Fruit Orchard 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 sets out the methods that should be used to estimate the carbon benefits from planting and managing fruit trees on small holding farms in the project area. It summarises 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 objective of a fruit orchard is to produce fruits for domestic consumption and commercial fruit production. Additional benefits include soil conservation, improved water quality, and enhanced biodiversity. The carbon finance will make a critical difference in allowing for the implementation of this system by helping to finance the purchase of tree seedlings, increasing capacity in managing this land use system and putting in place frequent monitoring to ensure compliance with the technical specification and that the carbon sink will form. This system allows for widespread participation of small holding farmers in carbon markets. Fruit orchards may be widely adopted by individual farmers with small areas of landholding whilst contributing to enhanced food production. The most suitable areas for this system are neglected / degraded lands. This system may be more widely adopted on community land and amongst individuals with slightly larger landholdings (>1 hectare) i.e. those farmers that have sufficient land not to jeopardise their food security by introducing a land-use system that cannot be combined with growing other food crops in the long term. This system may also be suitable for use along roadsides, in schools and in military barracks and similar land use types.

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

		1	2	3	4	2-(1+3+4)
Intervention type (Technical Specification)	**Fruit Species**	**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 (tCO_2/ha)**
Fruit Orchard	Avocado	7.33	41.47	0	8.19	25.95
	Mango	7.33	25.36	0	4.97	13.06
	Citrus	7.33	11.90	0	2.28	2.29
	Jack fruit	7.33	36.28	0	7.15	21.80

* 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. The higher, and therefore more conservative, value of 7.33 was therefore used for this technical specification when estimating carbon benefits.

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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$	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 fruit tree species for domestic consumption and commercial fruit production. Initial stocking density for fruit orchard is 9mX9m for avocado and 8mX8m for citrus, mango trees.

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. Regeneration of degraded land. Farmers adapting to climate change as a result of improved technologies and environmental services;
2. A means to sustainably satisfy the dependence on wood fuel as the main source of energy for household use;
3. Fodder to animals;
4. Enhanced income; small-scale fruit farming is a key economic activity in the area. Once demand for fruits in the community increase, fruit production may be developed as a source of income at household level; and
5. Increased food security and enhance nutrition. Due to their extensive and deep rooting systems, fruit trees are less sensitive to droughts as compared with for example banana (staple crops).

