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Emiti Nibwo Bulora dispersed interplanting technical specification

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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 nitrogen fixing and other agroforestry 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 dispersed interplanting system is to improve soil fertility and therefore increase yields of agricultural food products. Additional benefits will include soil conservation, improved water quality, enhanced biodiversity, and income diversification through firewood, medicine, bees and other non timber forest products (NTFPõs). 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. Dispersed interplanting may be widely adopted by individual farmers with small areas of landholding whilst contributing to enhanced food production.

The net carbon benefit and tradable carbon offset for the dispersed interplanting 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)
Dispersed interplanting	23	2	21	20	16.8	61

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 Land use system

This system involves the planting of nitrogen fixing tree species and other typical agroforestry tree species at a low stocking density throughout the area of cultivated land. Crops can continue to be grown. Nitrogen fixing trees will increase and extend the expected productivity of the cultivated land. These species increase soil nitrogen by actively manufacturing nitrogen compounds through symbiotic bacteria located in the roots. Any litter will act as a green manure (organic fertiliser) and the tree roots will also help to preserve the soil structure by retaining moisture and preventing erosion.

Planted trees should be pruned carefully every year to allow crops to continue to be grown throughout. Many studies indicate that interplanting of nitrogen fixing trees with crops (e.g. sorghum, maize) will increase crop yields significantly (University of Queensland, 1998) as well as extending the expected productivity of the land. Particular care should be taken where this system is implemented on banana plantations not to reduce banana production as a result of excessive shade being created by the trees canopy and competition (for nutrients and rooting space). This should be managed by regular thinning and pruning of trees. Intercropping of bananas with coffee is a common practise in this district. Coffee production should not be negatively impacted by the use of shade trees as the current practise is already to shade coffee using banana plants.

The planted trees should be managed for future fuelwood, poles and timber (saw log) production.

1.1 Main tree species

Table 1: Main species recommended for dispersed interplanting land use system

Botanical name	Common name (English)	Natural range	Nitrogen fixing
Markhamia lutea	Markhamia	Indigenous	N
Maesopsis eminii	Umbrella tree	Indigenous	N
Albizia lebbeck	East Indian walnut, English woman's tongue, fry wood	Naturalized	Y
Albizia coriara	Mugavu (Swahili)	Naturalized	Y
Acacia polyacantha	African catechu tree, white thorn tree	Indigenous	Y
Acacia nilotica	Babul acacia, Egyptian thorn, prickly acacia, scented thorn, scented-pod acacia	Indigenous	Y
Acrocarpus fraxinifolius	Australian ash, Indian ash, pink cedar, shingle tree	Naturalized	Y
Cedrela odorata	Spanish cedar, Mexican cedar	Naturalized	N

1.2 Ecology

Table 2: Ecological requirements of species recommended for dispersed interplanting land use system

Botanical name	Ecology

Markhamia lutea	The tree is drought resistant but cannot withstand water-logging.
Maesopsis eminii	Very common in the ecozone between high forest and savannah.
Albizia lebbeck	The species occurs on soils overlying basalt and among sandstone boulders and basalt outcrops on breakaway slopes. It is also found on the banks of riverine sites, on stabilized dunes or low lateritic ledges above the beach
Albizia coriara	Is a pioneer species common in wooded grassland, woodland and thicket.
Acacia polyacantha	The species occurs in wooded grasslands, deciduous woodland and bushland, riverine and groundwater forests in altitudes between sea level and 1800 m.
Acacia nilotica	It is drought resistant and occurs in plain, flat or gently undulating ground and ravines.
Acrocarpus fraxinifolius	Grows best in sub-montane areas in the humid and sub-humid tropics with a short, dry spell.
Cedrela odorata	Typically wet lowland areas with well aerated soils

1.3 Altitudinal range

Table 3: Altitudinal range of species recommended for dispersed interplanting land use system

Botanical name	Altitudinal range and climatic factors
Markhamia lutea	900-2000 m, Mean annual temperature: 12-27 deg. C, Mean annual rainfall: 800-2000 mm
Maesopsis eminii	700-1500 m, Mean annual temperature: 22-27 deg. C, Mean annual rainfall: 1200-3000 mm
Albizia lebbeck	0-1 800 m, Mean annual temperature: 19-35 deg. C, Mean annual rainfall: 500-2 500 mm
Albizia coriara	850-1 700 m
Acacia nilotica	0-1 340 m, Mean annual temperature: 4-47 deg. C Mean annual rainfall: 200- 1 270 mm.
Acacia polyacantha	Altitude 200-1 800 m, Mean annual rainfall: 300-1 000 mm
Acrocarpus fraxinifolius	0-1500 m, Mean annual temperature: 19-28 deg. C, Mean annual rainfall: 1000-2000 mm. It is very sensitive to frost.
Cedrela odorata	Up to 1900 m. Mean annual temperature: 22-26 deg. C, Mean annual rainfall: 1000-3700 mm

