Plan Vivo Project Design Document (PDD)

CommuniTree Carbon Program

Taking Root

APRODEIN

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Executive Summary

The CommuniTree Carbon Program in Nicaragua is Taking Root's flagship smallholder reforestation project. Together with the local reforestation partner APRODEIN, Taking Root has been successfully rehabilitating forest ecosystems while improving farmer livelihoods since 2010. Over the last decade, the project has become an example across the industry of how to scale community-led natural climate solutions. In 2019, the CommuniTree Carbon Program became the single largest reforestation initiative in Nicaragua, and in 2021, it was featured by the UN Decade on Ecosystem Restoration as one of its Founding 50 implementers. This document outlines an updated project design document (PDD) that will continue to grow the success of the CommuniTree Carbon Program.

In Nicaragua, there is a crucial need for forest rehabilitation to improve smallholder farmer livelihoods and mitigate climate change. Historically, the country has suffered from significant deforestation, largely from agriculturally based land-use change. As a result, there is a large amount of land in need of rehabilitation, which is primarily owned and managed by smallholder farmers. At the same time, Nicaragua is the second poorest country in the Western Hemisphere, with many of its population struggling to maintain secure livelihoods. Nicaragua also ranks 6th on the global long-term climate risks index, making it paramount to offer mitigation strategies for farmers to address the effects of rising temperatures and water scarcity on their lands. If farmers could improve their livelihoods by growing trees, they could become part of the solution for wide-scale forest restoration and climate change mitigation. However, they often lack the administrative, financial, and technical resources to implement successful and long-term forestry and agroforestry planting models.

The CommuniTree Carbon Program aims to fill this gap by enabling farmers to benefit from growing trees through the creation of forest carbon removal credits (hereinafter "carbon credits"). The project does this by combining a community led approach with best-practice forestry techniques and cutting-edge technology. The project engages farmers over a 10-year period to help them grow trees in a way that is beneficial to them in both the short and long term. In the short term, they benefit through the sale of carbon credits, and in the long term, through new sustainable sources of income.

At every step of the project, CommuniTree upholds exceptional standards to ensure the highest quality. Community consultations and farmer workshops are held for education and knowledge sharing, acknowledging the needs and values of individual communities. Upon joining the program, farmers choose to integrate any of Taking Root's available tree plantation interventions (tech specs), designed in a way to complement existing agricultural practices and provide them with additional and diversified value over time. As farmers start growing trees, the Taking Root technology platform facilitates the collection of ground data, monitoring of tree growing activities, quantification of carbon, and delivery of carbon credits to buyers. The delivery of carbon credits enables access to project financing, as well as payments for ecosystem services to farmers enrolled in the program.

This updated Project Design Document reflects the increased ambition of the CommuniTree Carbon Program. Most notably, an expansion beyond the Northwestern region into the rest of the country, as well as further integration of the Taking Root technology platform to facilitate the implementation of the project at scale. The CommuniTree Carbon Program continues to push the boundaries of what can be achieved with smallholder farmers, demonstrating that forest restoration at scale is possible while benefiting the communities who need it the most.

Part A: Aims and objectives

Project aims

The aim of the CommuniTree Carbon Program, hereafter referred to as 'the project', is to build a large-scale, locally empowered, and inclusive reforestation-based economy which will mitigate climate change, improve smallholder farmer livelihoods, and rehabilitate the ecosystem's environmental integrity.

Objectives

The project has the following strategic objectives:

- Grow trees with farmers to sequester carbon from the atmosphere
- Grow trees on farmland to improve and diversify farm productivity
- Implement a reforestation model which supports the growth of native tree species to rehabilitate biodiversity, habitat, and degraded landscapes
- Generate alternative income sources to improve farmers livelihoods through
    - Payments for ecosystem services (PES)
    - Sales of sustainable forest products and agroforestry commodities
- Increase forest cover to protect critical watersheds and regional water resources

Part B: Site Information

B1 Project location and boundaries

The project is co-managed by Taking Root and its reforestation partner APRODEIN, and the project boundaries are defined as Nicaragua's national territory (Figure 1), which stretches from the Pacific Ocean in the west to the Atlantic Ocean in the east, sharing land borders with Honduras to the north and Costa Rica to the south. The project started in 2010 in the municipality of San Juan de Limay (marked in red); it has since grown, and now operates nationwide. Farmers from any municipality in the country's main regions (Central, Pacific, and Atlantic) can join the project.

