TAKING ROOT ENRACINE

Social reforestation & Carbon offsets

Technical Specification
Boundary Planting

Registered Plan Vivo Project:
The CommuniTree Carbon Project

(Formally known as the Limay Community Carbon Project)

Authors: Baker, K., Baumann, D., Michaud, J.S., van Mossel-Forrester, B.

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1. Executive Summary

The CommuniTree Carbon program (formally know as the Limay Community Carbon Project) is a community-based reforestation initiative that regroups small-scale farming families in the municipality of San Juan de Limay and Somoto, Nicaragua, to develop ecosystem services for the voluntary carbon market. The program is developed by Taking Root, a non-profit organization based in Montreal, Canada, in partnership with the Nicaraguan organization, APRODEIN.

The CommuniTree Carbon program uses reforestation as a tool to restore ecosystems, improve livelihoods and tackle climate change. Taking into account the causes of deforestation, the project works with smallholder farmers to reforest and maintain under-utilized portions of their land in exchange for payments for ecosystem services.

Reforestation within the project boundary is imperative as the region is situated in a critical watershed that feeds into one of the country's most important estuaries, the Estero Real. This estuary is home to one of the biggest extension of mangroves and migratory birds in the region, and has been recognized by the Ramsar Convention on Wetlands of International Importance. By reforesting this region, the project plays an important role in regulating the hydrological cycle and provides important water and biodiversity benefits both locally and internationally.

Over the past 60 years much of the area has been severely deforested, largely due to the expansion of the agricultural frontier. Presently, the predominant land use is cattle grazing, followed by agriculture for subsistence farming. While 58% of the labour force is smallholder farmers, agricultural productivity within the region is low due to a prolonged dry season and lack of financing. Consequently, the region and its inhabitants are quite poor.

In addition to deforestation, the collection of firewood, which is used by 99.2% of the municipality's population for cooking, is a large contributor to forest degradation. Moreover, the inhalation of smoke from burning firewood within the homes has serious health implications for the women in the families who spend a higher proportion of their time in the kitchen area.

In order to ensure a sustainable solution to these challenges, CommuniTree Carbon program works to make forestry a competitive land-use option. This Boundary Planting Technical Specification (TS) involves planting three native tree species along existing boundaries, such as fences. The fast growing nitrogen fixing species provide an early harvest while fertilizing the soil and making room for the other trees to grow. The longer-lived hardwood species are continuously managed to provide a sustainable source of posts and lumber while improving the pasture below and adding biomass to the soil. Over time, the trees will grow to replace existing fence posts, eliminating the need to replace decayed wooden posts while also providing ecosystem benefits.

The ex-ante sale of ecosystem services generated through the project is used to fund the establishment and maintenance of new family-led projects while the sustainable production of forest products provides on ongoing source of value in the medium and long run.

This Technical Specification was developed through a community-led design process where participating communities and local professionals determined the tree species, planting method, and payment process used, among other things. Each project participant then develops and follows their own personalized farm management plans (*plan vivos*) and is involved in every step of the process, including pre-planting, planting, and maintenance and management activities.

In order to be eligible, farmers must own economically under-utilized land within the project boundary that is in need of reforestation. They must also demonstrate that participating in the project will not conflict with their subsistence activities, notably cattle ranching and agriculture.

The average net carbon benefit of this technical specification is 58.58 tonnes of carbon per kilometer. This carbon benefit was calculated by estimating the average annual carbon stock expected under the baseline scenario and subtracting a risk buffer of 15%.

To guarantee the accuracy and success of the project, Taking Root had developed a rigorous monitoring system for its project. Systematically distributed permanent sample plots have been established on a minimum of 10% of each kilometer using this technical specification and annual monitoring is conducted to gather information on species composition, mortality, height, and diameter at breast height. Based on these results, participating producers receive ecosystem service payments upon successfully meeting established management and growth targets. Furthermore, this monitoring, along with research results, is used to modify management on a continual basis to ensure that carbon sequestration objectives are being met. This system of adaptive forest management is achieved by allowing room to account for natural regeneration and early or delayed harvest of firewood species based on actual stand growth.

2. Introduction

The CommuniTree Carbon Program (CTCP) is a community-based reforestation initiative in the municipalities of San Juan de Limay and Somoto, Nicaragua, located in the departments of Estelí and Madríz, respectively. Although once entirely forested, the region has suffered from heavy environmental degradation predominantly due to unsustainable agricultural practices. To this day, the majority of livelihoods are dependent on agriculture and raising cattle despite low productivity caused by poorly distributed rainfall.

The CTCP invites smallholder farming families to work together to reforest underutilized portions of their land in exchange for ecosystem service payments, technical training and market development for their plantation products. However, to participate in the reforestation activities described in this specification, smallholder farmers must have a clear land title that is not currently forested.

The ecosystem services provided by the project are then sold as Plan Vivo certificates, which represent the long-term sequestration of one tonne of carbon dioxide (tCO_2) plus additional livelihood and ecosystem benefits. However, in addition to these benefits, the project plays an important role in the regulation of the hydrological cycle as it is developed on one of the region's most critical watersheds.

The initiative is coordinated by Taking Root Nicaragua, a Canada-based non-profit organization, in partnership with APRODIEN, a Nicaraguan service provider and partner.

This technical specification entitled Boundary Planting, provides details on the project intervention, the planting methodology, the calculation of the carbon baseline scenario, the calculation of the carbon benefit, how long-term carbon sequestration is assured, what measures are taken to avoid leakage, the additionality of the project, the monitoring plan and additional ecosystem benefits provided by this technical specification.

3. Project intervention

Boundary planting, often referred to as living fences or barrier planting, is the practice of planting trees along all types of boundaries. Typically, these are used to delimitate property, agricultural fields, pastures, roads or any other place where fences might be located.

The potential benefits of boundary planting are numerous. In the tropics, fence posts that are exposed to the elements tend to decay rapidly and need to be replaced frequently, which can be expensive and labour-intensive. With Boundary planting, trees are planted along the fence and eventually replace the posts as they grow. These trees tend to have a much longer life cycle. Moreover, when the trees are harvested they provide tangible products, which contribute to the diversification of income for smallholders.

In addition, this system is designed to have a multitude of ecosystem functions, predominantly through system interactions. In the arid tropics during the dry season, some trees have deep roots, enabling them to remain green when most other vegetation has dried out. This shade affects the microclimate, which reduces heat stress for cattle, provides a source of fodder, and benefits the pasture beneath the trees. Furthermore, studies in Nicaragua have shown that increased forest cover in cattle pastures can lead to an increase in milk production.[1] Trees also tend to have beneficial effects on soil fertility through nitrogen fixation. Lastly, they increase organic soil matter through leaf litter and root residue, bringing up nutrients only available deeper within the soil and recycling nutrients that would have otherwise been lost to leaching.[2]

A predominant intended role of these plantings is to restrict animal movement. However, although crowns of the living fences cover up a fraction of total pasture area, from an ecological perspective they play a particularly important role in increasing the structural connectivity of woody habitat across the landscape.[3]

All of the selected species in the technical specification are native to the region and are chosen in consultation with local producer groups and professional foresters in order to consolidate the community's preferences with those of technical experts. The result is a variety of multi-species, multi-purpose boundary planting design used throughout the community.

Within their capacity, each participating producer and their family establishes the technical specification(s) that best suit their needs. Individual land management plans, called *plan vivos*, are then integrated within the family farm management. Taking Root, the project coordinator, is responsible for monitoring and managing the project as a whole and disbursing the payments for ecosystem services over time to the producers as they reach their monitoring targets.

For information on the process of community-led design, the social context of the communities, the local economy and population, and additionality of the project, please refer to the Project Design Document available at:

http://www.planvivo.org/wp-content/uploads/Limay-Community-Carbon-PDD-Plan-Vivo-approved.pdf

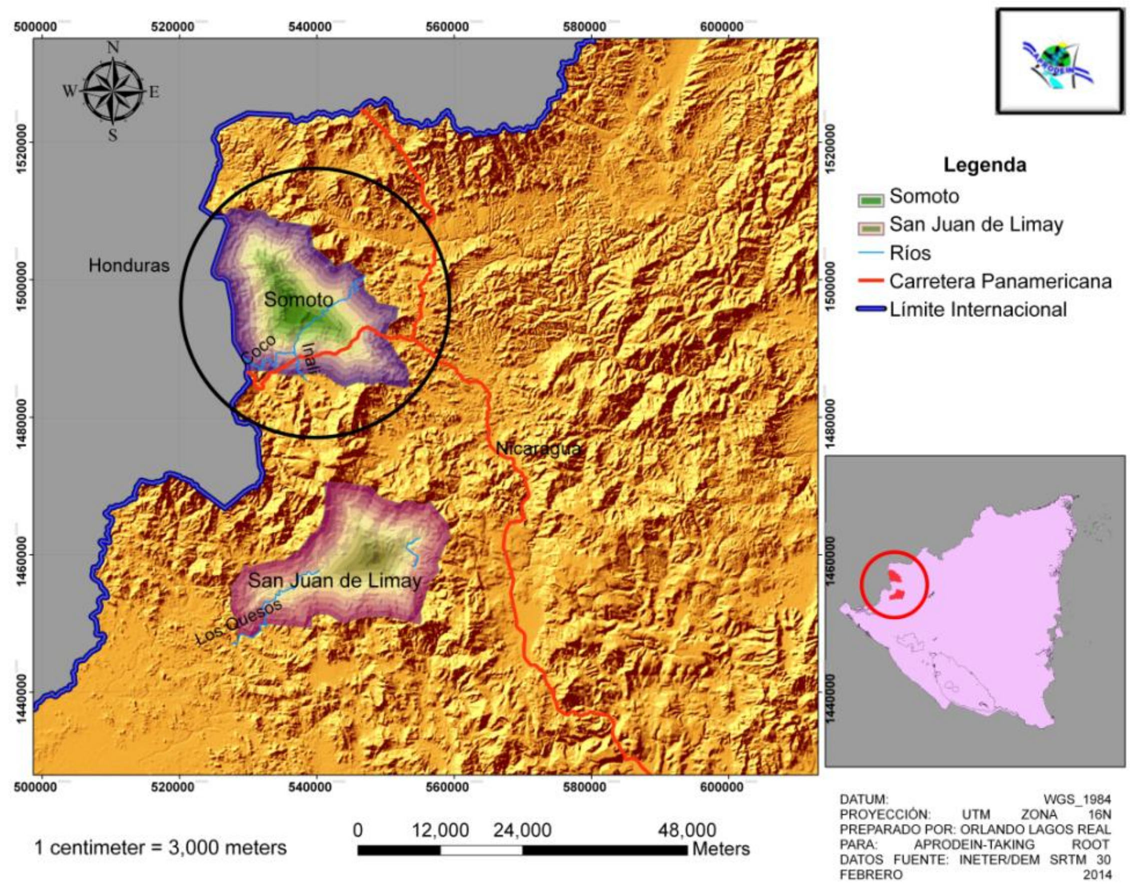
The components of the LCCP as a whole are designed to reduce emissions with the sequestration of carbon through tree growth, the production of sustainably produced forest products, and the building of fuel-efficient cookstoves.

3.1. Applicability

In order to be eligible to participate in the program, farmers must have underutilized land that falls within suitable areas of the current program boundary. This boundary corresponds with the municipal boundary of San Juan de Limay and Somoto, highlighted in Figure 1.

Additionally, the participating farmers must make personalized farm management plans (*plan vivos*) that demonstrate that they own sufficient additional land to meet their agricultural needs. Farmers cannot clear forested land to gain eligibility and they must demonstrate clear land title to their farm.

Figure 1 Program boundaries within municipality of San Juan de Limay and Somoto.



3.2. Elevation requirements

Due to the choice of tree species, optimal growth for the selected plantation design must take place at elevations below 900 metres above sea level. An elevation map of the project boundary is illustrated in Figure 2Figure 2 - and Figure 3.

Figure 2 - Elevation map of San Juan de Limay.

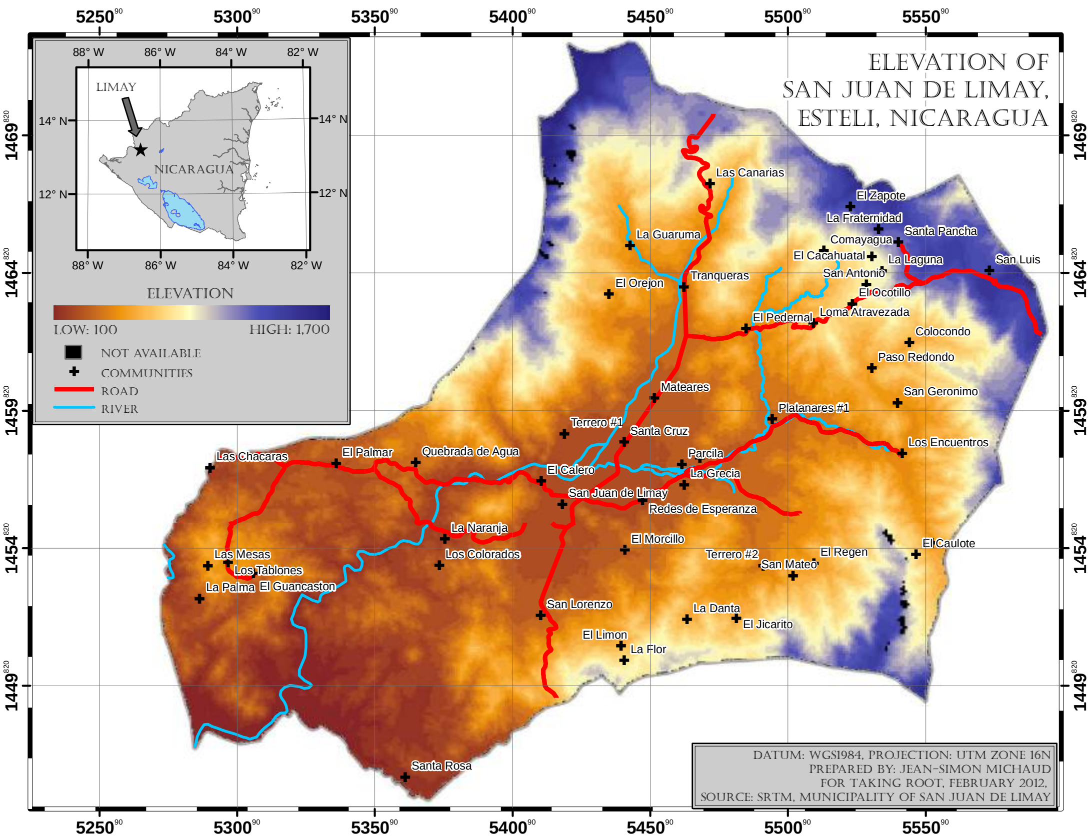
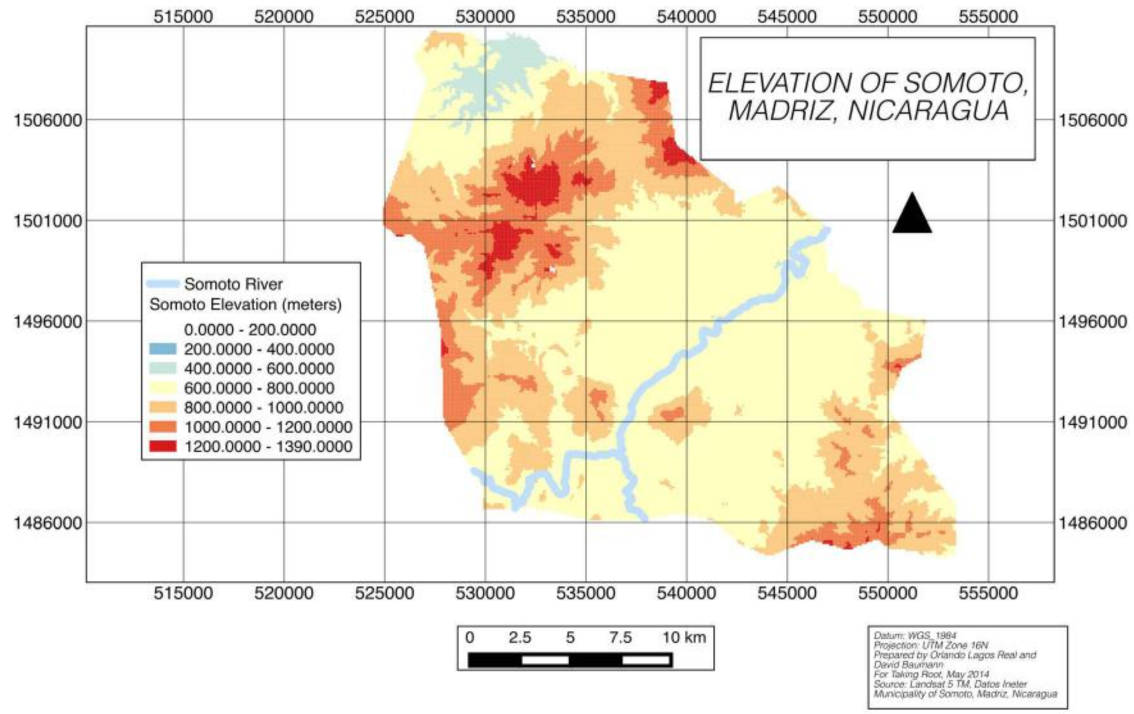


Figure 3 – Elevation map of Somoto.



3.3. Land-Use and Land cover

The land use and land cover of the program area have changed drastically over the past century. Once blanketed in forest with abundant precipitation and wildlife, the program area was transformed during the "Green Revolution" of the 1950s when vast areas of land were cleared for large-scale cotton production. By the end of the 1980s, a drop in world cotton prices left farmers in ruins. The area faced heavy erosion and was contaminated with toxic pesticides, leaving behind what is now a seasonal desert with only small patches of secondary forest at higher elevations.[4]

The steeper summits of taller mountains still contain some old pine forests, and remnants of the giant trees that were once typical in the region remain scattered throughout the valley. The most common mature large trees are *Enterolobium cyclocarpum*, *Ceiba pentandra*, and *Albizia saman*. These are extremely fast growing trees that are not particularly valuable timbers. Valuable timber trees such as, Pacific Mahogany (*Swietenia humilis*) and Spiny Cedar (*Bombacopsis quinata*), that were once abundant in the area are close to eliminated.