1.4 Habitat requirements

Table 4: Habitat requirements of species recommended for dispersed interplanting land use system

Botanical name	Habitat requirements.
Markhamia lutea	Trees prefer red loam soil but can tolerate well-drained, heavy, acidic clay soils.
Maesopsis eminii	Tolerates a wide range of site conditions but grows best on deep, moist and fertile sandy loam soils with a neutral to acid pH.

Albizia lebbeck	-Roots are near the surface so requires a high water table - prefers black-cotton soils but will grow in a wide range of soils including acid, , alkaline and saline
Albizia coriara	Found on a variety of soils
Acacia nilotica	Grows best on alluvial soils in ravine areas subject to periodic inundation
Acacia polyacantha	It prefers sites with a high groundwater table, indicating eutrophic and fresh soils. It occasionally prospers on stony slopes and compact soils.
Acrocarpus fraxinifolius	-Is a pioneer and demands light, but it can tolerate slight shade when young. - Grows best in deep, well-drained, clayey loam soils with a pH of 4-7. It I also thrives in shallow and compacted soils.
Cedrela odorata	It is not demanding of soil nutrients, tolerating soils high in calcium; it prefers fertile, free draining, weakly acidic soil but tolerates heavy soil.

1.5 Growth habit

Table 5: Growth habits of species recommended for dispersed interplanting land use system

Botanical name	Growth habit.
Markhamia lutea	Should be planted in a deep hole, as the roots are long. The tree coppice and can be coppiced when they are about 1.7 m in height.
Maesopsis eminii	It is an early successional species, adept at colonizing grasslands and disturbed areas in the high forest.
Albizia lebbeck	Grows to 15 ï 20 m.
Albizia coriara	Has high light requirements thus its absence in closed canopy rainforest
Acacia nilotica	-Fast growing in favourable conditions - Bears full leaf in the dry season but is often very thorny
Acacia polyacantha	Fast growing to 18m with open canopy
Acrocarpus fraxinifolius	Up to 60 m in height. Very few lower branches.
Cedrela odorata	Straight, grows to 40 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. Trees improve soil fertility through root and litter decomposition.
2. Farmers adapting to climate change as a result of increased food, income, improved technologies and environmental services
3. Trees can convert unused unproductive land into productive use.
4. Dependency on wood fuel as main source of energy for household use, trees on farm can sustainably provide such benefits

5. Trees provide windbreaks, water conservation and shade on farm.
6. Other needs for tree products such as timber and poles for construction can be supplied through this system.

