Woodlot Technical Specification for *Emiti Nibwo Bulora* Plan Vivo Project, Tanzania

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Summary

This "technical specification" has been developed for use by Plan Vivo projects involving communities participating in the Kagera Region of Tanzania. The technical specification aims to summarise the best available evidence about the environmental benefits associated with the sustainable management of this land use system.

This technical specification has been revised after five years of implementation following consultations with Vi Agroforestry project staff and other stakeholders between 25th and 31st of January 2016 in both Karagwe and Kyerwa Districts where the project is currently being implemented. Periodic revision is a requirement of the Plan Vivo Standard which in Subsection 5.3 of the revised 2013 version provides requires that:

"Technical specifications must be updated at least every 5 years where they are still being used to sign new Payment for Ecosystem Services (PES) Agreements, by reviewing both available data from project monitoring results, e.g. species growth data, and new available data from outside the project."

Hence this revised version reinforces the original recommendations but also incorporates changes deemed necessary based on the challenges observed after five years of implementation.

The original land use system was developed in consultation with communities and individual farmers in the Kagera Region of Tanzania. Other valuable contributions to the development of this system were received from Vi Agroforestry staff, national and district government officials and forestry and agricultural extension workers. The inputs were received through a structured process of meetings and interviews with these key stakeholders between May 2008 and December 2008.

The system involves planting a variety of indigenous timber species on fragmented land plots which farmers have difficulty managing because of labor shortage, distance, theft or other constraints. This technical specification 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 main objective of the woodlot system is to diversify farm production and provide multiple benefits such as timber, firewood, medicine and fodder. Additional environmental and social benefits include soil conservation, improved water quality, enhanced biodiversity, and income diversification through firewood, medicine, bees and other non-timber forest products (NTFP's). As attested by the participants, the carbon finance makes a critical difference in allowing for the implementation of the system by helping to finance the purchase of tree seedlings, increasing capacity in managing the land use system and putting in place frequent monitoring to ensure compliance with the technical specification that is responsible for creation of the carbon sink. The net carbon benefit and tradable carbon offset for the woodlot land use system is shown in the table below:

	1	2	3	4	2-(1+3+4)
Intervention type (Technical Specification)	**Baseline carbon uptake / emissions i.e. without project (tCO_2e/ha)***	**Carbon uptake/emissions reductions with project (tCO_2e/ha)**	**Expected losses from leakage (tCO_2e/ha)**	**Deduction of risk buffer (tCO_2e/ha)**	**Net (Tradeable) carbon benefit (tCO_2e/ha)**
Woodlot	7.33	195.35	0	38.97	149.05

* Whilst a baseline of 6.38 tCO2e/ha was modelled through the updated growth models, the baseline assessment of carbon levels suggested a baseline of 7.33 tCO2/ha. The higher, and therefore more conservative, value of 7.33 was therefore used for this technical specification when estimating carbon benefits.

The carbon sequestration is highly dependent on the species combination selected for planting as well as their growth performance.

Acknowledgements

This revision was done by Emmanuel Ekakoro of Camco Advisory Services Kenya Limited in furtherance of the Plan Vivo project implementation in the Kagera Region of Tanzania upon the request of Vi Agroforestry. The author wishes to acknowledge the contribution made by the staff of Vi

Agroforestry in Kayanga (Kagera) and Nairobi (Kenya), and all the stakeholders consulted during the five-day field visit to assess the performance of trees planted following the original technical specification.

Table of Contents

List of Tables

Table of Figures

List of Acronyms, Abbreviations and Symbols

$	Dollar(s)
A/R	Afforestation/Reforestation
cm	Centimetre
DBH	Diameter at Breast Height
ECCM	Edinburgh Centre for Carbon Management
ESDA	Energy for Sustainable Development Africa
ha	Hectare
ICRAF	International Centre for Research in Agroforestry (now 'World Agroforestry Centre')
m	Metre
mm	Millimetre
PV	Plan Vivo
RSCU/SIDA	Regional Soil Conservation Unit/Swedish international Cooperation Development Agency
tC	Tonne of Carbon
tCO_2	Tonne of Carbon Dioxide
US	United States (of America)
UK	(The) United Kingdom
VER	Verified Emission Reductions

1 Description of land use system

The woodlot system involves planting a variety of indigenous and naturalised tree species on fragmented land plots which farmers have difficulty managing because of labour shortage, distance, or other constraints. Different species may be planted in different blocks of the same piece of land, although the current practice shows farmer preference for a single species system. The aim of this system is to diversify farm production and provide multiple benefits such as timber, firewood, medicine and fodder while minimizing land management requirements. This system may be used on degraded land i.e. previously-wooded lands currently with few or no trees, or under-utilised land which, in the long term, helps re-habilitate degraded lands. Growing of crops during the initial years after tree planting helps assist with tree establishment and subsequent maintenance by helping subsidise the cost of weeding and pest control.

1.1 Scope and applicability of this system

In order to be eligible to participate in the program, farmers must have underutilized land that falls within suitable areas of the current project area as shown in Figure 1.1 below. Additionally, participating farmers must make personalized farm management plans (Plan Vivos) that demonstrate they own additional land sufficient for their agricultural needs. Farmers are not allowed to clear forested land to gain eligibility and they must demonstrate clear land title and user rights to their farm.

The Kagera region is situated in the north-western corner of Tanzania. The region shares borders Uganda to the north, Rwanda and Burundi to the west, Kigoma and Mwanza regions to the south and Lake Victoria to the east. It lies just south of the equator between 1˚00’ and 3˚15’ south latitudes. Longitudinally it lies between 30˚25’ and 32˚00’ east of Greenwich. This region includes a large part of the waters of Lake Victoria.

The area falls within the perennial banana/coffee agro-ecological zone with elevation of 1300-1600 meters. The annual precipitation is between 800 and 2000 mm and mean annual temperature of 20˚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. High demand for wood fuel as main source of energy for household use, woodlots can sustainably provide such benefits;
2. Farmers adapting to climate change as a result of increased food, income, improved technologies and environmental services;
3. Other needs for tree products such as poles for construction can be supplied through this system;
4. Important source of income to the households; and
5. A financial safety net during crop failure or sickness in the families.