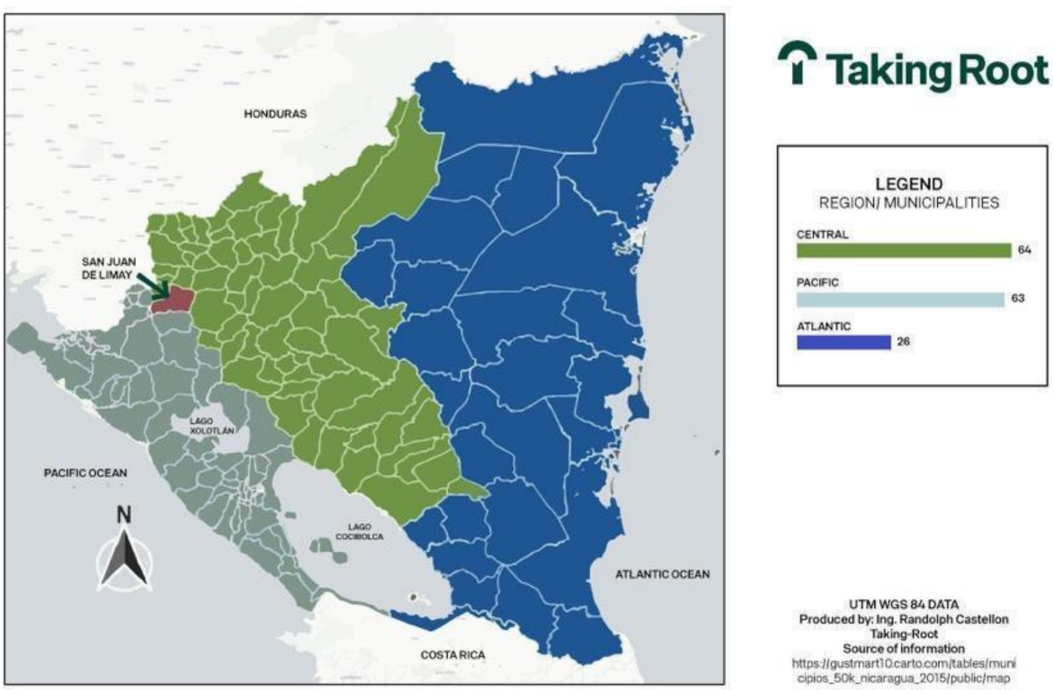

Figure 1. Project location and boundaries. The original project area within the municipality of San Juan de Limay is highlighted in red.

B2 Description of the project area

Nicaragua is located in Central America in tropical latitudes between 10˚and 15˚ North. It has an area of 130.000 km^2. The topography of the country is a mix of coasts, plains, and high mountains that determine the climate, which is classified as tropical wet-dry (Taylor & Alfaro, 2005).

The Atlantic Coast has rainfall throughout the year, especially from October to December, and, to a lesser extent, between January and April (Hastenrath & Polzin, 2013). The Pacific side has a well-defined cycle of precipitation that is characterized by a rainy season from May to November with a period of lower rainfall in July and August (mid-summer drought), and a dry season for the rest of the year, which is typical of the wet-dry tropics of Central America (Hund et al., 2020). The Central highlands in the country's interior have a longer rainy season than the Pacific lowlands (Hastenrath & Polzin, 2013). This marked precipitation season defines the tree planting season for the project in the Pacific and Central regions of the country.

Temperatures across the country also vary with topography (Taylor & Alfaro, 2005). The Atlantic region has temperatures above 24ºC. The mountainous ranges in the Central region are cooler, with mean temperatures around 22ºC. The volcano dotted plains along the Pacific Ocean see higher temperatures that hover around 27ºC.

The main rivers in the country are the San Juan, Coco, Grande, and Escondido. The country also features the largest lake in Central America, called the Lago Cocibolca.