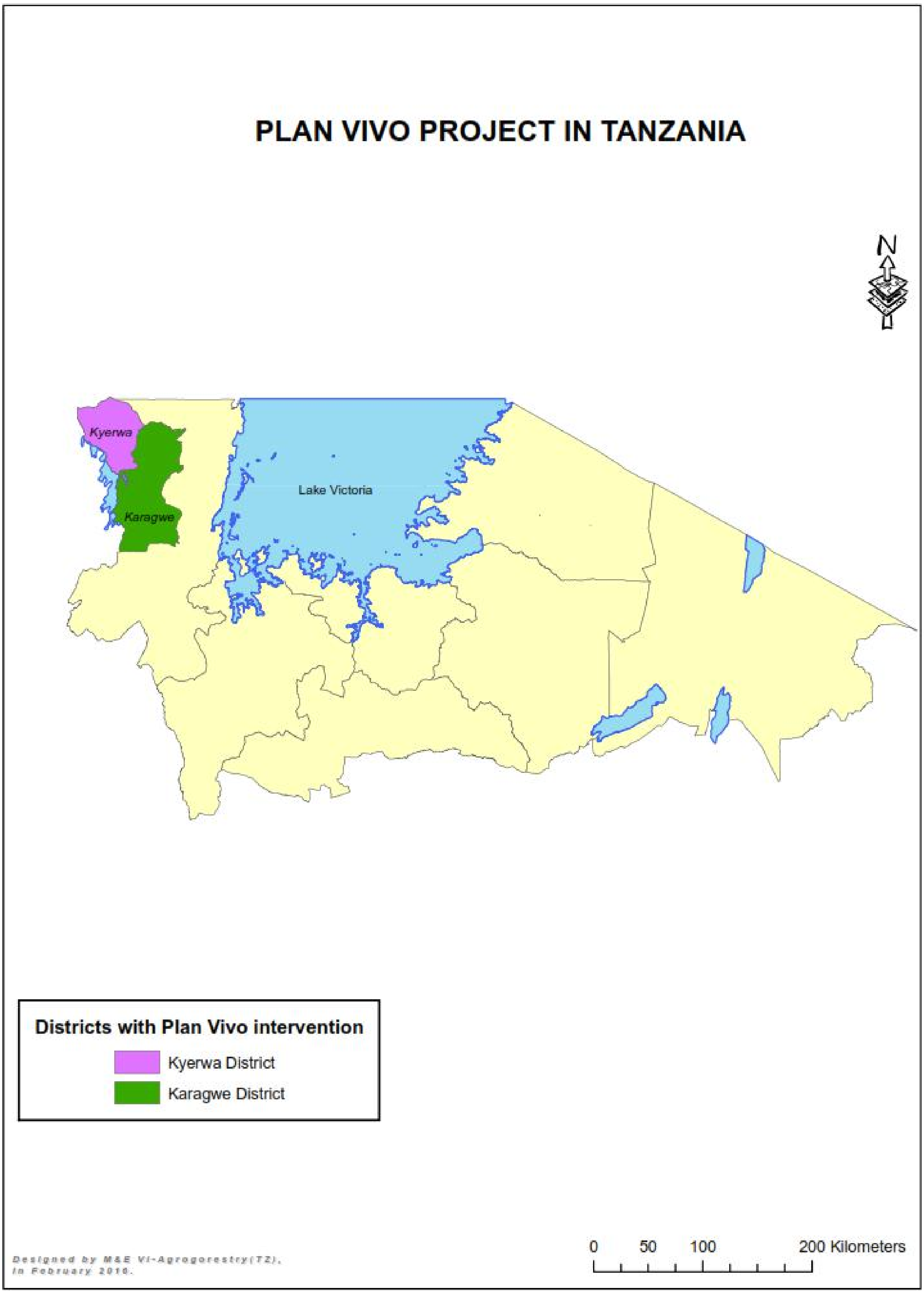


Figure 1.1 - Plan Vivo intervention area boundaries (Karagwe and Kyerwa Districts)

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 *Persea americana* (avocado), *Citrus limon* (lemon) and *Mangifera indica*. Currently, participating farmers are planting only Avocado.

Table 1.1 - Trees species recommended for the fruit orchard land-use system

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

Although the other species in Table 1.1 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 (2016) 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 the recommended species.

Table 1.2 - Ecological requirements of recommended species

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

1.4 Altitudinal range and climatic requirements

The selected tree species exhibit optimal growth for the selected fruit orchard design at elevations ranging from 0 – 2500 metres above sea level as shown in Table 1.3 for each species. Figures 1.2 and 1.3 show the rainfall and topographical maps respectively.