Presently, the predominant land-use in the area is cattle grazing. However, due to the prolonged 6-month dry season, it requires an estimated 1.4 hectares of pasture to support just one head of cattle. A common land-use strategy in the region is to grow grains for a couple of years then convert the area to cattle pasture. Once the area becomes too degraded to support pasture, it is abandoned for several years and is eventually cleared again for agriculture.

3.4. Climatic Conditions

The region's climate is characterized as dry tropical savannahs with a small sub-humid zone at altitude. Temperatures range between 24-34^{o} C with distinct wet and dry seasons. The wet season begins in May and ends in October. Annual precipitation within the program boundary is 1,394 mm per year, almost all of which falls during the wet season.

3.5. Social Context

The regions of San Jan de Limay and Somoto, as well as the whole of Nicaragua, have undergone drastic political shifts throughout the last century. Clashes between the Sandinista National Liberation Front, the Contras and the Somoza dynasty caused much turmoil for the economy, the people and the land.

International financial institutions, such as the World Bank and the International Monetary Fund, have placed strict regulations on the Nicaraguan government while it pays back external debts that were amassed during this time. As a result, the government has had to cut back on spending, including huge slashes to environmental programs and law enforcement. [4]

3.6. Population

The following socio-economic information is available for the municipality of San Juan de Limay:[7]

Urban inhabitants: 3,668
Rural inhabitants: 9,787
Total inhabitants: 13,455
Population density: 31.5/km^2
Indigenous population: 5,519

The following socio-economic information is available for the municipality of Somoto:

Urban inhabitants: 15,974
Rural inhabitants: 16,406
Total inhabitants: 32,380

Somoto is a "young town", with nearly half of the population in the age groups of 0-4 years (15.5%), 5-9 years (14.2%), and 10-14 years (14.5%) as of 2000.

3.7. Predominant Religions

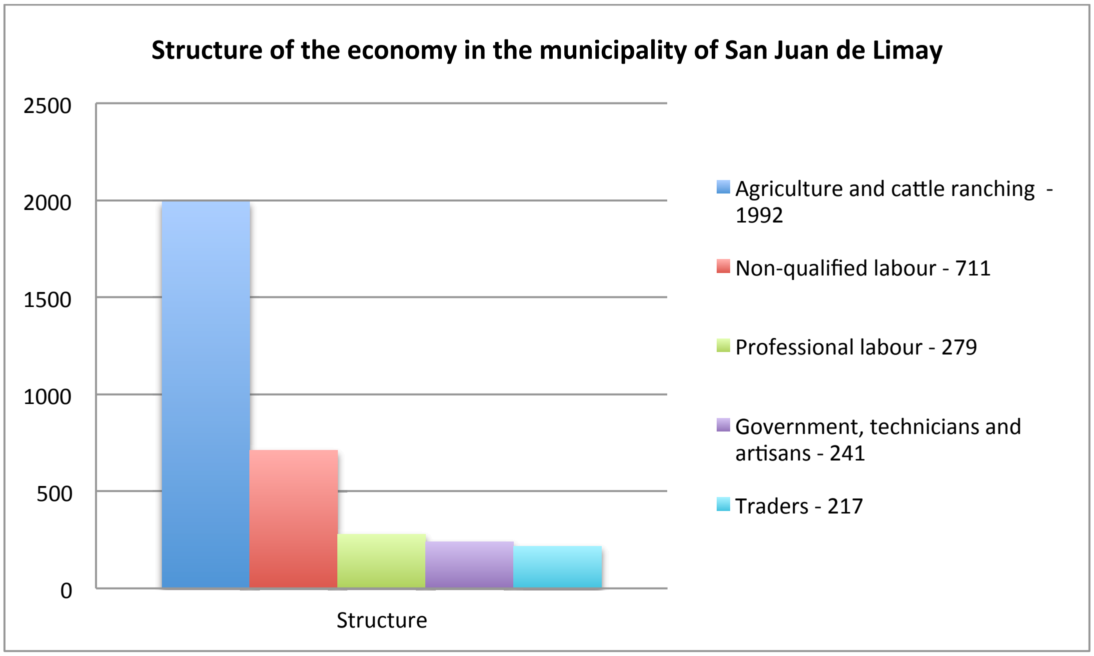
Catholic and Evangelical Christianity are the primary religions in the project area.

3.8. Local Economy

The local labour force in the program area is divided as follows (Figure 4):

- 58% smallholder farmers, earning sustenance directly from the cultivation of beans, corn, sorghum dairy and cattle (project target group)
- 21% non-qualified labours, generally working as contractors on other farms or doing general construction work
- 8% office-based professionals or technicians
- 7% government employees and artisans, predominantly carving soapstone
- 6% traders, generally buying and selling farmers agricultural surplus

Figure 4 – Structure of local economy[7]



Agriculture is the most important sector of the economy and encompasses both the production of agricultural goods and, to a minor extent, processing and trading. However, agricultural activities commonly take place without regard to zoning or optimizing the potential of the area. While farmers in the region have relatively large properties with fertile soils, most farming in the region is done purely as a form of subsistence rather than a business and is therefore not very productive. This is largely due to the poorly distributed rainfall, lack of irrigation, and the lack of access to financing.

Presently, only a relatively small area is dedicated to agriculture within the program area. The main crops are sorghum, corn, and beans. The average yields are usually low and are therefore predominantly used for subsistence. In the regions with higher elevations, coffee is cultivated.

Poor management of the available resources have contributed to food insecurity and excessive deforestation has adversely affected people's economic opportunities.

Firewood Use

Within the program area, 95.5% of the population uses firewood for cooking. Outside of the urban centre and within the project boundary, this percentage increases to 99.2%.[8] The collection of this firewood is a continuous cause of degradation for the surrounding forest, as virtually none of it is sustainably produced. Regionally and nationally, forests are becoming increasingly scarce, making it difficult to find accessible sources while demand for the resource increases.

A secondary consequence of burning firewood within the household is the negative health effect it has on people's vision and respiratory tracts caused by excessive smoke inhalation. This adversely affects the women in the families as they spend a higher proportion of their time in the kitchen.

3.9. Community Led Design

As is the standard of all Plan Vivo projects, the development process of the project intervention was highly influenced by a process of Community Led Design (CLD). CLD gives producers a vital role in shaping the project according to their needs and allows them to develop a strong sense of ownership. This process is implemented on a continuous basis throughout the project lifetime.

3.10. Community Led Process Determination

The Boundary Planting requires multiple steps, from conception, to payment, to cultivation. These steps are continuously revaluated and improved upon to ensure efficient and equitable results for the producers and the participating communities. The following are some of the types of decisions made through the CLD process concerning the project development:[*]

- The selection of the project boundary to encompass watershed management
- The tree species used
- The fencing and labour loan system
- The timing of payments

See the Taking Root's *Limay Plan Vivo Project Design Document – Limay Community Carbon Project* for more information.[9]

[*] All of the meetings mentioned in this section have been recorded and are available upon request.

4. Description of Activities

Intervention: Reforestation
Title: Boundary Planting

Brief Description

This proposed system involves the planting and intensive management of a multi-purposed, mixed species boundary planting system. The selected species are common and native species to the region. The design consists of the planting of *Caesalpinia velutina, Swietenia humilis* and *Bombacopsis quinata* along existing boundaries, usually fences. C. *velutina* is a short rotation, fast growing tree, whereas B. *quinata* and *S. humilis* are highly valued longer rotation hardwood species commonly used for lumber. C. *velutina* is nitrogen fixing and will be coppiced at a younger age, providing an early harvest while fertilizing the soil. The hardwood species are of variable growth rates and shapes allowing for various thinnings before the entire stand reaches maturity.

C. *velutina* will predominantly be used for the production of posts for new fences, for rural construction, or for firewood. As the old existing fence posts start to decay, the planted C. *velutina* trees can be used to support the barbed wire. Since the wood will never be milled it is inconsequential if it grows into the fencing or if nails are used to attach it to the wire. Otherwise, this would present a safety hazard to a saw operator and lower the value of the product. As such, two C. *velutina* trees will be planted between alternations of B. *quinata* and *S. humilis.* The C. *velutina* trees are harvested and replanted at alternating intervals so that at least one tree is always present to support the fencing.

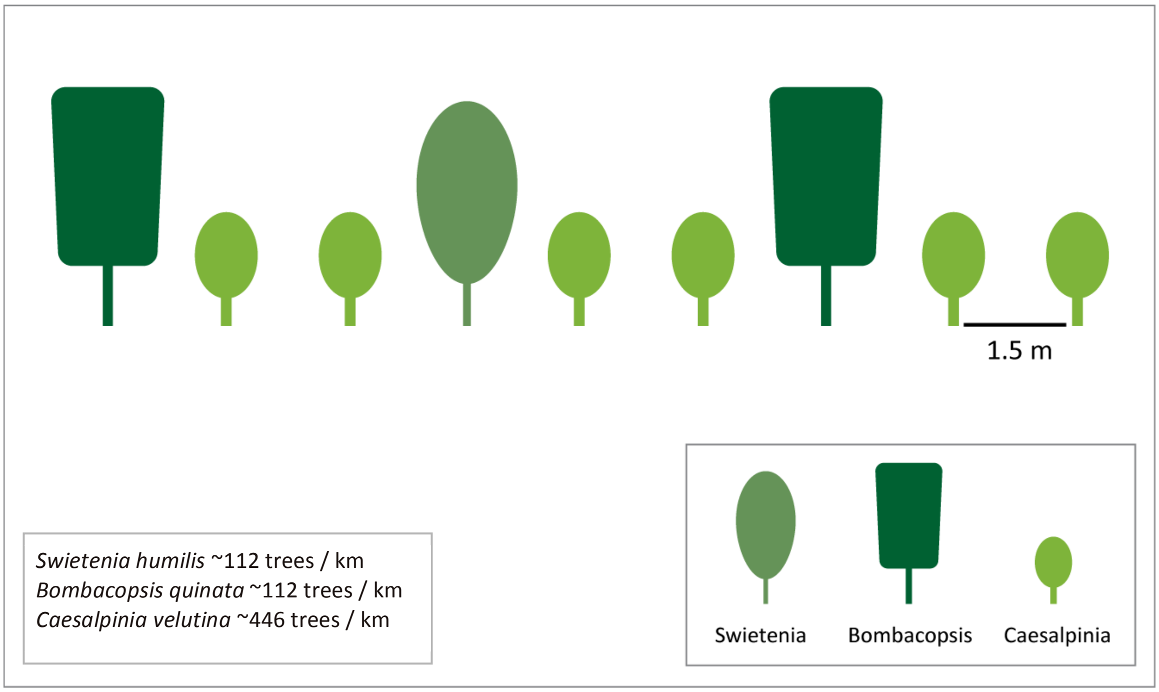
This boundary planting design will sequester carbon dioxide, providing ecosystem services in the short run, posts in the medium run, and highly prized lumber in the long run. Furthermore, the system will provide additional services such as improving the pasture below the trees and adding biomass to the soil while providing the function of a fence.

The payments for the ecosystem services are targeted towards the participating families' short-term needs; the C. velutina wood is targeted towards their medium-term needs; and the thinnings and hardwood harvests are targeted towards their long-term needs. Over the second half of the project, producers will begin receiving revenue from their harvests. This creates incentive for the farmers to continue participating in the project, since the revenue is expected to be large compared to the ecosystem service payments of the first part of the project. During the span of the project, producers will receive continual education on the environmental, economic and social benefits of the project.

4.1. Planting Design

Two *Caesalpinia velutina* trees are planted between alternating *Bombacopsis quinata* and *Swietenia humilis* trees along farm barriers, generally pre-existing fences. The proposed distance between each tree is 1.5 metres as illustrated in Figure 5.

Figure 5 – Planting Schematics



4.2. Activity plan

The activity plan sets forth the various steps that need to be undertaken for the proper establishment of the technical specification and outlines the project members' responsibilities. The plan is designed through a process of consultation between various stakeholders, producer groups and regional experts. Since it is the producers who are responsible for their own part of the project, the activity plan serves as the minimum standard required for the project to be effective and payments are based on the successful implementation of this plan. However, individual producers have the freedom to exceed the standards set forth by the plan.

Pre-planting activities

Seed collection

Seeds from native tree species are collected and purchased throughout the region by project staff and participating producers. Whatever cannot be found locally is purchased from outside communities.

Nursery development

Many of the seedlings are grown in communal nurseries, established by the year's participating producers and supervised by the community technicians to ensure the highest quality of seedlings (see Figure 7**Error! Reference source not found.**). Some nurseries are established directly on producers' land to simplify transportation.

The earth for the seedlings is 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 sewn between February and April depending on the species.

Figure 6 - Nursery establishment

Clearing

Prior to the planting season, the barriers that will be reforested are cleared of all brush and small bushes. Due to the dispersed nature of these plantings, the barren land between them functions as natural firebreaks.

Planting activities

The following activities are carried out by producers and members of the community during the planting season.

Planting site demarcation

Rope with knots or labels at even distances are used to demarcate where the trees will be planted according to the planting design (see Figure 8).

Clearing

A 2-meter diameter circle is cleared around each site demarcation to remove competing grasses and shrubs before the seedling is planted.

Hole digging

At the centre of each clearing, a hole slightly larger than the seedling rootstock is dug (see Figure 9).

Tree planting

The seedling is carefully removed from the nursery bag and planted in the hole. Particular attention is paid to ensure the correct species are planted according to the planting design. Each seedling is planted at ground level (or slightly deeper) so that water accumulates around the seedling (see Figure 10).

Figure 7 - Site demarcation

Figure 8 - Hole digging

Figure 9 - Tree planting

Fence Placement

When the trees planted are deemed to be large enough to withhold the fence without dealing damage to their growth, the fence will be stapled to the tree and the wooden post used for support.

Maintenance and Management activities

Once the seedlings have been planted, the following activities are carried out to ensure their survival.

Clearing

A 2-meter diameter circle is cleared around each tree with a machete as needed to remove competing grasses, shrubs and lianas.

Pruning

On hardwood species, the lateral branches of the bottom two thirds of the tree are sawn off to encourage upward apical growth and to minimize knotting. Montero and Viquez suggest that pruning schedules are based on tree height as opposed to age and that a cost effective schedule should start when the trees reach between 5 and 6 metres in height.[10] Branches are to be removed from the bottom two metres of the tree. The second pruning should take place when the trees reach between 8 and 9 metres, and the branches at the bottom 4 metres of the tree are removed. A third and final pruning should take place when the trees reach 12 metres and the bottom 7 metres are cleared of lateral branches. All pruning should take place during the dry season and pruning should be done using well-sharpened tools to avoid damaging the tree as much as possible and subsequently avoiding pests and diseases.[10] Pruning is not required for *Caesalpinia velutina* since these trees will only be used for firewood and the presence of knots is not important.

The above activities as well as their time requirements, frequency and estimated costs are summarized in Table 1 below.

Table 1 - Summary of Activity Plan

Tasks	Responsible parties	Time-frame	Resource requirements	Time requirements per km	Estimated initial cost per km	Estimated annual cost per km
Construction of tree nurseries	Community technicians + producer families	January until May	Machete, rope, shovel, wheelbarrow, barbed wire, sifter, bags, manure, sand, earth, water, seeds.	Case specific	$33.50	n/a
Fencing area; Maintaining or repairing property fence	Producer families	Prior to planting	Fencing and wire	Dependent on needs	$0.00	n/a
Clearing land for planting	Producer families	March-April	Machete	2 days	$22.50	n/a
Planting activities	Producer families + guidance from community technicians	After the first big rain (~May 15th)	Shovel, rope, machete, wheelbarrows.	~7 person working days	$26.00 (Producer's work contribution)	n/a
Clearing around trees	Producer families	1st few years	Machete	4 person working days 3 times per year	n/a	$16.00 (Producer's work contribution)
Pruning	Producer families	Ongoing as needed	Saw or pruning scissors	As required	n/a	$4.00 (Producer's work contribution)

4.3. Thinning and Harvests

The boundary planting system is designed to provide high valued merchantable timber products on a sustainable basis in addition to providing the function of a natural barrier. Although the trees are planted at a close spacing, it is in a linear fashion in open fields allowing for plenty of lateral light. As such, new trees will be planted at the same rate that trees are removed as they reach maturity. Consequently, this planting design will provide a periodic supply of products. *Caesalpinia* trees provide high quality posts while *Bombacopsis* and *Swietenia* provide high quality timber.

Table 2 outlines when species are harvested, the year of harvesting, the purpose of the harvested wood, the processing factor (the proportion of the harvest that is utilized and continues storing carbon), and the volume that is represented through these activities over the initial 25 years of the project.

Table 2 - Harvest years and associated volume of merchantable timber per kilometre

Beginning of Year	Species	Harvested stem volume (m^3 / ha)	Product	Processing factor	Merchantable volume (m^3 / ha)
10	Caesalpinia velutina	19.64	Posts/ firewood	1.0	9.85
26	Bombacopsis quinata	15	Sawn-wood	0.35	5.25
26	Swietenia humilis	15	Sawn-wood	0.35	5.25

4.4. Thinning and Harvests – Stand Management Phase (yrs 26-50)

After the first 25 years, the stand will have approached its optimal rotation cycle and ongoing selective harvesting will commence. The mature trees will be harvested at a rate comparable to the long-term growth rate of the stand. As a whole, the overall volume and carbon stocks fluctuate around the long-term average. Starting in year 26, 30 cubic metres of wood products per kilometre will be selectively cut from the stand every 5 years. (See Appendix 3 - Stand Growth Modelling for more information.)

4.5. Incentives for participation in the project

The various expected benefits of this project encourage the participating producers to stay in the project during its 50-year lifetime. They are as follows:

- Merchantable wood products, which Taking Root will help to commercialize and create market access;
- The regular ecosystem payments of the first 10 years;
- A natural long-living fence that is self-renewing;
- Increased pasture quality and higher milk production from existing cattle;
- Increased soil fertility.

Note: The wood products used in this project are all of high value and should provide a large amount of income, dwarfing the carbon payments of the first 10 years. Also, through the project contract, the participating producers have the legal obligation to stay in the project for 50 years.

4.6. Species Selection

The boundary planting design is based on three species of varying growth, use and shape. All species are well adapted to the climactic conditions of the region, and are valued by the participating producers, technical experts and local markets.

Species selection process

The selection process was conducted in the following order:

1. Producer groups were consulted to determine the favoured native species with which to work;
2. Expert groups were also consulted to determine the favoured species with which to work within the technical specification;
3. The species that overlap with both producer and expert groups were selected; and
4. Based on experience using older versions of this technical specification, species selection has been refined based on experience in the field.