The climatic features of the country, its complex topography and tropical location between the Pacific and Atlantic Oceans, make Nicaragua exceptionally vulnerable to the effects of climate change. The country holds 6th place in the global long-term climate risk index (CRI) for 1998-2017 (Eckstein et al., 2019). Nicaragua is under the effect of El Niño-Southern Oscillation (ENSO) which has been observed to result in regional drought and water-related conflicts in the Central American Pacific region (Kuzdas & Wiek, 2014; Vignola et al., 2018). Inter-annual variability is high for both the Atlantic and Pacific watersheds, with near decadal cycles of extreme precipitation (Hastenrath & Polzin, 2013). Distressing climate events such as severe storms, floods, and droughts occur frequently, affecting rural livelihoods, and causing disturbances across landscapes and ecosystems (Imbach et al., 2017).

Nicaragua has the largest tropical rainforest north of Amazonia (Weaver et al, 2003). A rainforest to dry-forest (rainfall) gradient stretches along the southern border of the country, and a rainforest to cloud forest (altitudinal) spans the Pacific lowlands and North Central regions. The Central region also features lowland pine savannas, cloud forests, and oak-pine forests. These species-rich forest ecosystems, however, are threatened by the vast, and ongoing, clearance of forests for agriculture. Only 27% of the country remains covered by forests, as deforestation is advancing at an average rate of 76,000 hectares per year, the second highest deforestation rate in Central America (Global Forest Watch, 2022). Today, many areas of the country only feature patches of mature trees that once defined the landscape and provided abundant precipitation, water resources protection, and wildlife.

B3 Recent changes in land use and environment conditions

Clearing forests for agriculture and extensive cattle ranching have been the main factors leading to changes in land use and environmental conditions in the project area. Nicaragua's economy has relied on agricultural exports since the 1900s, initially focusing almost inclusively on bananas in the lowlands and coffee in intermediate altitudes. By the late 1940s, beef and cotton were added to the portfolio. Since the late 1970s, the production of beef has expanded rapidly across lowland areas. Coffee remains the most important export product and is predominantly cultivated as a monocrop, due to its high export value (Imbach et al., 2017). However, national coffee crop productivity and yield has become increasingly vulnerable to climate change (Rahn et al. 2014).

Throughout Nicaragua, approximately 1.5 million hectares are dedicated to agriculture, which represents just about 40% of the country's territory (The World Bank, 2022a). While traditional crops such as sugarcane and bananas are predominantly controlled by large companies, smallholder farmers are increasingly included in the export economy for basic grains, and non-traditional products (horticulture and fruits), notably coffee and beef (Imbach et al., 2017). Coffee is produced in big plantations and by a large number of small-scale farmers (Imbach et al., 2017). Beef is the second most important agricultural commodity and makes up 25% of exports (World Bank, 2015a). There exists a total of 135,000 cattle ranchers in the country, 90% of which are small-scale producers (Augustin et al., 2021).

As a result of agricultural expansion, the country has experienced the widespread conversion of forest to pasture over the past decades. With extensive agriculture came degradation of soils and pastures, and the loss of valuable genetic resources. The carbon dioxide released by cutting trees and slash-burning forests contributes to global warming (Curtis et al., 2018). Given Nicaragua's high vulnerability to climate change, extreme weather events are bound to affect these heavily altered landscapes ever more severely (Eckstein et al., 2019) and it is projected that social, environmental and economic costs will outweigh the benefits of any future deforestation (IPCC, 2022).

B4 Drivers of degradation

In Nicaragua, the main driver of deforestation and ecosystem degradation is the expansion of the agricultural frontier and the intensification of agricultural production (Figure 2).

The past few decades have seen the expansion of the industrial agricultural model in the country. Coffee and beef, among other products, have become important cash crops for smallholder farmers who depend on them as their principal source of income. As a result of external demand, farmers clear forestland to further intensify production when they expect the value from their land to be higher than the forest that would otherwise occupy it. This has resulted in the large-scale conversion of forests for livestock herding and monocrops, such as unshaded intensive coffee plantations (i.e., sun coffee).

Coffee productivity has declined as a result of increasing temperatures driven by climate change across the producing coffee regions (Rahn et al. 2014). Increasingly higher temperatures pose a threat to arabica coffee producers through higher incidence of pests and diseases (V. der Vossen et al., 2015) such as leaf rust, *Hemileia vastatrix*, which is ravaging coffee agroforestry in Central America. The disease causes coffee leaves to fall prematurely, reducing yields by 10-40% (V. der Vossen et al., 2015). Currently, 80% of coffee stands in Central America possess susceptibility to leaf rust. However, most coffee farmers cannot afford to switch to disease resistant varieties.

