CITRUS ORCHARD TECHNICAL SPECIFICATION

For

TREES OF HOPE PROJECT

{A Plan Vivo Payment for Ecosystem Services (PES) Project}

Clinton Development Initiative

Off Mphonongo Road

Plot No. 10/42

Lilongwe

Malawi

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SUMMARY

This technical specification has been developed for use by Trees of Hope Project, a Plan Vivo Payment for Ecosystem Services (PES) project involving rural communities participating in Malawi. Through the Plan Vivo system communities may be able to access carbon finance by land use change activities that involve afforestation and reforestation.

This technical specification sets out the methods that should be used to estimate the carbon benefits from planting and managing citrus fruit orchards on small holding farms in Malawi. It further details the management requirements for this system over a long period of time, and the indicators to be used for monitoring the delivery of the carbon benefit. The technical specification aims to summarise the best available evidence about the environmental benefits associated with the sustainable management of this land use system. Further information and research is welcome and will be incorporated periodically.

This land use system has been developed in consultation with communities and individual farmers in Neno and Dowa districts of Southern and Central Malawi respectively. Other valuable contributions to the development of this system have been received from Clinton Development Initiative (CDI), formerly Clinton Hunter Development Initiative (CHDI) staff, national and district government officials and forestry and agricultural extension workers. The inputs have been received through a structured process of meetings and interviews with these key stakeholders between September 2007 and October 2008.

The objective of the citrus fruit orchard system is to provide an alternative / additional source of income to other agricultural activities. Additional benefits will include soil conservation through the 1m by 1m basins made around each tree which will trap water allowing it more time to percolate into the soil as opposed to running off the surface causing soil erosion. Biodiversity will also be enhanced through attracting and providing more suitable micro-environment for insects and other fauna. The carbon finance will make a critical difference in allowing for the implementation of this system by providing tree seedlings, increasing capacity in managing fruit orchards and putting in

place frequent monitoring to ensure compliance with the technical specification that will create the carbon sink.

The project in which this technical specification is part is being piloted in Neno and Dowa districts but during the scale up phase, the project will spread to other districts with similar agro ecological conditions like temperature regimes, rainfall pattern, soil factors as described in section 5.0 of the Project Design Document (PDD) and where the tree species to be used are known to traditionally grow and have positive impact on local livelihoods. Within the districts where this technical specification will be established, it is important to ensure that appropriate pockets of land are chosen for the system to avoid unintended negative impacts on the socio-economic and environmental well-being of the communities. Table 1 below offers a guideline to the eligibility of different land types to establishment of the citrus orchard technical specification.

Table 1: Land type eligibility for citrus orchard technical specification

Land type	**Basic characteristics**	**Eligibility**
Natural forest	➢ Covered with trees (government controlled or under customary control).	➢ Not eligible as trees must not be cut down to establish a citrus orchard.
Cultivated land	➢ Generally of high fertility and production potential. ➢ Less prone to erosion. ➢ Slopes of not more than 12%. ➢ Grown to food crops annually for the household.	➢ Not eligible to avoid displacement of other food crops for the communities.
Degraded land	➢ Low soil fertility with low production potential. ➢ Shallow soils. ➢ High soil erosion hazard. ➢ Rarely put to arable cropping.	➢ Eligible only in cases where the household has enough more productive land elsewhere for production of food crops for its food security.
Neglected land	➢ Very low soil fertility and productive capacity. ➢ Shallow rocky soils with high erosion hazard. ➢ Abandoned for arable crop production. ➢ Slopes of over 12%.	➢ Eligible but any existing trees on site should only be planted around and not cut down.
Wetlands	➢ Permanent wetness.	➢ Not eligible.

The citrus orchard technical specification, like others in the project, can be established by individuals or communal groups. However, where this technical specification is established, farmers should demonstrate possession of sufficient land so that the establishment of the system does not negatively interfere with the household's food production system by taking land out of production of food crops.

