Boundary Planting 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 and 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.

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 boundary planting system involves the planting of a variety of indigenous and naturalised hard wood tree species along the perimeters of farmer's properties for timber, fruit, fuel wood and shade. Some nitrogen fixing trees might also be planted. In the first years after planting farmers will be able to continue cropping around the trees right up to the edge of the property. 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. Boundary planting may be widely adopted by individual farmers with small areas of landholding without jeopardising their food security. This system may also be suitable for use along roadsides, water courses etc. The boundary planting system is very popular with many farmers because it helps to clearly define their area of landholding. However, the key limiting factor to bear in mind for this planting system in Tanzania is the minimum planting area and viability.

The net carbon benefit and tradable carbon offset for the boundary planting system, assuming four species are planted in equal proportions is shown in this table:

	1	2	3	4	2-(1+3+4)
Intervention type (Technical Specification)	**Baseline carbon uptake / emissions i.e. without project (tCO2e/100m)**	**Gross carbon uptake/emissions reductions with project (tCO2e/100m)**	**Expected losses from leakage (tCO2e/100m)**	**Deduction of risk buffer (tCO2e/100m)**	**Net (Tradeable) carbon benefit (tCO_2/100m)**
Boundary planting	0.33*	7.79	0	1.49	5.95

*Whilst a baseline of 0.22 tCO2e/100m was modelled at the start of the project (see baseline modelling technical specification), the updated growth models predicted a baseline of 0.33 tCO2e/100m. The carbon benefit value estimated here (5.95) therefore uses the more conservative baseline value of 0.33.

The carbon sequestration is highly dependent on the species 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.

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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 the land use system

This system involves the planting of trees along the perimeter of individual farmers or communal property with the objective of obtaining environmental and livelihood benefits including windbreaks, soil erosion control, shade/shelter, sale of poles, among others. The system would involve planting of different tree species to meet the intended objectives. This section gives a synopsis of the main tree species ecology, altitudinal range, growth requirements, among other important factors for consideration where it is proposed to use this tree planting system.

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. Being an agro-ecological zone also means the area is suitable for implementing the project and the four technical specifications. Beside carbon revenues, the system provides:

1. The commonly practiced banana production requires that banana plantations are protected from strong wind, incidents of which are on the increase due to climate change;
2. Farmers adapting to climate change as a result of increased food, income, improved technologies and environmental services;
3. A means to sustainably satisfy the dependence on wood fuel as the main source of energy for household use;
4. Traditional land tenure system on un-surveyed land makes it necessary for boundary demarcation, hence boundary planting of long-term tree species is the most appropriate in terms of affordability by small scale farmers; and
5. The boundary planting system can help meet other needs for tree products such as supporting poles for banana plant management.