The demand for productivity under this intensive agricultural model, coupled with lax environmental policies and legislation, has resulted in large-scale damage to soil and pastureland. Declines in soil fertility and reduced biodiversity can be observed across most of the country's agricultural hot-spots (Stubenrauch et al. 2018) and in Nicaragua's dry corridor, where most cattle herds are maintained. Overgrazing from livestock production has led to a reduction in grass cover, invasion by weeds, and deterioration of biological and chemical soil properties (Holman et al., 2014).

Aside from the effects of agriculture, logging forests for timber and fuelwood acts as an additional driver for forest degradation. In pursuit of economic opportunities to sustain their livelihoods, smallholder farmers in Nicaragua often divert to fuelwood trade, which can be countercyclical to the agricultural season, providing an important source of household income during ‘off-peak’ agricultural production times (Baker et al., 2014). However, lack of knowledge and education in sustainable forest management has led to the overexploitation of the resource, which undermines long-term opportunities for farmers to sustain their livelihoods from these activities in the long term.

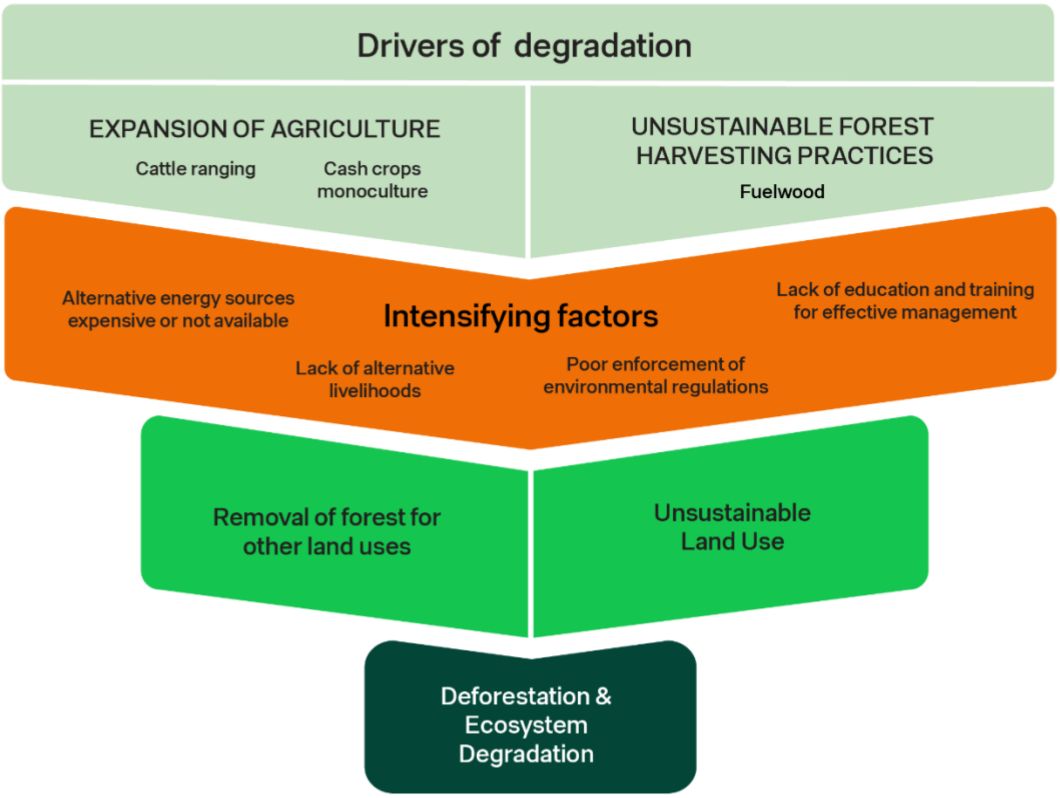

Figure 2. Conceptual model showing the drivers of deforestation and ecosystem degradation.

Part C: Community and Livelihoods Information

C1 Description of the population in the project area

Population and administrative division

Nicaragua has a total population of 6.5 million people, of which 40% reside in rural areas (World Bank, 2022a). Administratively, the country is divided into two self-governing autonomous regions (*Atlántico Norte* and *Atlántico Sur*), 15 administrative divisions (*departamentos*), and 153 municipalities ruled by local councils.