The net carbon benefit of this system above the baseline (with 20% set aside as risk buffer) is calculated to be 14.74 tonnes of carbon per hectare as a long-term average over 50 years. This is equivalent to 54 tonnes of carbon dioxide per hectare.

ACKNOWLEDGEMENTS:

This work has been undertaken by Edinburgh Centre for Carbon Management (ECCM) for Trees of Hope Payment for Ecosystem Services (PES) of the Clinton Development Initiative (CDI), formerly Clinton Hunter Development Initiative (CHDI) in Malawi. It has only been possible because of the financial support received from the Hunter and Clinton Foundations. ECCM wish to acknowledge the contribution made by all the staff of CDI Malawi, and all the other stakeholders engaged during the participatory planning process used to design and collect data for this technical specification.

1.0 DESCRIPTION OF LAND USE SYSTEM

This system involves the planting of citrus fruit trees for commercial fruit production as well as providing a source of additional nutrition to those households that use this system through consumption of citrus fruit products.

1.1 Main tree species

Table 2: Tree species for citrus orchard technical specification

Botanical name	Common name (English)
Citrus sinensis *Citrus reticulata*	Sweet orange Tangerine

1.2 Ecology

Table 3: Ecological requirements for citrus orchard technical specification

Botanical name	Ecology
Citrus sinensis and Citrus reticulata	Subtropical rather than tropical species. Prefer a prominent change of seasons and do not tolerate water logging.

1.3 Altitudinal range and climatic factors.

Table 4: Altitudinal and climatic requirements for citrus orchard technical specification

Botanical name	**Altitudinal range and climatic factors**
Citrus sinensis and Citrus reticulata	Do well in areas below 1000 metres above sea level and mean annual temperature of 26 Degrees Celcius, with mean annual rainfall of 900-2500 mm.

1.4 Habitat requirements.

Citrus cultivars will generally not do well in the humid tropical lowlands. They will prosper more in areas of intermediate elevation - high constant humidity makes trees very susceptible to pests and diseases. They have a moderate frost tolerance but no tolerance of water logging.

Table 5: Habitat requirements for citrus orchard technical specification

Botanical name	**Habitat requirements**
Citrus sinensis and Citrus reticulata	Grows well in almost any soil type if well aerated. Fertile, light to medium, well-drained, deep, loose loams; soils with a high water table should be avoided. The species are sensitive to excess salts; pH range of 5-8 is preferred. High constant humidity makes them susceptible to pests and diseases.

1.5 Growth habit.

Table 6: Growth habit of citrus tree species in the citrus technical specification

Botanical name	**Growth habits**
Citrus sinensis and Citrus reticulata	Small, shallow-rooted evergreen trees about 6-13 m high, with an enclosed conical top and mostly spiny branches. Twigs angled when young, often with thick spines.

2.0 MANAGEMENT OF CITRUS ORCHARD LAND USE SYSTEM

2.1 Management objectives

The main management objective is the commercial production of citrus fruits. Citrus fruits will provide a dietary supplement to those households that will adopt this system and any off-cuts / pruning material can be used as fuel wood. Citrus fruit trees are also important for apiculture, as the flower nectar provides excellent fodder for bees.

3.0 COSTS OF IMPLEMENTATION

3.1 Nursery costs

The activities and costs for establishing 400 seedlings during the setting up of the nursery are

- Preparation of media.
- Seed sowing and bed management.
- Pot filling, transfer and topping.
- Pricking out and selection/transfer.
- Watering and sanitation.
- Pest and disease control.

- Purchase of budwood for budding and *citrus limoni* fruits to extract seed to establish rootstocks.
- Budding.
- Cost of budding tapes and knives.
- Green house sheeting materials.
- Cost of one wheelbarrow, hoes, spades, machete, green house sheets, poles, water cans.

The total nursery cost is $ 600 for 400 seedlings.

3.2 Establishment cost

The activities in the establishment phase would include:

- Land preparation (clearing of weeds and other trash to allow easy pitting and basin preparation).
- Chaining/marking.
- Pitting.
- Planting.