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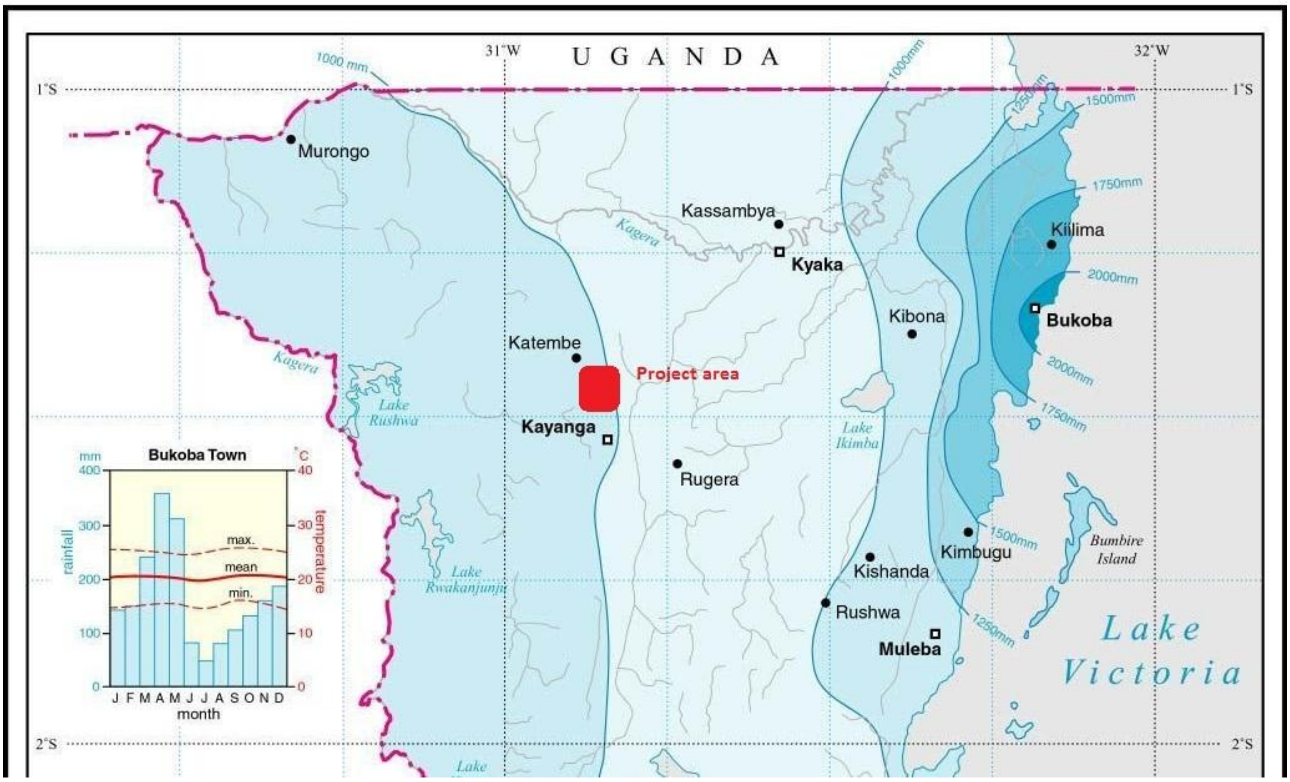

2 Managing this land use system

2.1 Management objectives

The main management objective is soil improvement to increase yields of agricultural products. Some fuel wood and fodder may also be obtained from pruning and pruning material can be used as firewood.

Table 6: Management objectives for species recommended for dispersed interplanting land use system

Species	Management objective
Markhamia lutea	**Timber** Soil improver (provides mulch which enhances soil moisture retention and increases organic matter), **poles** used as props to support banana trees, soil erosion control, shade.
Maesopsis eminii	Reforestation purposes, **firewood**, medicines (leaves, barks and roots), bee-forage, fodder (leaves), ornamental, shade (coffee), **timber**
Albizia lebbeck	**Timber**, Fodder (leaves), **construction**, **erosion control** (good soil binder due to its extensive, fairly shallow rooting system), **shade/shelter**, soil improver as it is nitrogen fixing, mulch, ornamental,
Albizia coriara	**Timber**, Fodder (leaves), **construction**, **erosion control** (good soil binder due to its extensive, fairly shallow rooting system), **shade/shelter**, soil improver as it is nitrogen fixing, mulch, ornamental,

Acacia nilotica	Bee forage, **fuel** (charcoal and firewood), degraded soil/land **reclamation**, **timber**, Nitrogen fixing, wind break
Acacia polyacantha	**Firewood**, charcoal, timber, medicine, nitrogen fixing, soil conservation, fodder
Acrocarpus fraxinifolius	**Timber**, Apiculture, shade/shelter, firewood and charcoal, soil erosion control, soil reclamation (on degraded areas), soil improver (mulching), furniture
Cedrela odorata	Timber, firewood and good for apiculture

2.2 Costs of implementation

These costs of implementation are based on planting 200 trees. All costs are merely indicative.

2.2.1 Nursery costs

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

- Cost of seeds
- Digging and mixing of the soil
- Pot filling, transfer, and topping
- Seed sowing and bed management
- Pricking out and selection/transfer
- Watering and sanitation
- Stores operations cost

The total cost of these activities for 200 trees tree seedlings is estimated at $ 73

2.2.2 Establishment cost

The activities in the establishment phase would include

- Demarcation and soil test
- Bush clearing
- Chaining/marking at a spacing of 5m by 10m
- Planting

The total cost for this phase for 200 trees per hectare is estimated to be $ 50

2.2.3 Maintenance cost

Year one to include grass slashing, spot weeding, firebreaks, and uprooting shrubs. The cost for 200 trees per hectare is estimated to be $35

Year two operations include grass slashing, spot weeding, firebreaks maintenance and uprooting shrubs. The total cost in this year is estimated to be $ 20

Operations for year 3, 4, and 5 (including maintenance of firebreaks) are estimated to be $45 for 200 trees per hectare

Additional costs for equipment (e.g. one slasher, one hoe, one machete, a pair of boots and one overall coat) are estimated to be $52.