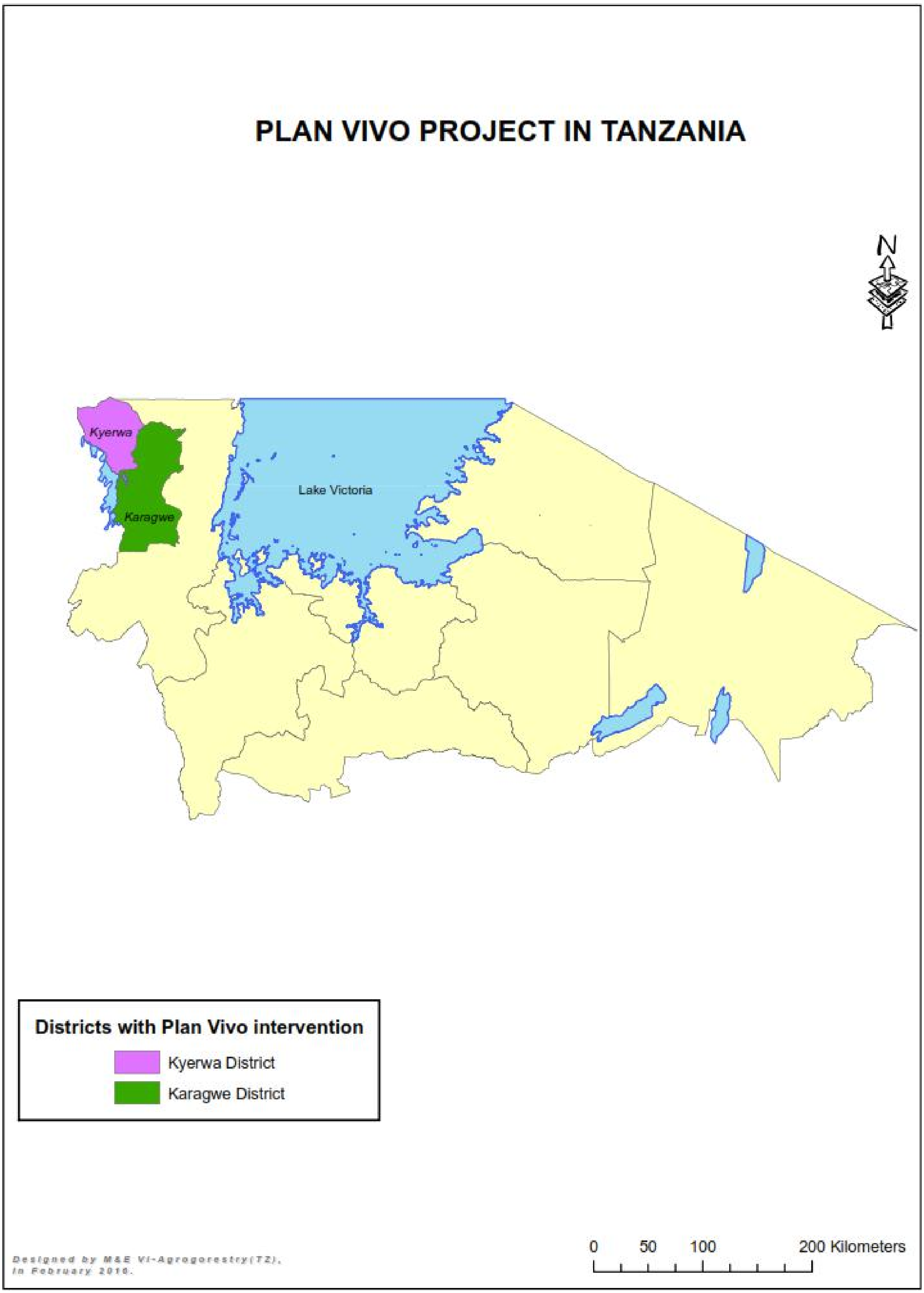


Figure 1.1 - Plan Vivo intervention area boundaries (Karagwe and Kyerwa Districts)

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 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, Markhamia lutea, Grevillea robusta* and *Acrocarpus fraxinifolius* which was not originally recommended for this system.

Table 1.1 - Trees species recommended for Boundary planting land use system[1]

Botanical name	Common name (English)	Natural range
Markhamia lutea	Markhamia	Indigenous
Maesopsis eminii	Umbrella tree	Indigenous
Grevillea robusta	Silky oak	Naturalized
Acrocarpus fraxinifolius	Australian ash, Indian ash, pink cedar, shingle tree	Naturalised
Casuarina equisetifolia	Australian pine, beach she-oak, beefwood tree	Naturalized
Albizia lebbeck	East Indian walnut, English woman's tongue, fry wood	Naturalized
Acacia polyacantha	African catechu tree, white thorn tree	Indigenous
Other indigenous tree species	E.g. *Khaya nyassica, Albizzia* spp.[2]	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 which shows the rainfall map for Kagera region. Table 1.2 below shows the ecological requirements of recommended species.

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 *Markhamia*, *Grevillea*, *Maesopsis* and *Acrocarpus*

2 These other indigenous tree species currently only constitute a small proportion of planting (no more than 10%) so additional information is not contained in this report.

Table 1.2 - Ecological requirements of recommended species

Botanical name	Ecology
Markhamia lutea	The tree is drought resistant but cannot withstand waterlogging.
Maesopsis eminii	Very common in the ecozone between high forest and savannah.
Grevillea robusta	Grows on fairly well drained and neutral to acidic soils
Acrocarpus fraxinifolius	Grows best in sub-montane areas in the humid and sub-humid tropics with a short, dry spell.
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
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.

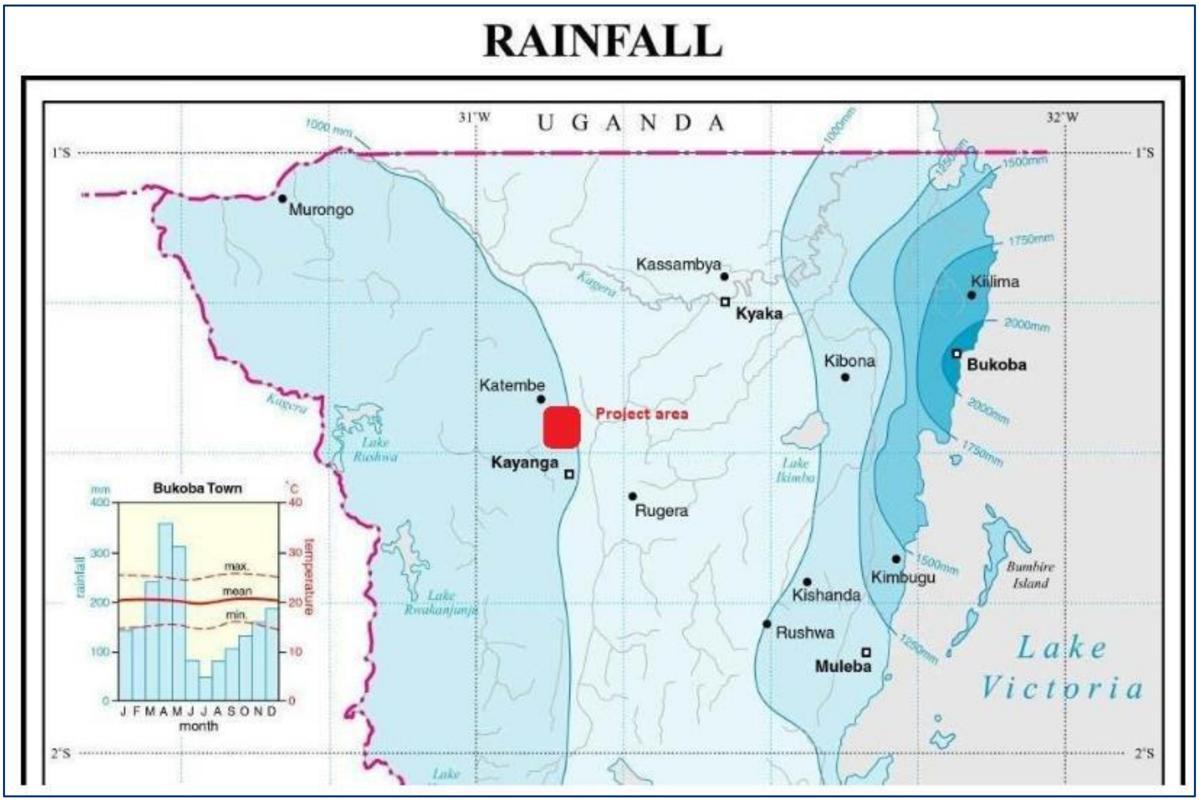


Figure 1.2 - Rainfall map of the project area

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 planting system design at elevations ranging from 700 – 2000 metres above sea level as shown in table 1.3 for each species. Figure 1.3 shows the topographical map of the project area.

