DISPERSED SYSTEMATIC INTERPLANTING (DSI) TECHNICAL SPECIFICATION

For

TREES OF HOPE PROJECT

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

Clinton Development Initiative (CDI)

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 nitrogen fixing trees 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) 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 dispersed inter-planting system is to improve soil fertility and therefore increase yields of agricultural food and in some cases, cash crops. Additional benefits will include soil and water conservation, enhanced biodiversity, firewood, and potential bee keeping in the longer term. The carbon finance will make a critical difference in allowing for the implementation of this system by providing tree seedlings, increasing capacity in its management 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 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 the land are chosen for the system to avoid unintended negative impacts on the socio-economic and environmental well-being of the communities. This technical specification is inter-planted with arable crops hence could be established wherever crops are grown as long as the other factors favour good growth and survival of the tree species involved. The table below offers a guideline to the eligibility of different land types to establishment of this technical specification.

Table 1: Land type eligibility for DSI technical specification

Land type	Basic characteristics	Eligibility
Natural forest	➢ Covered with trees (government controlled or under customary control).	➢ Not eligible since is designed to be inter-planted with arable crops.
Cultivated land	➢ Generally of high fertility and high production potential. ➢ Less prone to erosion. ➢ Slopes of not more than 12%. ➢ Grown to food crops annually for the household.	➢ Eligible (this is where the system fits).
Degraded land	➢ Low soil fertility with low production potential. ➢ Shallow soils. ➢ High soil erosion hazard. ➢ Rarely put to arable cropping.	➢ Eligible as long as crops are planted on the land.
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%.	➢ Not eligible.
Wetlands	➢ Permanent wetness.	➢ Not eligible.

The Dispersed Systematic Inter-planting (DSI) technical specification, like others in the project, can be established by individuals or communal groups. The net carbon benefit of this system above the baseline (with 20% set aside as risk buffer) is calculated to be 19.15 tonnes of carbon per hectare as a long-term average over 50 years. This is equivalent to 70.2 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 currently involves the planting of nitrogen-fixing *Faidherbia albida* as the main tree species at a low stocking density throughout the area of cultivated land. Other tree species that can be used in the system are shown alongside *F. Albida* in Table 2 below. Nitrogen fixing trees will increase and extend the expected productivity of the cultivated land. These species increase soil nitrogen by actively manufacturing nitrogen compounds through symbiotic bacteria located in the root nodules. Any litter will act as green manure (organic fertiliser) and the tree roots will also help to promote good soil structure by increasing soil organic matter content through the release of nitrogen-rich and easily decomposable materials into the soil. The trees will also help in nutrient cycling by absorbing nutrients from deeper soil layers (through the deep rooting system) onto surface soil layers where shallow rooted crops growing in association can access them.

Many studies indicate that inter-planting of nitrogen fixing trees with crops (e.g. sorghum, maize) will increase crop yields significantly (University of Queensland, 1998) as well as extending the expected productivity of the land thereby reducing the pressure to clear new areas of forest.

Table 2: Tree species for DSI technical specification

Botanical name	**Common name (English)**	**Range**
Faidherbia albida	Faidherbia	Indigenous
Albizia lebbeck	Woman’s tongue, Siris tree	Naturalised
Acacia polyacantha	White Thorn	Indigenous
Acacia galpini	Monkey Thorn	Indigenous

1.1 Ecology

Table 3: Ecological requirements for tree species in the DSI technical specification

Botanical name	Ecology
Faidherbia albida	Grows on the banks of seasonal and perennial rivers and streams, on sandy alluvial soils but generally grows on a wide range of soils from sands to heavy clays.
Albizia lebbeck	*Albizia lebbeck* establishes well on fertile, well-drained loamy soils but poorly on heavy clays. Tolerates acidity, alkalinity, heavy and eroded soils and waterlogged conditions.
Acacia polyacantha	The species occurs in wooded grasslands, deciduous woodland and bush land, riverine and groundwater forests in altitudes between sea level and 1800 m.
Acacia galpini	Typically occurs in riverine woodlands with loamy or clayey soils. The tree can survive hot and dry conditions.