4.7. Species description

Name: *Bombacopsis quinata* (recently renamed to Pachira quinata)
Common names: Pochote, Spiny Cedar
Family: Bombacacea
Distribution: Found naturally from Nicaragua to Columbia and Venezuela
Elevation: 0-900 metres above sea level
Precipitation: 800-2200 millimetres
Description: The tree is deciduous with numerous thorns and reaches up to 30 metres in height with medium sized buttresses. It is highly prized for its reddish brown wood and has been overexploited in many parts of its natural range.
Uses: Lumber

Name: *Swietenia humilis*
Common names: Caoba, Pacific Coast Mahogany, Honduran Mahogany
Family: Meleaceae
Distribution: Found naturally from Mexico to Costa Rica
Elevation: 0-1,200 metres above sea level[9]
Precipitation: 1100-1400 millimetres
Description: The tree reaches heights between 25 and 40 metres
Pests: Hypsipyla grandella, a shoot-borer that attacks and kills the young shoots causing excessive branching. This only takes place during the first 2 to 3 years and thus requires pruning. This species should not be planted in monocultures.
Uses: Lumber

Name: *Caesalpinia velutina*
Common names: Mandagual
Family: Caesalpiniaceae
Distribution: Dry regions from Southern Mexico to Northern Nicaragua
Elevation: 50-1000 metres above sea level
Precipitation: 400-1200 millimetres
Description: Fast growing leguminous tree that thrives in dry conditions, Mandagual rarely reaches heights above 10 metres and diameters of 30 centimeters.
Uses: Posts, fences, firewood and soil fertilization

5. Baseline

The first phase of determining the baseline consists of establishing the initial carbon stock present within the above ground woody biomass and the below ground woody biomass. Deadwood was excluded from this baseline because its presence is negligible, which was confirmed by an original baseline calculation in a sub-region of the current project boundary. The objective is to obtain an estimate of initial carbon stocks with a precision of plus or minus 15% with a 90% confidence level (two-tailed). To do so, the project boundary was stratified into various vegetation land-covers and sampled to estimate the initial carbon stock. The methodology in the section is based on the Winrock International Sourcebook for Land Use, Land-Use Change and Forestry Projects.[12] The second phase consists of determining the likely trend of the carbon stock over time in the absence of the project.

Baseline calculations for the San Juan de Limay program area were performed in 2011. Baseline calculations for the new program area in Somoto were preformed in 2014.

5.1. Stratification

First, two Landsat 5 TM+ images (2010-12-23, 2011-01-08) of the scene 17-51 were acquired from the United State Geological Survey (USGS) web site.[13] These 30-meter spatial resolution images were selected by considering seasonality of the imagery, minimum variation in reflectance related to dry or wet season vegetation characteristics, and atmospheric contamination. Atmospheric correction was computed on the two images, which yielded reflectance values corrected from the contamination effect of atmospheric particles that absorb and scatter the radiation from the Earth's surface. Clouds and cloud-shadow presence are also a significant problem when using remote sensing images over humid and tropical latitudes.[14] Therefore, in addition to the reflectance computation, it was necessary to mask clouds and cloud-shadows when encountered.

Second, a fieldwork campaign was conducted to develop a stratification scheme of the different vegetation types and also to train and test the classification products. Patches of uniform vegetation cover of different sites across the study area were identified with handheld GPS units. Based on the initial surveys, the project area was stratified into three broad classes: (i) agriculture-pasture, (ii) bushy vegetation and (iii) forest.

Thirdly, clouds were identified using a decision tree based on the brightness values of the band 1 (blue) and band 6 (thermal). Cloud shadows were identified using a threshold of the band 4 (near infra-red).

A 90-meter buffer was computed on areas masked from clouds and cloud-shadow to ensure that all scenes were free of cloud contamination. Following this procedure, an unsupervised classification was performed on each individual scene (TM+ image), purged from cloud contamination using the ISODATA (Iterative Self Organizing Data Analysis Technique) approach. ISODATA, one of the most used unsupervised classification algorithms,[15] assigns given pixels to a specific cluster based on the multidimensional space attributes and aggregates clusters together based on their spectral similarity.[16] The classification approach was conducted over a combination of products derived from the Landsat 5 TM+ spectral bands. A Normalized Difference Vegetation Index (NDVI) was calculated from the red and near-infrared bands, which represents an indicator of density of healthy vegetation. This vegetation index is valuable for this project as it normalizes the illumination effects that are substantial in mountainous regions and can yield significant differences in the reflectance values. In addition to the NDVI, the Principal Component Analysis (PCA) technique was used, which is a useful variable reduction technique that is commonly employed with environmental remote sensing imagery.[17] This approach was conducted over all the Landsat 5 TM+ bands, except the band six (thermal band) to exclude the noise and summarise most of the variance. The PCA components containing most of the variance (PCA1, PCA2, and PCA3) were coupled with the NDVI and used as input in the classification algorithm. After performing the classification on each individual image, the two classifications were combined by giving priority to the 2010-12-23 scene, as this scene had less cloud contamination and thus provided a more uniform representation of the landscape.

Lastly, the accuracy of the final classification product was evaluated by comparing the vegetation cover types observed from the pilot biomass survey points (further described in Section 5.2) to the classified vegetation cover types (see Table 3). Agriculture and forest vegetation cover classes were accurately classified, yet the bushy vegetation strata resulted in a lower accuracy (i.e., user's accuracy of 50%). However, most of the erroneous classification for this stratum was due to agriculture (lower carbon stock) being classified as bushy vegetation (higher carbon stock) and not the other way around. Considering that this vegetation cover classification will be used to establish the initial carbon stock present in the various vegetation covers, this type of misclassification makes the classification result more conservative. Once the classification was computed, a random sampling approach was used to establish 416 plots across the study area where forest is not present.

Table 3 - Confusion matrix of predicted classes of vegetation classification

	Predicted class			
Observed class	**Agriculture**	**Bushy Vegetation**	**Forest**	**Σ**
Agriculture	11	9	3	23
Bushy Vegetation	1	11	6	18
Forest	0	2	11	13
Σ	12	22	20	54
User's accuracy (%)	91.67	50.00	55.00	
Overall accuracy (%)	61.10			

The stratification results are illustrated in Figure 10 below.

Figure 10 – Vegetation cover stratification

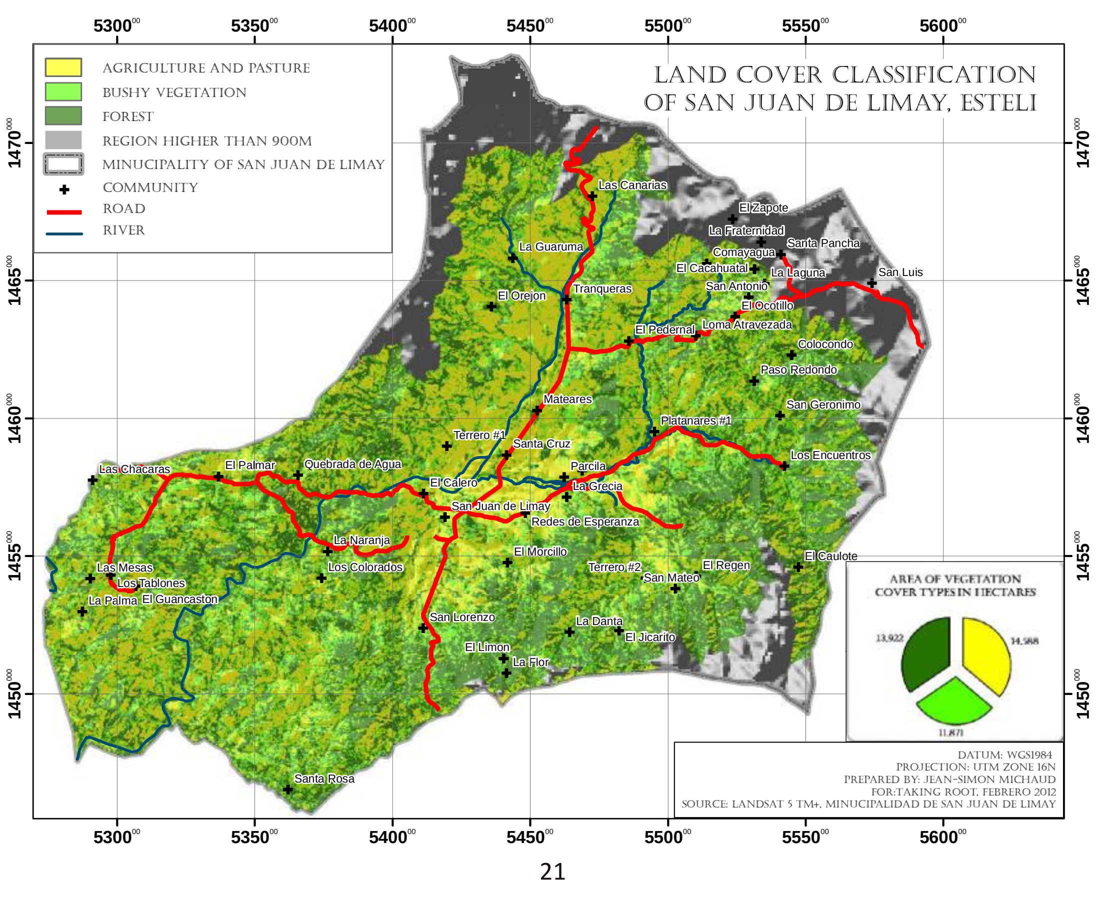
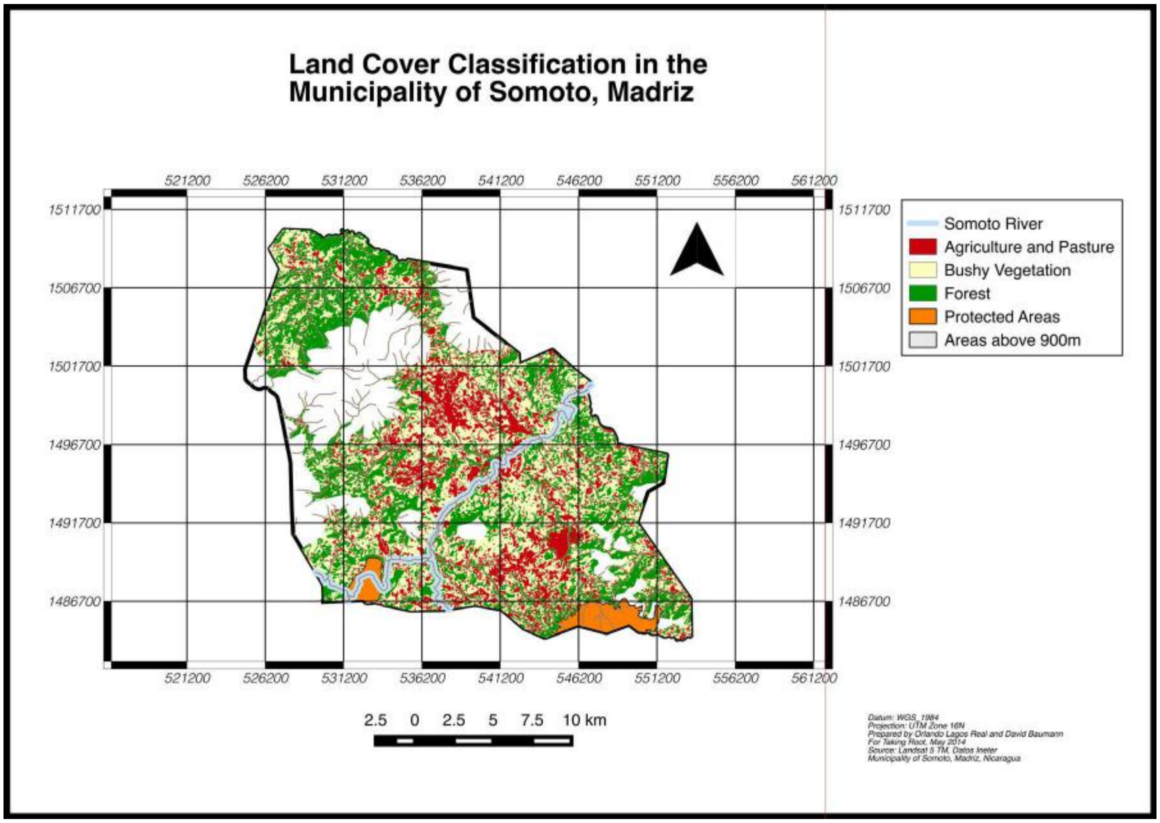


Figure 11 - Vegetation cover classification below 900 m for Somoto.



5.3. Sampling

Initially, a biomass pilot survey was established (n=52) using a non-stratified random sampling approach. With the data acquired from the pilot survey, the average amount of carbon within the eligible areas for reforestation was determined using the following equation.

$$\bar{y}_{ST} = \sum\left(\bar{y}_h \times \frac{N_h}{N}\right) = \sum\left(\bar{y}_h \times W_h\right) \quad \text{(a)}$$

Where $\bar{y}_{ST}$ = Estimate of the overall mean; $\bar{y}_h$= Mean carbon value in metric tons of stratum *h*; N = Population of samples; $\overline{N}$ = Population of samples is stratum h; and W_h = Weight assigned to stratum *h*.

The variance was estimated using the following equation:

$$S_{\bar{y}_{ST}} = \sqrt{\sum\left(S_{\bar{y}h} \times \frac{N^2{}_h}{N^2}\right)} = \sqrt{\sum\left(S^2_{\bar{y}_h} \times W_h^2\right)} \quad \text{b)}$$

Where $S_{\bar{y}_{ST}}$ = Standard Deviation of the mean; and $S_{\bar{y}_h}$ = Standard deviation of the mean of stratum *h*.

With these results, a Neyman allocation (sometimes known as optimal allocation) was used to determine the minimal sample size required to meet the specified allowable error using sampling without replacement. This allocation procedure was chosen because it takes into account both variation within the different strata and the size of each stratum. The equation for determining the total number of samples required and the number within each stratum is as follows:

$$n = \frac{t^2 \times \left(\sum W_h s_{y_h}\right)^2}{AE^2 + \frac{t^2 \times \sum W_h s^2_{y_h}}{N}} \quad \text{(c)}$$

and

$$n_h = \frac{W_h s_{y_h}}{\sum W_h s_{y_h}} \times n \quad \text{(d)}$$

Where AE = Allowable sampling error; n = Number of samples required; S_{y_h} = Standard deviation of the sample of stratum h; $S^2_{y_h}$ = Variance of the observations of stratum h; t = Student's random variable from *t*-distribution; and W_h = Weight assigned to stratum *h*.

However, to construct confidence limits, the appropriate degrees of freedom for the estimate need to be estimated since the required sample size is yet to be determined. As such the effective degrees of freedom was used.

$$EDF = \frac{\left(s^2_{\bar{y}_{ST}}\right)^2}{\sum \frac{\left(W_h^2 \times s^2_{\bar{y}_h}\right)^2}{n_h - 1}} \quad \text{(e)}$$

Where all the variables are the same as in the previous equations.

As a result, it was determined that an additional 340 sample plots were need in the bushy vegetation classification. As such, an additional 347 additional points were established throughout the stratum using a random sampling approach but with a 60-metre buffer (the length of the largest plot) to ensure that sampling plots would not overlap with a different vegetation cover type. The locations of these sample plots are illustrated below in Figure 12 and 13 below.

Figure 12 - Location of biomass samples

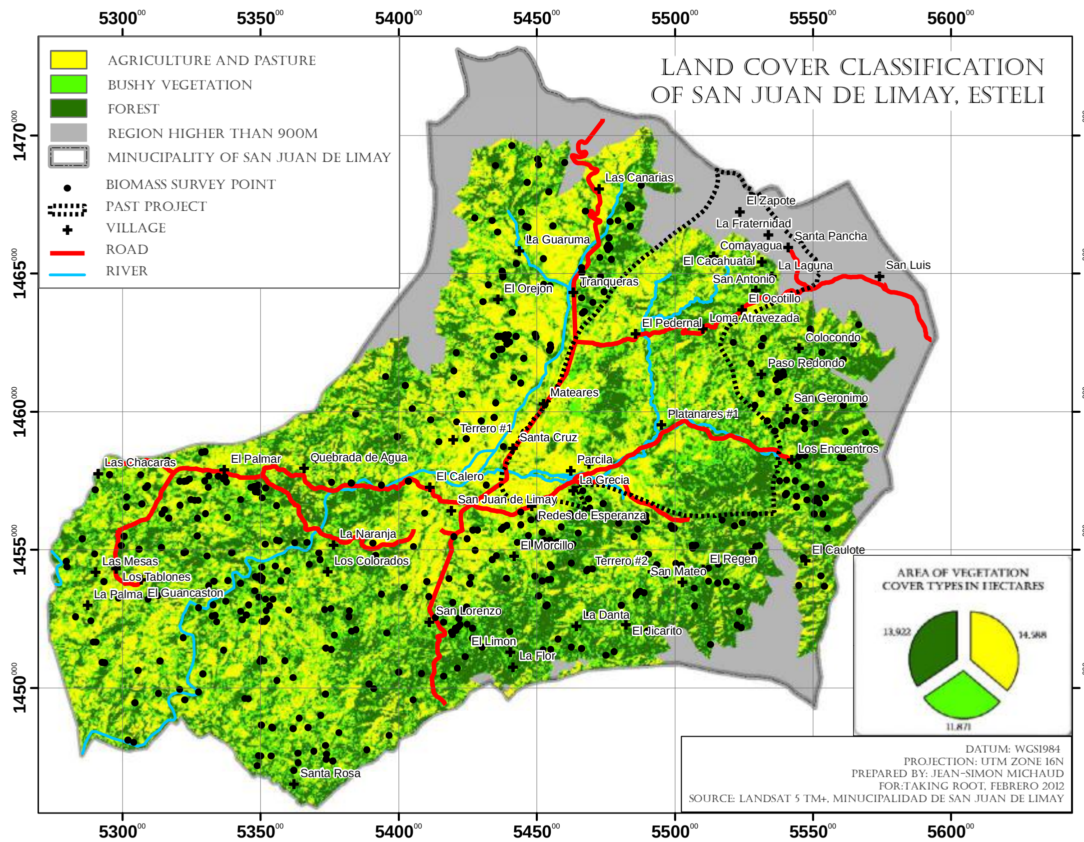
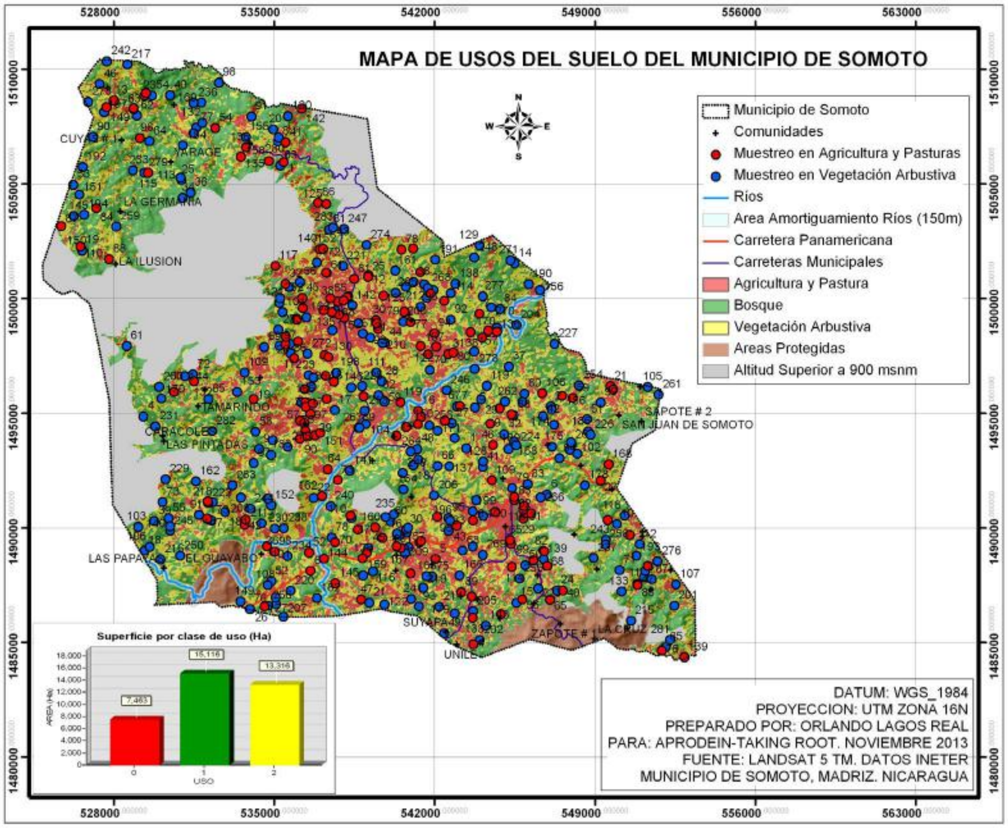


Figure 13 – Location of biomass samples in Somoto.