Table 1.3 - Suitable altitudinal and climatic ranges for recommended species

species	Altitudinal range (metres above sea level) 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
Grevillea robusta	0-2300 m, Mean annual temperature: 14-23 to 25-31 deg. C, Mean annual rainfall: 600-1700 mm
Acrocarpus fraxinifolius	0-1500 m, Mean annual temperature: 19-28 deg. C, Mean annual rainfall: 1000-2000 mm
Casuarina equisetifolia	0-1400 m, Mean annual temperature: 10-35 deg. C, Mean annual rainfall: 200-3500 mm
Podocarpus spp	1 550-3 000 m, Mean annual temperature: 13-20 deg. C, Mean annual rainfall: 1 200-1800 mm
Acacia nilotica	0-1340 m, Mean annual temperature: 4-47 deg. C Mean annual rainfall: 200- 1270 mm.
Albizia lebbeck	0-1800 m, Mean annual temperature: 19-35 deg. C, Mean annual rainfall: 500-2 500 mm
Acacia polyacantha	Altitude 200-1800 m, Mean annual rainfall: 300-1000 mm

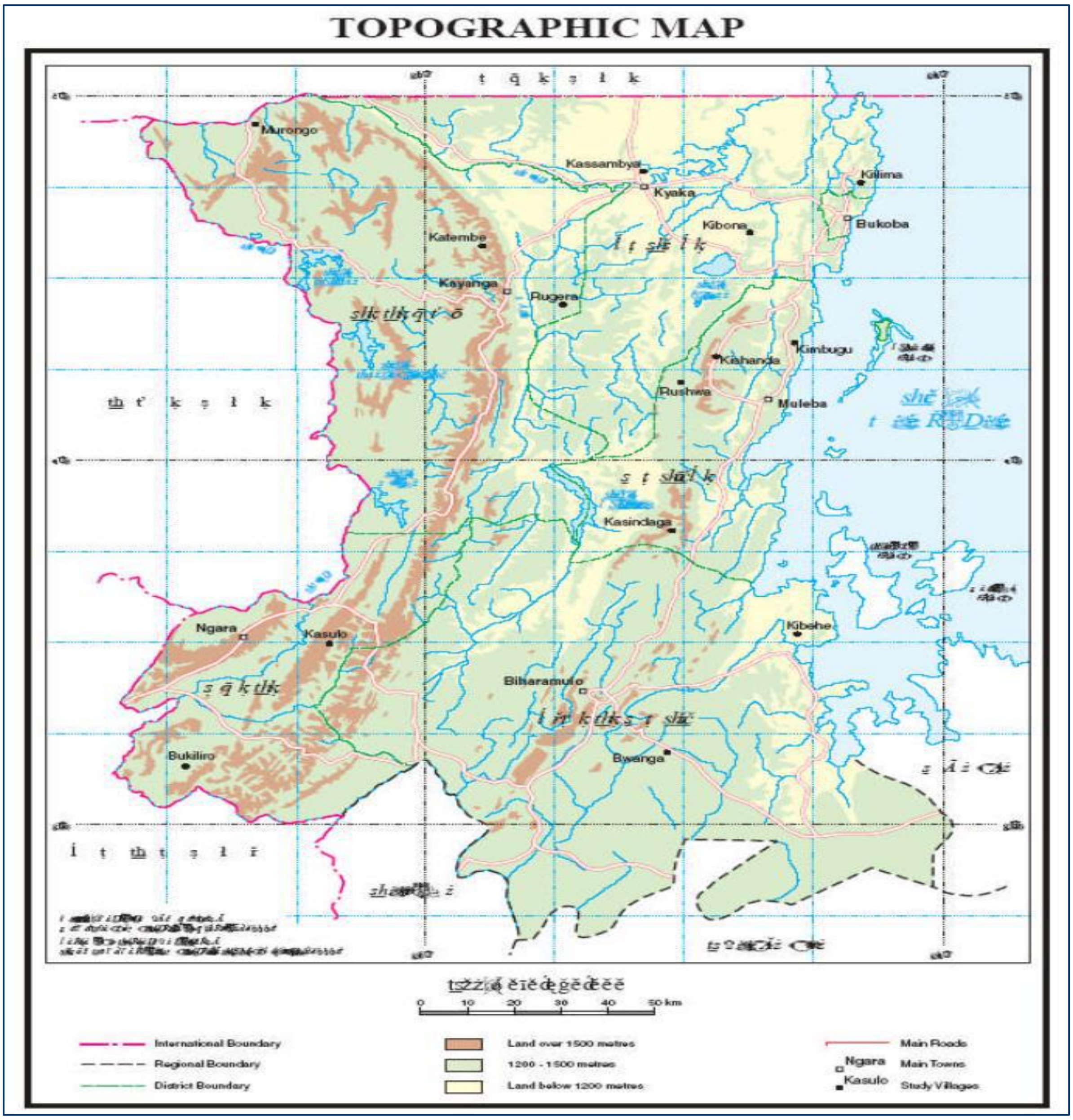


Figure 1.3 - Topographical map of Kagera

1.5 Habitat requirements

Table 1.4 - Habitat requirements of species recommended for boundary planting 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.
Grevillea robusta	Does not stand water logging or heavy clays
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.
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
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 habits

Table 1.5 - Growth habits of species recommended for boundary planting land use system