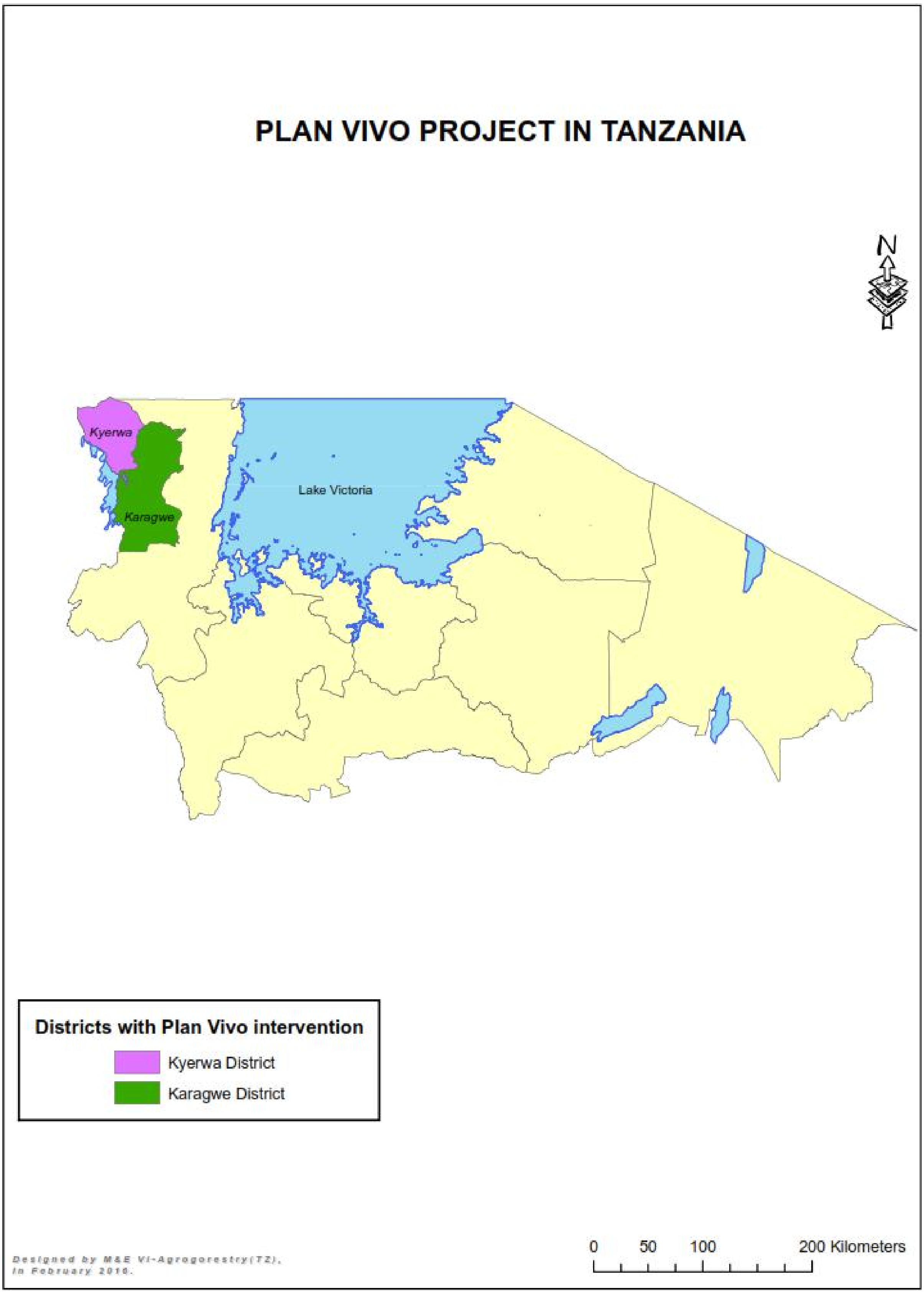


Figure 1.1 - Plan Vivo intervention area boundaries (Karagwe and Kyerwa Districts)

1.2 Main tree species

The species selection process was conducted in the following order:

1. Potential participants were consulted to determine the favored native species as candidate species;
2. Experts, including government forestry staff, augmented with a literature review, were also consulted to determine the favored species with which to work within the technical specification;
3. The species that overlap with both participants and experts were selected; and
4. From experience using the older versions of this technical specification, species selection was refined based on experience in the field.

Following the process above, an assortment of indigenous and naturalized tree species were recommended, although field assessment shows farmers have a preference for *Maesopsis eminii, Acrocarpus fraxinifolius, and Markhamia lutea* in that order. Some farmers prefer to plant *Grevillea robusta* and *Cedrella odorata* under the woodlot system although they had been recommended for a different land use system.

Table 1.1 - Tree species recommended for the woodlot planting system.

Botanical name	Common name (English)	Range
Maesopsis eminii	Umbrella tree	Naturalised
Acrocarpus fraxinifolius	Australian ash, Indian ash, pink cedar, shingle tree	Naturalised
Grevillea robusta	Silky oak	Naturalised
Markhamia lutea	Markhamia	Indigenous
Cedrela odorata	Spanish cedar, Mexican cedar	Naturalized
Casuarina equisetifolia	Australian pine, beach she-oak, beefwood tree	Naturalised
Podocarpus spp	East African yellow wood	Indigenous
Acacia nilotica	Babul acacia, Egyptian thorn, prickly acacia, scented thorn, scented-pod acacia	Indigenous
Albizia lebbeck	East Indian walnut, English woman's tongue, fry wood	Naturalised
Acacia polyacantha	African catechu tree, white thorn tree	Indigenous

Although some of the species in the table have not been planted by any of the current participating farmers, they have been retained in the technical specification nevertheless as some farmers currently undergoing recruitment may prefer to plant them.

1.3 Ecology and climate

The Kagera Region has a series of hilly ridges running north to south parallel to the shores of Lake Victoria. It has reasonably fertile but old soils in most parts of the region. The region has a pleasant climate, with monthly maximum and minimum temperatures of 26°C and 16°C respectively. The region’s climate is influenced greatly by its proximity to Lake Victoria. Prevailing winds from the east tend to bring higher rainfall to the shore strip and highlands close to the shore. The shore highlands create a rainfall shadow over the central area. The main rains come twice a year (bimodal) in March to May and during the months of October to December. The average annual rainfall for the whole region ranges between 800 mm and 2000 mm. In the western highlands of Ngara and Karagwe annual rainfall is over 1,000 mm whereas in Biharamulo it ranges between 800 mm and 1000 mm. The dry period begins in June and ends in September. There is also a short and less dry period during January and February. See Figure 1.2 for details of rainfall within the project area. Table 1.2 below shows the Ecological requirements of recommended species.

Table 1.2 - Ecological requirements of recommended species[1]

Species	Ecology
Maesopsis eminii	Very common in the ecozone between high forest and savannah.
Acrocarpus fraxinifolius	Grows best in sub-montane areas in the humid and sub-humid tropics with a short, dry spell.
Grevillea robusta	Grows on fairly well drained and neutral to acidic soils.
Markhamia lutea	The tree is drought resistant but cannot withstand water-logging.
Cedrela odorata	Typically, wet lowland areas with well-aerated soils.
Casuarina equisetifolia	Its natural range is semi-arid to sub humid. Commonly confined to a narrow strip adjacent to sandy coasts, rarely extending inland to lower hills.
Podocarpus spp	A humid and warm climate is preferable; in dry and hot areas, plantations fail.
Acacia nilotica	It is drought resistant and occurs in plain, flat or gently undulating ground and ravines.
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.
Acacia polyacantha	The species occurs in wooded grasslands, deciduous woodland and bushland, riverine and groundwater forests in altitudes between sea level and 1800 m.

1 For lack of data, and because the other species are not currently planted by any participating farmer under the programme, carbon modelling has been done only for *Acrocarpus, Grevillea, Maesopsis*, *and Markhamia*.