5.4. Biomass Survey Methodology

A biomass survey was carried out at each sample plot to estimate the quantity of woody biomass within the agriculture and pasture stratum and the bushy vegetation stratum. All trees with a diameter at breast height (DBH) greater than 5 centimetres were included in the survey. Nested sub-plots of varying sizes were used within the sample plots to measure trees according to the Table 4 below.

Table 4 - Size of sampling plots, sub-plots and trees measured

Sub-plot	Square	Area	Trees
Small	20 m	0.04 ha	>5 cm DBH
Medium	40 m	0.16 ha	>20 cm DBH
Large	60 m	0.36 ha	>50 cm DBH

Field Measurements

In the field, a standard methodology was used to record the necessary information for the baseline calculation. The GPS coordinates were located using a hand-held GPS receiver and the project boundary map. Once located, the coordinates represented the south west corner of the square nested plot.

The DBH of each tree was measured and the height of one representative small, medium and large tree were recorded using a clinometer. If this location was not representative of the tree's diameter due to an irregular growth, a second measurement was taken slightly above the growth and the point of measurement was used as opposed to the DBH. All small trees in the small sub-plot were measured, all medium trees were measured in the small and medium sub-plot and all large trees were measured in the entire plot. If the tree bifurcated below the point of measurement, it was measured as two separate trees. The information with the tree's local name was noted in the data sheet along with the slope of the land at its steepest point.

Estimating the Average Carbon Stock Per Hectare

To calculate the average carbon stock per stratum per hectare, various calculations were made.

1) The slope of the plot was corrected for using the formula:

$$L = L_s \times \cos(S) \quad \text{(f)}$$

Where L = the true horizontal plot radius; L_s = the standard radius measured in the field along the steepest slope; S = the slope in degrees; Cos = the cosine of the angle.

By taking the steepest slope, the carbon in each sample is overestimated. This methodology is concurrent with the baseline being calculated in a conservative manner.

2) The results of each plot were expanded to a per hectare basis using the following expansion factor:

$$EF = \frac{10000}{A} \quad \text{(g)}$$

Where EF= Expansion factor; A= Area of sub-plot in m^2

Using an allometric equation developed for tropical dry forests,[18] with annual precipitations > 900 mm, the above ground biomass was calculated as:

Biomass (kg) = exp{-1.996+2.32 x ln(DBH) (h)

3) The expansion factor multiplied by the total calculated biomass of trees on the sample sub-plot gave an estimate of the aggregate of all trees on the land.

4) Below ground biomass was calculated by multiplying the AGB by 0.56 when AGB < 20 t/ha and by 0.28 when AGB > 20 t/ha.[19]

5) The aggregate of above ground and below ground biomass were summed together to get total biomass (TB), which was converted to Total Carbon (TC) by multiplying (TB) by the carbon fraction.[19]

TC = 0.49 * TB (i)

5.5. Change of Carbon Stock in Absence of Project

A consultation was held with environmental committee representatives from various communities within the project boundary to discuss likely land-use changes in connection with land resources use.

The first phase involved discussing the environmental history of the area from the participants' perspective over the course of their lives to establish a sense of the time frame of this technical specification. The testimonies of community elders reiterated the devastating impacts of the "Green Revolution" on the local economy and environment. While vegetation was able to recover somewhat from the destruction of the cotton monocrops, elders noted that the forest cover has been in steady decline since the 1990s, which is consistent with published literature on the history of the region.[20]

The second phase of the consultation involved discussing and identifying the various factors that lead to land-use change in terms of intensity and area. Using a pair-wise ranking method, the main threats and their respective intensities were compared to one another to determine their relative importance. The two most important factors identified were the expansion of agricultural land and pastureland.

The third phase involved assessing the communities' expectations regarding the future evolution of each land-use over the project lifetime, relative to the present. It was clear that the communities expected the trend of deforestation and forest degradation to continue. Consultation with an outside expert validated the likeliness of the presented scenario. This confirmation letter can be found in Appendix 6 and the minutes of this consultation are available upon request.

5.6. Baseline Results

Due to environmental and socio-economic conditions in the municipality of San Juan de Limay and Somoto, land-use commonly cycles from agricultural fields, to cattle pasture land, then to fallow fields where bushy vegetation regenerates.

Satellite imagery was used to determine the proportions of the project boundary that was under each different type of vegetation cover at a given point in time. Although the exact location of each vegetation type changes over time, what is relevant is the ratio that the different vegetation covers occupy throughout time. Through the use of this technical specification, the relative proportion of agricultural land is likely to remain constant whereas the relative proportion of pastureland and woody vegetation is likely to diminish due to gains in efficiency brought about by the reforestation project.

At the time of this baseline study, the predominant vegetation cover was bushy vegetation. However, the majority of the project's producers chose to establish this technical specification in open fields, where the baseline would be close to zero. Since woody vegetation will likely be cleared elsewhere as part of the normal land-use cycle, the project chose to take a more conservative approach and integrates the carbon stock present in the other vegetation covers. Due to the land-use and the cycle of land-use change, the two eligible categories of vegetation cover have been considered as one land-use stratum for the baseline.

The carbon stock baseline is an area-weighted average of the following two land-use types: (i) agriculture and pasture, and (ii) bushy vegetation. These areas were included in the average scenario because each will be directly or indirectly affected by the project intervention. Despite evidence of a probable decline in carbon stocks over time in the absence of the project within the municipality (a relative increase in low carbon stock vegetation covers), this project recognizes the difficulty in accurately quantifying the decline of the baseline over time. Therefore, the baseline will be conservatively assumed to stay constant, which is consistent with simplified baseline and monitoring methodologies for small-scale A/R CDM project activities.

The results of the initial carbon stock are presented in Table 5 below:

Table 5 - Baseline results

	Area (ha)	Above ground woody biomass (tC/ha)	Below ground woody biomass (tC/ha)	Total (tC/ha)
Agriculture and pasture	14,588	0	0	0.00
Bushy vegetation	11,871	5.79	1.67	7.46
Area weighted total	26,459	2.60	0.75	**3.35**[*]

Table 6 Baseline results in Somoto.

	Eligible Area (ha)	Eligible Area (%)	Average Carbon per Class	Total Average Weighted Carbon (tC/ha)
Agriculture and pasture	6,645	54.2	1.17	-
Bushy vegetation	5,624	45.8	5.34	-
Area weighted total	12,269	100	-	3.08

Although the program area in Somoto has a lower baseline, in order to be conservative, Taking Root uses the higher value for the two program areas, 3.35 (tC/ha) from San Juan de Limay to calculate the carbon benefits of this technical specification.

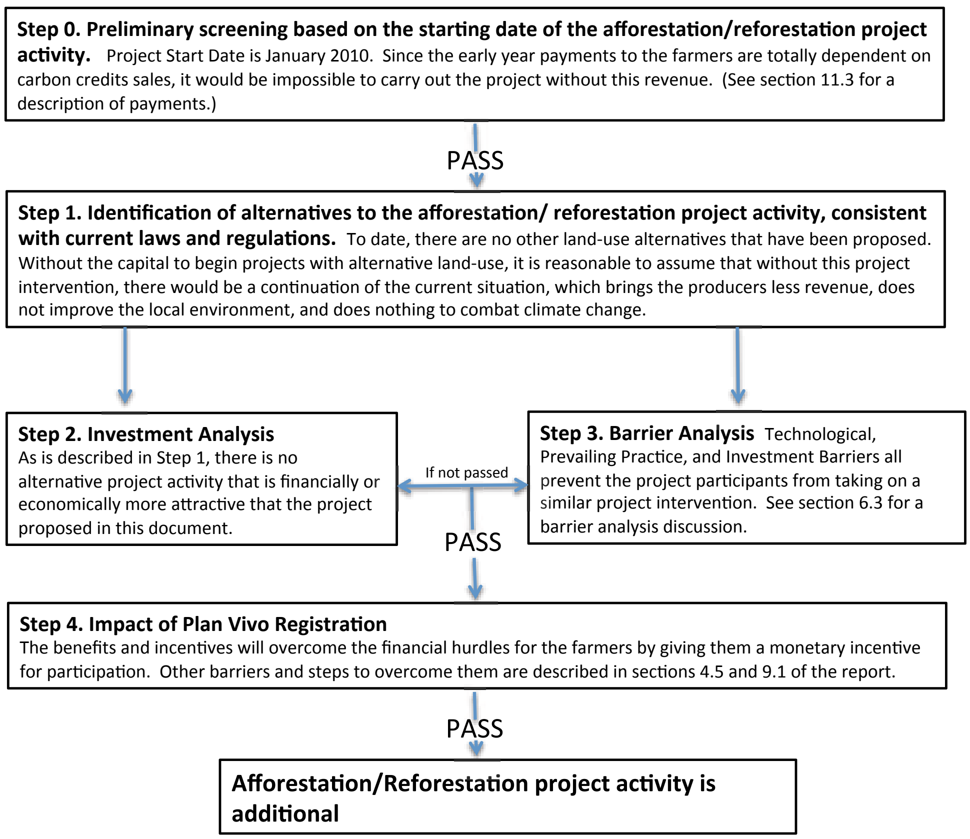
[*] Assuming that the width of crown of the mature trees in this Technical Specification reaches 10 metres, one kilometre of the boundary planting will occupy 10,000m2 (10 x 1000), which represents one hectare. As such, the carbon baseline per kilometer is equal to 3.35 tC

6. Additionality

Taking Root Nicaragua is a non-profit organisation with no ties to any government whether contractual or financial. All of its activities are designed independently and the scale of these reforestation projects is limited by available funding. The primary objective of adopting the Plan Vivo Standard is to increase the marketability of the carbon sequestered. Without this type of finance, this project would not take place.

Figure 13 displays the results from a step-wise tool to test the additionally of prospective project activities.[21] The results of the tool indicate that the project intervention is additional.

Figure 14 - Step Wise Test for Additionality



In Section 6.3 of this document, a barrier analysis is carried out. This is a rapid assessment tool used in community development projects to identify behavioural determinants associated with a particular behaviour so that effective change can be developed.[22] Since the Technical Specification is designed to be beneficial to the community, a barrier analysis is an important tool to help understand what prevents these activities from taking place in the absence of this project, and therefore ensures additionality.

6.1. Comparison to Normal Practice

To ensure additionality, it is important to understand the land-use processes before the project intervention. In the communities of Limay and Somoto, traditional means of subsistence farming are normal practice, notably through the expansion of the agricultural frontier. New land is continuously cleared for agriculture as the soil in previous sites loses fertility. Cattle is grazed on the degraded land, which prevents natural regeneration. Forested lands in the area are also degraded through the harvest and sale of firewood and timber. Through this expansion, natural resources become increasingly scarce.

6.2. Risk of Loss of Ecosystem Services

As a consequence of normal land-use practice, the land surface loses vegetation at a continuous rate. Without this vegetation cover, the soil no longer retains water for long periods of time during the rainy season. The overexploited soil then becomes barren and dry, and no longer cycles humidity. Consequently, wildlife habitat and agricultural productivity declines, and water security worsens. Due to this loss of ecosystem services, these factors lead towards a decline in the quality of life for the residents of the area.

6.3. Barrier Analysis

The predominant barriers to the successful long-term implementation of forest projects are summarized in Table 6 below.

Table 7 - Barrier analysis

Barrier	Why Barrier Exists	Action
Lack of technical expertise	Due to the inaccessibility and unaffordability of education in the region, many people are unable to get formal training in forestry and other necessary fields.	This project utilizes the expertise of experienced foresters and brings such expertise into the community.
Lack of funding	The region is poor and many of the residents do not have adequate sources of income.	The sale of Plan Vivo certificates will enable funding for seeds, nurseries, labour, equipment, and other needs of the project.
Lack of reforestation project examples in this region of Nicaragua; Globally, similar ecosystem services projects are fledgling	This method of sustainable ecological and economic development is a new field. No project of this type has been attempted in the region.	As the project grows and brings together experts from a wide range of fields, more successful examples to learn from will become available. The science and methodology of this type of sustainable development project will also advance.
Difficult for smallholders to register their plantations with the government making legal management of the plantations impossible	In an attempt to protect the remaining forests, it is now illegal to harvest trees without the land being registered as a plantation. This law is more geared towards large plantations and not smallholders as the process requires technical expertise and a heavy bureaucratic process in the capital.	All projects will have their forestry plan registered by Taking Root with the Nicaraguan government forestry authorities, INAFOR.
Not a part of cultural heritage	No project of this type has ever been developed in the region.	As the project grows within the community, it will slowly gain importance in the community's way of life. The benefits from the project will provide incentives for participation and will become a greater part of the culture of the region.

7. Leakage

The Plan Vivo Standard defines leakage as "the unintended loss of carbon stocks outside the boundaries of a project resulting directly from the project activity."

There are three broad categories of leakage to be considered:

Activity Shifting

This is the loss of vegetation cover outside the project boundary as a direct result of the project intervention. i.e. Clearing new agricultural land elsewhere if the reforested area replaces needed agricultural land.

Market Effect

Although unlikely to have much of an impact from small-scale reforestation projects, market effect leakage occurs when changes in supply and demand cause the loss of forest cover outside the project boundary. i.e. Preventing a large logging activity creates a gap in supply, leading to the felling of trees elsewhere.

Super-Acceptance

This takes place when alternative livelihood activities are so successful that people from the surrounding regions move into the area to take part in the activity. Note that this can have a positive or a negative effect on leakage.

7.1. Assessing the Risk of Leakage

The first step in assessing the risk of leakage involves defining and understanding the processes that lead to deforestation and forest degradation in the area. In San Juan de Limay and Somoto, the harvest of firewood and timber, plus the clearance of pastoral and agricultural land, are human activities that fuel the local community. These integral activities also cause deforestation. If a project intervention conflicts with the aforementioned activities, the risk of leakage is considered high.