Botanical name	Growth habit
Markhamia lutea	It is an upright evergreen tree 10-15 m high, with a narrow, irregular crown and long taproot.
Maesopsis eminii	It is an early successional species, adept at colonizing grasslands and disturbed areas in the high forest.
Grevillea robusta	Moderate to fast growing. Only young trees copies well.
Acrocarpus fraxinifolius	It is a pioneer and demands light, but it can tolerate slight shade when young. It grows best in deep, well-drained, clayey loam soils with a pH of 4-7.
Casuarina equisetifolia	Crown shape initially conical but tends to flatten with age.
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

The main objective of this system is land demarcation, timber, fruits, fuel wood, shade, soil improvement through nitrogen fixing and mulching. Each species has its own primary management objectives as shown in Table 2.1:

Table 2.1 - Management objectives of recommended species

Species	Management objective
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.
Maesopsis	Reforestation purposes, firewood, medicines (leaves, barks and roots), bee-forage, fodder (leaves), ornamental, shade (coffee), and/or timber.
Casuarina equisetifolia	Boundary planting as it doesn't intercept much of incoming solar radiation. Reclamation on barren polluted sites, firewood (even when green), ornamental, windbreak, and/or intercropping for soil fertility.
Grevillea robusta	**Fodder**: Leaves are browsed by livestock. Fuel (charcoal), **timber** (the mature timber is strong, durable and termite resistant wood and can be used for construction, beams and rafters, poles and posts, tool handles and mortars and pestles). Soil improver (mulch), shade or shelter, and/or ornamental.
Acrocarpus fraxinifolius	**Timber**, Apiculture, shade/shelter, firewood and charcoal, soil erosion control, soil reclamation (on degraded areas), soil improver (mulching), and/or furniture.
Markhamia lutea	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.
Acacia polyacantha	Firewood, charcoal, timber, medicine, nitrogen fixing, soil conservation, and/or fodder.

2.2 Estimate of costs for implementing the system

These costs of implementation are based on planting 100 metres with a distance of 3m between trees (i.e. 33 trees). All costs are merely indicative.

2.2.1 Nursery costs

The activities and costs 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

From farmer interviews, the total cost of producing one seedling taking into account all the activities above is estimated at Tshs 200 (US$0.09) per seedling (which is equivalent to the cost of purchasing ready-to plant seedlings). For 33 seedlings this works out approximately to a total of US$3. Assuming 10% mortality and rounding off, the farmer needs to budget for 40 seedlings which works out to US$3.6 or nearly US$4 per 100m.

2.2.2 Establishment cost

The activities in the establishment phase would include:

- Demarcation and soil test
- Bush clearing
- Chaining/marking
- Planting (US 4 Cents per 100m)

The estimate of establishment costs is negligible most probably because farmers are unable to estimate the cost of 'free' family labor hence the total cost for this phase per hectare is retained at US$20 as in the previous version.

2.2.3 Maintenance cost

The trees in the field will be maintained for five years:

i. Operations for year one are grass slashing, spot weeding, firebreaks, and uprooting shrubs. The total cost is $20 based on four weeding's per year @US$3.5 per weeding and US$ for slashing, firebreaks and uprooting shrubs.

ii. Operations for year two are grass slashing, spot weeding, firebreaks maintenance, and uprooting shrubs. The total cost in this year would be $6.

iii. Operations for year 3, 4, and 5 are maintaining of firebreaks will cost $15.

Table 2.2 - Maintenance costs for boundary planting system

Activity	Cost (per 100 m for boundary planting)
Nursery costs	$4
Establishment	$20
Maintenance year 1	$20
Maintenance year 2	$6
Maintenance year 3	$5
Maintenance year 4	$6
Maintenance year 5	$6
Operations	$15
Total	**$82**

2.2.4 Potential income

The income generated using this land use system is relatively small compared to other systems as well as other economic activities on the same land. The calculations are based on planting 33 trees along 100 metres of boundary. The potential income is merely indicative.

2.2.5 Timber

Assumptions:

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

Therefore 1 hectare of boundary planting would yield $\frac{300*0.0297*25*110}{100} = \$245$

2.2.6 Fuelwood

Assumptions:

- Firewood from timber off cuts (75%)

$$\frac{300*0.0297*75*18}{100} = \$40$$

2.2.7 Management operations activity plan

Demarcate the planting area and clear any unwanted undergrowth to remove 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. Collect and burn the litter
3. Uproot any stumps in the area.
4. Opening of holes (60cm x 60cm width and depth respectively) before the onset of rains.
5. Planting should be done immediately 50 mm of rain is achieved (i.e. after about 10 days of rainfall) during the onset of rains.
6. During planting, application of termiticides may be done for some species which are susceptible to termite attack. However, farmers are encouraged to use local environmentally-friendly methods to prevent termite attacks, such as the use of wood ash.

When planting nursery grown stock:

- Water the seedlings before planting to hold the 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 the delicate bark;
- Only remove plastic from around root-ball at the time of planting. Care should be taken to remove all the plastic as this will restrict the penetration of the young roots into the soil;

- Prune back roots (especially any circular roots) at the time of planting to stimulate new root growth once in the ground;
- Plant to the depth of the root collar (i.e., for bagged plants, to level of existing soil). Never plant deeper than in nursery leaving no roots exposed; and
- Ensure that soil is replaced firmly around trees (i.e., well-heeled in). Put the top soil back in the planting hole first.