Table 1.3 - Suitable altitudinal and climatic ranges for recommended species

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

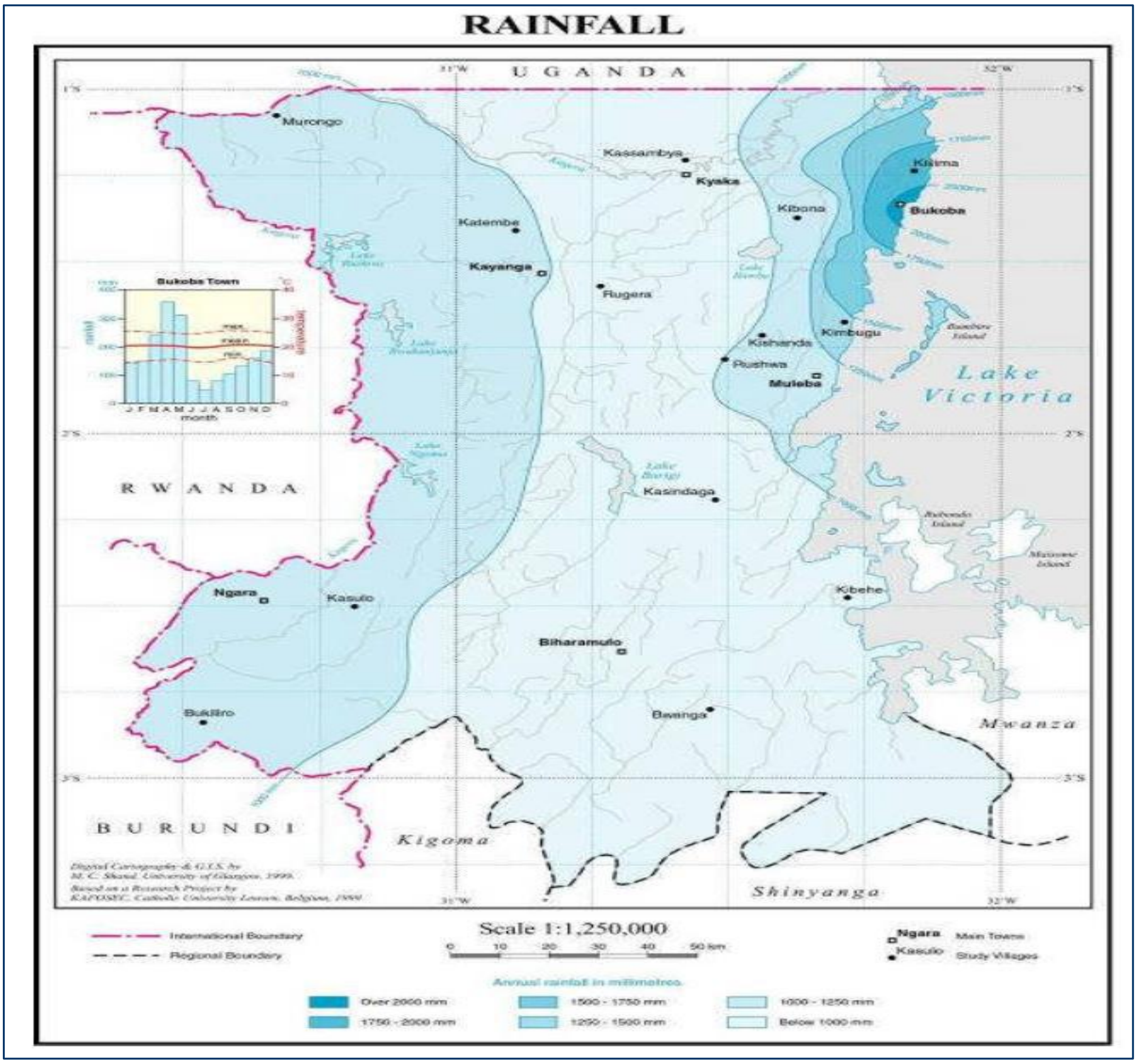


Figure 1.2 - Rainfall map of the project area

Source: Atlas of Food Security – Kagera Area, Tanzania

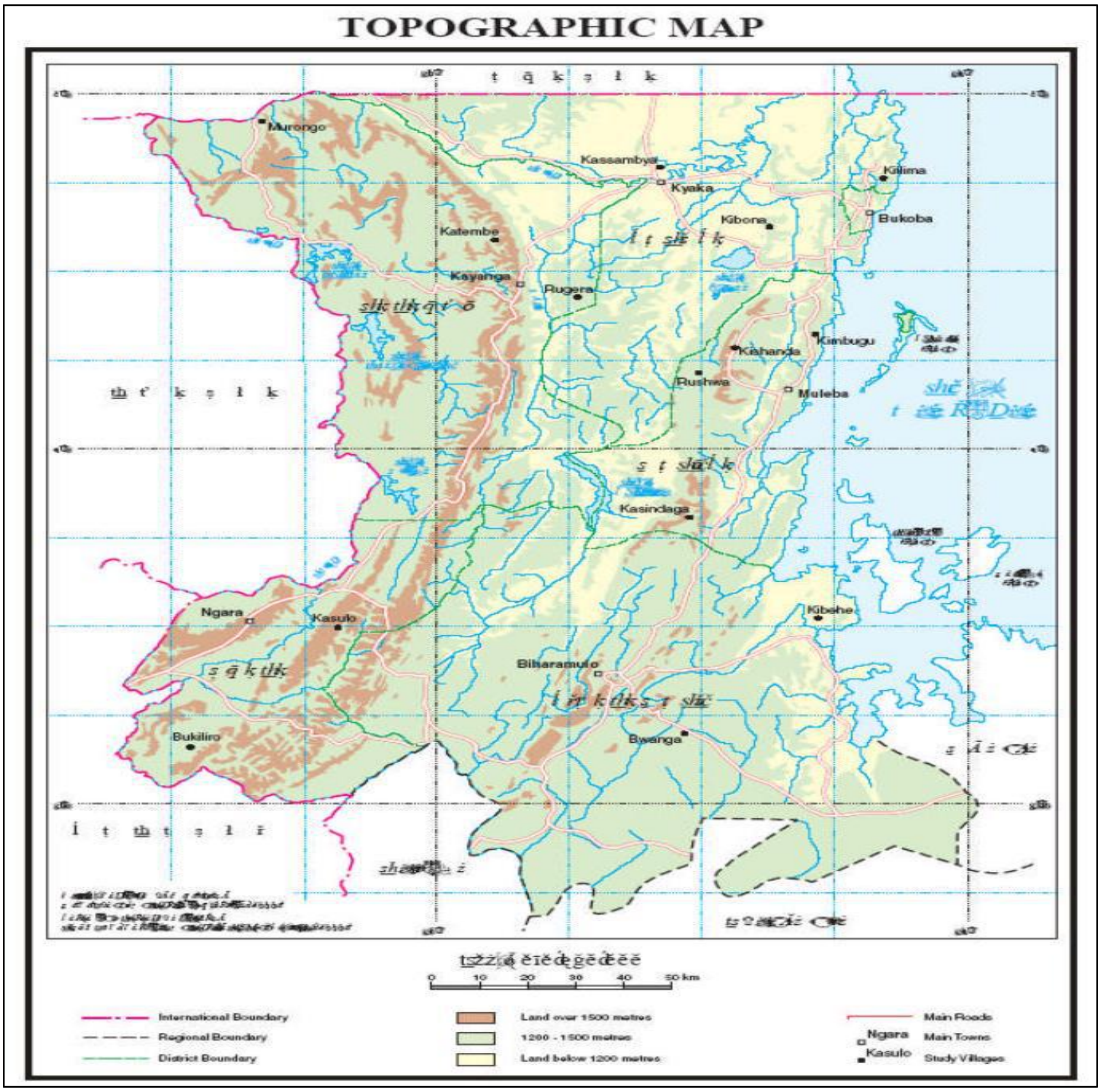


Figure 1.3 - Topographical map of Kagera

1.5 Habitat requirements

Table 1.4 - Habitat requirements of species recommended for fruit orchard land-use system

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

1.6 Growth habits

Table 1.5 - Growth habits of species recommended for the fruit orchard land-use system

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

2 Managing the land use system

2.1 Management objectives

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

Table 2.1 - Management objectives of recommended species

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

2.2 Estimate of costs for implementing the system

These costs of implementation are based on planting 150 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, transporting and mixing of the soil
- Pot filling, transfer, and topping
- Seed sowing and bed management
- Pricking out and selection/transfer
- Watering and sanitation
- Grafting
- Green house sheeting
- Cost of one wheelbarrow, 3 hoes, 2 spades, 1 machete, shade netting, poles, water, and fuel costs

The total nursery cost for the planting of 150 trees is estimated to be $280.