Table 7: Maintenance costs for species recommended for dispersed interplanting land use system

Activity	Cost (per hectare for dispersed interplanting)
Nursery costs	$73
Establishment	$50

Maintenance year 1	$35
Maintenance year 2	$20
Maintenance year 3	$ 15
Maintenance year 4	$ 15
Maintenance year 5	$ 15
Equipment	$52
Total	$ 275

2.3 Potential income

Any income generated using this land use system may be small. The calculations are based on planting 200 trees. The potential income is merely indicative

2.3.1 Timber

No revenue from timber because tree harvesting will not happen during the 25 year crediting period

2.3.2 Fuel wood

Some revenue may be derived from pruning trees to maintain adequate light levels for cultivation which may be used as firewood in the homestead or sold.

2.4 Management operations

2.4.1 Establishment

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

Planting pits should be dug before the onset of the short rains. The farmer must first remove any competing vegetation from the farm. All foliage and green waste should be spread on site to break down and enrich the soil. This will also help to retain moisture. The whole site must be turned to a low depth (5 ï 10 cm). The farmer will then sow any crops (e.g. maize, sorghum), before planting the trees in the planting pits at the onset of the long rains.

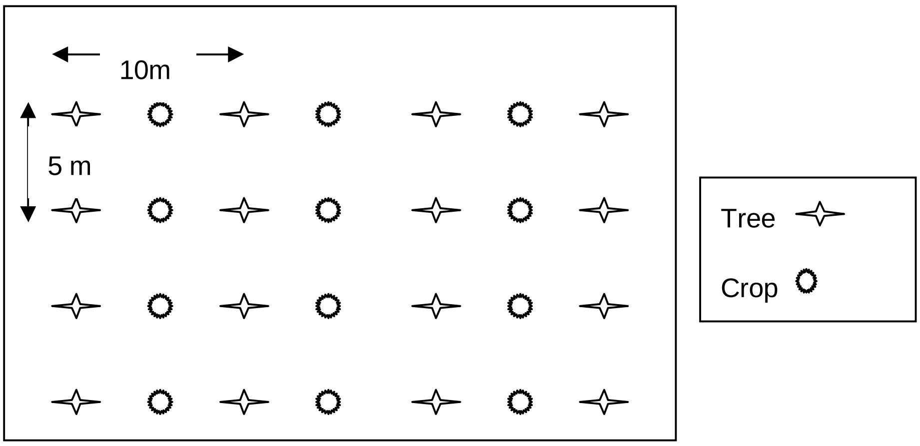

Figure 1: Layout of dispersed interplanting system

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 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 Mycorrhizal inoculation

The following simple mycorrhizal inoculation process is recommended as a way of promoting an association between soil borne fungus and the leguminous trees being planted in farm land.

1. Collect soil (only top 15 ï 20 cm) from under an area of undisturbed vegetation (including non burning in recent years). Either place this soil in a large container or in a ground pit lined with plastic.
2. Plant a mixture of food crops (maize) and leguminous plants (pigeon peas) into this soil. Maintain by watering regularly.
3. After 3 months cut both the food and leguminous crops at ground level. Stop watering.
4. After a further week (with no watering) pull up the roots of the food and leguminous crops and cut into 1 cm sections. Mix the soil and cuttings together. This is the inoculum.
5. The inoculum should be placed around the root ball of the plant when planting out. Alternatively the inoculum is placed in the container in which the seed is sown, a few centimeters below the seed.

2.4.3 Maintenance

Any weeding should be done as required particularly in the first year after planting to ensure successful establishment. It is assumed that extensive weeding will be associated with crop maintenance.

Pruning in the 2nd year to about half the tree height may be needed to control low branching.

For the first two years after planting any dead trees should be replaced at the beginning of the following wet season.

Crops will continue to be grown throughout the area planted with trees.

There should be **no** burning at any time. Any foliage and green waste should be left on site and worked into the ground. Woody material from pruning can either be used as fuel wood or for poles etc.

2.4.4 Harvest

Trees should be grown to maturity and not harvested until year 30.

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

- Soil improvement - nitrogen fixing trees will increase and extend the expected productivity of the cultivated land
- 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

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 nitrogen fixing trees as part of the dispersed interplanting system that are overcome through the project activity and receipt of carbon finance are:

- 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 the dispersed interplanting system where trees are planted in order to increase food yields per hectare on cultivated land leakage is not likely to occur.