2.2.8 Pre-planting activities

1. Seed collection

Seeds from the recommended tree species are collected or purchased throughout the region by project staff and distributed to the participating farmers, or by the farmers themselves. 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, 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

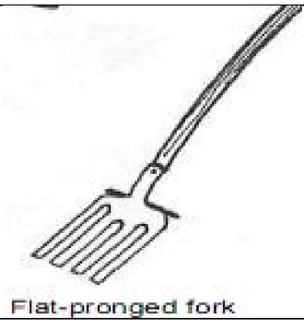
There are varieties of equipment that are needed for effective production of seedlings in the nursery. These include tools for:

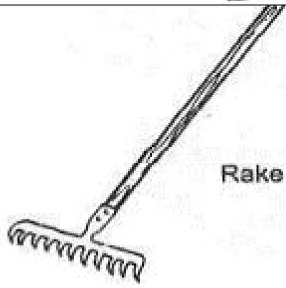
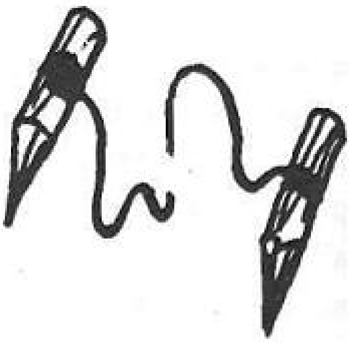
a. Working the soil and layout of the nursery
b. Preparation of potting soil and pot filling
c. Watering
d. Pricking-out
e. Weeding tools
f. Transportation

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

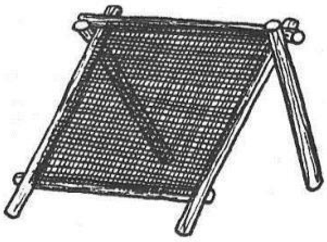
Table 2.3 - Tools for working the soil and nursery layout

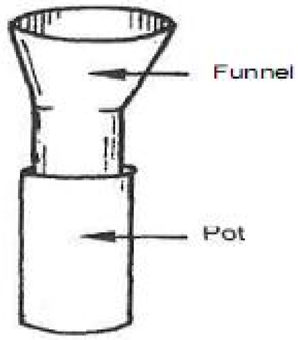
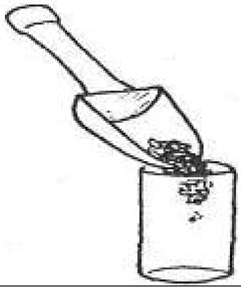
Tool	Illustration
Pick-axe: Used to break up hard and stony ground	
Traditional hoe: Used for loosening soil, weeding areas between pot beds, etc.	
Spade: Used for digging.	
Flat-pronged fork: Used for turning compost, lifting bare-root seedlings, loosening soil.	

Tool	Illustration
Shovel: Used for moving earth, sieving soil, soil mixing, etc.	
Rake: Used for breaking up and levelling soil.	
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.	

Tool	
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.

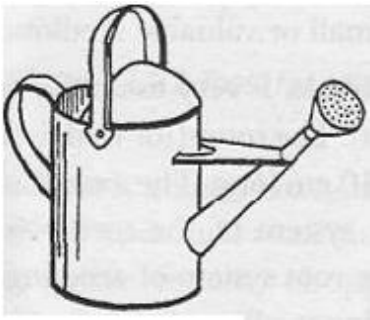
Water reservoir: A main reservoir plus numerous smaller ones for filling watering cans should be built. For strength, a circular main reservoir is preferable to a square one. The reservoir should be elevated to enable gravity distribution of water, and if possible, provide sufficient pressure for a sprinkler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

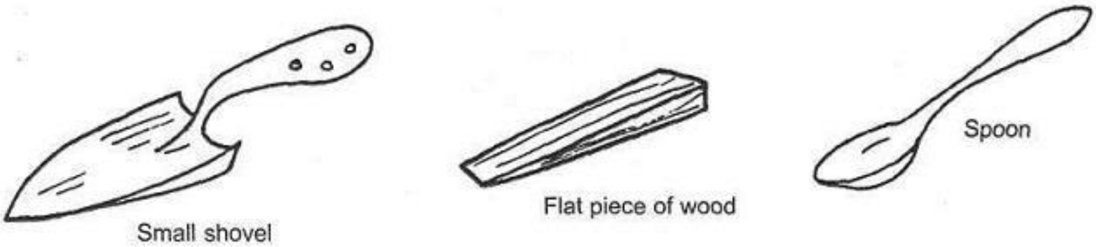
Hoses: If watering by hand-held gravity-fed hoses is intended, there must be several hoses, each at least 25 m long, of adequate diameter. Both fine and coarse roses should be available to attach to the hose for obtaining a fine spray for germination beds and a coarser spray for larger seedlings.

***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.



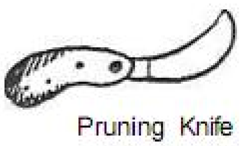
d. Tools for pricking-out

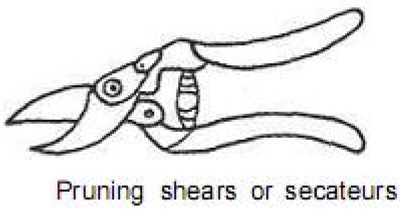
A round, sharpened, piece of wood, or dibble, is very useful for making the hole to receive a seedling for transplanting (i.e. pricking-out). The round (or wedge-shaped) dibble should be about 1 cm in diameter (or 2 cm wide) and 10 cm long. The dibble is also useful to help in lifting out the root system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





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.

2.2.9 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

Trees should be planted 3 meters apart within a single row. More than one row of trees may be planted (staggered with spacing of 3X2 metres) where the planting is not adjoining neighbouring cultivated land. Plant trees a minimum of 3 metres in from the boundary so as to prevent interference with neighbouring properties. This is illustrated in Figure 2.2 below. Trees planted for fuel wood, poles and soil improvement should be planted between timber trees (see Figure 2.2). These trees will be coppiced and thinned out over time.