7.2. Minimizing the Risk of Leakage

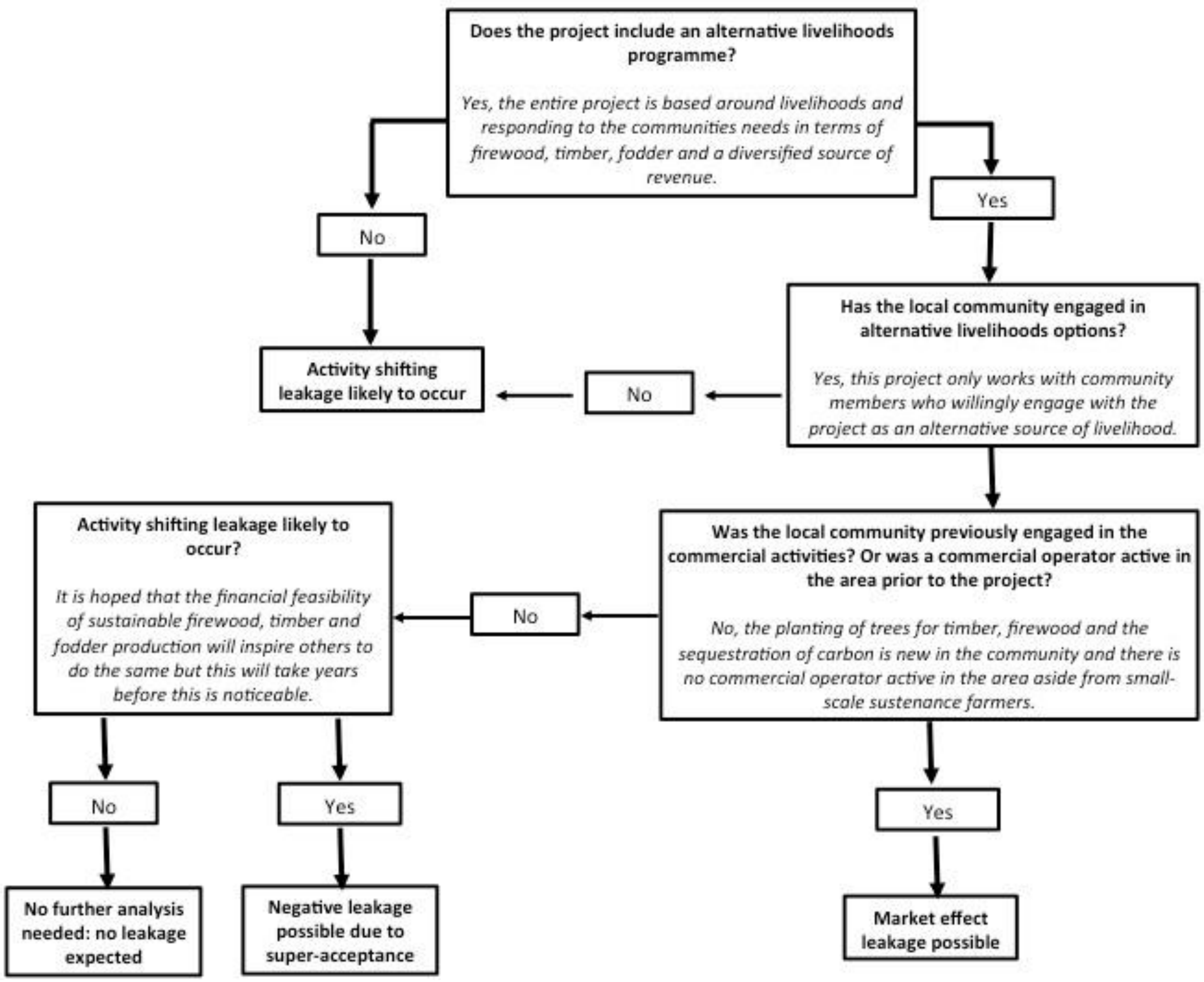
Since a significant portion of the land within the project boundary is either not being utilized for any economic activity or, if so, very minimally (i.e. for occasional firewood collection), leakage is relatively easy to minimize as long as appropriate land-use planning is employed. Every participating producer that uses a technical specification is required to demonstrate through the creation of a plan vivo that they have sufficient additional land to provide for their agricultural and pasture needs and adequate space for reforestation activities.

7.3. Quantification of Leakage

Activities of the Mixed Species Forest Plantation technical specification are designed to reduce the need for further forest clearing. Notably, the integration of firewood production within the forest plantation will reduce the need to harvest unsustainably produced firewood. Additionally, the firewood species in the project produce a source of high protein foliage that makes excellent fodder for cattle, thus reducing the amount of land needed to sustain cows, particularly in the dry season. It is also hoped that due to the increase in family income associated with sustainable firewood and forest plantations, surrounding communities will start using similar land-use strategies on the under-productive portions of their farms - a negative leakage scenario. However, for this to take place, the community will have to overcome cultural barriers (see Section 6.3).

Based on the decision tree, *Assessing the Potential for Leakage* (see Figure 14) from *Sourcebook for Land Use, Land-use Change and Forestry Projects* 12 the potential for leakage was evaluated. After conducting the analysis, the leakage potential is considered as negligible and therefore not calculated within the carbon benefit.

Figure 15 - Assessing the Potential for Leakage



7.4. Activities to Minimize Risk of Leakage

Although it is suspected that leakage will not affect the project, it is still necessary to be proactive in preventing it currently or into the future. Both positive and negative leakage need to be considered as results of this project. The principal economic activities that could be responsible for leakage are the increase of pasture and agricultural land outside the project boundary.

The following Table 7 outlines these and other factors that could lead to leakage, assesses the associated risk level and outlines appropriate management measures. These risks will be monitored at regular intervals and adjusted if necessary.

Table 8 - Activities to minimize risk of leakage

Leakage Risks	Level of risk (low/medium/high)	Management Measures
Displacement of agricultural activity	Low	– Technical support in the development of the plan vivos. – Periodic longitudinal land cover analysis through remotely sensed aerial surveying using GIS and Landsat images to monitor land-use changes in and outside of the project area.
Displacement of pastureland	Low	– Technical support in the development of the plan vivos. – Periodic longitudinal land cover analysis through remotely sensed aerial surveying using GIS and Landsat images in and around project area to monitor land use changes in and outside of the project area. – Use of high protein fodder species to provide source of food during dry season and thus reduce the area need for pastureland.
Increased harvesting to meet demand for timber and posts	Low	– Establishment of forest plantations on producer land to provide a sustainable source of timber and posts.
Increased firewood collection	Low	– Establishment of forest plantations on producer land to provide a sustainable source of firewood. – Distribution of fuel-efficient cook stoves.

8. Permanence

Projects will only succeed if land-use practices are viable over the long-term and provide sustainable economic benefits to communities over and above the carbon payments. The project intervention has a lifespan of 50 years and therefore must incorporate long-term risk management. Considering the lifespan, assuring the permanence of the project through risk management is an essential and intricate task. First, the participation of the producer, and in some cases their successors, throughout the project lifetime is crucial. Second, it is necessary to mitigate external risks unrelated to the producer's participation. A discussion of how to manage these risks follows.

8.1. Activities to Minimize Risk of Non-Permanence

Participation

The most important factors in guaranteeing permanence is ensuring continual participation by the producer. To do so, producers must genuinely want to participate. For this project, participation is voluntary and the yearly payments to the producers are not exceptionally high. Consequently, participants do not only participate for the money but rather for the long-term benefits of the project. Furthermore, there is no aggressive recruitment strategy but rather a series of community consultations. Through these consultations, each plan vivo is designed by the participants and are therefore inline with their needs, resources and capabilities. Additionally, the species used have been selected and are desired by the community, and are chosen to provide multiple benefits to the participants beyond the carbon payments that they receive. As a result, producers participate only if they wish to reforest sections of their farm to gain the benefits of reforestation, and if they lack the means to do so independently.

Establishing a Risk Buffer for Externalities

Even if producers are committed to the project through its lifespan, there are many other risks that can halt the project. In order to prevent such externalities, a risk buffer is calculated. With the buffer in place, the Plan Vivo system can insure the project against such risks.

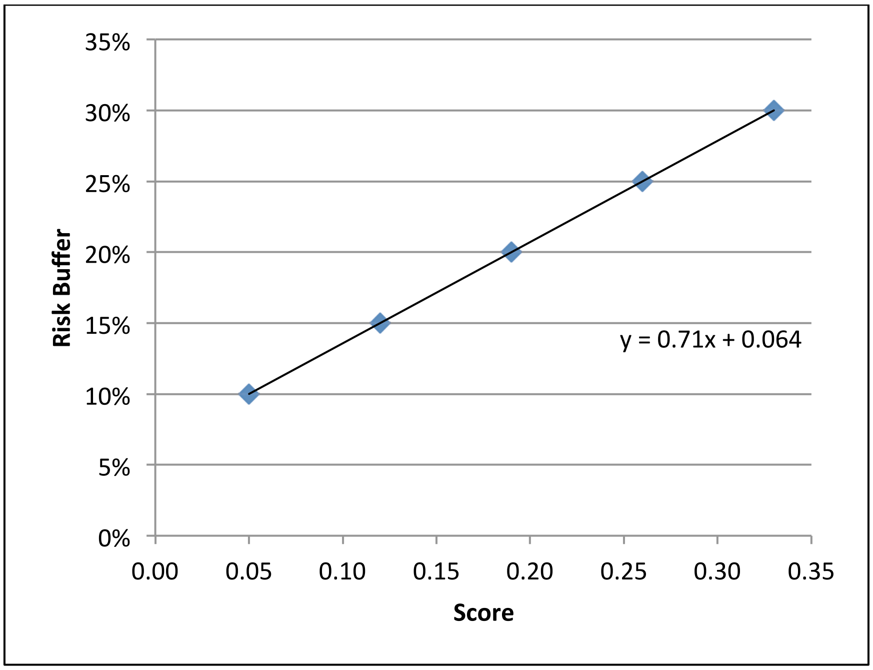
In accordance with the Plan Vivo Standard, this technical specification uses a risk buffer approach that resembles an insurance policy for the buyer of the Plan Vivo certificates. A risk buffer can be defined as a stock of unsold and non-saleable carbon held from each plan vivo, which is generated by deducting a specified percentage from each producer's carbon sequestration potential according to the risk level determined for the project as a whole.[23] If the anticipated carbon sequestered is lower than anticipated, the amount of CO_2 purchased is still sequestered because of the carbon reserve in the unsold risk buffer.

Risk Identification

There are various risks to be considered for a project lasting 50 years. The community itself identified these risks during a series of community meetings. A pair-wise ranking system was created to identify and to measure the risks, the methodology for which was taken from the BR&D document: *Community mapping: Baseline & threat assessment*. Pair-wise ranking can be used to help reach consensus about the relative importance of a list of identified threats of land-use change to land-uses with lower biomass stocks.

The buffer percentage is established using the Managing Risks for Non-Sustainability Tool.[24] This method evaluates each risk and designates values to the project's control over the risk, the risk's estimated timeframe, the probability of the risk after mitigation, and the impact of the risk. The score is then associated with an appropriate risk buffer according the following graph by BioClimate (see Figure 15).

Figure 16 - Risk Buffer and Corresponding Score[*]



Risk Buffer Results

After performing the analysis, the final risk buffer score was determined to be 13.65%. In order to be conservative and to take into account unidentified risks, the buffer was rounded up to 15%. This further guarantees the stability of the project. Appendix 4 outlines various risk factors to permanence and outlines the mitigation strategy for each.

[*] In the "Managing risks for non-sustainability" tool, "minimal risk" occurs when all probabilities of risk and all impacts of risk are low (score 0.05). "Higher risk" occurs when all probabilities of risk and all impacts of risk are high (score 0.35). A score of 0.05 is associated with a recommended risk buffer of 10%, and a score of 0.35 is associated with a recommended risk buffer of 60%. A linear relationship between these two points is used to arrive at a recommended risk buffer for each score.

9. Carbon Benefit and Accounting

In order to calculate the benefits of carbon sequestration over the project lifetime, a carbon model for 50 years of tree and stand growth is created. Using a variety of quantitative methodologies and allometric equations derived from relevant journals and datasets, the model estimates the average carbon sequestration over the project period. To do so, the model predicts the growth of the trees in the first 25 years and then of the stand in the last 25. Included in this timeframe is the decay of a selection of the harvested trees. To ensure the project's carbon obligations, a technique called adaptive management guarantees that the actual sequestration of carbon reflects the predicted sequestration in the model.

9.1. Carbon Periods

Crediting Period

The crediting period is for 50 years from each participant's starting year. For example, the project period for the producers that join the project in 2012 will last until 2062 and a producer that joins the project in 2013 will have a project period that ends in 2063. This time period was selected to allow sufficient time for transition from a non-forested landscape to plantation forestry, to sustainable forest management. This demonstrates the project's intent to generate a permanent land-use change and allow for the variability of carbon stocks over the harvest and re-growth period to be averaged out. This crediting period also allows sufficient time to transition towards financially viable sustainable forestry practices.

Project Period

Activities related to the maintenance of the project interventions take place over the entire crediting period. However, the bulk of the work takes place in the first three years when establishing, planting, and clearing the property requires a sufficient labour investment. After year 4, occasional silvicultural activities are required but to a much smaller extent. For all future years, plantation activities are largely dominated by harvesting.

Payment Period

Ecosystem service payments are made during the first ten years (see Table 12 for more details). Like most afforestation/reforestation projects, the payment period is shorter than the crediting period as payments are made when carbon finance is needed to incentivise the establishment of a new land-use system. Larger payments are made in the early years to help farmers get through the costly stage of the plantation before the first saleable forest products are generated. Afterwards, the majority of participants will continue with their land-use system and benefit from the selective cutting and sale of wood products. From that point on, the forest itself is the incentive and ensures the perpetual use of sustainable forestry as a more viable land-use option.

Training is given over this period to guarantee that the benefits involved in maintaining the land-use system are understood. Furthermore, when the forest stands approach merchantable sizes, Taking Root will play an active role in facilitating the marketing, logistics, and sale of the forest products so that producers receive a fair price, which will keep the incentive system in place.

9.2. Adaptive Carbon Management

The carbon benefit is calculated using the *ex-ante* forecasted average carbon stock of the system over the crediting period minus the baseline and a risk buffer of 15%. Section 4 describes the schedule of activities, including the planned harvest schedules, which have a direct impact on the carbon benefit of this land-use system. This technical specification uses multiple tree species managed for multiple objectives, notably carbon sequestration, ecosystem restoration, and commercial post, firewood and timber production.

The forecasted carbon benefit is based on the best information available; however results are likely to vary from one stand to another. Therefore, a dynamic approach to forest management is applied in which the effects of treatments, natural regeneration, and decisions are continually monitored and, along with research results, are used to modify management on a continual basis to ensure that carbon sequestration objectives are being met. In order to conservatively account for this variability, a distinction is made between forecasted *ex-ante* stand growth and monitored *ex-post* stand growth.

Forecasted stand growth: The forecasted carbon benefit per kilometre only takes into account the carbon benefit of the longer rotation species (*Swietenia humilis and Bombacopsis quinata*). The other species are excluded to actively manage the carbon sequestration of the system based on adaptive management. If the longer rotation species grow at a lower rate than is forecasted in this report, the project can delay or remove fewer of the trees scheduled for shorter rotations (*Caesalpinia velutina*) so that on a stand level the carbon requirements are being met. For example, if one timber species is not growing to expectation, more *Caesalpinia velutina* can be left uncut to ensure a wider growth until it must be removed to make room for more longer-lived and valuable species, all while guaranteeing the carbon obligations for that year. This also ensures that producers can meet their growth milestones since approximately double the number of trees is planted than what was used for the carbon forecasting.

Monitored stand growth: Monitored stand growth accounts for all trees within the stand. If naturally regenerated trees take root, their growth will be encouraged and if they perform better than the plantation trees, they will be given priority. For a full description of the monitoring methodology, see Section 11.

9.3. Carbon Pool Choices

In order to calculate the total carbon benefit, it must be determined what sources of carbon are to be considered. Table 8 describes the choice and justification for the carbon pools included and excluded in the carbon accounting.

Table 9 - Carbon pools included in the calculation of the carbon benefit

Carbon Pool	Factors in calculation	Included (Source Given)	Excluded (Reason for Exclusion)
Above ground biomass	Stem growth	In-house allometric equations for *Swietenia humilis* plus published growth information for more *Caesalpinia* and *Bombacopsis*	
	Biomass Expansion Factor (BEF), which is the ratio of above ground tree biomass in relationship to the tree's stem volume.	IPCC default values	
	Specific density	Published information	
	Carbon fraction	IPCC default values	
Above ground non-woody biomass			Expected to increase as a result of project activities, but difficult and costly to measure with only a small increase in carbon benefit. Thus, conservatively excluded.
Below ground biomass		IPCC default values for shoot to root ratios	
Litter			Expected to increase as a result of project activities, but difficult and costly to measure with only a small increase in carbon benefit.
Soil			Expected to increase as a result of project activities, but difficult and costly to measure.
Hardwood products (*Swietenia humilis*, and *Bombacopsis*)	Decay rate	IPCC default values	
	Processing loss	Published information	
Caesalpina velutina			Allows to be more conservative in our carbon calculations, and is vital for the realisation of the adaptive carbon management plan.

9.4. Carbon Modelling

Given that ecosystem service payments are based on the growth of the proposed Boundary Planting technical specification, forecasting the mass of carbon sequestered by the proposed system is of great interest. The average carbon stock sequestered over the crediting period is calculated using the following equation:

$$C_{Avg} = (C_{ABGB} + C_{AAGB} + C_{AHWP}) \quad \text{(i)}$$

Where C_{Avg} = Average mass of carbon sequestered over the crediting period; C_{AAGB} = Average carbon in above ground biomass of tree components; C_{ABGB} = Average carbon in below ground biomass of tree components; C_{AHWP} = Average carbon stored in harvested wood products for all species

Above Ground Biomass of Tree Components (AGB)

The carbon in the AAGB is calculated as follows:

$$C_{AAGB_{avg}} = \frac{\sum_{t=1}^{n}\sum_{p=1}^{2} AGB_{tp} \times D_p \times CF}{n} \quad \text{(j)}$$

Where AGB_{tp} = AGB for species p at time t; D_p = the specific density of the wood of species p; CF is assumed to be constant representing the carbon fraction of dry biomass for tropical forests and is equal to 0.49.[19]

Below is a list of equations used to calculate AGB for the various species employed.

Bombacopsis quinata

Above ground biomass in tonnes was estimated for *Bombacopsis* using the following equation:

$$AGB_{Bombacopsis_t} = V_t \times BEF \times D_{Bombacopsis} \quad \text{(k)}$$

Where BEF is the biomass expansion factor, which was estimated using the following equation[25]

$$BEF = 3.233983 \times DBH^{0.45162} \times ht^{-0.67457} \quad \text{(l)}$$

Where DBH = the diameter of breast height in centimetres; ht = the height of the tree in metres.

Published growth equations for *Bombacopsis quinata* from Costa Rican plantations were found however they proved to be overly optimistic based on our experience in the region. As such, the standard Chapman-Richards growth and yield model for both DBH and ht was used but calibrated to local conditions where $Yield_t = b_0*(1-e^{(-b2*t)})^{b3}$. With this functional form, b_1 and b_2 determine the shape of the curve whereas the b_0 coefficient determines the asymptote of the growth curve (the maximum obtainable yield value). As such, as long as realistic and conservative values are used for the asymptote, the yield modelling will always remain constrained to realistic values over a sufficiently long time period. To conservatively calibrate the asymptote, data well below maximum plantation values were used from a recent study on *Bombacopsis quinata*[26] so that DBH was caped at 42 centimetres and height was caped at 26 metres. For the shape of the curve, the model was calibrated to intersect observed datasets from the region. As such, the DBH equation is as follows:

$$DBH_t = 42*(1-e^{(-0.16*t)})^{4.2} \quad \text{(m)}$$

Where t = age in years; and e is a constant representing the base of the natural logarithm.

The height equation is as follows:

$$ht_t = 26*(1-e^{(-0.17*t)})^{1.6} \quad \text{(n)}$$

Where ht = the height in metres and t = the age in years.

The maximum height (b_1) of 26 metres was taken from this study's dataset.

Stem volume (v_t) was estimated using the following model.[27]

$$\ln(v) = -8.0758 + 1.2678 \times \ln(dbh) + 0.9729 \times \ln(ht) \quad \text{(o)}$$

Where *v* represents volume in cubic metres.