Cultural and ethnic groups

As an ethnic group, the majority of the Nicaraguan population (70%) identifies as 'mestizo' (people with mixed European/Indigenous heritage). Six percent identify as African/Indigenous. According to official estimates, only 3.6% of the population self-identifies as Indigenous (World Bank, 2022b), the majority of which resides in remote rural settings with limited access to electricity, piped water, and sewerage (World Bank 2015b). Strengthening property rights and modernizing land administration remains a challenge in Nicaragua, especially for Indigenous people that occupy their traditional territories. Estimates are that about one-third of parcels in rural areas are still held without a clear title, affecting tenure security for the rural poor and access to credit (World Bank, 2020a).

Gender equity

Nicaragua has a female population of approximately 3.3 million, which is 50.7% of the total population (World Bank, 2022a). Women are legally allowed to own land, of which they own 13% of the national farmland under production, 40.3% of which has been acquired through inheritance (Flores et al. 2017). Despite participating in economic activities, Nicaragua's female farmers remain under-represented in agricultural committees and administrative roles, and despite government plans to launch a gender equity initiative for rural women to access finance for farming and equipment, no such fund has been put in place since the announcement was made in 2010 (Oxfam, 2016).

C2 Socio-economic context

Nicaragua is one of Latin America's least developed countries, with significant social and economic inequities. According to official figures, approximately one-fourth of the country's entire population lives below the poverty line. In rural areas, this percentage is twice as high. Fifty-two percent of the rural population counts as poor (i.e., lives on $3.20 a day (2011 PPP) or less) (World Bank, 2022a).

A large part of the country's agricultural production, approximately 70%, is produced by smallholder farmers that operate at non-industrial scales and rely on the land to feed their families and derive firewood for electricity and heat (Oxfam, 2016). Despite their important contributions to the agricultural sector, these farmers face low and unstable incomes as a result of their dependence on fluctuating global commodity prices (World Bank, 2015b). Their delicate economic situation is compounded by a lack of access to social infrastructure and services. To this day, Nicaragua has poor and insufficient roads that restrict mobility, increase transport costs and productivity losses, and preclude economic opportunities, especially for the rural poor (The World Bank, 2020b).

Because of a direct dependence on the land for income and livelihoods, the consequences of climate change are likely to disproportionately affect smallholder farmer welfare. Coffee production, for example, is expected to vastly shrink in some critical areas, as suitability is to be reduced up to 40% in the country due to temperature rise and water supply shortages (Rahn et al., 2014). It is estimated that, under current climate change predictions, by 2050, it will no longer be possible to produce coffee in Nicaragua under 700 meters above sea level (masl) (Läderach et al. 2017). Therefore, crop diversification, alongside crop management, has been suggested as vital to strengthen food security in the face of climate hazards such as drought and coffee leaf rust (Bacon et al. 2021).

Farmers depend on the land for firewood and subsistence (Baker et al., 2014). Maize and bean production (among other crops) feed the rural population, and both crops are anticipating severe losses due to climate change (Bacon et al. 2021). For all the above reasons, smallholder farmers face the need to diversify their production and income sources, strengthen local food security and land tenure, and increase the resilience of local ecosystems from degradation and climate change.

C3 Land tenure & ownership of carbon rights

The project works with smallholder farmers who possess documentation to prove that they own their land. In Nicaragua, carbon rights are associated with land ownership (see section G2 for the relevant national laws for the carbon market).

Private ownership of farmland can be acquired through land market purchase, inheritance, and land reform, and there exist several broad categories of titles, including legal deeds, individual land reform titles, but also (problematic) informal titles (i.e., pieces of paper that attempt to document recognized property rights; and documentation issued in the name of someone else) (Broegaard, 2009). Strengthening property rights and modernizing land administration presents a challenge to Nicaragua's social and economic development. Previous conflicts in the country and decades of inconsistent administrative decisions affected land records and tenure security (World Bank, 2020a).

Given this context, farmers that want to participate in the project must possess officially recognized documentation in their own name to demonstrate ownership of their land. This will ensure the long-term sustainability of the trees planted, and the lawful rights of the participants regarding the ownership of carbon credits generated through the project.