1.2 Altitudinal range and Climatic factors

Table 4: Altitudinal and climatic requirements for the tree species in the DSI technical specification

Species	Altitudinal range and climatic factors
Faidherbia albida	The tree can be found below sea level and up to 2800 m.a.s.l, Mean annual temperature: 18-30 Deg. Celcius, Mean annual rainfall: 250-1000 mm.
Albizia lebbeck	Will grow up to 1,800 m.a.s.l. *Albizia lebbeck* prefers annual rainfall of 1,300-1,500 mm and a very dry winter. It is tolerant of long, hot, dry periods and cold winters. *Albizia lebbeck* requires mean annual temperature of between 19-35^{0}C.
Acacia polyacantha	Altitude 200-1 800 m, Mean annual rainfall: 300-1 000 mm
Acacia galpini	Prefers loamy or clayey soils but can survive hot and dry conditions. Altitudinal requirement is between 350 and 1500 m.a.s.l.

1.3 Habitat requirements

Table 5: Habitat requirement for the species in the DSI technical specification.

Botanical name	Habitat requirement
Faidherbia albida	The tree is widely adapted capable of growing on a wide range of climatic, soil and water conditions.
Albizia lebbeck	*Albizia lebbeck* establishes well on fertile, well-drained loamy soils but poorly on heavy clays. Tolerates acidity, alkalinity, heavy and eroded soils, and waterlogged conditions.
Acacia polyacantha	Widely adaptable. It prefers sites with a high groundwater table, indicating eutrophic and fresh soils. It occasionally prospers on stony slopes and compact soils.
Acacia galpini	The tree can survive hot and dry conditions and on loamy or clayey soils.

1.4 Growth habit.

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

Botanical name	**Growth habit**
Faidherbia albida	Can reach 30 m in height, with spreading branches and a rounded leafless crown during the wet season allowing for more light to reach crops during the growing season. The roots can grow to 40 m deep. When the leaves return during the dry season the shade will greatly reduce soil moisture losses through evaporation. The leaves drop at the onset of the wet season so that valuable organic matter is fed into the soil in advance of the planting of crops.
Albizia lebbeck	*Albizia lebbeck* can attain heights of 30 m with a dbh of 1m. It is fast growing and responds well to pollarding, coppicing and lopping.
Acacia polyacantha	Fast growing to 20m with open canopy. It responds well to pollarding and coppicing.
Acacia galpini	Fast growing, small to fairly large tree up to 30 m tall; bole usually straight up to 60cm in diameter. It is a deciduous tree losing its leaves during the Southern African winter (April to July). It nodulates well with indigenous rhizobium or Bradyrhyzobium.

2.0 MANAGEMENT OBJECTIVES OF THE SYSTEM

The main management objective is soil improvement to increase yields of agricultural crops principally maize and other crops. However, fuel wood and fodder may also be obtained from thinnings and branches such as off-cuts / pruning material while at maturity the trees can also be sewn into high value timber for various purposes including utensils, canoes, furniture, boxes, drums and oil presses. *F. Albida* is very suitable for apiculture because its flowers provide bee forage at the end of the rainy season and the leaves and pods are palatable to domestic animals and an important source of protein for livestock in the dry season.

3.0 COSTS OF IMPLEMENTATION

3.1 Nursery cost

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

- Cost of seeds and polythene tubes.
- Seed pre-treatment (nicking).
- Sourcing and mixing of media.
- Pot filling, transfer, and topping.
- Seed sowing into tubes on raised platforms to air-prune seedlings for *F. Albida*.
- Thinning and weeding.
- Watering and sanitation.
- Other management operations.

The total cost of these activities for 200 seedlings is estimated at $30.

3.2 Establishment cost

The activities in the establishment phase would include:

- Land preparation (normally done for the associated crop).
- Marking at a spacing of 5m by 10m.
- Pitting.
- Planting.

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

3.3 Maintenance cost

Maintenance activities in year one will include grass slashing, spot weeding, firebreaks, and uprooting shrubs. The cost for 200 trees per hectare is estimated to be $35 while year two operations include grass slashing, spot weeding, firebreaks maintenance and uprooting shrubs costing an estimated $20. Operations for years 3, 4, and 5 (including maintenance of firebreaks) are estimated to be $45 for 200 trees per hectare and additional costs for equipment (e.g. one slasher, one hoe, one machete, a pair of boots and one overall coat are estimated at $50. The full cost profile is summarized in the Table 7 below:

Table 7: Nursery, establishment and short-term maintenance cost profile for the DSI technical specification