2.2.2 Establishment cost

The activities in the establishment phase would include:

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

Clearing one ha cost 400,000 Tsh, whilst cultivating 1ha costs 500000 Tsh. Spot preparation costs 1000 Tsh per spot, and tree planting 500 Tsh per tree seedling. This equates to around 156 trees per hectare. In total, this would cost around 400 USD per ha.

2.2.3 Maintenance cost

- Year one maintenance includes grass slashing, spot weeding, firebreaks, and uprooting shrubs. The cost for 150 trees per hectare is estimated to be $30.
- Year two operations include grass slashing, spot weeding, firebreaks maintenance and uprooting shrubs. The total cost in this year is estimated to be $ 20.
- Operations for year 3, 4, and 5 (including maintenance of firebreaks) are estimated to be $60 for 200 trees per hectare.
- Additional costs for equipment (e.g. one slasher, one hoe, one machete, a pair of boots and one overall coat) are estimated to be $20.

Table 2.2 - Maintenance costs for a homestead fruit orchard system

Activity	Cost (per 100 m for fruit orchard)
Nursery costs	$280
Establishment	$ 70
Maintenance year 1	$ 30
Maintenance year 2	$ 20
Maintenance year 3	$ 20
Maintenance year 4	$ 20
Maintenance year 5	$ 20
Operations	$ 20
Total	**$ 480**

2.3 Potential income

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

2.3.1 Income from fruit trees

Either one or two fruit species or a mixture of all the fruits can be planted. There will be a total of 150 fruit trees per hectare with a spacing of 8X8 metres. Up to a maximum of 150 kg of orange fruit can be produced per tree / year. The current market value for orange fruit is $0.4 per kg.

Up to 70 kg of mango fruit can be produced per tree/hectare/year, whereas avocado trees can yield 250-300 kg of fruit per harvest season. A brief market survey showed that the current market value for mango fruit is $2.00 per kg whereas the current market value for avocado fruit is $0.4 per kg.

2.4 Management operations activity plan

Demarcate the planting area and clear any unwanted undergrowth that will otherwise present competition and mark where individual trees will be planted.

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

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.

2.4.1 Pre-planting activities

1. Seed collection

Seeds from the recommended tree species are collected or purchased throughout the region by project staff and 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, 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

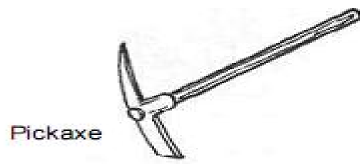
There are varieties of equipment that are needed for effective production of seedlings in the nursery. These include tools for:

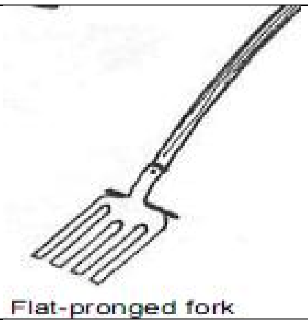
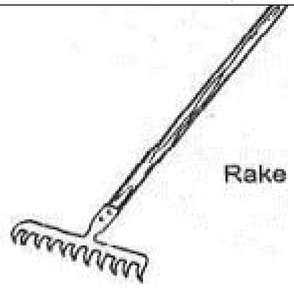
a. Working the soil and layout of the nursery
b. Preparation of potting soil and pot filling
c. Watering
d. Pricking-out
e. Weeding tools
f. Transportation

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

a. Tools for working the soil and nursery layout

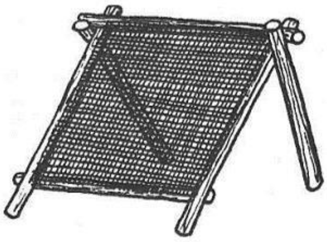
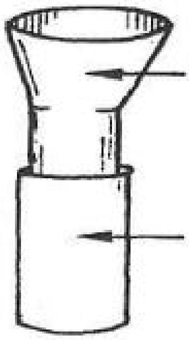
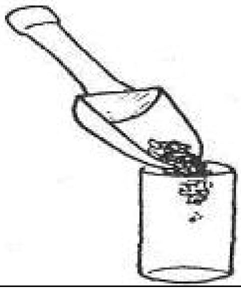
Table 2.3 - Tools for working the soil and nursery layout

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.	

Tool	Illustration
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.	
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.