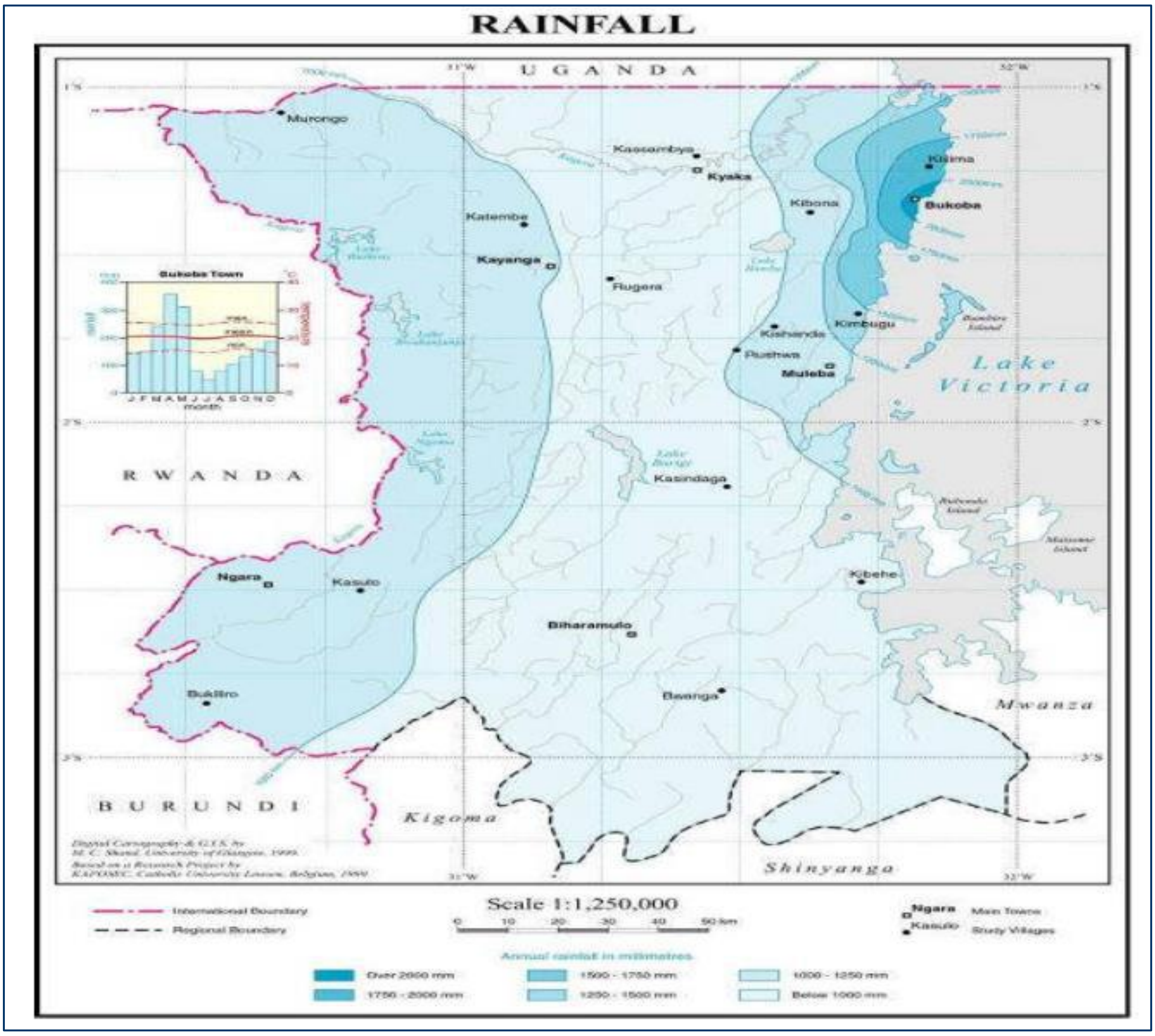


Figure 1.2 - Rainfall map of the project area

Source: Atlas of Food Security – Kagera Area, Tanzania

1.4 Altitudinal range and climatic requirements

The selected tree species exhibit optimal growth for the selected woodlot design at elevations ranging from 700 – 2000 metres above sea level as shown in Table 1.3 for each species.

Table 1.3 - Suitable altitudinal and climatic ranges for recommended species

species	Altitudinal range (metres above sea level) and climatic factors
Maesopsis eminii	700-1500 m, Mean annual temperature: 22-27 deg. C, Mean annual rainfall: 1200-3000 mm
Acrocarpus fraxinifolius	0-1500 m, Mean annual temperature: 19-28 deg. C, Mean annual rainfall: 1000-2000 mm
Grevillea robusta	0-2300 m, Mean annual temperature: 14-23 to 25-31 deg. C, Mean annual rainfall: 600-1700 mm
Markhamia lutea	900-2000 m, Mean annual temperature: 12-27 deg. C, Mean annual rainfall: 800-2000 mm
Cedrela odorata	Up to 1900 m. Mean annual temperature: 22-26 deg. C, Mean annual rainfall: 1000-3700 mm
Casuarina equisetifolia	0-1400 m, Mean annual temperature: 10-35 deg. C, Mean annual rainfall: 200-3500 mm
Podocarpus spp	1550-3 000 m, Mean annual temperature: 13-20 deg. C, Mean annual

species	Altitudinal range (metres above sea level) and climatic factors
	rainfall: 1 200-1 800 mm
Acacia nilotica	0-1 340 m, Mean annual temperature: 4-47 deg. C Mean annual rainfall: 200-1270 mm.
Albizia lebbeck	0-1 800 m, Mean annual temperature: 19-35 deg. C, Mean annual rainfall: 500-2500 mm
Acacia polyacantha	Altitude 200-1800 m, Mean annual rainfall: 300-1 000 mm

Figure 1.3 - Topographical map of Kagera

1.5 Habitat requirements

Table 1.4 - Habitat requirements for recommended species

Species	Habitat requirements
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.
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 also thrives in shallow and compacted soils.
Grevillea robusta	• Does not stand water-logged or heavy-clays soils.
Markhamia lutea	• Trees prefer red loam soil but can tolerate well-drained, heavy, acidic clay soils.
Cedrela odorata	• It is not very demanding of soil nutrients, tolerating soils high in calcium; it prefers fertile, free draining, weakly acidic soil but tolerates heavy soil.
Casuarina equisetifolia	• The species tolerates both calcareous and slightly alkaline soils but is intolerant of prolonged water logging and may fail on poor sands where the subsoil moisture conditions are unsatisfactory.
Podocarpus spp	• Can tolerate moderate frost but not drought.
Acacia nilotica	• Grows best on alluvial soils in ravine areas subject to periodic inundation.
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 soils.
Acacia polyacantha	• It prefers sites with a high groundwater table, indicating eutrophic and fresh soils. It occasionally prospers on stony slopes and compact soils.

1.6 Growth habitats

Table 1.5 - Growth habits of recommended species

Species	Growth habit
Maesopsis eminii	• It is an early successional species, adept at colonizing grasslands and disturbed areas in the high forest.
Acrocarpus fraxinifolius	• Fast-growing and very sensitive to frost.
Grevillea robusta	• Moderate to fast growing. Only young trees copies well.
Markhamia lutea	• It is an upright evergreen tree 10-15 m high, with a narrow, irregular crown and long taproot
Cedrela odorata	• Straight tree, growing to 40 m.
Casuarina equisetifolia	• Crown shape initially conical but tends to flatten with age.
Podocarpus spp	• It is an evergreen tree up to 46 m in nature but much smaller if planted, with a long clean and cylindrical trunk.
Acacia nilotica	• Fast growing in favourable conditions. • Bears full leaf in the dry season but is often very thorny.
Albizia lebbeck	• Fast growing on good sites. • A deciduous tree which may reach 25m, usually 8-14m, trunk often short, crown low and spreading.
Acacia polyacantha	• Fast growing to 18m with open canopy.

2 Managing the land use system

2.1 Management objectives

This mixed-native woodlot system provides an opportunity for farmers to use available land which is not optimally utilized in a profitable manner and place it under a less intensive management system. Land may be too far from farmers' compounds because of fragmentation, or crops grown may be affected by theft or vermin originating from the neighbouring protected area. Farmers may not have the necessary labour to cultivate. Each species has its own primary management objectives as follows:

Table 2.1 - Management objectives of recommended species

Species	Management objective
Podocarpus spp	**Timber, fuel (firewood), furniture**, windbreaks around homesteads, soil reclamation/conservation, shade/shelter, food and/or panelling.
Maesopsis	**Reforestation purposes**, **firewood**, medicines (leaves, barks and roots), bee-forage, fodder (leaves), ornamental, shade (coffee), and /or **timber**.
Acrocarpus *fraxinifolius*	**Timber**, apiculture, shade/shelter, firewood and charcoal, soil erosion control, soil reclamation (on degraded areas), soil improver (mulching), and/or furniture.
Grevillea robusta	**Fodder**: Leaves are browsed by livestock. Fuel (charcoal), **timber** (strong, durable and termite resistant wood is used for construction, beams and rafters, poles and posts, tool handles and mortars and pestles). Soil improver (mulch), shade/shelter, and/or ornamental purposes.
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, and /or shade.
Cedrela odorata	**Timber, firewood** and good for **apiculture**.
Casuarina equisetifolia	**Timber**, reclamation on barren polluted sites, **firewood** (even when green), ornamental, windbreak, and/or intercropping for soil fertility.
Acacia nilotica	Bee forage, **fuel** (charcoal and firewood), degraded soil/land **reclamation**, **timber**, nitrogen fixation, and/or wind break
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, and/or ornamental.
Acacia polyacantha	Firewood, charcoal, timber, medicine, nitrogen fixing, soil conservation, and/or fodder.

2.2 Estimate of costs for implementing the system

These costs are based on planting 1,000 seedlings per hectare (assuming a mixture of 3m x 3m and 4m x 4m tree spacing is used)[2] at an average cost of Tshs 200/seedling (0.1 USD/seedling). The costs presented are merely indicative.

2.2.1 Nursery costs

The activities and costs during the setting up of the nursery are:

- Seeds/seedlings at 55 USD/ha
- Digging and mixing of the soil
- Pot filling, transfer, and topping
- Seed sowing and bed management
- Pricking out and selection/transfer

[2] The four-species mix gives 898 trees per hectare. Assuming 10% mortality or damage during transportation and rounding off, it is logical to budget for 1,000 seedlings.

- Watering and sanitation
- Cost of one wheelbarrow at 10 USD, 3 hoes, 2 spades, 1 machete, shade netting, poles, water, and fuel costs.

The total cost of these activities per hectare is estimated to be $200.

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 per hectare is estimated to be $250.

2.2.3 Maintenance cost

Operations for year one are grass slashing, spot weeding, firebreaks, uprooting shrubs. The cost per hectare is estimated to be $150.

Year two operations include grass slashing, spot weeding, firebreaks maintenance, and uprooting shrubs. The total cost in this year is estimated to be $100.