The total cost for this phase per hectare would be $ 50.

3.3 Maintenance cost

Operations for year one would include grass slashing, spot weeding, firebreaks and uprooting shrubs. The cost per hectare will be $40 while year two operations that include grass slashing, spot weeding, firebreaks maintenance and uprooting shrubs are estimated to cost a total of $20 per hectare. Operations for years 3, 4, and 5 include maintaining of firebreaks and pruning which will cost $20 per hectare per year. Other costs would go towards buying equipments such as one slasher, one hoe, one machete, a pair of boots, and one overall coat costing an estimated $ 50. In total, the maintenance cost will be $ 295. Table 7 below shows the nursery, establishment and short-term cost profile for the citrus technical specification.

Table 7: Nursery, establishment and short-term cost profile for citrus technical specification.

Activity	**Cost (per hectare for citrus fruit orchard)**
Nursery costs	$600
Establishment	$50
Maintenance year 1	$40
Maintenance year 2	$20
Maintenance year 3	$20
Maintenance year 4	$20
Maintenance year 5	$20
Equipment cost	$50
Total	**$820**

4.0 POTENTIAL INCOME

There will be a total of 400 citrus fruit trees per hectare from a spacing of 5m by 5m. The average yield per hectare of a citrus orchard is estimated at 60kg per tree per year for an estimated productive life of 10 years giving a cumulative total production of 240000kg. At an estimated price of MK75 per kg, the yield would have a value of MK18000000 over ten years. However, it should be noted that this is a conservative estimate since the productive life of citrus orchards can reach over 15 years under good management and optimal climatic conditions.

5.0 MANAGEMENT OPERATIONS

5.1 Establishment

Minimal land preparation should be done at the site of planting to facilitate digging of holes and making of basins around the trees. Any existing trees on site should not be cut but only planted around and all plots showing wholesale clearing of vegetation are disqualified. Create basins of 1m by 1m around each tree so that water is trapped and percolates into the soil instead of running off, causing soil erosion. Apply mulch in the basins to assist in moisture conservation and weed suppression but the mulch should stay clear of the root collar to reduce risk of termite attack. Trees should be planted in rows in holes dug 60cm wide and 60cm deep at a spacing of 5m by 5m. When digging the holes, top soil should be put on one side of the hole and sub soil on the other side and when filling the hole at planting, put top soil into the hole, first before sub soil.

Intercropping with other crops will only be possible until canopy closure. It is best to plant at the beginning of the wet season to minimize the requirement to water the seedlings. At planting, the following actions need to be considered:

- Water seedlings before planting to hold nursery soil together and to increase soil moisture in the pot to assist in establishment.
- Planting should be done when there is adequate moisture in the field.
- Plant at the beginning of the rainy season.
- Care should be taken in 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.
- 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).
- Regular watering especially in the first year will help trees survive.

5.2 Maintenance

Particular attention should be paid to weeding and uprooting of competing shrubs where citrus has been planted. The orchard should also be protected from livestock browsing and bush fires. Recommended procedures, as stipulated in manuals like the “Horticulture Crop Production Recommendations” by W. S. Braunworth of 1992 and other documents on pest and disease management and crop nutrition will be followed in management of the orchard. Some of the common pest and disease problems in citrus are highlighted in Annex 16.1. In a case where spot weeding is preferred, grass slashing will immediately follow. Pruning is practiced to encourage branching and to keep the tree low for easy harvesting of the fruits. Any growth below where budding took place should be removed. Pruning, sanitation, use of resistant varieties and spraying are some of the pest and disease management measures.

5.3 Pruning and harvesting.

Pruning of unwanted branches should be done carefully to leave smooth scars to minimise infection. This activity is necessary to allow better penetration of photosynthetic active radiation, vital for fruit set. As the orchard ages, its productivity will decrease hence pollarding should be considered or complete re-establishment at approximately about 50 years.