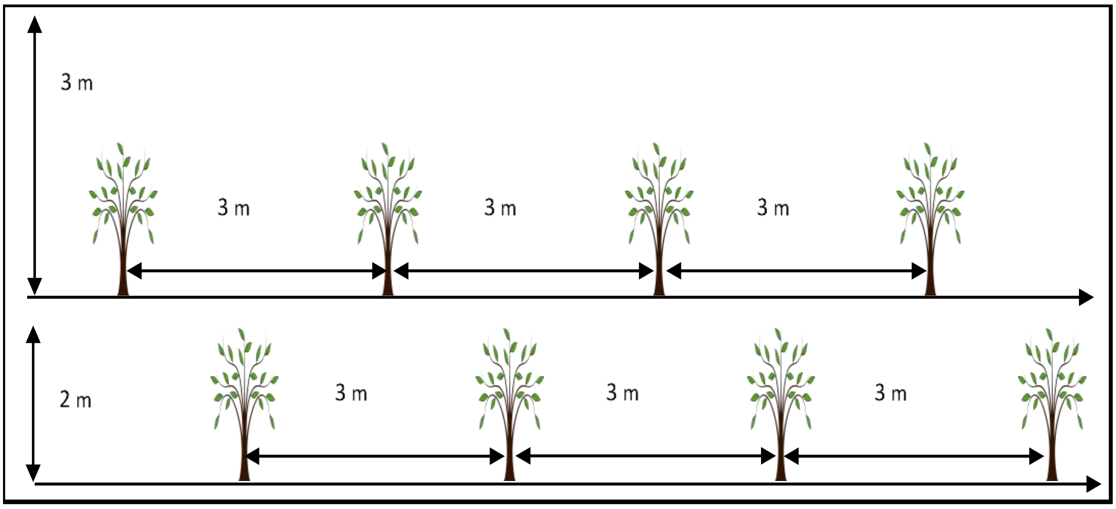


Figure 2.1 - Layout of boundary planting on two lines

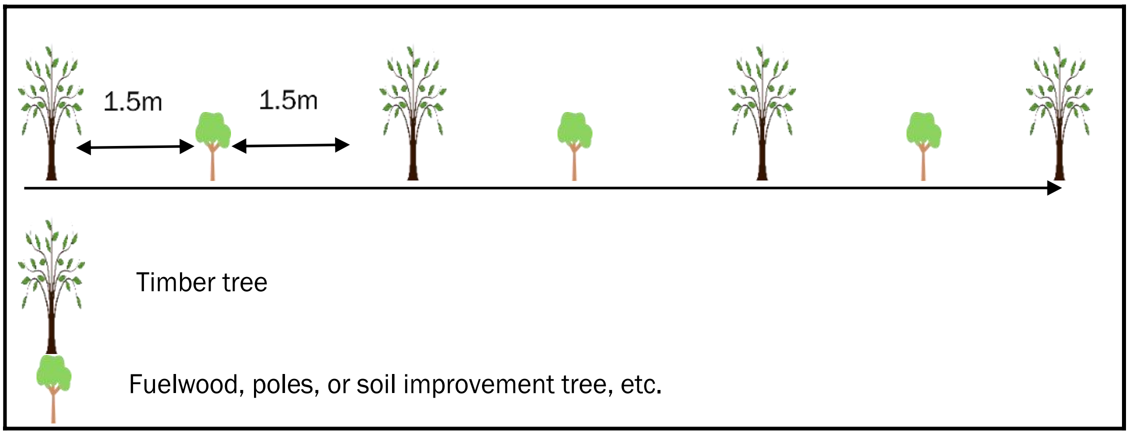


Figure 2.2 - Fuelwood, etc. trees interplanted between timber trees in boundary planting system

The system should be developed 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.

Table 2.5 - Tree establishment requirements for recommended species

Species	Establishment
Markhamia lutea	• Trees may also be propagated by seedling or wildings. They should be planted in a deep hole, as the roots are long.
Maesopsis	• Established by use of seeds but best with seedling
Casuarina equisetifolia	• Propagation is mainly by seed; however, there is an increasing use of cuttings. • 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.
Albizia lebbeck	• It is best established using potted seedlings although bare-rooted seedlings, direct seeding and stump cuttings have all been used successfully
Grevillea robusta	• 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.
Acrocarpus fraxinifolius	• Established by use of seeds

Acacia polyacantha	• It prefers sites with a high groundwater table, indicating eutrophic and fresh soils

C. Weeding

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

2.2.10 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 boundary planting system

Species	Maintenance
Markhamia lutea	• Trees can be pruned and pollarded to reduce shading and are coppiced when they are about 5 m in height. • Should be planted in a deep hole, as the roots are long. The tree coppice and can be coppiced when they are about 8-10 m in height.
Maesopsis	• In case of attack by *Fusarium solani*, selective thinning should be carried out to remove the affected stems.
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.
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.
Acrocarpus fraxinifolius	• Pruning at 4 years.
Acacia polyacantha	• Fast growing, weeding required.

2.2.11 Thinning and harvesting

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

Species	Harvesting
Markhamia lutea	• Harvesting should be done at age 50.
Maesopsis	• Rotations are about 8 years for fuel wood and poles.
Casuarina equisetifolia	• Rotation period varies depending on the farmer's need e.g. the

Species	Harvesting
	rotation period ranges from 7-8 years for fuel wood and 10-15 years for poles but it has a life span of 25-30 years.
Albizia lebbeck	• Fuelwood plantations can be clear felled on a 10-year rotation and for timber at age 25.
Grevillea robusta	• Rotations of 8-12 years for firewood and 15-20 for timber production. A growth reduction after 20 years has been reported.
Acrocarpus fraxinifolius	• 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.
Acacia polyacantha	• 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:

- Definition of property boundaries.
- Soil conservation - particularly the prevention of soil erosion associated with heavy rainfall events and siltation of water courses (climate change adaptation benefit).
- Hydrological benefit – harvesting 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.
- Pruning material may be used as firewood.