Operations for year 3, 4, and 5 are maintaining of firebreaks is estimated to cost $150 per hectare.

Other costs would go towards buying equipment 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 $400 per hectare.

Table 2.2 - Maintenance costs for woodlot planting system

Activity	Cost (per hectare of woodlot)
Nursery costs	$ 200
Establishment	$ 250
Maintenance year 1	$ 150
Maintenance year 2	$ 100
Maintenance year 3	$ 50
Maintenance year 4	$ 50
Maintenance year 5	$ 50
Operations	$ 50
Total	**$ 900**

2.3 Potential income

The calculations are based on 698 trees (taking into account thinning). The potential income is merely indicative.

2.3.1 Timber

Assumptions:

- 1 hectare = 300m3
- The recovery rate is 25%
- 1m3 is $110

Therefore 1-hectare woodlot would yield $\frac{300 * 25 * 110}{100} = \$8,250$

2.3.2 Fuelwood

Assumptions:

- Firewood from timber off cuts (75%)

  $$\frac{300 * 75 * 18}{100} = \$4,050$$

- Firewood from intermediate first and second thinning (60 m3)

  $$60 m^3 X\, 30 = \$1,800$$

2.4 Management operations activity plan

The objective of this system is to produce high-quality timber at the end of established rotations, as well as fuelwood obtained through woodlot management operations (thinning and pruning). Integration of indigenous trees into rural landscapes also provides soil erosion control as well as biodiversity-conservation benefits. The system can be combined with intercropping during the two first growing seasons before competition would affect tree growth. Intercropping can provide significant tree maintenance benefits.

The activity plan below presents the various steps that need to be undertaken for the proper establishment of the woodlots and outlines the responsibilities of program members. The activity plan serves as the minimum standard required for the project to be effective since payments are based on the *successful* implementation of the activity plan. In other words, individual farmers can (and should strive to) exceed the minimum standards set forth by the plan if their circumstances permit it.

2.4.1 Pre-planting activities

1. Seed collection

Seeds from the recommended tree species are collected or purchased throughout the region by project staff and participating farmers. Whatever cannot be found locally may be purchased from elsewhere.

2. Nursery establishment

The seedlings may be grown in communal nurseries, established by the year's participating farmers and supervised by the project field technicians to ensure the highest quality of seedlings. If possible, nurseries should be established directly on farmers' own land to simplify transportation.

The soil for the seedlings should be a mixture of sand from the riverbed, on-site soil, and manure. Seedling bags are filled with the earth mixture and placed in trenches approximately 10 centimeters deep. The seeds are sowed early enough so as to be ready for planting out at the onset of the long rains.

Nursery site location is very important. Careful attention to the selection of a permanent nursery site will amply repay all the effort expended. An unsatisfactory site will sooner or later increase the cost of operations and could lead to unnecessarily high seedling losses and poor stock production. Site selection has to be done in in consultation with the field technician.

a. Water source and quality

Water is a vital resource since nurseries are established during dry season. Its quality, accessibility, and availability are important factors to consider when selecting a nursery site. The sources of water could include springs, ponds, ditches, boreholes, taps, well. The water source should offer an adequate and reliable water supply and be as close as possible to the nursery. The water source may have contaminants or water-borne diseases which can infect root systems and foliage. Whenever possible, any potential site must have its water sources evaluated.

b. Soil, Topography/Drainage

Relatively flat land, ideally with a 2—5% slope, is most suitable for a nursery. Undulating topography can cause water-logging causing complete destruction of nursery stock because of oxygen depletion and build-up of toxic gases. A gentle slope will permit water to run off so that water-logging does not become a problem. The lower or mid-slopes of an area with undulating topography usually provide suitable sites. If flat land is not available, terracing may be constructed, although this might be expensive, will also help in reducing erosion problems. The soil must also be well drained to avoid water logging. The site should receive full sunlight on all areas used for pot beds so that proper hardening-off is possible.

c. Accessibility

There must be a good road to the nursery if the seedlings will be transported using vehicle or an ox-cart. The site must be accessible even during wet weather conditions since seedlings are usually planted during rainy season. Parking areas for the vehicular transport should also be evaluated.

d. Wind and livestock

Animals and wind can cause great damage in the nursery. High winds can desiccate seedlings, cause soil erosion, the blowing away of tree-seed cover and blasting of stems and foliage. Avoid areas with frequent, long-lasting, high-velocity winds and animals. Planting of live fences along the periphery of the nursery should be considered. Windbreaks should be planted so that pot beds receive full sunshine to allow proper hardening-off.

3. Nursery equipment

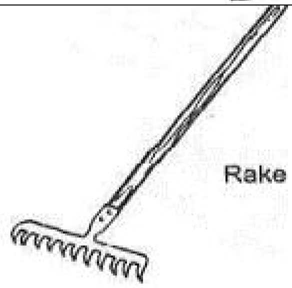
There are varieties of equipment that are needed for effective production of seedlings in the nursery. These include tools for:

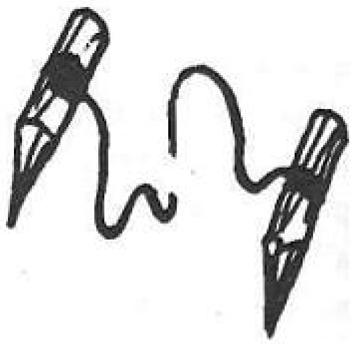
a. Working the soil and layout of the nursery
b. Preparation of potting soil and pot filling
c. Watering
d. Pricking-out
e. Weeding tools
f. Transportation

A wide variety of simple equipment is needed for efficiently producing seedlings using labour-intensive methods. A basic list of items is the following:

a. *Tools for working the soil and nursery layout*

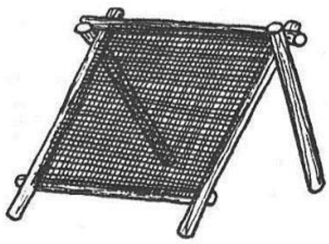
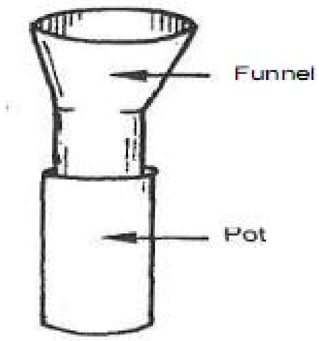
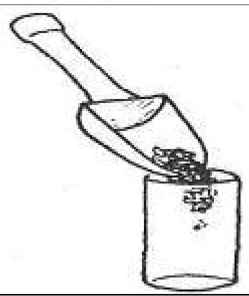
Table 2.3 - Tools for working the soil and nursery layout

Tool	Illustration
Pick-axe: Used to break up hard and stony ground	
Traditional hoe: Used for loosening soil, weeding areas between pot beds, etc.	
Spade: Used for digging.	
Flat-pronged fork: Used for turning compost, lifting bare-root seedlings, loosening soil.	
Shovel: Used for moving earth, sieving soil, soil mixing, etc.	
Rake: Used for breaking up and levelling soil.	

Tool	Illustration
Tracing line: Thin nylon cord, 20 m long (with knots at 1-m intervals) attached to 50-cm long steel pegs at each end. Used to mark straight lines for seedbeds, paths, etc.	
Tape measure: To accurately measure the length of beds, roads, make simple surveys, etc.	

b. Tools for preparation of potting soil and pot filling

Table 2.4 - Tools for preparation of potting soil and pot filling

Tool	
Sieve: Soil for seedbeds and for potting should not contain clods, stones, pieces of wood or similar objects. The potting mix ingredients (soil, sand, compost/manure) are passed through a coarse sieve with a mesh opening of 1 cm or, preferably, 0.5 cm. The mesh should be of wire fitted to a metal or sturdy wooden frame of at least 1 m x 1.5 m.	
Funnel: A simple funnel, which can be made from waste metal cans, considerably speeds up pot filling, especially if larger size pots are used. The diameter of the lower end of the funnel should be just a little smaller than the diameter of the tubes to be filled.	
Scoop: A scoop can be made of metal; any small container is suitable, however. The funnel and scoop together are much more efficient than filling tubes handful by handful and therefore help to reduce labour costs.	
Polyethylene tubing: The cheapest is endless tubing, which is sold in large rolls. Transparent polyethylene of 0.05-mm thickness is adequate for tubes that need only last one year. Tubing is usually specified by the width of the tubing when it is laid flat.	

c. Tools for watering

Water source: A well is the most usual source of permanent water supply for a nursery. However, if the water-table is at a considerable depth, a well can be costly and time consuming to construct.