Caesalpinia velutina

C. velutina is the species planted at the highest density is this technical specification but is scheduled to be harvested around year 10 to provide a merchantable source of posts for rural construction and firewood. As such, its carbon sequestration is excluded from the carbon modeling. However, the species can grow considerably larger and given the high density of its wood, has the potential to sequester considerable quantities of carbon. Through our system of adaptive management, should stand growth not meet expectations, some of the trees will not be removed to ensure that carbon obligations are met.

Above ground biomass in kg can be estimated for *Caesalpinia velutina* using the following equation:[28]

$$\ln(AGB_{Caesalpinia_t}) = -2.708 + 1.6155 \times \ln(DBH) + 1.1209 \times \ln(ht) \quad \text{(p)}$$

Where AGB = above ground biomass in kilograms, DBH = the diameter at breast height in centimetres and ht = the height in metres.

The stem volume in metres cubed can be estimated using the following equation:[28]

$$\ln(V) = -9.0215 + 1.4263 \times (DBH) + 1.1431 \times \ln(ht) \quad \text{(q)}$$

Where V = the stem volume in cubic metres, DBH = the diameter at breast height in centimetres = ht is the height of the tree in metres.

In order to forecast growth and yield, an in house stand level height equation was built using easily obtainable environmental and climatic variables as well as an allometric relationship between height and DBH. The dataset used for building these equations originated from sixty-eight permanent sampling plots (PSP) that were made available to the general public as part of the CATIE technical series[29]. The PSPs originated from Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama, thus representing a wide range of environmental and climatic growing conditions. Several years later, a newer version of the same dataset with older trees was published in a graduate thesis,[28] which was added to the dataset.

The equation for height is as follows:

$$\text{Ln}(ht) = -2.0144 + 0.9862 \times \ln(t) - 0.00179 \times elev + 0.000187 \times precip + 0.005728 \times slope \quad \text{(r)}$$

Where ht = the height in metres; t = the age of the trees in months; elev = the average elevation above sea level in m; precip = the average annual rainfall in mm; and slope = the average slope of the stand.

$$DBH = 2.22982 + 0.74529 \times ht - 0.00032 \times TPH - 0.000555 \times precip \quad \text{(s)}$$

Where TPH = the number of trees per kilometre in the stand.

Swietenia humilis

Above ground biomass (AGB) was estimated using the following equation:

$$AGB_t = (BA_t \times ht_t \times FF) \times BEF \times D \quad \text{(t)}$$

Where FF is form factor, which is assumed to be a constant equal to 0.5;[*] BEF is the biomass expansion factor, which is also assumed to be a constant equal to 1.5 times the stem biomass for tropical dry forests;[26] t is time measured in years; and Basal Area (BA) is:

$$BA_t = \left(\frac{DBH_t}{2}\right)^2 \times \pi \quad \text{(u)}$$

Where π = the mathematical constant pi whose value is equal to the ratio of any circle's circumference to its diameter; and FF = form factor, which is assumed to be a constant equal to 0.5.

Where BEF = biomass expansion factor, which is also assumed to be a constant for tropical dry forests;[30] and t = time measured in years.

Using data from an in-house study, the Chapman-Richards model was fitted and calibrated using height and DBH measurements from different years (for more details on this method, see the growth section for *Bombacopsis quinata*). The maximum DBH was set at 40 centimetres and the maximum height was set at 20 metres (again, well below the species potential). As such, the DBH equation was determined to be as follows:

$$DBH_t = 40*(1-e^{(-0.16*t)})^{4.2} \quad \text{(v)}$$

Where DBH = the diameter at breast height in centimetres; and t = age in years,

The height equation is as follows:

$$ht_t = 20*(1-e^{(-0.17*t)})^{1.6} \quad \text{(w)}$$

Where ht = height in metres; and t = age in years.

The maximum height (b_1) of 20 metres was is the maximum height from the in-house study.

Below Ground Biomass

Average carbon in the below-ground biomass (BGB) is calculated as follows:

$$C_{BGB_{avg}} = \frac{\sum_{t=1}^{n}\sum_{p=1}^{2} AGB_{tp} \times D_p \times CF \times R}{n} \quad \text{(x)}$$

Since species specific BGB equations were unavailable, IPCC default values were used where R is the ratio of below ground biomass to above ground biomass for tropical dry forests equal to 0.56 when AGB_t is less than 20 and equal to 0.28 when AGB_t is greater than 20.[31]

[*] Default form factor suggested in a professional consultation by Henriette Duda, Doctor of Biometrics at PrimaKlima -weltweit- e.V. and also inspired by various publications, notably: Malik, A. (2002). Untersuchungen über waldmess- und waldwachstumskundliche Grundlagen zur Bewirtschaftung der Baumart Diospyros celebica Bakh. (Ebenholz.)

Calculations for Harvested Wood Products

Wood products contribute to mitigating climate change through forming a storage pool of wood-based carbon, which can last longer than the lifespan of the tree when used in long-lived products. In this project, some of the carbon in the project trees will provide carbon storage benefits long after they are cut down. The average carbon in the harvested wood products (HWP) is calculated as follows:

$$C_{HWP_{avg}} = \frac{\sum_{p=1}^{2}\sum_{i=1}^{n}(C_{HWP_{tp}} + (C_{HWP_{t-1p}} \times k_p))}{n} \quad \text{(y)}$$

Where k is the decay rate of species p.

$$C_{HWP_{tp}} = HWP_{tp} \times D_p \times CF \quad \text{(z)}$$

and

$$HWP_{pt} = V_{merchantable_{pt}} \times V_{harvested_{pt}} \times PF_p \quad \text{(aa)}$$

where $V_{merchantable}$ is the standing volume per tree of merchantable timber of species p at year t, $V_{harvested}$ is the number of trees harvested from species p at year t and PF is a constant processing factor (the remaining volume after processing) of species p.

For *Caesalpinia velutina*, the following equation for merchantable standing volume was used:[28]

ln(V) = -9.0215 + 1.4263 x ln(DBH) + 1.1431 x ln(ht) (bb)

For Bombacopsis, merchantable volume was estimated using the following model.[27]

$$\ln(V_{merchantable_{Bombacopsis}})_t = -8.0758 + 1.2678 \times \ln(DBH) + 0.9729 \times \ln(ht) \quad \text{(cc)}$$

For Swietenia, the following equation was used for merchantable standing volume

$$V_{merchantable_{Swietenia\,t}} = BA_t \times H_t \times FF \quad \text{(dd)}$$

Values for Timber Processing Factors

When the trees are processed, only a minority of the stem is processed into long-lived timber products. For this project, a processing factor of 80% of the stem is used for posts and 35% is used for when larger stems are processed into lumber.[32] This factor is taken from a study done in Costa Rica where trees with a DBH of 19 centimetres had a processing factor of 35% and those with a larger DBH had a higher factor. Although trees used for lumber in this project all have a DBH much larger than 19 centimetres at harvest, to be conservative, a constant factor or 35% is being used.

Values for Decay Rates of Harvested Wood Products

The rate of decay of harvested wood products is taken into consideration at a constant rate of 2.3% per year,[33] which is consistent with decay rates used in other publications for tropical agroforestry environments.[34] The default value is appropriate because the majority of the lumber products use highly valued species with international markets under the trade names Honduran Mahogany and Spiny Cedar. These species are traditionally used for furniture and cabinetry. The projected harvested merchantable volumes of timber for each species is shown in Table 2, which is the wood that is decayed in the form of harvested wood products in the carbon modelling. As with carbon sequestration, the carbon stored in *Caesalpinia velutina* is excluded from the carbon modelling.

9.5. Mortality Considerations

This technical specification requires that all trees that die be replanted in the first few years, when tree mortality is much more likely. However, modelling mortality can be challenging and complex due to the lack of data. Consequently, the carbon modelling is done considering only 90% of the trees planted. If mortality dips below 90%, adaptive management ensures that the carbon obligations are met.

9.6. From Plantation Forestry to Sustainable Forest Management

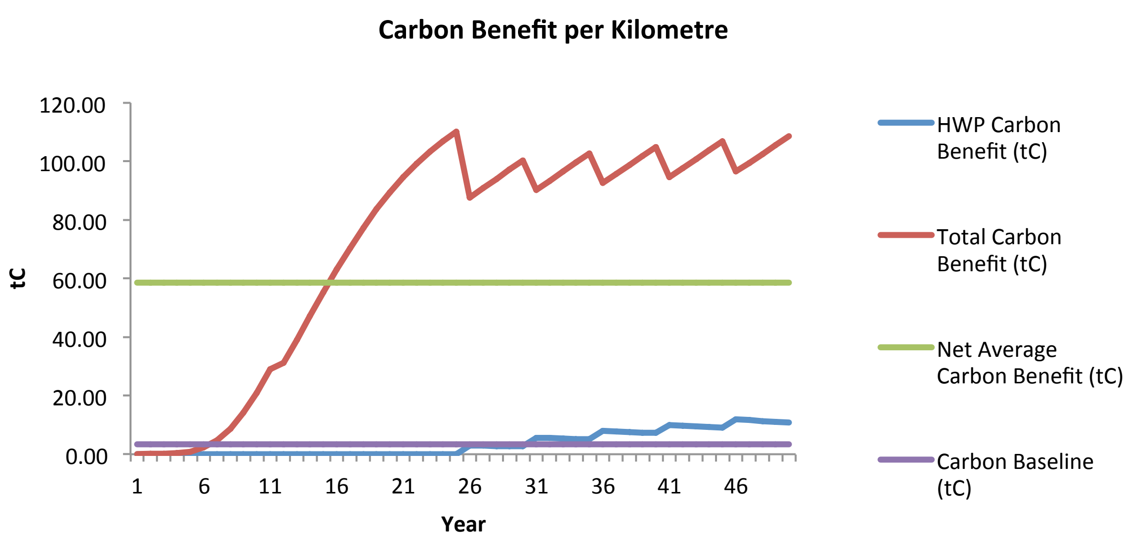
When the plantation approaches maturity near year 25, the management regime will progressively shift towards sustainable forest management. The larger trees will be selectively harvested while natural regeneration will be encouraged and, when needed, new trees will be planted. From this point on, the carbon modelling shifts from a tree level model to a stand level model. A conservative growth rate of 6 cubic metres per kilometre* per year is assumed with a harvest regime of 30 cubic metres every 5 years. The average density of the stand is assumed to be the average of the last species left in the stand, which is 0.57 grams per cubic centimetre.

9.7. Carbon Benefit

According to the calculations based on this methodology, the yearly average carbon per kilometre for the longer-lived trees over the project period, after subtracting the baseline, leakage, and the risk buffer, is of 58.58 tC. See the Appendix 2 for specific species growth information and further calculations.

The following Figure 16 and Appendix 3 describe the calculated carbon benefits:

Figure 17 - Carbon sequestered over time per kilometre



The net carbon benefit is then converted to CO_2 by multiplying the ratio of the molecular weight of CO_2 (molecular weight: 44) by the molecular weight of carbon (molecular weight 12). Therefore the average total CO_2 sequestration per kilometre is 214.81 tCO_2.

* This is based on local professional knowledge and is a common figure for timber stand growth.

10. Ecosystem Impacts

The CTCP takes a holistic approach to land-use management in an area that has suffered from intense environmental degradation for several decades. As a result, the community must cope with heavy soil erosion, water shortages and flooding, and a drastic decline in wildlife and tree species. Although carbon sequestration funds the project, its scope integrates watershed management, sustainable resource use and land-use planning. Table 9 provides a summary of the expected impacts:

Table 10 - Summary of expected impacts of project activities on key environmental services

Title of technical specification	Biodiversity impacts	Water availability impacts	Soil conservation impacts	Air quality impacts
Boundary Planting	**Positive impact:** Increase forest cover and thus wildlife habitat through the use of rare native tree species.	**Positive impact:** Entire project designed around increasing water security by prioritizing critical watersheds and thus reducing the probability of flooding in the wet season and increasing water retention in the dry season.	**Positive impact:** Renewed forest cycle, use of nitrogen fixing trees, and rapid biomass accumulation continue nourishing the soil while increased forest cover reduces erosion.	**Positive impact:** Retain humidity and thus reduce particulate matter in the air, particularly in the dry season; Sequester CO_2 and produce oxygen.

10.1. Biodiversity Impacts

Factors that increase biodiversity:

- Establishment of Boundary Planting systems on underutilized lands with minimal biodiversity
- Emphasis is placed on collecting tree seeds from around the community, instead of buying from one supplier, to promote variation within species.
- A more diverse tree stock will ensure the long term biodiversity preservation and growth as external environmental and human pressures are progressively placed on the ecosystem
- Increase in forest cover increases wildlife habitat and therefore biodiversity.

10.2. Soil Impacts

Factors that increase soil quality:

- Increase in forest cover
- Use of nitrogen fixing species

10.3. Water Impacts

Factors that increase water benefits:

- Increase in forest cover (increased water retention and decreased evaporation)
- Planting within the vicinity rivers and streams
- Planting within strategic watersheds

10.4. Air Quality Impacts

Factors that increase air quality benefits:

- Planting trees that sequester carbon and remove particulate matter

11. Monitoring Plan

Each technical specification includes a monitoring plan, which is used as a basis to assess the progress of each plan vivo. It also sets forth a series of milestones that must be reached in order for payments to be received.

Table 11 describes the variables being monitored as part of the monitoring plan as well as the instruments being used and the justification. Each participating producer's plan vivo is verified at various points of the year by the community technicians for a set of indicators.

Organizational annual reports are the basis by which Taking Root reports the monitoring work and progress. Annual reports will be submitted and reviewed by the Plan Vivo Foundation, and by on-site third party verification every five years. Taking Root management staff reviews the quality of the community technician's assessments before compiling annual reports.

11.1. Annual Monitoring Methodology

Resources needed: Handheld GPS, 7-metre plot cord, data collection sheet or tablet, clipboard, pen, measuring tape, spray paint, clinometer and DBH tape or calliper for trees with DBH < 5 cm.

Personnel: A community technician is responsible for completing an internal monitoring report for each producer according to this technical specification. Although it is the responsibility of the community technician to head the internal monitoring, it is performed with the participating producer so that all parties have a clear understanding of the process.

Plot selection and characteristics: The sampling procedure uses 14 metre linear PSPs systematically located on each boundary planting segment. The centre of the first PSP point placement is randomly generated through a GIS upon plan vivo registration. An average of 7.14 plots are taken along each kilometre of fencing to ensure that 10% of each kilometre is surveyed.

For the establishment of these plots, the plot location is identified using a hand held GPS and a high-density, thick wooden stake that is inserted into the ground. Approximately 20 centimetres of it should protrude above ground, be painted with a bright colour and a have a big nail hammered into the top of it. The paint is used to facilitate locating it visually whereas the nail can be used to attach the plot cord. Furthermore, should the stake not be replaced before entirely rotting, a metal detector can be used to detect the nail and pinpoint the plot's exact location for replacement.

Since the plot centres will be visible, it is possible that the trees within that area receive a different treatment, which would bias the results. However, since the stands and plots are relatively small, it will be easy to notice this bias should it take place.

In terms of measurement, when trees surpass breast height, a line demarking 1.3 metres of height (or slightly higher if that height happens to not be representative of the tree's diameter at that point) should be marked on each tree within each plot to ensure that annual measurements are always taken at the same spot. Figure 1817 is an illustration of the monitoring sheet that is used.

Summary of Monitoring Methodology

Sampling method: Systematic with random start
Sampling unit: 14-metre linear PSPs
Number of samples: Minimum of 10% of technical specification or 7.14 per kilometre
Population: All trees of this technical specification on producer's plan vivo
Frequency of sampling: Annual

Please note – Since the creation of this technical specification, the project has refined and improved its monitoring approach. This has resulted in a minor deviation from methods described in this section. More information about this is provided in Appendix 8. A larger update to this technical specification is expected later in 2021.

11.2. Specifics of Monitoring Metrics

Table 11 10 describes the variables being monitored as part of the monitoring plan as well as the instruments being used and the justification. Figure 17 gives an example of the monitoring sheet used by community technicians to record the monitoring criteria.

Table 11 - Details on metrics and their measurement

Variable	Instrument	Justification
Height	Measuring tape or clinometer	Commonly used variable for growth and yield information. When appropriate, a measuring tape is used because it is precise and efficient. When the trees are too tall, a clinometer is used.
Diameter	Caliper or DBH tape	Commonly used variable for growth and yield information. Two caliper measurements are used for seedlings and very thin trees and geometric mean is calculated. Calipers are used because they are easier to use on small diameter trees. However, a DBH tape will be used on trees with a diameter greater than 5 cm because it is faster, accounts for the tree's ecliptic shape, and the same tool can be used on small and large trees.
Point of measurement (POM)	Measuring tape	Used to specify where measurement was taken, which is typically at DBH. However, if the tree is too short, diameter at base is measured. Furthermore, if DBH is not a representative diameter of that region of the tree due to a point of branching or an irregular growth, the diameter just above that point should be used.
# of trees	N/A	Used to estimate stand density, estimate the number of new trees needed from the nursery and is necessary for estimating stand yield.
Species	N/A	Used for growth and yield information, used to know which species are needed from nursery for the following planting season and used to compare between species.
Condition: Dead or Alive	N/A	Used for carbon yield estimations.
Requires Clearing	N/A	Used to verify milestone completion.
Requires pruning	N/A	Used to verify milestone completion.

Figure 18 - Example of the monitoring sheet used by community technicians

M1 Data Collection Sheet

Plan Vivo #:______________

		Diameter		Height						
Tree #	Species	POM (base, DBH, other)	Diameter (cm)	Dist. from tree (m)	Angle to bottom (o)	Angle to top (o)	Height (m)	Requires clearing (Y/N)	Requires pruning (Y/N)	Dead/ Alive
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										

Notable observations:

Page 2

11.3. Basis of Payments

Each year, differing metrics determine the producer payment. Table 11 describes the targets that match up to the modelled carbon forecasting. Table 12 describes the producer payment ratio when meeting the threshold versus the target.