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 boundary planting 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:

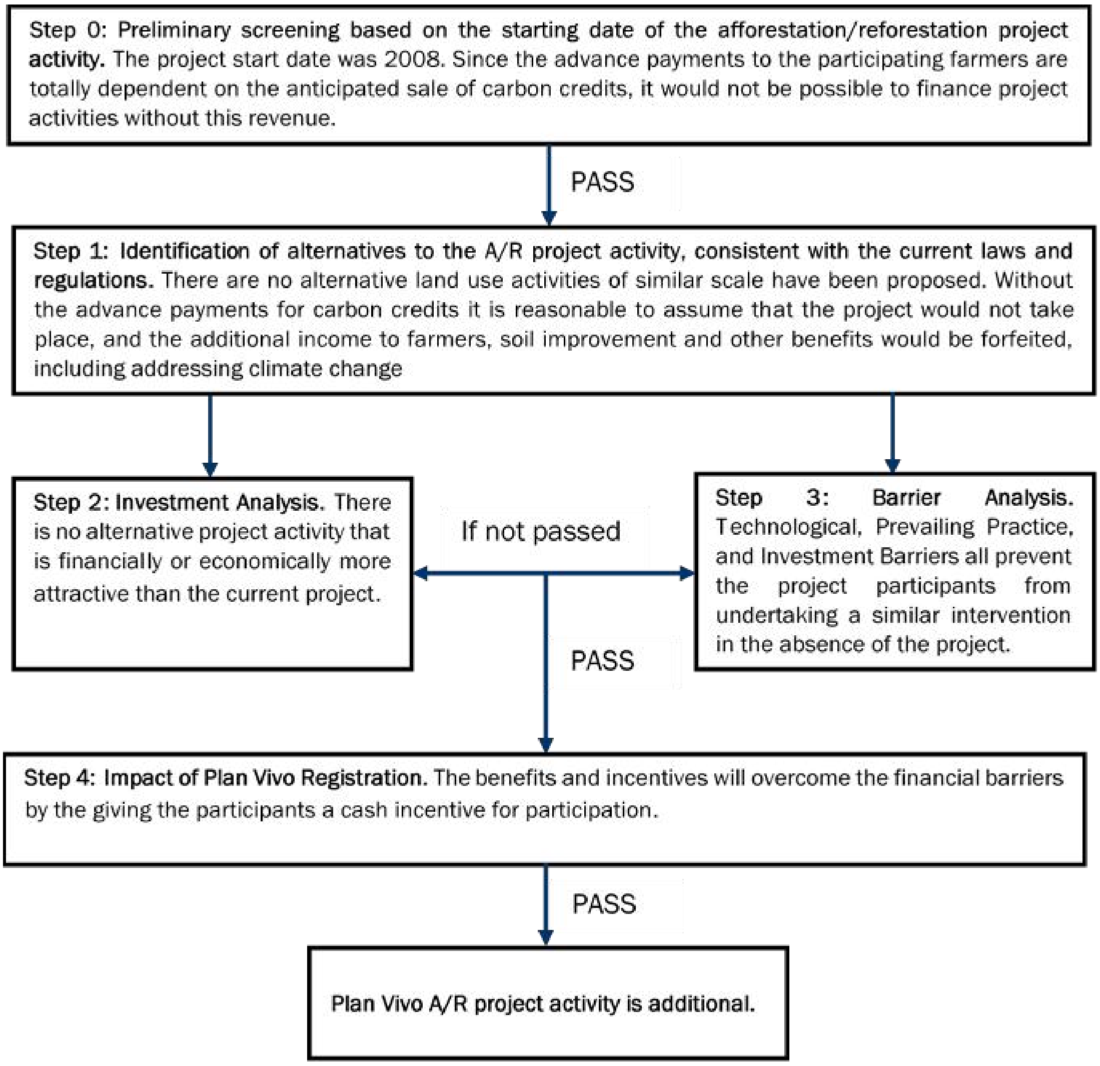


Figure 4.1 - Stepwise tool for demonstration of the project additionality

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 boundary planting system tree plant should not displace any food production activities.

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 boundary planting there should be no assumption of leakage.

In all probability the most likely outcome of the boundary planting system is positive leakage as a result of reduced pressure to exploit other forest resources. Boundary planting should combine the use of soil improving trees (reducing the pressure to extend cultivation of food activities to new areas) and fuel wood tree species (removing the pressure on surrounding 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 boundary planting system is set out in 'Assessment of Net Carbon Benefit of Vi Skogen Land Use Activities in Kagera, Tanzania' (Camco, 2009). There is no significant difference between the carbon baseline on cultivated land and that on neglected land hence 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. This translates to 0.06 tC/100m or 0.22 tCO_2e/100m in the absence of project activities based on the assumption that a single 100m line of boundary planting is equivalent to 2.97% of a hectare. In this technical specification, for conservativeness, a more conservative baseline of 0.33 tCO_2e/100m (0.09 tC/100m), which was predicted by the sequestration model, was used when calculating the net carbon benefit, from which the tradeable carbon is estimated (see Table 10.1).

7 Carbon sequestration potential of the boundary 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 boundary planting is set out in 'Assessment of Net Carbon Benefit of Vi Skogen Land Use Activities in Kagera, Tanzania' (Camco, 2009). The potential carbon sink created by this land use system (based on long term average carbon storage over 25 years) is calculated to be 1.62 tC/100m or 5.95 tCO_2/100m per line of trees.