Pump: A motorized pump if available is useful for all but the smallest nurseries to provide an economic supply of water. A good-quality diesel motor is preferred to maximize reliability.

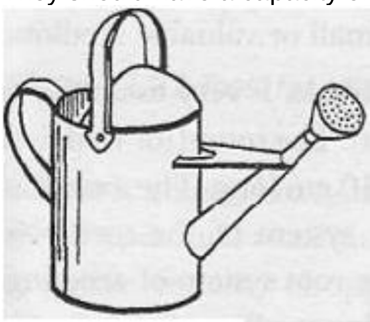
Water reservoir: A main reservoir plus numerous smaller ones for filling watering cans should be built. For strength, a circular main reservoir is preferable to a square one. The reservoir should be elevated to enable gravity distribution of water, and if possible, provide sufficient pressure for a sprinkler system to be installed in future.

Pipes: There must be an adequate length of piping to establish a reticulation system within the nursery. The pipes must be of sufficient diameter to supply the quantity of water needed without great loss of pressure.

Taps: There must be sufficient water taps such that no tap is further than 40 m from its neighbour throughout the nursery.

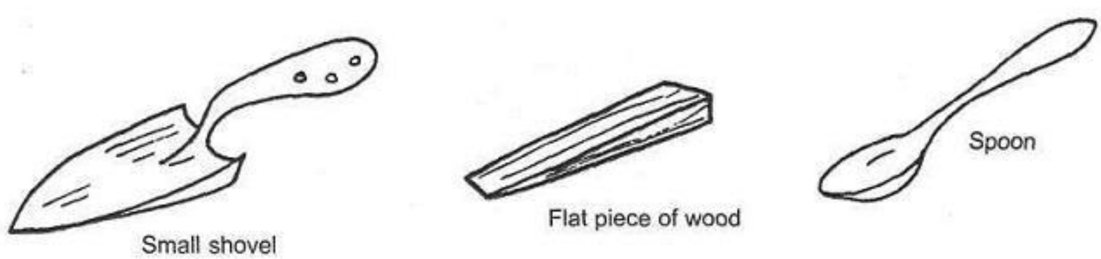
Hoses: If watering by hand-held gravity-fed hoses is intended, there must be several hoses, each at least 25 m long, of adequate diameter. Both fine and coarse roses should be available to attach to the hose for obtaining a fine spray for germination beds and a coarser spray for larger seedlings.

***Watering cans*:** Watering cans can be made of metal or plastic. Metal cans are more durable and can be locally made. Plastic cans are lighter but have to be imported and they are less durable. They should have a capacity of 10-12 litres.



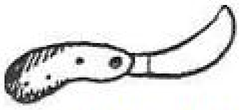
d. Tools for pricking-out

A round, sharpened, piece of wood, or dibble, is very useful for making the hole to receive a seedling for transplanting (i.e. pricking-out). The round (or wedge-shaped) dibble should be about 1 cm in diameter (or 2 cm wide) and 10 cm long. The dibble is also useful to help in lifting out the root system of seedlings to be pricked-out. Alternatively, a spoon is handy to help in removing seedlings from the germination bed, ready for pricking-out.

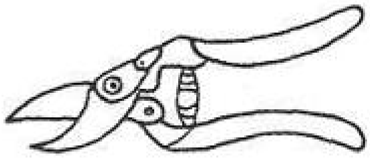


e. Weeding tools

Root-pruning tools: Knives, shears, secateurs, scissors and trowels can be useful when cutting roots that have penetrated below piano wire. Strong plastic sheeting can be preventing growth of a taproot.



Pruning Knife



Pruning shears or secateurs

Machete: This is a long, heavy knife which has a multitude of uses such as cutting woody weeds, trimming live fences, chopping waste etc.

f. Tools for transportation.

***Wheelbarrow*:** This is most useful for the transport of all kinds of materials in the nursery. A sturdy model fitted with a metal tray and pneumatic tyre is most satisfactory.

***Buckets*:** Buckets are useful for carrying small quantities of many things. Metal is much more durable and economic in the long term.

Planting boxes: Planting boxes are useful for carrying filled tubes to pot beds and convenient to carry seedlings from pot beds to trucks for transportation to the planting site. If sufficient boxes are available, they are very useful to maintain the seedlings in a vertical position during transportation.

4. Protection against nursery pests and diseases

Seedlings in nurseries are susceptible to pests and diseases. They include: insects; pathogens (microscopic organisms that include fungi, bacteria, viruses and nematodes); animals (include mice, rats and squirrels); birds; snails and slugs; and large domestic animals.

Insect pests can be controlled by use of pesticides or removal by hand if not many. Traps and poison baits can be used to control animals such as mice, rats and squirrels whereas adequate fencing excludes large domestic animals.

Damping-off disease is a pathogen-causing disease most common in tree nurseries. It is a disease of germinating seed and young seedlings and is normally most prevalent during the first two or three weeks after germination. It is particularly likely in wet, humid, shaded environments. There are two types of damping-off; pre-emergence and post-emergence damping-off.

In pre-emergence damping-off, the seed either rots before it germinates, or the pathogens kills the root and shoot once it has emerged from the seed but before it has broken through the soil surface. The post-emergence damping-off is characterized by infection and rotting of the stem of young seedlings close to ground level and discoloration (brownish and contrasting with the white colour of healthy stems) and reduction in the diameter of the stem.

In most nurseries it should be relatively easy to ensure that the following simple measures are taken to minimize damping-off:

- Use well-drained germination mix of light texture (i.e. with a high proportion of sand)
- Sowing density should give a spacing of 1-2 cm between seedlings
- Watering frequency should be carefully controlled to avoid excess wetness
- Shading should be reduced as soon as possible.

5. Preparation for planting out

a. Hardening off

This is a management technique applied to seedlings prior to transplanting to prepare them for the harsh field conditions. It is done by gradually reducing the amount of water supplied to the seedling by reducing the watering frequency and also reducing the amount of shading on the seedlings. This will encourage the seedling to develop a robust root system that can efficiently exploit limited water resource in the field. During the third last week to planting out, the seedlings should be watered once in 3 weeks and watering only when plants show signs of wilting, 2 weeks before planting out.

b. Grading

This is the process of separating the big strong seedlings from smaller weak ones. Seedling height, collar diameter and general appearance of seedlings are useful criteria on which to base grading. The seedling should be about twice the height of the tube; the collar diameter (stem diameter at soil level) should be as large as possible (at least 2mm); thin, etiolated plants should be discarded; seedlings should have a balanced and symmetrical growth of normal healthy green leaves without yellowing or other discoloration. There should be no evidence of insect pests, disease, or obvious mechanical damage.

c. Preparation for and planting out

Undertake the following:

- Water the seedlings thoroughly the day before lifting the tubes. Ensure that the whole depth of the tube has been moistened.
- When lifting seedlings, they should always be handled by holding the tube and not by pulling on the stem as this can easily damage the shoot, and also lead to subsequent pathogenic infections.
- Transport seedlings in a vertical position by placing them closely stacked in boxes. This minimizes shoot damage and soil loss from both the bottom and top of open-ended tubes. Pouring water over the truck platform or spreading a layer of straw, grass, soil or similar material on it helps to reduce death or desiccation of roots caused by heat on the platform.
- Use boxes to load the seedlings into trucks. To increase the carrying capacity of trucks, shelving is required so that several layers of boxes can be accommodated, one above the other, and so making transportation more economical.
- The seedlings should be covered so that they are not exposed to sun and wind during the trip from nursery to planting site. If covers are not available, the effects of desiccation can be reduced by transporting on rainy or cloudy days.
- Only dispatch the number of seedlings from the nursery that can be planted in one day, preferably within hours of arriving at the plantation site. After carefully unloading the seedlings, they should be placed in a shaded, sheltered, position which is the coolest available. If there is any delay in planting, it is essential that the moisture content of tubes be constantly monitored, and if they become dry supplementary watering is carried out.

2.4.2 Planting activities

Participating farmers need to carry out the following activities during the planting season:

A. Preparation and demarcation of site

A rope with knots or labels at even distances is used to demarcate where the trees will be planted according to the planting design. Demarcate the planting area and 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. Opening of holes (60cm x 60cm). This should be done before the onset of rains.
5. 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.