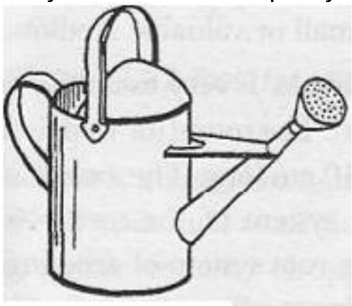
Water reservoir: A main reservoir plus numerous smaller ones for filling watering cans should be built. For strength, a circular main reservoir is preferable to a square one. The reservoir should be elevated to enable gravity distribution of water, and if possible, provide sufficient pressure for a sprinkler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

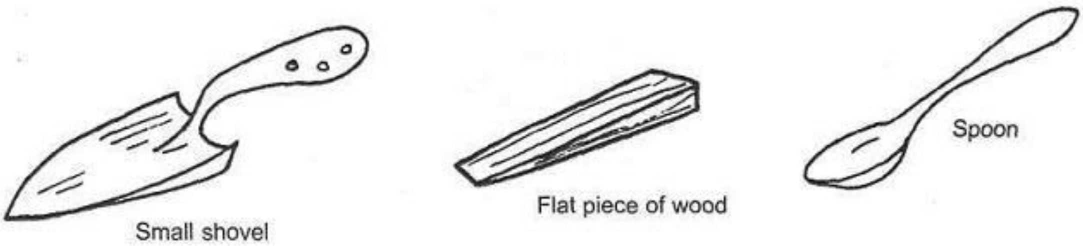
Hoses: If watering by hand-held gravity-fed hoses is intended, there must be several hoses, each at least 25 m long, of adequate diameter. Both fine and coarse roses should be available to attach to the hose for obtaining a fine spray for germination beds and a coarser spray for larger seedlings.

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.



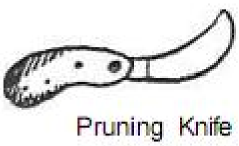
d. Tools for pricking-out

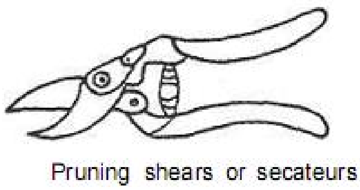
A round, sharpened, piece of wood, or dibble, is very useful for making the hole to receive a seedling for transplanting (i.e. pricking-out). The round (or wedge-shaped) dibble should be about 1 cm in diameter (or 2 cm wide) and 10 cm long. The dibble is also useful to help in lifting out the root system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





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

Trees should be planted 10 meters apart along the row and 5 m between rows as shown in Figure 2.1.

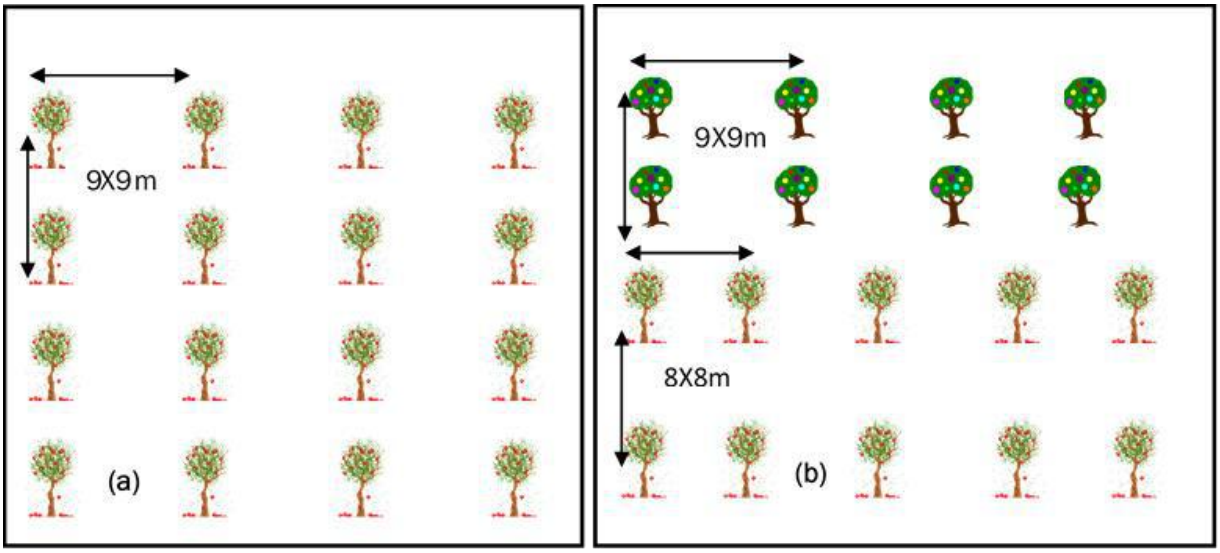


Figure 2.1 - Basic layout of the fruit orchard: (a) pure avocado and (b) mixed fruit orchard

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 - Establishment procedures for species under the homestead fruit orchard planting system

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

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 may also be required for the first three years and occasional uprooting of shrubs. Weeding reduces competition for nutrients and fire risk.

D. Protection form 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 operations for species recommended for homestead fruit orchard land use system

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

2.4.4 Harvesting

Table 2.7 below will act as a guide to rotation age of each species.

Table 2.7 - Rotations of species recommended for homestead fruit orchard land use system

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

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 fruit orchards 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:

- 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.
- Pruning material may be used as firewood.
- Improved nutrition from fruit harvests.