The government has begun to inscribe all formal land titles in the land administration system as part of recent reforms, but it is expected to be a lengthy process (World Bank, 2020a), which is why the lack of registration does not affect the legality or validity of farmers' existing documents. Specifically, prospective participants must demonstrate land ownership in one of the following four ways:

- Have a legal deed to their land (*escritura privada*), such as a sales agreement certified by a lawyer.
- Have a legal deed to their land, such as a sales agreement, and have registered ownership with the national land title register (*escritura publica*).

- Have a legal deed to the land in their parent's name with a legal contract demonstrating their right to a specified fraction of the property (*cesión de derechos*).
- Have signed a binding contract with another individual to purchase the land they farm (*Contract for Deed)*, certified by a lawyer (*promesa de venta*).

Once provided, the field technicians upload copies of farmers' legal land ownership documentation via Taking Root's mobile app for record-keeping and legal monitoring on the Taking Root technology platform.

Part D: Project Interventions & Activities

D1 Project interventions

The interventions in this project share a common vision: to make reforestation a beneficial land-use option for farmers. The project is currently built around three types of interventions: Mixed-Species Forest Plantations, Silvopastoral Planting, and Coffee Agroforestry. All three interventions contribute to ecosystem rehabilitation and provide benefits to farmers, as summarized below in Table 1.

Table 1. Summary of project interventions

Intervention Type	Project Intervention	Description	Eligible for PV Accreditation
Ecosystem Rehabilitation	Mixed-Species Forest Plantations	The project plants mixed-species tree plantations with farmers on underutilized portions of their farmland. Restoring tree cover on degraded lands reduces carbon emissions, provides biodiversity benefits, fertilizes the soil, and increases water security, by reducing the probability of flooding in the wet season, and increasing water retention in the dry season. Farmers receive benefits from sales of carbon credits and the production of sustainably grown fuelwood, posts and beams for rural construction, and high-value timber products.	Yes
	Silvopastoral Planting	The project implements an alternative production system with farmers that integrates trees and improved pasture with livestock. Adding trees to the landscape increases the structural connectivity of the forest and its habitat, improves soil water retention and soil quality through a more complex root structure and a more diverse assemblage of invertebrates and microbial communities in the soil. Silvopastoral systems also fix significant amounts of carbon in the soil and live	Yes

		tree biomass. Farmers receive benefits from more productive pasturelands, sales of carbon credits, and the production of sustainably grown fuelwood, posts and beams for rural construction, and high-value timber products.	
	Coffee Agroforestry	The project grows high-yielding coffee agroforestry systems with farmers. Establishing new coffee agroforestry systems at higher elevations protects crops from rising temperatures and reduces their susceptibility to rust attacks, improving farmers' resilience to climate change. The cultivation of shade grown coffee further acts as an effective carbon sink. Recuperating tree and permanent woody vegetation (coffee) land cover in high elevation farmland helps with the conservation of soil and water. Perennial vegetation cover helps stabilize soils and improve soil water retention, and thus reduces the probability of flooding, landslides, erosion, and nutrient leaching. Shade vegetation further improves water quality and replenishment of groundwaters. Farmers benefit from a more diversified agricultural production, more resilient farms, as well as sales of carbon credits and coffee.	Yes

D2 Project activities for each intervention

Table 2. Summary of project activities taking place in intervened farms for the proper establishment of the project interventions. A detailed explanation of these activities can be found in sections G1 and K1.

Project Interventions	Activities	Description of Activities
Mixed-Species Forest Plantations ***Silvopastoral Planting*** ***Coffee Agroforestry***	Selection of Interventions	• General assessment of farm • Creation of the *plan vivos* based on selected intervention • Area to intervene is mapped using Taking Root's mobile app • PES contract signing
	Nursery Establishment	• Delivery of inputs (bags, seeds, sieve etc.) • Nursery(ies) is/are established (in-farm and central) • Seed planting and growing of seedlings • Ongoing watering, pest/disease control, etc.
	Planting	• Planting areas are prepared • Fences are built to protect seedlings • Seedlings are planted
	Tree Maintenance (Silviculture)	• Weeding • Pruning • Thinning • Monitoring of tree maintenance activities
	Tree Growth Monitoring	• Field technicians perform forest inventories in the intervened areas using Taking Root's mobile app

Project field technicians discuss with farmers the most suitable interventions based on the general properties of the farm (e.g., elevation levels, road access, farm size) and the farmer's best interests. They then create *plan vivos* and keep records of all of them in the Taking Root technology platform. The platform, including its web and mobile applications, have been designed to support project implementation, track activities and progress, and enable tree growth and carbon field monitoring so that sequestered carbon calculations in intervened farms are automatically generated.