B. Establishment

Table 2.5 - Spacing and stocking density for recommended species

Species	Establishment	No. to plant per hectare
Maesopsis eminii	• Established by use of seeds and transplanted at a spacing of 4m x 4m.	625
Acrocarpus fraxinifolius	• Established by use of seeds and transplanted at a spacing of 4m x 4m.	625
Grevillea robusta	• Plant at 3m x 3m. • Can be propagated through seed and cuttings. Cuttings can be easily established using shoots from seedlings or saplings, which can also be air-layered. But, the use of seedling would be preferred for better establishment. • Some control of competing vegetation is required for the 1st 1-2 years after planting.	1,111
Markhamia lutea	• Plant at 3m x 3m. • Trees may be propagated by seedling or wildings. • They should be planted in a deep hole as the roots are long. Trees can be pruned and pollarded to reduce shading and are coppiced when they are about 1.7 m in height.	1,111
Cedrela odorata	• Established by use of seeds but best with seedlings.	
Casuarina equisetifolia	• Propagation is mainly by seed; however, there is an increasing use of cuttings. • Plant at 3m x 3m. • They can be established using containerized seedlings, bare root seedlings or rooted cuttings. • Seedlings should be planted in well-drained light soils, not clay soils, to decrease the incidence of diseases and pests.	1,111
Podocarpus spp	• The trees are established by use of seeds or cuttings but cuttings taken from lateral branches and shoots produce plants with a lateral growth habit, rather than an upright one. • When transplanting the seedling into the open ground, care must be taken not to damage the taproot, as it will result in a long period, sometimes up to a year, during which the tree will show no growth. Initial spacing will be 3m x 3m.	1,111
Acacia nilotica	• Direct seeding is commonly used to propagate the tree, though potted seedlings may also be used at	625

Species	Establishment	No. to plant per hectare
	a spacing of 4m x 4m. Bare-root seedlings are seldom used because the high incidence of root injury causes poor survival rates.	
Albizia lebbeck	• Typical spacing is 4m x 4 m for fuelwood, and 5m x 5 m for timber. • It is best established using potted seedlings although bare-rooted seedlings, direct seeding and stump cuttings have all been used successfully.	625
Acacia polyacantha	• Plant at 4m x 4m. It prefers sites with a high groundwater table, indicating eutrophic and fresh soils.	625

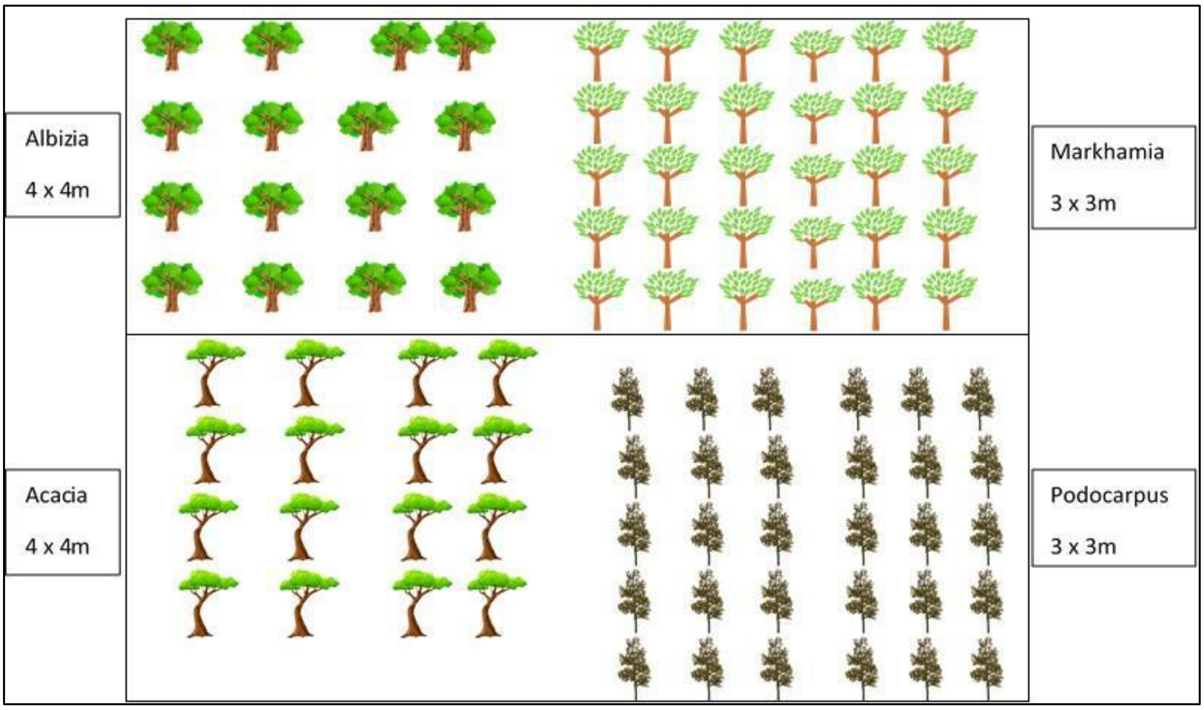


Figure 2.1 - A typical layout of a woodlot with 4 tree species

C. Weeding

Weeding should be done at least 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 is also be required for the first five years and occasional uprooting of shrubs. Weeding reduces competition for nutrients and fire risk.

D. Protection from Hazards

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

- ✓ 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.
- ✓ 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
- ✓ The boundary forest floor should be kept clean of any potential fire hazards.
- ✓ The farmer should always be on the lookout for any fires.

2.4.3 Maintenance

Appropriate good practice will be required for all trees planted in terms of planting techniques, weeding, and replacement of dead trees, irrigation, and pruning. Otherwise, each species requires different management regimes as described in Table 2.6 below.

Table 2.6 - Maintenance of various species recommended under the woodlot planting system

Species	Maintenance
Maesopsis eminii	• In case of attack by *Fusarium solani*, selective thinning should be carried out to remove the affected stems.
Acrocarpus fraxinifolius	• Pruning and thinning at 4 years.
Grevillea robusta	• Weeding should be done regularly to avoid competition for nutrients. • It coppices well after being cut back to ground level at ages of up to 2 years, but coppicing ability declines sharply thereafter, so management on a coppicing rotation is not feasible.
Markhamia lutea	• Pruning and thinning after attaining 2m in height,
Cedrela odorata	• Pruning is not required when grown as a stand. • Early weeding is essential. *C. odorata* is a fast-growing, light-demanding species. • Under natural conditions, it is a long-lived pioneer that tolerates shade only temporarily. In enrichment planting, it is important to ensure sufficient overhead light.
Casuarina equisetifolia	• Weeding is necessary as young trees are susceptible to competition from weeds, especially grasses. • This tree is a poor self-pruner. Pruning is necessary up to 2 m to make plantations accessible for maintenance. • The species is not fire resistant and protection is necessary.
Podocarpus spp	• It is self-pruning. However, branching associated with wide spacing necessitates pruning operations to maintain the quality of the timber. • The protection of plantations against fire attack is necessary since the bark does not provide adequate protection for the cambium.
Acacia nilotica	• Young seedlings are said to require full sun and frequent weeding.
Albizia lebbeck	• Coppices well, responds to pollarding, pruning and lopping, and will produce root suckers if the roots are exposed. The trees are vulnerable to strong winds and are killed by even light fires, thus requiring clearing of the forest floor and making use of firebreaks.
Acacia polyacantha	• Fast growing, weeding required.

2.4.4 Thinning and harvesting

Table 2.7 outlines the different harvesting and thinning regimes required for each species. Harvesting occurs in a rotational manner, with planting expected thereafter.