Activity	Cost (per hectare for dispersed inter-planting)
Nursery costs	$30
Establishment	$50
Maintenance year 1	$35
Maintenance year 2	$20
Maintenance year 3	$15
Maintenance year 4	$15
Maintenance year 5	$15
Equipment	$50
Total	**$230**

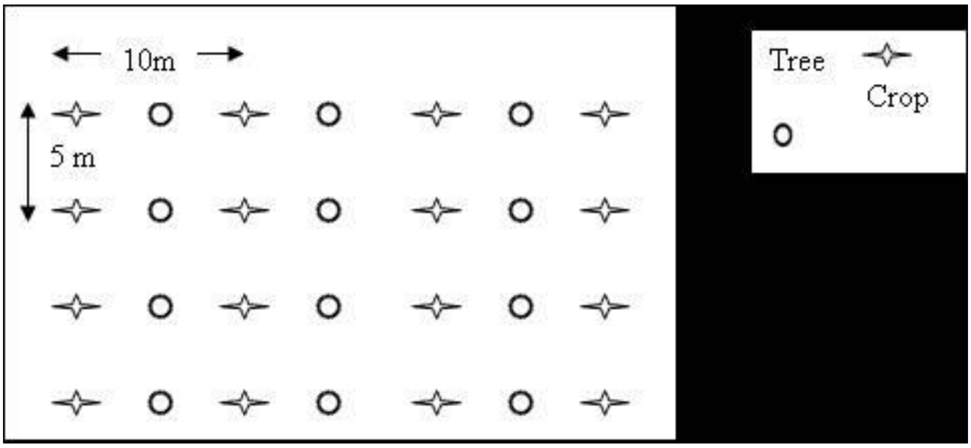
4.0 POTENTIAL INCOME

Poles and fuel wood may be sold but any additional income from this system is likely to be small. The primary objective of this system is soil improvement with by-products (fuel wood and fodder) from pruning crown for household use. Other incomes will be realised through increased crop production in the medium to long term due to increased soil fertility and from savings on mineral fertilizers as organic nutrients from the system become increasingly significant.

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 will be disqualified. Create basins of 1m by 1m around each tree so that water is trapped and percolates into the soil instead of running off. Apply mulch in the basins to assist in moisture conservation and weed suppression but the mulch should stay clear of the root collar. The planting of the associated arable crop will proceed with the usual recommended agronomic practices while trees should be planted in holes 60cm deep and 60cm wide. When digging the holes, put top soil on one side of the hole and the subsoil on the other and when filling the hole at planting, start putting the topsoil in the hole before the subsoil. Planting should establish 200 trees per hectare at a spacing of 10m x 5m. It is recommended that propagation be done through potted air-pruned seedlings for *F.albida* and not direct sowing in the field while the other species will be handled according to the recommended practices.



When planting nursery grown stock:

- Water seedlings before planting to hold nursery soil together and to increase soil moisture in the pot.
- Care should be taken handling plants not to cause damage to shoots, buds or bark.
- Planting should be done on a wet day when there is adequate moisture in the soil to assist in tree establishment.

- 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).

5.2 Maintenance

Any weeding should be done as required particularly in the first year after planting to ensure successful establishment. It is assumed that extensive weeding will be associated with crop maintenance and pruning in the second year to about half the tree height may be needed to control low branching.

For the first two years after planting any dead trees should be replaced at the beginning of the following wet season. Crops will continue to be grown throughout the area planted with trees and there should be **no** burning at any time even when the associated crop is harvested. Any foliage and green waste should be left on site and worked into the ground. Woody material from pruning / thinning can either be used as fuel wood or for poles etc. Heavy crown pruning is expected to provide fodder and fuelwood whilst maintaining suitable conditions for growing crops in association with the trees.

5.3 Thinning and harvesting

Thinning should begin at year 10. Trees should be removed progressively until a density of 25 trees per hectare is attained at about year 50. Table 8 below shows the thinning schedule.

Table 8: Thinning regime for tree species used in DSI technical specification.