6.0 DESCRIPTION OF THE ENVIRONMENTAL AND SOCIAL BENEFITS

The establishment of this land use system will bring about the following environmental and socio-economic benefits:

- Soil conservation - particularly the prevention of soil erosion associated with heavy rainfall events and siltation of water courses (climate change adaptation benefit) due to 1 metre by 1m basins made around bases of trees that trap water and allowing it to percolate into the soil as opposed to running off the surface, causing soil erosion.
- Hydrological benefit – harvesting of incidental moisture and encouragement of water infiltration which will help to reduce flooding (climate change adaptation benefit) through

the percolating water which will aid in recharging ground water systems and helping to raise the water table.

- Biodiversity benefit – through the provision of suitable microenvironment (below and above ground) potentially suitable for supporting diverse types of insects and other flora and fauna.
- Provision of potential bee keeping habitat as bee hives could be hung in the citrus trees.
- Pruning material may be used as firewood.

7.0 DESCRIPTION OF ADDITIONALITY

A key factor is that the emissions reductions from a project activity or intervention should be additional – i.e. the intervention would not have occurred in the absence of the carbon-derived finance. Additionality can be demonstrated through an analysis of the barriers to the implementation of activities in the absence of intervention. In this case the barriers to the establishment of citrus fruit orchards that are overcome through the project activity and receipt of carbon finance include:

- Community mobilisation and participation in planning processes.
- Awareness of climate change issues, carbon trading and role of citrus orchards in climate change management and livelihood improvement leading to renewed efforts in tree planting.
- Building of technical competence in development of budded citrus seedlings and their subsequent field establishment and management, vital for sustainability.
- Access to high-value citrus planting materials.
- Access to tools and other nursery materials including polythene tubes, watering cans, seed etc to enable seedling production.
- Training to enable long term sustainability of the 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.

8.0 LEAKAGE ASSESSMENT

Leakage is unintended loss of carbon stocks outside the boundaries of a project resulting directly from the project activity. In the case of establishing citrus orchards this is most likely to occur where farmers are establishing trees on currently cultivated land (these fruit trees are not suitable to be grown in combination with other cultivated food crops). If this were to occur it may result in displacement. The Plan Vivo system requires that potential displacement of activities within the community should be considered and that activities should be planned to minimise the risk of any negative leakage. These actions should include:

- All farmers establishing citrus orchards should be assessed individually to demonstrate that they retain sufficient land to provide food for themselves and their families.
- Signatories to Plan Vivo activities will be contractually obliged not to displace their farming or livestock 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 citrus fruit orchards, there should be no assumption of leakage.

9.0 PERMANENCE AND RISK MANAGEMENT

The project recognizes the importance of permanence of its activities (carbon stocks) so that they are not only initiated but also become sustained in the community and further realizes that risks exist that could threaten this intention. These risks have been foreseen and risk management measures put in place to minimize any effects. One of the threats to sustainability of project activities is the mere lack of sense of ownership of the project by the targeted communities. To minimize this threat, the project has a deliberate policy of striving to involve the communities in all project processes coupled with free flow of updated program information through a rigorous participatory training program. The project further attaches highest priority for registration to individuals and groups that show tendencies of self-selection. Other risks to permanence are also foreseen and are presented in Table 8 below along with their management measures.

Table 8: Risks to permanence, their levels and management.

Permanence risk	**Level of risk**	**Management measure**
Forest fires	High	- Adoption of recommended fire protection measures including establishment of fire breaks around plantations and incorporating into the soil all weeds and foliage from within the plantation. - Civic education to communities and their leaders on the dangers of bush fires to the environment and livelihoods. - Formation of community-based fire monitoring squads in the villages.
Pests and diseases (largely fungal infections and leaf-eaters and damping-off disease in the nursery). Termites in some sections cause damage soon after planting out.	Low	- Selection of indigenous tree species which are hardy to most pathological problems. - Recommended pest and disease management silvicultural practices both in the nursery and in the field following an integrated approach to pest and disease management. - Implement an effective pest and disease surveillance system led by Local Program Monitors (LPMs), a system of farmer volunteers based in the communities.
Drought	Medium	- Early planting of strong healthy seedlings. - Good silvicultural practices like deep pitting and use of organic manure which promote higher soil moisture retention. - Promotion of irrigation where applicable.