However, 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 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.
- A plan to monitor leakage on specific other woodland areas to ensure leakage is not occurring.
- Formation of community based ‰policingô 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 dispersed interplanting there should be no assumption of leakage.

In all probability the most likely outcome of the dispersed interplanting system is positive leakage as a result of improved land use reducing the pressure to extend cultivation of food activities to new areas.

6 Baseline Carbon Emissions

The ‰**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 (VERÕs) 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 ῝baseline῎ carbon emissions that would be associated with land management expected in the absence of the establishment of woodlots is set out in ΄Assessment of Net Carbon Benefit for Emiti Nibwo Bulora project in Kagera, Tanzania΅ (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 dispersed interlanting system is set out in ΄Assessment of Net Carbon Benefit Emiti Nibwo Bulora project in Kagera, Tanzania΅ (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 23 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 (%)
Dispersed Interplanting	*Maesopsis eminii*	30
	Grevillea robusta	25
	Acrocarpus fraxinifolius	25
	Cedrela odorata	10
	Markhamia lutea	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.
- 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 VERõs 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 VERõs 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 dispersed interplanting land use system (technical specifications) is presented in the table below:

Table 8: The net carbon benefit and tradable carbon offset for the dispersed interplanting land use system

Technical Specification	Sink (tC/ha)	Baseline (tC/ha)	Net benefit (tC/ha)	Buffer (%)	Tradeable (tC/ha)	Tradeable (tCO_2/ha)
Dispersed interplanting	23	2	21	20	16.8	61

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

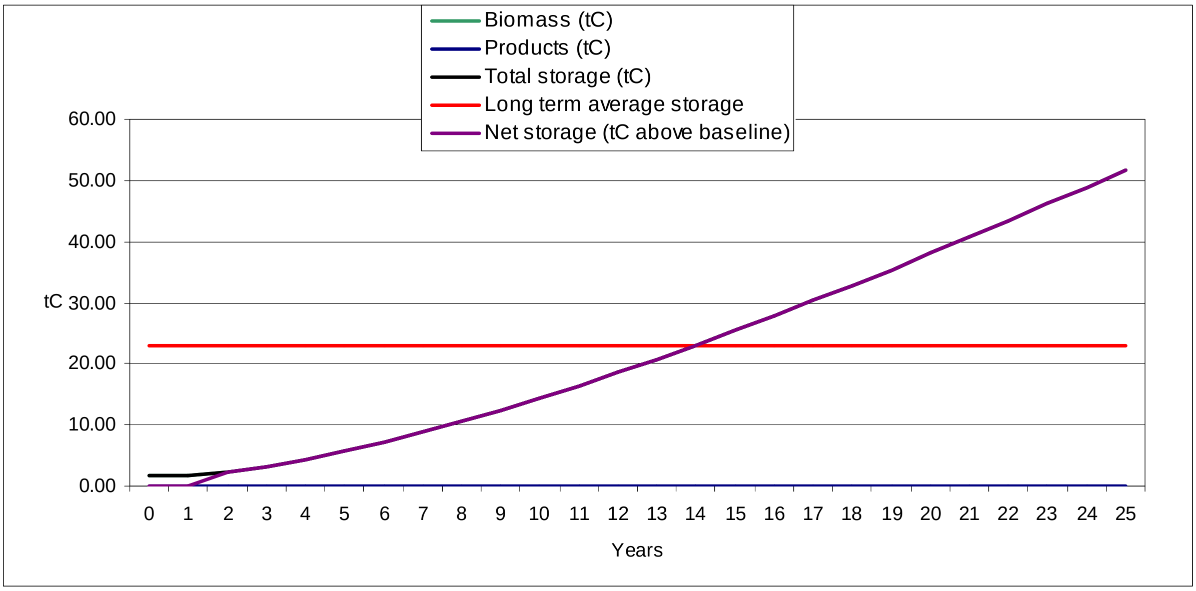

Figure 2: Dispersed interplanting technical specification carbon sequestration potential over 25 years

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.

Table 10: Monitoring indicator for species recommended for dispersed interplanting land use system

Year	Indicator
1	At least 50% plot established
2	Whole plot established, 90% survival (at least 170. stems /ha surviving)
3	Whole plot established , 90 % survival
4	Whole plot established
5	Whole plot established and average DBH not less than 10 cm
6	Whole plot established and average DBH not less than 13 cm
7	Whole plot established and average DBH not less than 15 cm
10	Whole plot established and average DBH not less than 21 cm

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