Using the mobile app, field technicians record farm and farmer general information, map the perimeter of the planting plot (parcel), track progress of several project activities, and regularly perform tree growth monitoring following a science-based tree sampling methodology. The monitoring data is recorded and stored in the platform database. For more information on how the Taking Root technology platform is used within the project, refer to sections G Technical Specifications, J1 PES Agreements, and K1 Ecosystem Services Benefits.

To ensure the implementation of all the activities listed in Table 2 above, project field technicians train farmers during frequent in-farm visits, track the implementation of the prescribed maintenance activities, and carry out tree growth monitoring via forest inventories to confirm contractual carbon targets are being met.

D3 Effects of activities on biodiversity and the environment

Project activities affect biodiversity positively by improving biodiverse habitats through native species reforestation. The project emphasizes the collection of seeds from around the community whenever possible, instead of buying only from commercial suppliers, to promote genetic variation within species. A more diverse tree stock increases vegetation biodiversity within farms and at the landscape level while providing increased habitat for wildlife.

Environmentally, the planting of trees on degraded land promotes diversification of soil microbial populations, stabilizes the soil structure, and improves the capacity of the soil to hold and infiltrate rainwater, contributing to the replenishment of ground and surface water storage. The inclusion of nitrogen-fixing leguminous trees in the planting designs improves soil health and fertility.

Project activities also affect the environment positively by contributing to the reduction of greenhouse gases in the atmosphere and helping regulate temperature by increasing shade. Planting trees in areas that are close to critical watersheds helps regulate the hydrological cycle, helps stabilize river flows, improves groundwater recharge, and provides buffers against winds and intense rain events.

Nicaragua maintains around 72 protected conservation areas throughout the country (MARENA, 2020). MARENA, the Nicaraguan Ministry of the Environment, oversees the forest management in these areas. Due to the often-degraded state of these protected regions, the government actively promotes reforestation initiatives therein. Protected areas have individualized land use plans which delineate 1) core and buffer zones, and 2) the harvesting and management of the forests in each zone.

Taking Root collaborates with local farmers to plant trees on degraded lands within these buffer zones. In doing so, we engage closely with MARENA to ensure compliance with the area's land use policies and to secure the necessary permissions for wood harvesting, consistent with our Plan Vivo approved planting designs.

Given Taking Root's focus on degraded smallholder lands, the project is anticipated to yield a net positive impact on biodiversity. Anecdotal reports from project members indicate regular sightings of diverse wild fauna, including birds, reptiles, and mammals such as deer, anteater, and wild sloth.

While there isn't a formal system in place for monitoring potential negative biodiversity impacts, the project's long-term approach emphasizes the education of farmers and communities on sustainable forestry and farming practices, as well as promoting awareness around climate change and the environment among its participants.

Part E: Community Participation

E1 Participatory project design

The project uses a four-stage participatory design process to ensure long-term success (Figure 3). This participatory process begins in the recruitment stage and continues thereafter for a minimum of 10 years during which Taking Root and APRODEIN support participating farmers with the establishment of project interventions. Revisions to the process are performed every five years to accommodate the evolving interests and concerns of all project stakeholders. The following sections elaborate on each step of the participatory design process.