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 fruit orchards 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:

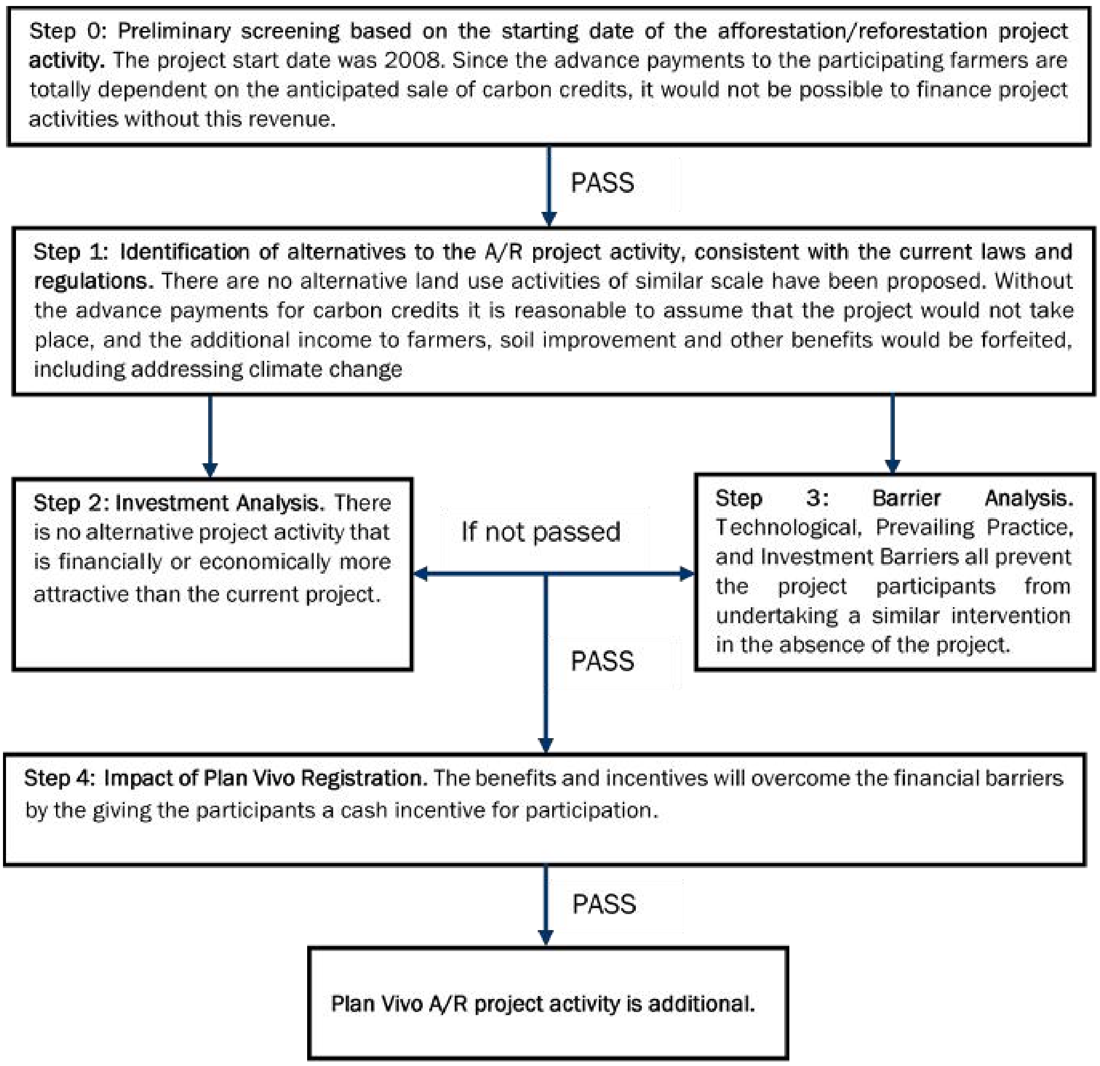


Figure 4.1 - Stepwise tool for demonstration of the project activity

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 the fruit orchard system, where trees are planted in order to increase food yields per hectare on cultivated land, leakage is not likely to occur.

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 fruit orchards, there should be no assumption of leakage.

In all probability, the most likely outcome of the fruit orchard system is positive leakage as a result of reduced pressure to exploit other forest resources. Fruit orchards 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 fruit orchards 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 tCO2e/ha was modelled through the updated growth models, the baseline assessment of carbon levels suggested a baseline of 7.33 tCO2/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 fruit orchard 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 fruit orchards 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 100 years) is calculated to be 25.95, 13.06, 2.29 and 21.80 tCO_2e per hectare for avocado, mango, citrus and jack fruit (Artocarpus) respectively. This result is derived from carbon models based on planting each of the tree species as shown in Table 10.1.

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, which 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.

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.

Form the observation that participating farmers prefer to plant only one species of fruit trees under the project, the carbon models have been done separately for each species. The net carbon benefit, buffer stock and tradable carbon offsets (Plan Vivo certificates) generated by the homestead fruit orchard land-use system (technical specification) is presented in Table 10.1 below.

Table 10.1 - Summary of the net carbon benefit, buffer stock and tradable carbon offsets from the fruit orchard land-use system for different fruit trees

		1	2	3	4	2-(1+3+4)
Intervention type (Technical Specification)	**Fruit Species**	**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 (tCO_2/ha)**
Fruit Orchard	Avocado	7.33	41.47	0	8.19	25.95
	Mango	7.33	25.36	0	4.97	13.06
	Citrus	7.33	11.90	0	2.28	2.29
	Jack fruit	7.33	36.28	0	7.15	21.80

* 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.