Table 8: Risks to permanence, their levels and management (*continued*)

Permanence risk	**Level of risk**	**Management measure**
Livestock damage	Low	- Education of communities on recommended livestock management practices like tethering and zero grazing during periods when trees are vulnerable to livestock damage. - Placement of protective structures (normally thorny fences) around plantations or individual trees where feasible. - Enforcement of community by-laws by traditional leaders that regulate movement of livestock in communities. - In certain cases, establishment of tree species that are not vulnerable to livestock damage through browsing.
Overreliance on external support.	Low	- Capacity building on all technical aspects of tree establishment and management including community based seedling production. - Broadening income streams to producers over and above carbon finance. - Encouraging communities to contribute all locally available materials and labour for tree seedling production, with the project only providing materials that are difficult to source at community level. The latter materials will later also be the responsibility of the communities through carbon finance.

Based on the risks outlined above, the project will withhold 20% of carbon services generated from sale to form a carbon buffer (reserve of unsold carbon).

10.0 BASELINE CARBON EMISSIONS

The **baseline** refers to carbon sequestered and stored in any existing vegetation (excluding food crops) on a site at the time of planting. When calculating the number of Voluntary 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 citrus fruit orchards is set out in '*Assessment of Net Carbon Benefit of CDI Land Use Activities' (Camco, 2011)*. It is assumed that this system will be used only on cultivated land with an estimated carbon baseline of 0.37 tonnes of carbon per hectare in the absence of project activities.

11.0 QUANTIFICATION OF THE CARBON SINK

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 50 year period relative to the baseline. A three-staged approach is used as outlined below:

- Calculate tree growth rates based on tree measurement data captured within the project area
- The carbon uptake of each species was calculated using the CO2FIX-V3 model (Mohren et al 2004).
- These model outputs were 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 citrus fruit orchards is set out in '*Assesment of Net Carbon Benefit of CDI Land Use Activities' (Camco, 2011)*. The potential carbon sink created by this land use system (based on long term average carbon storage over 50 years) is calculated to be 19 tonnes of carbon per hectare.

12.0 BUFFER

Twenty percent (20%) of all VER’s generated by the project activities are maintained as a risk buffer and records of all buffer stock should be maintained in the database. It has yet to be decided at what stage the right to trade these VER’s will return to the farmer.

13.0 CALCULATION OF CREDITS

For the purposes of quantifying Plan Vivo certificates (carbon offset), the net carbon benefit of each tree planting system in addition to the baseline has been calculated. In accordance with Plan Vivo standards (http://www.planvivo.org/), 20% of all the carbon offset (i.e. net carbon benefit) is set aside to be kept as a risk buffer (i.e. non tradable carbon asset). Records of all buffer stock should be maintained in the database. The net carbon benefit, buffer stock and tradable carbon offset (Plan Vivo certificates) generated by the citrus fruit orchard land use system (technical specification) is presented in Table 9 below:

Table 9: The net carbon benefit and tradable carbon offset for the citrus fruit orchard land use system.

Technical Specification	**Sink (tC/ha)**	**Baseline (tC/ha)**	**Net benefit (tC/ha)**	**Net benefit (tCO_2/ha)**	**Buffer (%)**	**Tradeable (tCO_2/ha)**
Fruit Orchard (Citrus)	19	0.37	18.63	69	20	56

The figure below shows the long-term average carbon sink over the simulation period (50 years).