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	Assumed Proportion
Boundary planting	*Maesopsis eminii*	0.25
	Grevillea robusta	0.25
	Markhamia lutea	0.25
	Acrocarpus fraxinifolius	0.25

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 boundary planting land use system (technical specifications) is presented in the table below based on the assumed proportions in Table 7.1:

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

	1	2	3	4	2-(1+3+4)
Intervention type (Technical Specification)	**Baseline carbon uptake / emissions i.e. without project (tCO2e/100m)**	**Gross carbon uptake/emissions reductions with project (tCO2e/100m)**	**Expected losses from leakage (tCO2e/100m)**	**Deduction of risk buffer (tCO2e/100m)**	**Net (Tradeable) carbon benefit (tCO_2/100m)**
Boundary planting	0.33*	7.79	0	1.49	5.95

*Whilst a baseline of 0.22 tCO2e/100m was modelled at the start of the project (see baseline modelling technical specification), the updated growth models predicted a baseline of 0.33 tCO2e/100m. The carbon benefit value estimated here (5.95) therefore uses the more conservative baseline value of 0.33,

Figure 10.1 below shows the long-term average carbon sink over the simulation period (25 years). This average includes the model's baseline of 0.33tCO_2/100m.

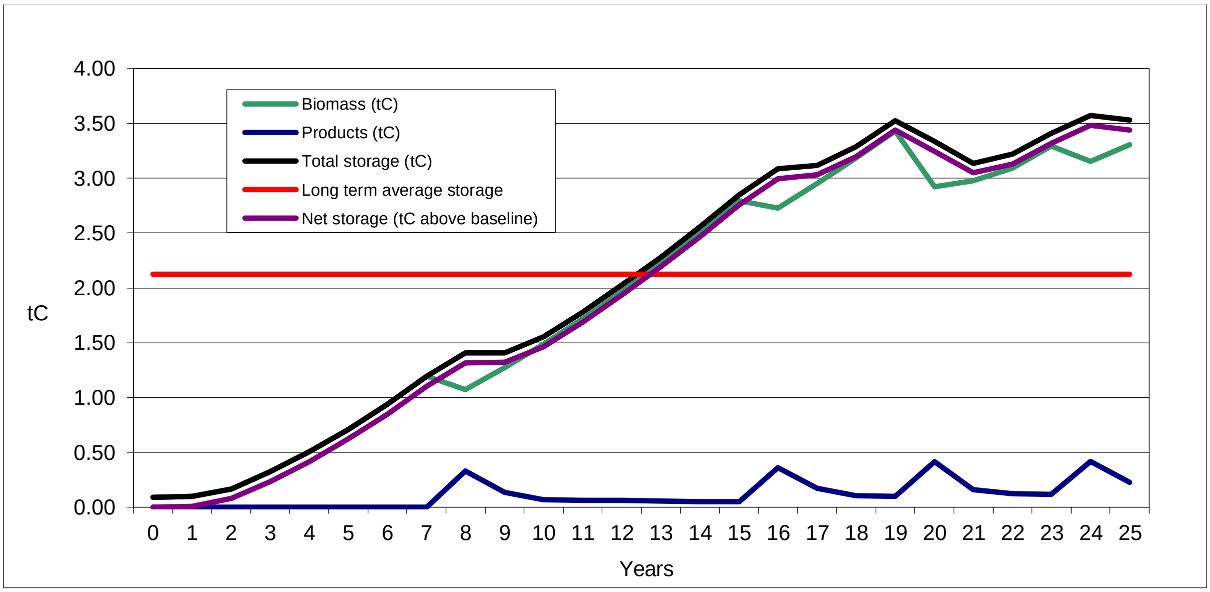


Figure 10.1 - Carbon sequestration potential for boundary planting land use system technical specification over 25 years

Table 10.1 above shows a marginal increase of 6.25% in the Tradeable tCO_2/ha from the previous 5.6 tCO_2/ha reported for the boundary system. 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 boundary land use system

Year	Indicator
1	At least 50% plot established
2	Whole plot established, 90% survival (at least 30 trees per 100m surviving)
3	Whole plot established, 80% survival
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

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The Plan Vivo Foundation. http://www.planvivo.org/

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 boundary planting system

			1	2	3	4	2-(1+3+4)
Technical Specification	**Species**	**Proportion (%)**	**Baseline carbon uptake / emissions i.e. without project (tCO2e/ha)***	**Gross 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/100m)**
Boundary planting	*Maesopsis eminii*	100	0.33	2.91	0	0.51	2.06
	Grevillea robusta	100	0.33	10.41	0	2.01	8.05
	Markhamia lutea	100	0.33	4.45	0	0.82	3.29
	Acrocarpus fraxinifolius	100	0.33	13.38	0	2.61	10.43
	M. lutea + A. fraxinifolius	50:50	0.33	8.92	0	1.72	6.86
	M. eminii + A. fraxinifolius	50:50	0.33	8.14	0	1.56	6.24
	M. eminii + G. robusta	50:50	0.33	6.66	0	1.26	5.06

*Whilst a baseline of 0.22 tCO2e/100m was modelled at the start of the project (see baseline modelling technical specification), the updated growth models predicted a baseline of 0.33 tCO2e/100m. Net (tradeable) carbon benefit value estimated here therefore uses the more conservative baseline value of 0.33,

Table 12.1 shows that for this system, farmers planting *Acrocarpus fraxinifolius* alone have the highest carbon sequestration potential due its fast growth. This explains the observation that the majority of farmers have elected to participate in the project under this system. High carbon sequestration is correlated with faster biomass accumulation and volume growth, i.e. the trees can be harvested for timber within a relatively shorter time compared to the other species under the system.