Figures 10.2 - 10.5 below show the long-term average carbon sink over the simulation period (25 years) for avocado, mango, citrus and jack fruit, respectively.

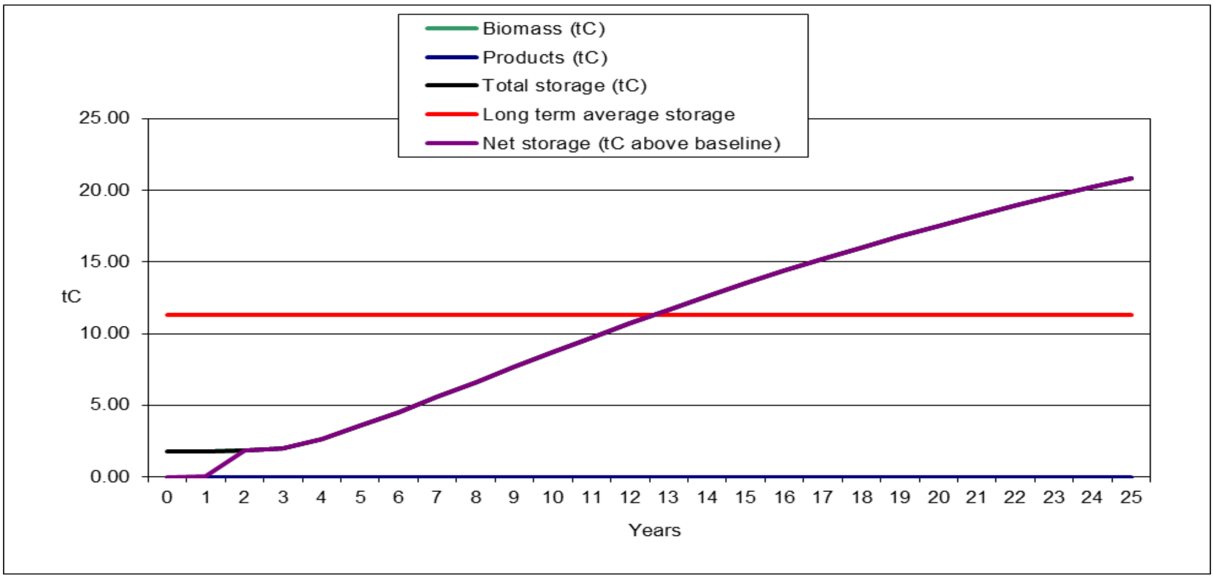


Figure 10.1 - Carbon sequestration potential for homestead fruit orchard land use system technical specification over 25 years (Avocado)

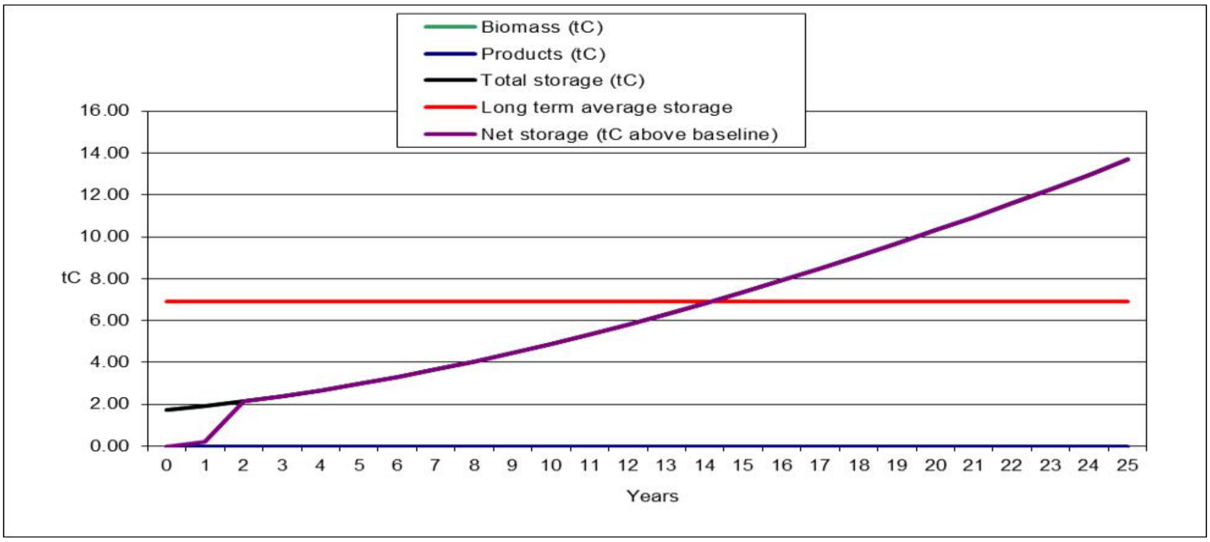


Figure 10.2 - Carbon sequestration potential for homestead fruit orchard land use system technical specification over 25 years (Mango)