Table 2.7 - Thinning and harvesting schedules of recommended species under the wood lot planting system

Species	Thinning	Harvesting
Maesopsis eminii	50% in year 4, 50% of the remaining by year 14	• Rotations are about 8 years for fuel wood, and 20 to 25 years for timber (depending on local conditions). It is expected that conversion will be done through local pit sawing.
Acrocarpus fraxinifolius	50% in year 8	• Rotation of 20 - 25 years for timber.
Grevillea robusta	50% in year 8-10	• Rotations of 8 - 12 years for firewood and 15-20 for timber production. A growth reduction after 20 years has been reported.
Markhamia lutea	50% in year 8-10, 50% of the remaining by year 12	• Harvesting should be done at age 35 – 40. Modelling is based on 40-year rotation.
Cedrela odorata	None	• Harvesting should be done at age 30-40 years depending on the site. Modelling is based on 30 yeas rotation. • The tree does not coppice.
Casuarina equisetifolia	50% in year 8-10, 50% of the remaining by year 12	• Rotation period varies depending on the farmer's need e.g. the rotation period ranges from 4-5 years for fuel wood and 10-15 years for poles and 25 to 30 years for timber years.
Podocarpus spp	50% in year 10, 50% of the remaining by year 15	• 17-18 years old show the wood to be of excellent quality, with an increase in cubic metres when cut 2 years later, at 20 years of age. • On good sites, trees should be large enough for harvesting 35 to 40 years depending on site conditions. Carbon modelling has been done based on 30-year rotation.
Acacia nilotica	50% in year 6 - 8	• Can be harvested firewood at age 8 and for timber at age 20.
Albizia lebbeck	50% in year 6 - 8, 50% of the remaining by year 12	• Fuelwood plantations can be clear-felled on a 10-year rotation and for timber at age 25
Acacia polyacantha	50% in year 6 - 8	• Can be harvested firewood at age 8 and for timber at age 20.

3 Environmental and social benefits that may be derived from this land use system

The Plan Vivo system has significant ancillary benefits beyond sequestering carbon. The focus is on agroforestry systems and small-scale plantations to improve incomes, provide increased access to fuelwood and building materials and reduce deforestation pressures on nearby forests. The contribution of trees and tree products to the livelihood security of farmers is well-demonstrated. While working towards establishment of tree stands for carbon sequestration, the trees will, at the same time, provide multiple products to the farmers, thereby improving their incomes and livelihood security. The ancillary benefits can therefore be summarized as:

- Woodlots will provide a local and sustainable source of firewood, poles and timber.
- Reduced pressure other forest resources (potentially resulting in positive leakage – see below).
- Income diversification through timber and NTFP's.
- Soil conservation - particularly the prevention of soil erosion associated with heavy rainfall events and siltation of water courses (climate change adaptation benefit)
- Hydrological benefit – capturing of incidental moisture and improved water flows which will help to reduce catastrophic flooding (climate change adaptation benefit)
- Biodiversity benefit – through the protection of wildlife habitat (birds, bees).
- NTFP – beekeeping, medicines, fruits etc.
- Shading for humans and livestock.

4 Description of additionality of community and individual on-farm tree planting in the project area

A key factor is that the emissions reductions from a project activity or intervention should be additional – i.e. a demonstration that 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 woodlots 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, and
- 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. This is elaborated in the Additionality Tool in Figure 4.1 below:

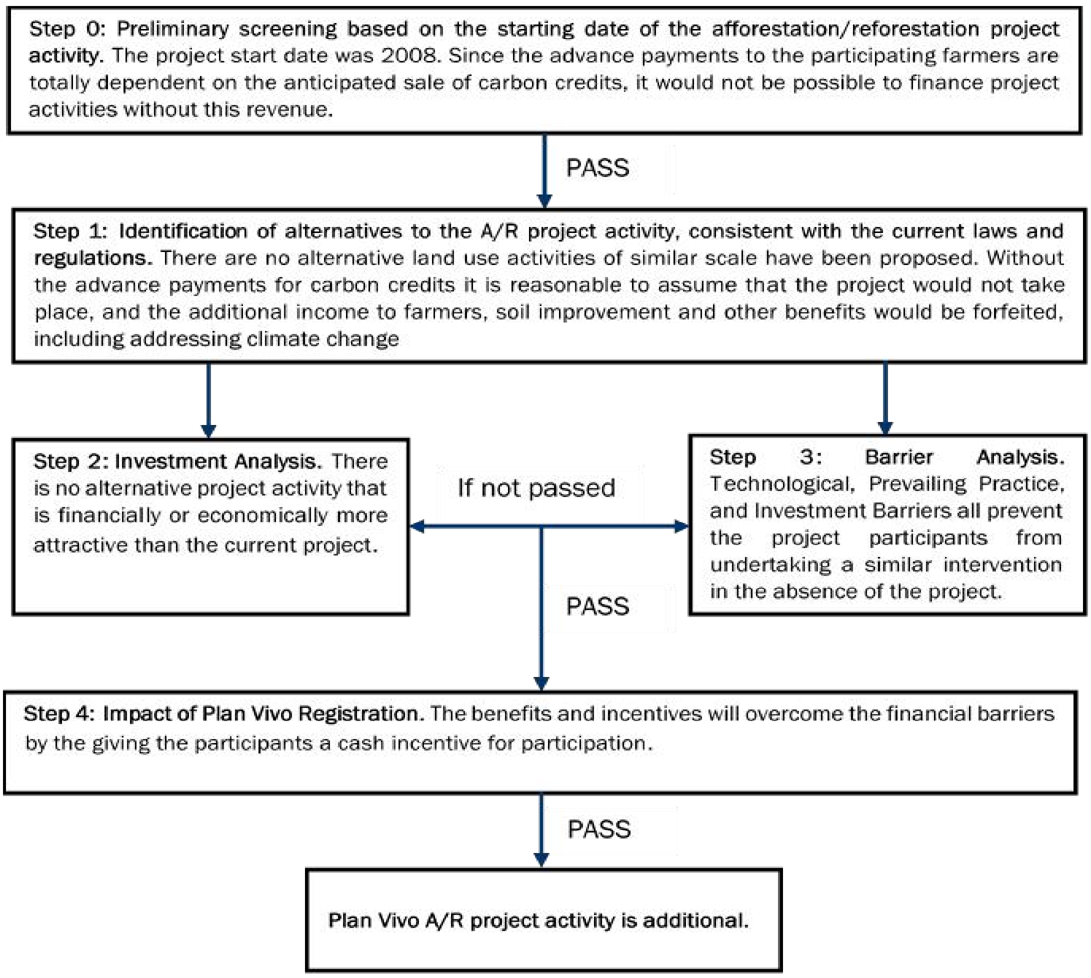


Figure 4.1 - Stepwise tool for demonstration of the project activity

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 woodlots, this is most likely to occur where farmers are establishing trees on cultivated land (many of these tree species 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 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 'policing' 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 woodlots, there should be no assumption of leakage.

In all probability, the most likely outcome of establishing woodlots is positive leakage as a result of reduced pressure to exploit other forest resources.

6 Baseline carbon emissions

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 (VER's) 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 of Vi Skogen Land Use Activities in Kagera, Tanzania' (Camco, 2009). 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. Whilst a baseline of 6.38 tCO_2e/ha was modelled through the updated growth models, the baseline assessment of carbon levels suggested a baseline of 7.33 tCO_2/ha (≈2 tC/ha). The higher, and therefore more conservative, baseline value of 7.33 was chosen for this technical specification.

7 Carbon sequestration potential of the woodlot system

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, adjusted in the case of the *Emiti Nibwo Bulora* project for a twenty-five-year timeframe. 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 woodlots is set out in 'Assessment of Net Carbon Benefit of Vi Skogen Land Use Activities in Kagera, Tanzania' (Camco, 2009). The potential net carbon sink created by this land use system (based on long term average carbon storage over 25 years) is calculated to be 149.05 tCO_2e per hectare (see Table 10.1).

This result is derived from carbon models based on planting tree species in the proportions shown in Table 7.1. 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 7.1 - Species used in carbon modelling

Technical Specification	Species	Proportion (%)
Woodlot	*Maesopsis eminii*	60
	Grevillea robusta	10
	Markhamia lutea	5
	Cedrela odorata	5
	Acrocarpus fraxinifolius	20

8 Identification of risks and risk mitigation options

The risks involved in relation to this technical specification have been identified as follows:

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 for engaging in tree planting activities is regarded to be high by the farmers.
- Theft/illegal cutting of trees for fuelwood, fodder, poles etc. without consent of the property owner.
- Inadequate knowledge and capacity of the smallholder 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 from practicing the system.

Market

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

9 Risk buffering

20% of all VER's generated by the project activities are maintained as a risk buffer. Records of all buffer stock should be maintained in the database. The level of buffer credits deposited in the Plan Vivo pooled buffer account may be reassessed at a later date if the risks to permanence are deemed to have been reduced. This may occur after several verification audits have been conducted, in line with guidance provided in the Plan Vivo Standard and Procedures Manual.

