs are 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 fruit orchards is set out in ó Assessment of Net Carbon Benefit of Emiti Nibwo Bulora Project in Kagera, Tanzaniaô (Camco, 2010). The potential carbon sink created by this land use system (based on long term average carbon storage over 25 years) is calculated to be 8[1] tonnes of carbon per hectare.

This result is derived from carbon models based on planting tree species in the proportions shown in table 10. Tree growth data was not made available for all the tree species that may be planted by farmers adopting this land use system. Camco have therefore used the available tree growth data to model carbon sequestration potential using information gathered in the field relating to the most likely proportions of different tree species to be planted i.e. models are based on the most representative trees.

Table 10: Species used in carbon modelling

Technical specification	Species	Proportion (%)
Homestead Fruit Orchard	*Mangifera indica*	40
	Persea Americana	40
	Citrus spp.	10
	Artocarpus heterophylla	10

8 Risks

The risks involved in relation to this technical specification:

Technical

- Lack of technical skills among farmers and long term extension services from government and NGOs.

[1] This figure is lower than those estimated by Camco (ESD) in previous specifications for a similar system in other countries because initially, the trees were recommended to be planted at higher initial stocking, followed by thinning later on. However, the additional cost associated with thinning led Camco to recommend lower stocking that will remain unchanged throughout the life of the trees.

- Availability of recommended species of seeds/seedlings is limited and hinders tree planting
- High mortality rates in the plantations due to pest and diseases and/or browsing by animals.
- Improved microclimate resulting from establishment of the system may lead to diversified flora and fauna, that might have negative effect on agricultural production (e.g vermin) leading to negative perception

Social

- Investment cost involved becomes a barrier
- Labour requirement is regarded to hign by the farmers for engaging in tree planting activities
- Thefty/illegal cutting of trees for fuelwood, fodder, poles etc without consent of owner of property
- Inadequate knowledge and capacity of the small holder farmers to undertake improved agricultural production may lead to negative perceptions on the system in case of crop failure, similarly the same could be true in case of crop failure due to inability to adapt to climate change in agricultural production
- Possibility for Land relocation as per existing land legislation may affect realising the carbon sink benefits form practicing the system

Market

- If pricing for timber increases it can motivate farmers to cut trees before the optimum rotation age.

9 Buffer

20% of all VERûs 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 VERûs will return to the farmer.

10 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 offsets (Plan Vivo certificates) generated by the fruit orchard land use system (technical specifications) is presented in the table below:

Table 11: The net carbon benefit and tradable carbon offset for the 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)
Homestead fruit orchard	8	2	6	20	4.8	17

The figure below shows the long-term average carbon sink over the simulation period (25 years).

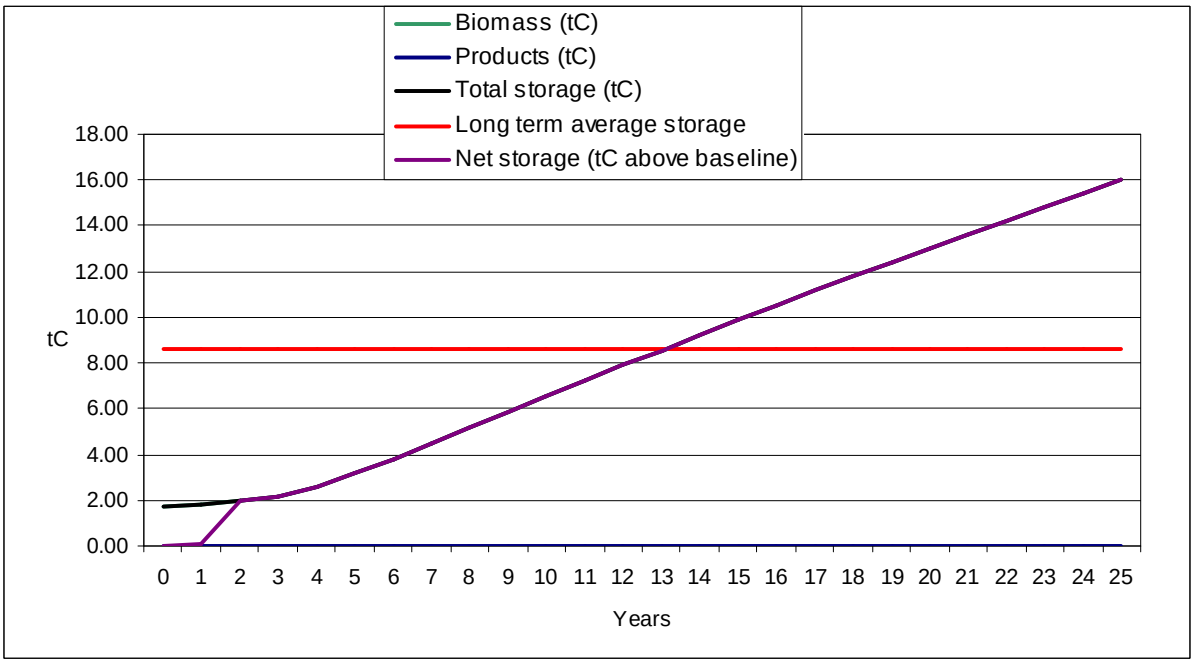

Figure 2: Homestead fruit orchard technical specification carbon sequestration potential over 25 years

11 Monitoring

Monitoring targets for the first 4 years are based on establishment; the whole plot must be established by the second year with at least 90% 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 50% plot established
2	Whole plot established, 90% survival (at least 132 stems /ha surviving)
3	Whole plot established , 90% survival
4	Whole plot established
5	Whole plot established and average DBH not less than 12 cm
6	Whole plot established and average DBH not less than 14 cm
7	Whole plot established and average DBH not less than 15 cm
10	Whole plot established and average DBH not less than 18 cm

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