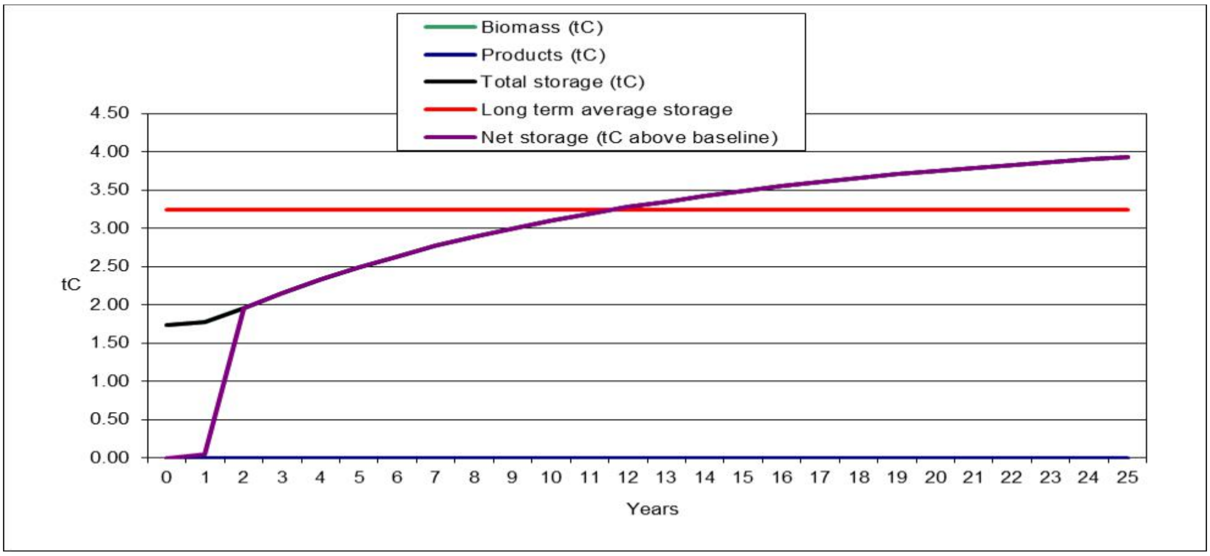


Figure 10.3 - Carbon sequestration potential for homestead fruit orchard land use system technical specification over 25 years (Citrus)

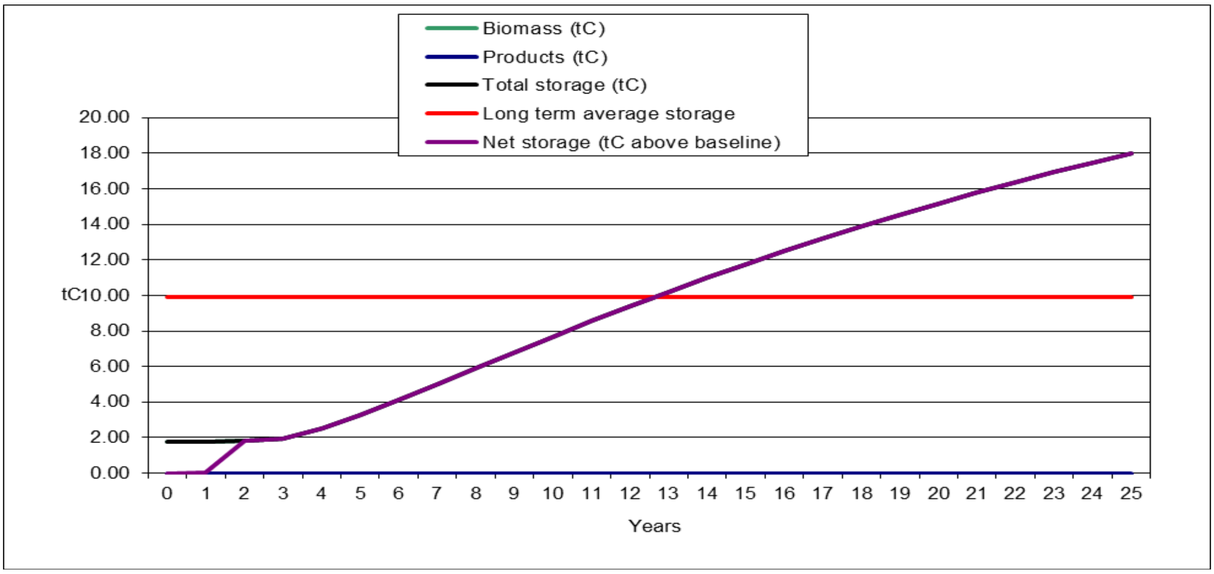


Figure 10.4 - Carbon sequestration potential for homestead fruit orchard land use system technical specification over 25 years (Jack fruit)

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 85% 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 fruit orchards land-use system

Year	Indicator
1	At least 50% plot established
2	Whole plot established, 90% survival (at least 132 stems / ha surviving)
3	Whole plot established, 80% survival
4	Whole plot established
5	Average DBH not less than 12cm
6	Average DBH not less than 14cm
7	Average DBH not less than 15cm
10	Average DBH not less than 18cm

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