Table 12 - Payments Breakdown

Year	Basis of payment	Threshold	Target	Percent of total payment received per kilometre
1	Tree planting Fences placed on area		Minimum density of 200 trees per kilometre* Fence complete	25%
2	Areas cleared Trees replanted	50% of the plots cleared	80% of the plots cleared Minimum density of 200 trees per kilometre	20%
3	Areas cleared Survival Rate	75% of the plots cleared	90% of the plots cleared Minimum density of 200 trees per kilometre	15%
4	Growth milestone	Basal area no less than 0.13 m^2/km	Basal area no less than 0.17 m^2/km	10%
5	No payment			0%
6	Pruning and clearing	75% of trees show evidence of clearing and timber trees are pruned.	90% of trees show evidence of clearing and timber trees are pruned.	11.4. 10%
7	Growth milestone	Basal area no less than 1.97 m^2/km	Basal area no less than 2.63 m^2/km	10%
8	No payment			0%
9	No payment			0%
10	Pruning and clearing Harvest	75% of trees show evidence of clearing and timber trees are pruned.	90% of trees show evidence of clearing and timber trees are pruned. Harvest of *Caesalpinia velutina*	10%

For the extent of the payment period, during the internal annual monitoring of each plan vivo, payments are issued to the producer according to a predetermined schedule based on the different project indicators over the project lifetime. If the technicians determine that the target is met, full payment is received. If the target has not been met but the threshold is achieved, partial payment is made and corrective actions are implemented. If the threshold is not met, payments are withheld until the following

* The density requirements reflect the needed number of trees for those species included in the carbon accounting.

year when the objectives have been reached. In accordance with the carbon accounting model, the majority of the producers will reach 100% planting by first year. If they miss the target, they will replant to 100% capacity by the following year.

Corrective Actions

When producers do not meet their targets, a predetermined amount of pay is withheld from their annual payment until the milestone has been reached (details are in Table 12). Furthermore, corrective actions must be taken to ensure that milestones will be met the following year, which are established on a case-by-case basis. For example, if a producer fails to reach the required planting density, their corrective action would be to replant new trees.

Table 13 - Basis of payments

Performance	Payment
Meets target	100% of payment
Meets threshold	50% of payment withheld and corrective actions taken
Fails to meet threshold	100% of payment withheld and corrective actions taken.

11.5. Quality Assessment and Quality Control

Various steps are taken to ensure quality control. The operations manager reviews all monitoring data, cleans it, and enters it into the project database. The database calculates if the producer has reached their target for the year. The results of the monitoring are brought to the community technicians in Nicaragua for review. They verify if the monitoring results conform to their field experience. The results of the monitoring from both the database and the community technicians are analysed by Taking Root and published in annual reports. Furthermore, every participating producer is assigned to a specific community technician so that the performance of each technician's group of producers can be compared to each other to identify needs for additional capacity building.

11.6. Monitoring Leakage

In order to ensure that leakage is not affected by the project, periodic longitudinal land cover analyses are performed using Landsat imagery. The target for these surveys is that the change in the proportion of agriculture and pasture inside the project boundary relative to outside the project boundary not be smaller. If there is a detected change, then risk of leakage may be higher than expected and a more detailed review and corrective actions will need to be undertaken.

Appendix 1: Species Growth Modelling and Carbon Accounting (First 25 Years)

Constants used in the carbon accounting section.

Carbon Accounting Constants	Value	Source or *Notes*
Carbon Fraction of Dry Matter	0.49	*Agriculture, Forestry and Other Land Use, in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, Editor 2006, Institute for Global Environmental Strategies. p. 1-83*
Ratio of Below-Ground Biomass to above-ground Biomass - Tropical Dry Forest	1.56 1.28	When above ground biomass is smaller than 20 t/ha When above ground biomass is larger than 20 t/ha *Agriculture, Forestry and Other Land Use, in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, Editor 2006, Institute for Global Environmental Strategies. p. 1-83*
Biomass Expansion Factor	*1.5*	*Good Practice Guidance for Land Use, Land Use Change and Forestry, IPCC, Editor 2003. p. 151-186. Table 3A.1.10 Default values of biomass Expansion Factors (BEFs)*
Rate of Decay (k)	*0.023*	*Agriculture, Forestry and Other Land Use, in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, Editor 2006, Institute for Global Environmental Strategies. p. 1-83*
Form Factor	0.5	Default form factor suggested in a professional consultation by Henriette Duda, Doctor of Biometrics at PrimaKlima -weltweit- e.V. and also inspired by various publications, notably: *Malik, A. (2002). Untersuchungen über waldmess- und waldwachstumskundliche Grundlagen zur Bewirtschaftung der Baumart Diospyros celebica Bakh. (Ebenholz.)*

Wood Densities

Wood Density		Source
Swietenia humilis	0.718	*Maluenda, J., et al., Guia de Especies Forestales de Nicaragua. 1 ed2002, Managua: Editora de Arte, S.A. 304.*
Bombacopsis quinata	0.428	*“”*
Caesalpinia velutina	0.722	*“”*
Average of *Swietenia humilis* and *Bombacopsis quinata*	0.573	The average of the two species is used in the stand management phase since they will be the primary species in the stand.

Site Index Variables

Variable	Value	Source
Annual Precipitation	1394 mm	*Resumen Meteorologico Annual De San Juan De Limay*, M.o.S.J.d. Limay, Editor.
Slope	2 degrees	Based on currently established plantations within the project.
Length of Dry Season	6 months	Ficha Municipal, Municipality of San Juan De Limay. Given to Taking Root by the municipality of San Juan de Limay in 2010.
Average Elevation	400 m	

Appendix 2: Specific Species Information

Swietenia humilis

Spanish Name: Caoba		Type: Lumber
Processing factor	0.35	Quirós, R., O. Chinchilla, and M. Gómez, *Rendimiento en aserrio y procesamiento primario de madera proveniente de plantaciones forestales.* Agronomía Costarricense, 2005. **29**: p. 7-15.
DBH Equation	$DBH_t = 40*(1-e^{(-0.16*t)})^{4.2}$	In-house modeling using Chapman-Richards model and in-house allometric equation
Height Equation	$ht_t = 20*(1-e^{(-0.17*t)})^{1.6}$	In-house modeling using Chapman-Richards model and in-house allometric equation

Predicted Growth for *Swietenia Humilis*

Age (years)	Count of Trees per Kilometer with Mortality	Tree Height (m)	Tree Dbh (cm)	Stem Volume per Kilometer (m3)	Basal Area per Kilometer (m2)	Above Ground Biomass per Kilometer (t)	Shoot to Root Ratio	Below Ground Biomass per Kilometer (t)	Total Biomass per Kilometer (t)	Carbon per Kilometer (tC)
1	100	1.03	0.01	0.00	0.00	0.00	0.56	0.00	0.00	0.00
2	100	2.73	0.17	0.00	0.00	0.00	0.56	0.00	0.00	0.00
3	100	4.61	0.70	0.01	0.00	0.01	0.56	0.01	0.01	0.01
4	100	6.46	1.72	0.07	0.02	0.08	0.56	0.05	0.13	0.06
5	100	8.20	3.26	0.34	0.08	0.37	0.56	0.21	0.58	0.28
6	100	9.78	5.27	1.07	0.22	1.15	0.56	0.64	1.79	0.88
7	100	11.19	7.62	2.55	0.46	2.75	0.56	1.54	4.28	2.11
8	100	12.44	10.18	5.07	0.81	5.46	0.56	3.06	8.51	4.19
9	100	13.54	12.85	8.77	1.30	9.45	0.56	5.29	14.74	7.26
10	100	14.48	15.51	13.69	1.89	14.74	0.56	8.26	23.00	11.33
11	100	15.30	18.10	19.69	2.57	21.20	0.56	11.87	33.07	16.30
12	100	16.00	20.55	26.55	3.32	28.59	0.28	8.01	36.60	18.04
13	100	16.61	22.84	34.01	4.10	36.63	0.28	10.26	46.89	23.11
14	100	17.12	24.93	41.79	4.88	45.01	0.28	12.60	57.61	28.39
15	100	17.56	26.83	49.63	5.65	53.46	0.28	14.97	68.42	33.72
16	100	17.93	28.53	57.33	6.39	61.74	0.28	17.29	79.03	38.94
17	100	18.25	30.04	64.70	7.09	69.68	0.28	19.51	89.19	43.95
18	100	18.52	31.38	71.63	7.73	77.14	0.28	21.60	98.74	48.66
19	100	18.75	32.56	78.05	8.33	84.05	0.28	23.54	107.59	53.02
20	100	18.94	33.59	83.91	8.86	90.37	0.28	25.30	115.67	57.00
21	100	19.11	34.48	89.21	9.34	96.07	0.28	26.90	122.98	60.60
22	100	19.25	35.26	93.95	9.76	101.18	0.28	28.33	129.51	63.82
23	100	19.36	35.93	98.16	10.14	105.72	0.28	29.60	135.32	66.69
24	100	19.46	36.51	101.88	10.47	109.73	0.28	30.72	140.45	69.21
25	100	19.55	37.01	105.15	10.76	113.24	0.28	31.71	144.95	71.43

Bombacopsis quinata

Spanish Name: Pochote		Type: Lumber
Processing factor	0.35	*Quirós, R., O. Chinchilla, and M. Gómez, Rendimiento en aserrio y procesamiento primario de madera proveniente de plantaciones forestales. Agronomía Costarricense, 2005. 29: p. 7-15.*
DBH:	$DBH_t = 42*(1-e^{(-0.16*t)})^{4.2}$	In-house modeling using Chapman-Richards model,; *Kanninen, M., et al., Stand growth scenarios for Bombacopsis quinata plantations in Costa Rica. Forest Ecology and Management, 2003. 174: p. 345-352.*
Height (m)	$ht_t = 26*(1-e^{(-0.17*t)})^{1.6}$	In-house modeling using Chapman-Richards model,; Kanninen, M., et al., *Stand growth scenarios for Bombacopsis quinata plantations in Costa Rica.* 2003. **174**: p. 345-352
Biomass Expansion Factor	$3.23983*DBH^{45162} *ht^{-.67457}$	*Avendaño, R., Modelos Genéricos de Biomasa Aérea para Especies Forestales en Función de la Arquitectura y la Ocupación del Rodal, 2008, Centro Agronómico Tropical de Investigación y Enseñanza.*
Stem Volume per Tree	ln(v)= -8.0758 + 1.2678 * ln(DBH) + .9729 * ln(height)	*Kanninen, M., et al., Stand growth scenarios for Bombacopsis quinata plantations in Costa Rica. Forest Ecology and Management, 2003. 174: p. 345-352.*
Site Index	8.5565+0.0015*precip+1.5969*monthsdry-0.0839*slope	*Navarro, C., Evaluación del crecimiento y rendimiento de Bombacopsis quinatum (Jacq) Dugand en 14 sitios en Costa Rica. Indices de sitio y algunos aspectos financieros de la especie., 1987, Tesis Mag. Se. Turrialba, CR, Programa Universidad de Costa Rica/CATIE. p. 1-151.*

Bombacopsis quinata is one of the more commonly used native timber plantation species in Central America due to its highly prized wood and fast performance in arid regions.

Predicted Growth for *Bombacopsis quinata*

Age (years)	Count of Trees per Kilometer with Mortality	Tree Dbh (cm)	Tree Height (m)	Stem Volume per Kilometer (m3)	Basal Area per Kilometer (m2)	Above Ground Biomass per Kilometer (t)	Below Ground Biomass per Kilometer (t)	Total Biomass per Kilometer (t)	Above Ground Carbon per Kilometer (tC)	Below Ground Carbon per Kilometer (tC)	Total Carbon per Kilometer (tC)
1	100	0.01	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	100	0.18	3.55	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
3	100	0.73	5.99	0.12	0.00	0.04	0.02	0.07	0.02	0.01	0.03
4	100	1.81	8.40	0.52	0.03	0.22	0.13	0.35	0.11	0.06	0.17
5	100	3.43	10.65	1.48	0.09	0.73	0.41	1.13	0.36	0.20	0.56
6	100	5.53	12.71	3.23	0.24	1.74	0.98	2.72	0.86	0.48	1.34
7	100	8.00	14.55	5.87	0.50	3.42	1.92	5.34	1.69	0.94	2.63
8	100	10.69	16.18	9.41	0.90	5.82	3.26	9.07	2.87	1.61	4.47
9	100	13.49	17.60	13.71	1.43	8.90	4.98	13.88	4.38	2.46	6.84
10	100	16.29	18.83	18.60	2.08	12.55	7.03	19.58	6.19	3.46	9.65
11	100	19.01	19.89	23.85	2.84	16.64	9.32	25.95	8.20	4.59	12.79
12	100	21.58	20.81	29.28	3.66	20.98	5.87	26.85	10.34	2.89	13.23
13	100	23.98	21.59	34.69	4.52	25.42	7.12	32.54	12.53	3.51	16.04
14	100	26.18	22.26	39.93	5.38	29.83	8.35	38.19	14.70	4.12	18.82
15	100	28.17	22.83	44.92	6.23	34.10	9.55	43.65	16.80	4.71	21.51
16	100	29.96	23.31	49.57	7.05	38.14	10.68	48.82	18.80	5.26	24.06
17	100	31.55	23.73	53.84	7.82	41.91	11.73	53.64	20.65	5.78	26.43

18	100	32.95	24.08	57.71	8.53	45.37	12.70	58.07	22.36	6.26	28.62
19	100	34.19	24.37	61.19	9.18	48.50	13.58	62.08	23.90	6.69	30.59
20	100	35.26	24.63	64.29	9.77	51.32	14.37	65.69	25.29	7.08	32.37
21	100	36.20	24.84	67.03	10.29	53.84	15.07	68.91	26.53	7.43	33.96
22	100	37.02	25.02	69.43	10.76	56.06	15.70	71.76	27.63	7.74	35.36
23	100	37.73	25.17	71.54	11.18	58.02	16.24	74.26	28.59	8.01	36.60
24	100	38.34	25.30	73.37	11.54	59.73	16.72	76.45	29.43	8.24	37.68
25	100	38.86	25.41	74.96	11.86	61.22	17.14	78.37	30.17	8.45	38.62

Caesalpinia velutina

Spanish Name: Mandagual		**Type: Posts for rural construction**
Processing factor	1	Entire biomass assumed to be instantly returned to the atmosphere at time of harvest.
Rate of decay	N/A	
DBH	2.22982+0.74529*ht-0.00032*tph-0900555*precip	In house allometric equations developed using datasets published in CATIE. (1986). *Crecimiento y rendimiento de especies para lena en areas secas y humedas de America Central, 1986: Centro Agronómico Tropical de Investigación y Enseñanza.; and* Hurtarte, E.O., *Comportamiento en Plantacion de Mangium (Acacia mangium willd) y Aripin (Caesalpinia velutina (B y R) Standl) en America Central*, 1990, Turrialba (Costa Rica). p. 117.
Height	ln(ht) = -2.0144 + .9862*ln(t) - 0.00179 * ele + 0.000187*precip + 0.005728* slope	In house allometric equations developed using datasets published in CATIE. *Crecimiento y rendimiento de especies para lena en areas secas y humedas de America Central*, 1986: Centro Agronómico Tropical de Investigación y Enseñanza.
Above Ground Biomass	ln(agb)= -2.708 + 1,6155 * ln(DBH) + 1.1209 * ln(ht)	Hurtarte, E.O., *Comportamiento en Plantacion de Mangium (Acacia mangium willd) y Aripin (Caesalpinia velutina (B y R) Standl) en America Central*, 1990, Turrialba (Costa Rica). p. 117.
Stem Volume	ln(v) = -9.0215 + 1.4263 * ln(DBH) + 1.1431 * ln(ht)	Hurtarte, E.O., *Comportamiento en Plantacion de Mangium (Acacia mangium willd) y Aripin (Caesalpinia velutina (B y R) Standl) en America Central*, 1990, Turrialba (Costa Rica). p. 117.

Predicted Growth for *Caesalpinia velutina*

Age (years)	Count of Trees per Kilometer with Mortality	Tree DBH (cm)	Tree Height (m)	Stem Volume per Kilometer (m3)	Basal Area per Kilometer (m2)	Above Ground Biomass per Kilometer (t)	Below Ground Biomass per Kilometer (t)	Total Biomass per Kilometer (t)	Carbon per Kilometer (tC)
1	401	2.00	0.99	0.13	0.13	0.08	0.05	0.13	0.06
2	401	2.73	1.97	0.53	0.23	0.29	0.16	0.45	0.22
3	401	3.45	2.93	1.32	0.37	0.66	0.37	1.03	0.51
4	401	4.17	3.89	2.59	0.55	1.23	0.69	1.92	0.95
5	401	4.88	4.85	4.45	0.75	2.03	1.14	3.17	1.56
6	401	5.59	5.81	7.00	0.99	3.10	1.74	4.84	2.38
7	401	6.30	6.76	10.32	1.25	4.46	2.50	6.96	3.43
8	401	7.01	7.71	14.50	1.55	6.14	3.44	9.58	4.72
9	401	7.72	8.66	19.64	1.88	8.17	4.58	12.75	6.28
10	200	8.49	9.61	13.02	1.13	5.34	2.99	8.33	4.11
11	200	9.20	10.56	16.69	1.33	6.75	3.78	10.53	5.19

12	200	9.90	11.51	20.97	1.54	8.37	2.34	10.72	5.28
13	200	10.61	12.45	25.90	1.77	10.22	2.86	13.09	6.45
14	200	11.31	13.40	31.51	2.01	12.31	3.45	15.76	7.76
15	200	12.02	14.34	37.85	2.27	14.64	4.10	18.74	9.24
16	200	12.72	15.28	44.96	2.54	17.24	4.83	22.07	10.87
17	200	13.42	16.22	52.88	2.83	20.10	5.63	25.73	12.68
18	200	14.12	17.16	61.64	3.13	23.25	6.51	29.76	14.67
19	200	14.82	18.10	71.28	3.45	26.69	7.47	34.17	16.84
20	200	15.52	19.04	81.85	3.78	30.44	8.52	38.96	19.20
21	200	16.22	19.98	93.37	4.13	34.49	9.66	44.15	21.76
22	200	16.92	20.92	105.89	4.50	38.88	10.89	49.76	24.52
23	200	17.62	21.86	119.45	4.88	43.59	12.21	55.80	27.50
24	200	18.32	22.80	134.07	5.27	48.65	13.62	62.28	30.69
25	200	19.02	23.73	149.80	5.68	54.07	15.14	69.21	34.11

Appendix 3: Stand Growth Modelling (Years 26-50)

Assumptions	Quantity	Source
Growth rate under forest management (m^3/km/yr)	6	This is based on local professional knowledge, and is a common figure for timber stand growth.
Density of stand	0.573 (g/cm^3)	Average density of *Swietenia humilis* and Bombacopsis

The following gives the carbon benefit per kilometre of the fifty years of the project intervention. It also describes the harvesting in the stand management period.