10 Calculation of carbon credits derived from the system

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 Standard (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 woodlot land use system (technical specifications) is presented in Table 10.1 below based on the proportions in Table 7.1:

Table 10.1 - Summary of the net carbon benefit, buffer stock and tradable carbon offsets from the woodlot planting land use system

	1	2	3	4	2-(1+3+4)

Intervention type (Technical Specification)	Baseline carbon uptake / emissions i.e. without project (tCO_2e/ha)*	Carbon uptake/emissions reductions with project (tCO_2e/ha)	Expected losses from leakage (tCO_2e/ha)	Deduction of risk buffer (tCO_2e/ha)	Net (Tradeable) carbon benefit (tCO_2e/ha)
Woodlot	7.33	195.35	0	38.97	149.05

* Whilst a baseline of 6.38 tCO2e/ha was modelled through the updated growth models, the baseline assessment of carbon levels suggested a baseline of 7.33 tCO2/ha. The higher, and therefore more conservative, value of 7.33 was therefore used for this technical specification when estimating carbon benefits.

Figure 10.1 below shows the long-term average carbon sink over the simulation period (25 years).

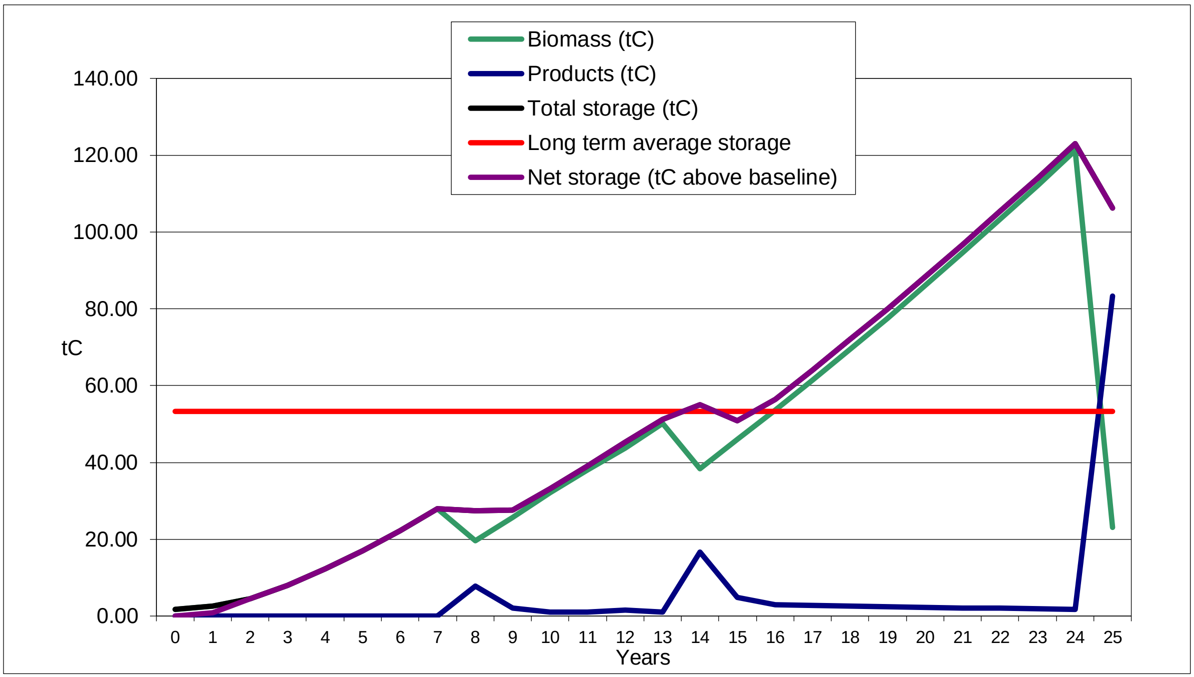


Figure 10.1 - Carbon sequestration potential for woodlot planting land use system technical specification over 25 years

It is observed from Table 10.1 above that there is nearly a 6.46% increase in the tradeable tCO_2/ha from the previous 140 tCO_2/ha reported for this system. This is the result of removing *Podocarpus* spp from the simulation model (due to no farmer is planting it) and replacing it with *Grevillea robusta*. There is also a marginal effect from reducing the thinning age for *Maesopsis eminii* from Year 5 to Year 4. To reflect the actual current practice, other possible sequestration scenarios under this system are reported in Annex 1 based on the species combination applied by farmers.

11 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 80% survival of seedlings. Thereafter, monitoring targets are based on DBH average. 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 11.1 - Monitoring indicators for the woodlot land use system

Year	Indicator
1	At least 50% plot established
2	Whole plot established, 90% survival (at least 732 stems / ha surviving)
3	Whole plot established, 80% survival

Year	Indicator
4	Whole plot established
5	Average DBH not less than 8cm
6	Average DBH not less than 11cm
7	Average DBH not less than 13cm
10	Average DBH not less than 19cm

References

Bein E, Habte B, Bernie A, Tengnas B. (1996). Useful Trees and Shrubs in Eritrea: *Identification, Propagation and Management for Agricultural and Pastoral communities.* Regional Soil Conservation Unit, RSCU/SIDA, Nairobi.

Berry, N (2008). Carbon modelling for reforestation and afforestation projects. Unpublished but available at ECCM (part of the Camco Group), UK.

Berry, N (2008). Estimating growth characteristics of agroforestry trees. Unpublished but available at ECCM (part of the Camco Group), UK.

Berry, N (2008). Protocol baseline survey for agroforestry projects. Unpublished but available at ECCM (part of the Camco Group), UK

ESDA (2006). Bio-fuel Production on Mining Reserve Land and in Rehabilitated Quarries of Lafarge East Africa (LEA): Feasibility Study of Bamburi, Mombasa.

FACT (1998). A quick guide to multipurpose trees from around the world. In http://www.winrock.orghttp://www.greenhouse.gov.au/nrm/fieldmeasurement/part02/section4two.html. Australian Government, Department of the Environment and Heritage Australian Greenhouse Office.

http://www.planvivo.org/

ICRAF. Agroforestry Tree Data Base. A tree species reference and selection guide. http://www.worldagroforestrycentre.org/

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

12 Annexes

Annex 1: Other potential carbon sequestration scenarios based on species combination (25 years modelling)

Table 12.1 - Potential carbon sequestration scenarios based on species combination for the woodlot system

			1	2	3	4	2-(1+3+4)
Technical Specification	**Species**	**Proportion (%)**	**Baseline carbon uptake / emissions i.e. without project (tCO2e/ha)***	**Carbon uptake/emissions reductions with project (tCO2e/ha)**	**Expected losses from leakage (tCO2e/ha)**	**Deduction of risk buffer (tCO2e/ha)**	**Net (Tradeable) carbon benefit (tCO2ee/ha)**
Woodlot	*Maesopsis eminii*	100	7.33	214.10	0	42.72	164.05
	Acrocarpus fraxinifolius	100	7.33	138.96	0	27.69	103.94
	Grevillea robusta	100	7.33	291.48	0	58.19	225.96
	Markhamia lutea	100	7.33	83.57	0	16.61	59.63
	Cedrela odorata	100	7.33	115.42	0	22.98	85.11
	M. lutea + A. fraxinifolius	50:50	7.33	111.26	0	22.15	81.78
	M. eminii + A. fraxinifolius	50:50	7.33	176.53	0	35.20	134.00
	M. eminii + C. odorata	50:50	7.33	164.76	0	32.85	124.58
	M. eminii + G. robusta	50:50	7.33	252.79	0	50.46	195.00
	A. fraxinifolius + G. robusta	50:50	7.33	215.22	0	42.94	164.95
	A. fraxinifolius + C. odorata	50:50	7.33	127.19	0	25.34	94.52

* Whilst a baseline of 6.38 tCO2e/ha was modelled through the updated growth models, the baseline assessment of carbon levels suggested a baseline of 7.33 tCO2/ha. The higher, and therefore more conservative, value of 7.33 was therefore used for this technical specification when estimating carbon benefits.

Table 12.1 shows that, for this system, farmers planting *Grevillea robusta* alone have the highest carbon sequestration potential due its fast growth. *Markhamia lutea* has the least sequestration potential but planting it could be justified by other advantages such as a source of poles when managed under pollarding system. In consideration of the non-carbon benefits, there could be advantages in combining more than one species as insurance against species-specific diseases or vulnerability to other forms of damage, provided the farmer is prepared to make the trade-off from having less credits to sell.