Year	Proportion of trees removed (%)	Number of trees harvested	Number of trees remaining
10	25	50	150
15	25	50	100
20	12.5	25	75
25	12.5	25	50
30	2.5	5	45
35	2.5	5	40
40	2.5	5	35
45	2.5	5	30
50	2.5	5	25

6.0 DESCRIPTION OF THE ENVIRONMENTAL AND SOCIAL 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 the 1 metre basins 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. Improved soil organic matter content will also improve soil porosity thereby enhancing water infiltration and percolation.
- 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 wildlife habitat for a diverse plant and animal life through the micro-environment (below and above ground) created by the *F. albida* trees.
- Non-Timber Forest Products (NTFPs) that include beekeeping, medicines, livestock fodder etc.
- Shading for humans and livestock.

- Pruning and thinning material may be used as fuel wood.

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

- Community mobilisation and participation in planning processes.
- Capacity (on improved land use management systems, agriculture and agroforestry)
- Increased awareness of climate change and the role of dispersed inter planting system in climate change management and livelihood improvement (benefits that may be derived from tree planting)
- Production of seedlings for establishment of the DSI land use system.
- 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.

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 the dispersed interplanting system where trees are planted in order to increase crop yields per hectare on cultivated land leakage is not likely to occur. However, the Plan Vivo system requires that potential displacement of activities within the community should be considered and that activities should be planned to minimise the risk of any negative leakage. These actions should include:

- All farmers should be assessed individually to demonstrate that they retain sufficient land to provide food for themselves and their families.
- Signatories to Plan Vivo activities will be contractually obliged not to displace their activities as a result of the tree planting.
- A plan to monitor leakage on specific other woodland areas to ensure leakage is not occurring.
- Formation of community based '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 dispersed inter-planting, there should be no assumption of leakage. In all probability, the most likely outcome of the dispersed inter-planting system is positive leakage as a result of improved land use reducing the pressure to extend cultivation of crops to new areas.

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 to community groups and individuals that are self-selected. Other risks to permanence are also foreseen and are presented in Table 7 below along with their management measures.

Table 9: 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 monitoringcommittees 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 known 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 that promote higher soil moisture retention. - Promotion of irrigation where applicable. - Promotion of indigenous, drought-tolerant tree species.

Table 9: 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 dispersed interplanting system is set out in '*Assesment 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 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 the dispersed interplanting system 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 25 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. 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 offsets (Plan Vivo certificates) generated by the dispersed inter-planting land use system (technical specification) is presented in Table 10 below:

Table 10: The net carbon benefit and tradable carbon offset for the dispersed inter-planting 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)
Dispersed inter-planting	25	0.37	24.63	90	20%	72

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

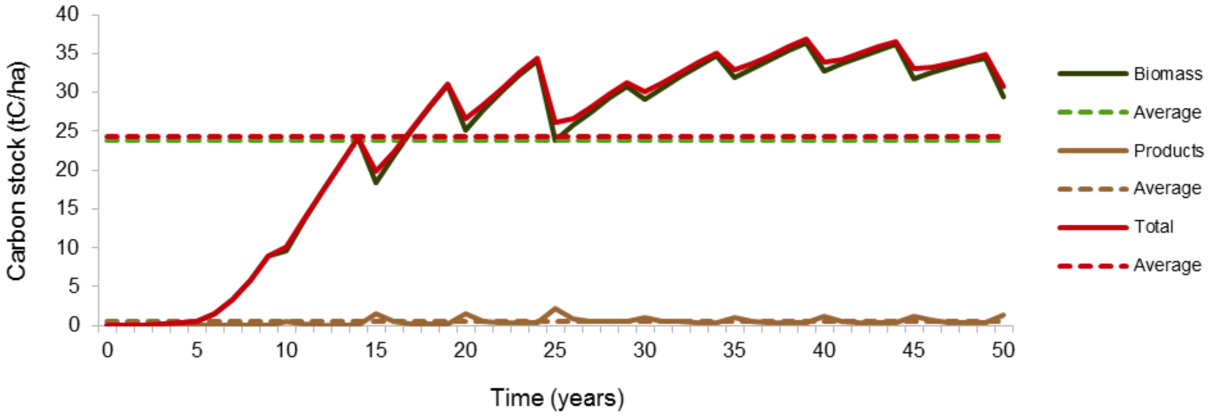


Figure 1: Dispersed inter-planting technical specification carbon sequestration potential over 50 years.

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 indicated by the 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 11 below shows the monitoring schedule (in years) and the corresponding key indicators or targets that are expected to be met by producers to warrant receipt of carbon finance upon selling of their carbon credits.

Table 11: 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.

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