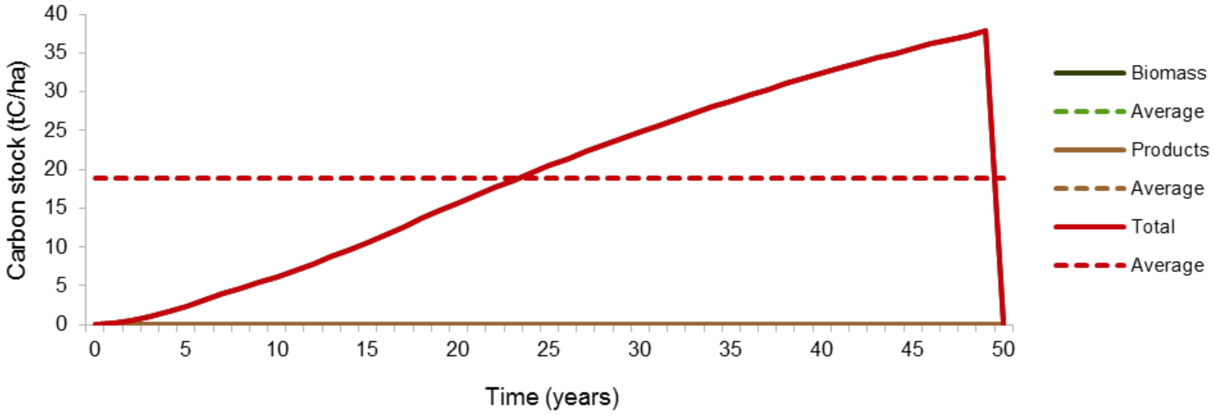

Figure 1: Citrus fruit orchard technical specification carbon sequestration potential over 50 years.

14.0 MONITORING

Monitoring targets for the first 4 years are based on establishment whereby the whole plot must be established by the fourth year with at least 90% survival of trees. Thereafter monitoring targets are based on growth rates monitored by measurements of the tree Diameter at Breast Height (DBH). The expected DBH at the time of monitoring is based on a predicted mean annual diameter increment on which carbon sequestration estimates are based. Table 10 below shows the monitoring schedule (in years) and the corresponding indicators or targets that are expected to be met by producers to warrant receipt of carbon finance upon selling of their carbon credits.

Table 10: Monitoring milestones at different monitoring periods

Year	Monitoring Indicator
1	At least 50% plot established
2	At least 75% plot established
3	Whole plot established with 85% survival of trees.
4	Whole plot established with at least 90% survival of trees.
5	Average DBH not less than 4cm
7	Average DBH not less than 8cm
10	Average DBH not less than 15cm

15.0 REFERENCES

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16.0 ANNEXES

16.1 Common pest and disease problems in citrus

Citrus, just like any other agricultural crop, are susceptible to pest and disease attack which affect productivity. Some of the common pests and diseases in citrus are outlined below along with their recommended management practices (Guide to Agricultural Production and Natural Resources Management in Malawi):

16.3.1 Diseases

16.3.1.1 Citrus greening disease

- Is a serious disease in all areas in the country where citrus is grown.
- Is transmitted through infected planting material or a psyllid (*Trioza erytriea*).
- The disease is characterised by leaf mottling, stunted growth, leaf fall, twig die back and eventual death of tree.
- The fruit may be malformed and remain green after maturing and is bitter.

16 3.1.1.1 Control of citrus greening disease

- Plant clean planting materials.
- Pruning and burying or burning all infected branches.
- Raise seedlings in hot areas where the vector does not thrive.

16.3.1.2 Citrus woolly white fly (*Aleurothixus floccosus*).

- Adult flies are tiny about 1mm, just visible with unaided eyes and yellowish in colour. Colonies of larvae look like a mass of cotton wool, hence the name.
- The larvae cause damage by extracting leaf sap when feeding and by development of sooty mould that grows on honeydew (sugary waters), which consequently compromises efficiency of photosynthesis.

- Fruits from affected plants are reduced in size and quality and in severe infestation, fruiting may fail.

16.3.1.2.1 Control of citrus woolly white fly.

- Practice nursery hygiene in and around the nursery.
- Otherwise it is best controlled biologically by using a natural enemy, a wasp called *Cales noaki* but it is yet to be practised to any significant scale in the country.