Predicted carbon sequestered throughout crediting period per kilometre

Year	Count of Trees per Kilometer without Mortality	Count of Trees per Kilometer with Mortality	Above Ground Carbon (tC)	Below Ground Carbon (tC)	Live-Wood (tC) (AGB+BGB)	HWP Carbon Benefit (tC)	Total Carbon Benefit (tC)	Net Average Carbon Benefit (tC)
1	670	601	0.00	0.00	0.00	0.00	0.00	58.58
2	670	601	0.00	0.00	0.00	0.00	0.00	58.58
3	670	601	0.03	0.01	0.04	0.00	0.04	58.58
4	670	601	0.15	0.08	0.23	0.00	0.23	58.58
5	670	601	0.54	0.30	0.84	0.00	0.84	58.58
6	670	601	1.42	0.80	2.22	0.00	2.22	58.58
7	670	601	3.04	1.70	4.74	0.00	4.74	58.58
8	670	601	5.55	3.11	8.67	0.00	8.67	58.58
9	670	601	9.04	5.06	14.10	0.00	14.10	58.58
10	447	400	13.45	7.53	20.98	0.00	20.98	58.58
11	447	400	18.65	10.44	29.09	0.00	29.09	58.58
12	447	400	24.43	6.84	31.27	0.00	31.27	58.58
13	447	400	30.58	8.56	39.14	0.00	39.14	58.58
14	447	400	36.88	10.33	47.21	0.00	47.21	58.58
15	447	400	43.15	12.08	55.23	0.00	55.23	58.58
16	447	400	49.22	13.78	63.00	0.00	63.00	58.58
17	447	400	54.99	15.40	70.39	0.00	70.39	58.58
18	447	400	60.37	16.90	77.28	0.00	77.28	58.58
19	447	400	65.32	18.29	83.62	0.00	83.62	58.58
20	447	400	69.83	19.55	89.38	0.00	89.38	58.58
21	447	400	73.88	20.69	94.56	0.00	94.56	58.58
22	447	400	77.49	21.70	99.19	0.00	99.19	58.58
23	447	400	80.69	22.59	103.28	0.00	103.28	58.58
24	447	400	83.51	23.38	106.89	0.00	106.89	58.58
25	447	400	85.98	24.07	110.05	0.00	110.05	58.58
26	N/A	N/A	66.12	18.51	84.64	2.96	87.60	58.58
27	N/A	N/A	68.66	19.23	87.89	2.90	90.79	58.58
28	N/A	N/A	71.20	19.94	91.14	2.83	93.97	58.58
29	N/A	N/A	73.75	20.65	94.39	2.77	97.16	58.58
30	N/A	N/A	76.29	21.36	97.65	2.70	100.35	58.58
31	N/A	N/A	66.12	18.51	84.64	5.60	90.24	58.58
32	N/A	N/A	68.66	19.23	87.89	5.48	93.36	58.58

33	N/A	N/A	71.20	19.94	91.14	5.35	96.49	58.58
34	N/A	N/A	73.75	20.65	94.39	5.23	99.62	58.58
35	N/A	N/A	76.29	21.36	97.65	5.11	102.75	58.58
36	N/A	N/A	66.12	18.51	84.64	7.95	92.59	58.58
37	N/A	N/A	68.66	19.23	87.89	7.77	95.66	58.58
38	N/A	N/A	71.20	19.94	91.14	7.59	98.73	58.58
39	N/A	N/A	73.75	20.65	94.39	7.42	101.81	58.58
40	N/A	N/A	76.29	21.36	97.65	7.25	104.89	58.58
41	N/A	N/A	66.12	18.51	84.64	10.05	94.68	58.58
42	N/A	N/A	68.66	19.23	87.89	9.81	97.70	58.58
43	N/A	N/A	71.20	19.94	91.14	9.59	100.73	58.58
44	N/A	N/A	73.75	20.65	94.39	9.37	103.76	58.58
45	N/A	N/A	76.29	21.36	97.65	9.15	106.80	58.58
46	N/A	N/A	66.12	18.51	84.64	11.91	96.54	58.58
47	N/A	N/A	68.66	19.23	87.89	11.63	99.52	58.58
48	N/A	N/A	71.20	19.94	91.14	11.37	102.51	58.58
49	N/A	N/A	73.75	20.65	94.39	11.10	105.50	58.58
50	N/A	N/A	76.29	21.36	97.65	10.85	108.50	58.58

Appendix 4: Non-Permanence – Risks and Mitigation Strategies

	Risk type	Project's control over risk	Initial situation	Mitigation measure	Risk estimate time-frame	Probability (After management)	P	Impact (After management)	I	Score
A	Unclear land tenure and potential for disputes									0.1375
A.1	Land tenure	High	Privately owned land but often not registered nationally	Ownership and individual is verified with the municipality	Medium	Medium	0.1	Medium	2	0.2
A.2	Potential for disputes with landless individuals	Medium	Some individuals do not own land	Involve landless individuals in group activities (e.g. Nursery building) and seasonal work on neighbor's land.	Long	Low	0.05	Low	1	0.05
A.3	Disputes caused by conflicting land-use interests	High	A significant potion of land is underutilized but cattle often roam all over the place, which can destroy young trees	All projects are fenced in	Short	Medium	0.1	Medium	2	0.2
A.4	With inheritance to land, new land owner decides to not participate in project	Medium	Privately owned land usually by the patriarch or matriarch of the family	Education to current and future inheritors on medium and long term benefits of project. Continually education on importance of project on environment.	Medium	Low	0.05	Medium	2	0.1
B	Financial failure									**0.175**
B.1	Project financial plan	High	Financial strategy in place with backing and support from the Community Economic Development Corporation + future payments to producers kept in separate guaranteed fund	Development of business plans (reviewed periodically) for economically viable management	Medium	Medium	0.1	High	3	0.3
B.2	Decrease in timber value	Low	Fuel-wood and timber have high relative value	Diversification of chosen species	Long	Low	0.05	Low	1	0.05
C	Technical failure									**0.075**
C.1	Technical capability of project implementer	High	Proven capacity to design and implement activities	Only hire highly qualified staff	Short	Low	0.05	Medium	2	0.1
C.2	Poor choice of trees	High	Use of species well adapted to region	Evaluation of species based on experience	Short	Low	0.05	Low	1	0.05
D	Management failure									**0.05**
D.1	Management activities not carried out	High	Organization has experience carrying out	Project managers and staff adequately	Short	Low	0.05	Low	1	0.05

	effectively		project activities	trained						
D.2	Double-counting due to poor or bad faith record keeping	High	Proper record keeping system in place	Transparent record-keeping procedures written in project design document and quality mapping of project activities and area; up-to-date database maintained with records of all carbon monitored and sold	Short	Low	0.05	Low	1	0.05
D.3	Staff with relevant skills and expertise	High	Staff highly qualified	Careful selection of project staff and training	Short	Low	0.05	Low	1	0.05
E	Rising land opportunity costs that cause reversal of sequestration and/or protection									**0.1**
E.1	Returns to producer and implementer stakeholders	High	Opportunity cost of land very low	Financial analysis of project interventions. In addition of the payments for ecological services, the projects are designed to provide high valued products in the form of fuel wood and timber.	Long	Low	0.05	High	3	0.15
E.2	Introduction of new cash crop in region	Low	Tabaco production, the latest cash cop in region, is banned in municipality	Appropriate land use planning through Plan Vivos	Short	Low	0.05	Low	1	0.05
F	Political instability									**0.075**
F.1	Land reform removes property rights	Low	Government currently in process of legalizing property	N/A	Short	Low	0.05	Low	1	0.05
F.2	Social unrest	Low	Very peaceful community. Economic hardship is generally dealt with by searching for employment in cities of other countries	Continuous process of community consultations	Long	Low	0.05	Medium	2	0.1
G	Social instability									**0.05**
G.1	Disputes caused by conflict of project aims or activities with local communities or organisations	High	Project was build in consultation with other NGOs, community and government consultation	Participatory planning and continued stakeholder consultation over project lifetime	Medium	Low	0.05	Low	1	0.05
G.2	Participants lose interest in project	High	High degree of desired participation by	Project aims aligned with producers' needs	Short	Low	0.05	Low	1	0.05

			community							
H	Devastating fire									**0.1**
H.1	Forest fire	medium	Forest cover in the area is minimal and isolated making it difficult for fires to spread.	Removal of fuel wood from project areas	Long	Low	0.05	High	3	0.15
H.2	Intentional burning of agricultural land	medium	The local government has recently imposed heavy restrictions on the use of fire to clear land.	Ongoing involvement and dialogue with producers	Short	Low	0.05	Low	1	0.05
I	Pests and diseases									**0.05**
I.1	Incidence of tree crop failure from pests or disease	medium	Mahogany is the only chosen species subject to insect attack by the shoot borer, *Hypsipyla grandella.* These attacks are common and effect apical growth but rarely kill the tree when grown in polycultures.	Assessment of tree species, careful selection of tree species, strong diversification	Long	Low	0.05	Low	1	0.05
J	Extreme weather events									**0.25**
J.1	Drought	low	frequent (<1 in 10 years)	Replanting of trees as required, planting at the very beginning of wet season, selection of drought resistant species	Short	High	0.25	Medium	2	0.5
J.2	Hurricane	low	Hurricanes occasionally hit the region, notably hurricane Mitch in 1998.	Replanting of trees as required	Long	Medium	0.1	Medium	2	0.2
J.3	Floods	low	Infrequent (<1 in 10 years)	Replanting of trees as required in new areas	Short	Low	0.05	Low	1	0.05
K	Geological risk									**0.05**
K.1	Earthquakes	Low			Short	Low	0.05	Low	1	0.05
K.2	Landslides	medium	Land slides haven't cause much damage in the past	Projects don't take place in really steep areas	Short	Low	0.05	Low	1	0.05
	Overall Score (average of risk categories)									**0.10**
	Suggested risk buffer									**13.65%**

Appendix 5: Tree Count and Species Harvesting Schedule

The following table describes the number of expected trees in year 1, not taking into account mortality.

Expected # of Trees in Year 1

Trees Calculation	Type of Tree
670	Trees per kilometre
446	Posts
224	Lumber

The following table describes the harvesting of the different species in the project intervention.

Harvesting Schedule

Beginning of Year	Description of Harvest
1	Planting of all species
2	Replanting to take into account mortality of year 1
10	One half of *Caesalpinia velutina* is harvested for posts.
26	*Swietenia humilis* and *Bombacopsis quinata* are selectively harvested and processed.

Appendix 6: Baseline Approval Letter

Gobierno de Reconciliación
y Unidad Nacional
El Pueblo, Presidente!

2009: AÑO 30 DE
LA REVOLUCIÓN
Viva Nicaragua Libre!

Diciembre del 2009
Somoto Madriz - Nicaragua

La degradación de los recursos naturales en el departamento de Madriz en los últimos años es una realidad, la causa principal de esta degradación es la reducción del recursos forestal causada por el avance de la frontera agrícola (cambio de uso de suelo forestal a agrícola), y el uso de el recurso forestal para leña y madera; esta tendencia continuará sino se toman medidas urgente para frenar la reducción de los bosques en el departamento, medidas como por ejemplo: uso de suelo de acuerdo a su vocación (ordenamiento territorial), el aumento de la masa forestal mediante la reforestación, manejo de la regeneración natural y la protección del bosque existente actualmente.

La situación de los recursos naturales en el departamento de Madriz no es muy diferente a lo encontrado en la microcuenca Platanares, por lo que los resultados de la consulta realizadas a los miembros de las comunidades de esta microcuenca (aumento de tierras agrícolas y pastos y reducción de las tierras en descanso), no me parece poco realista.

Atentamente,

MSc Douglas Benavidez
Delegado Territorial MARENA - Madriz

PODER CIUDADANO
Nicaragua Gana con Vos!

Ministerio del Ambiente y los Recursos Naturales - DT Madriz
Del Reloj Público 2 ½ cuadras al sur - Somoto
Telefax 7222431
correo electrónico dbenavidez@marena.gob.ni
www.marena.gob.ni

Appendix 7: Technical Validation Report

Available through the Plan Vivo web site at:
http://www.planvivo.org/wp-content/uploads/Limay_Carbon_Project_Final_PlanVivoVal-_Report.pdf

Appendix 8: Minor Discrepancies in Monitoring Performance Indicators Outlined in the Technical Specification

Context

The CommuniTree Caron Program is a Plan Vivo Certified afforestation project managed by Taking Root and funded through the sale of ex-ante carbon credits. Ex-ante carbon credits are issued after the trees have been planted, monitored and reported through an annual report submitted to Plan Vivo. The same report also includes the results of periodic monitoring of land reforested in previous years against a number of performance indicators. The results of the monitoring events are used to 1) assure that the growth of the trees is aligned with carbon sequestration expectations, and 2) to form the basis of the conditional payments given to farmers for the silvicultural activities needed to achieve the targeted growth. The methods used to monitor the performance indicators related to tree growth and silvicultural activities are described and approved in the project's technical specifications.

While Taking Root continues to report monitoring results of newly planted land, members of the Plan Vivo secretariat have raised concerns that the way it reports the monitoring results of land planted from previous years imply the use of methods that differ from those outlined in its technical specifications.

As a result, the Plan Vivo secretariat has requested that Taking Root provides clarity on how the performance indicators are being monitored and how they differ from what is reported in its approved technical specifications.

As detailed in the sections below, despite the level of increased sophistication in how the CommuniTree carbon program operates since last updating its technical specifications in 2014, monitoring of performance indicators is surprisingly unchanged. The monitoring and frequency of performance indicators related to carbon sequestration is largely unchanged, the monitoring and frequency of performance indicators related to silvicultural activities is largely unchanged, but a number of discrepancies in CommuniTree's technical specifications create confusion and therefore need to be updated.

1. Monitoring and Frequency of Performance Indicators Related to Growth and Carbon Sequestration is Largely Unchanged

The carbon modelling used in CommuniTree's technical specifications is based on estimating carbon as a function of measurements of a sample of individual trees' DBH and extrapolating that to the population of trees planted. Specifically, Table 12 on p. 47 says that basal area per hectare (i.e. the sum of all the trees' diameters) are measured twice over a 10 year period (i.e. in years 4 and 7) and Section 11.1 specifies that such measurements take place using forest inventories.

To this day, this is how monitoring of performance indicators related to tree growth and carbon sequestration take place and is reported against in CommuniTree's annual reports. Taking Root has even started implementing a plan to increase the frequency of its forest inventories from two to four times over a 10-year period, in years 1, 3, 5, and 10.

2. Monitoring and Frequency of Performance Indicators Related to Activities is largely unchanged

CommuniTree's technical specifications specify that a number of silvicultural activities need to take place so that the trees reach the expected growth milestones, but that are themselves not directly related to carbon sequestration. These activities form the basis of farmer payments and include things like planting, weeding and pruning (see Table 12).

The documentation also says that in the early years, after a new piece of land is added to the program, multiple different payments are made to cover the costs of doing these required activities. The two paragraphs below Table 12 (p.47), also specify that completion of these activities is assessed by the supervising technician's judgment (i.e. not forest inventories).

To this day, this is how activity-based monitoring operates within the CommuniTree Carbon Program. Specific details are provided in Appendix 8.1. Silvicultural activities are assessed based on technician visits to visually determine whether activities have been performed such as trees planted, weeded, etc. Given that these activities are very time sensitive and critical to the project's success, the frequency can be as high as 17 visits per year. For such activities, the technician visits the site and takes a picture as evidence that the activity was performed before releasing payment. The summary on the number of this activity-based monitoring is reported in Taking Root's latest annual report in Table 7 on socio-economic data under Social Impact. In 2020, 18,889 of these events took place within the program.

3. Discrepancies in Approved Technical Specifications that need to be Updated

There are a number of relevant discrepancies in the CommuniTree's technical specifications that cause confusion and therefore need to be addressed in the PDD update scheduled for later this year.

Section 11.1 is called "Annual Monitoring Methodology" and explains how forest inventories are performed. While the forest inventory takes pace annually, this does not mean that every parcel of land is monitored annually using forest inventories. This confusion is amplified by the fact that many of the monitoring targets are very quantitative (e.g. 375 trees per hectare).

However, the following areas of the same document make clear that this was not intended to imply that every piece of land has a forest inventory performed every year:

- Some of the performance targets detailed in Table 12 are not easily addressed through forest inventories like the status of fences. Rather, forest inventories should only be used to measure the size of trees so that carbon estimates can be extrapolated.

- The text in the paragraph below Table 12 makes clear that activity-based monitoring takes place multiple times in one year, and that wouldn't sensibly be done using forest inventories.

Furthermore, no sensible forestry organization in the world performs ground-based forest inventories annually on the same piece of land given the cost and complexity of doing so. This holds true for large timber concessions, so it is especially untrue for smallholder programs that need to monitor thousands of small pieces of land spread over large distances.

These discrepancies are likely the result of an imperfect update in 2014 to the original version of the technical specifications published in 2010.

To fix this issue, the technical specifications need to be updated. Specifically, Section 11 should clearly specify that carbon sequestration targets are monitored using forest inventories and that these forest inventories are done at least every five years. It should also specify that activity-based monitoring of silvicultural activities is done more frequently by technician site visits.

Appendix 8.1 - Process made for monitoring activities and releasing payments to farmers

Payments to farmers are made using the following annual process:

1. The technician works with the farmer on a case-by-case basis to assess the activities required for the optimal establishment and growth of the trees (e.g. fencing the property, preparing the land for planting, preparing tree nurseries, planting, weeding, pruning, etc.).

2. The technician and the farmer agree on a budget for the given activity based on the state of the parcel, which has to be inferior to that year's annual budget based on their performance-based agreement.

3. The technician requests the budget from their regional coordinator, who confirms the availability of funds and that the request is reasonable based on completing and signing a request for funds form. If the request for funds is > $700, the head of operations (i.e. the regional coordinator's superior) also needs to approve.

4. The regional coordinator passes the signed request for funds form to the administration department, which does a final review against the allocated budget and issues a cheque for that amount in the farmer's name.

5. The technician reviews the completion of the farmer's activity and records the results, including a geo-tagged picture in FARM-TRACE, and gives the farmer the cheque. Should the activity not be completed, the farmer does not receive the payment.

6. When multiple activities are not complete and/or the farmer demonstrates an unwillingness to carry out the activities as outlined by the PES agreement, they are removed from the program and new land is recruited as a substitute.

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