Figure 3. Project participatory design cycle

1. **Stakeholder mapping**

Before the project starts operating in a new area or community (i.e., starts reforestation activities), consultations are held to learn about farmers' interests, priorities, shared values, culturally sensitive areas, and local key stakeholders. Stakeholder mapping is conducted by various people who are knowledgeable of the project (e.g., APRODEIN staff, long-term participating farmers, local experts) to ensure a complete picture of all relevant stakeholders, their status, and their needs regarding the project. Stakeholder mapping thereby involves a brainstorming exercise to determine for each identified stakeholder:

- Their level of influence for project success
- Their level of interest in project outcomes
- Whether they belong to a marginalized group, namely:
    1) women
    2) landless farmers
    3) farmers with insecure land tenure
- How frequently they are consulted

Once identified, the information is recorded in a stakeholder chart using the following headers:

Level of Influence in Success of the Project (High/Low)	Level of Interest in Project Outcomes (High/Low)	Marginalized (Yes/No)	Frequency of Engagement

2. **Stakeholder engagement**

Once stakeholders are mapped, their involvement and input will be ongoing. Meetings follow a tailored approach to ensure that the point of contact and meeting location fit the needs of each stakeholder, and are recorded as such in the stakeholder chart (Table 3):

Representative/ How to contact	Marginalized (how to accommodate)	Meeting Location

Special consideration is given to marginalized groups in various forms.

Meetings may also offer special accommodations for female farmers (as of 2022, the project has 20% female farmers among its active participants). To address gender and power dynamics amongst different genders, meetings may consider special seating arrangements for women farmers to sit separately with APRODEIN staff to express their opinions and concerns.

When planning and holding meetings, Taking Root selects a meeting location that accommodates availability or transportation needs. At a minimum, meeting minutes include date, location, attendance indicators, concerns expressed by participants, and requests noted. Photos or videos may be taken where appropriate. See Annex 7 for photographic evidence of stakeholder meetings.

There are several ways in which the project supports the engagement of community groups who experience initial barriers to participate in the project. The project supports interested farmers without secure land tenure by informing them of the process to obtain the legal documents required for project participation, as well as facilitating the application process. Interested elders who may not be physically able to participate in the program are given the option to sign a leasing agreement with their sons/daughters for the latter to become the main participants in the project on their behalf. The project also reduces limitations posed to financially unstable farmers by offering pre-payments and loan arrangements to help them overcome the initial financial participation barriers. More information on pre-payments and loans can be found in section J2. The project ensures that marginalized groups are aware of and invited to the community engagement events as well as informed of employment opportunities within the project.

Farmers in project areas without land of their own, known as landless farmers, typically find work on other farms, often their neighbour's. The project does everything it can to support landless farmers in the region. Most commonly, CommuniTree provides opportunities for landless farmers to be involved in project activities as workers (e.g., in nursery building) and/or as seasonal labour on project participant's land.

3 & 4. Integrating and offering continuous feedback

During stages three and four, key stakeholder input and feedback are considered as part of ongoing project improvement, project replication (scale-up) and for the long-term engagement plan across the country. They are recorded in the stakeholder chart:

Main Interest/Concerns	How the project addresses interests/concerns

Feedback from farmers is ongoing and is received during the frequent field visits and training sessions on their farms, where the technicians discuss the project with them, take note of any concerns, and communicate internally their ideas. An example that illustrates how the project is designed with stakeholder needs in mind is the selection of tree species and planting designs. Initial input expressed by farmers highlighted that planting trees should not limit other land uses (i.e., subsistence and agricultural production). As a direct result, the applicability conditions in the project interventions have been designed to prevent this from happening (see sections D1 and E2).

Table 3 summarizes all four steps of the project participatory process. The current stakeholder chart has all principal stakeholders, considerations for engagement, and demonstrates how feedback from engagement has been incorporated into the project design on a continuous basis.

Table 3. Summative project stakeholder chart

Participatory Project Design in 4 Steps									
Stakeholder Mapping (Step 1)					**Stakeholder Engagement (Step 2)**			**Integrating Feedback (Step 3)**	**Continuous Feedback (Step 4)**
Stakeholders	**Influence (High/ Low)**	**Interest (High/ Low**	**Marginalized (Yes/No)**	**Frequency of Meetings**	**Representative/ How to contact**	**Marginalized/ Special Considerations**	**Meeting Location**	**Main Interest/ Concerns**	**How the project addresses interests/concerns**
Smallholder Farmers	High	High	Y	Bi-Weekly + phone calls	Field Technicians (visit/call farmers)	limited transport; gender dynamics	Farms, Villages	Trees cannot take space needed to grow food for subsistence Upfront costs are high; Frequency of payments to sustain activities;	Farmers select species & tech specs to that they improve farm yield Offer pre-payments in year 1 to help farmers meet eligibility requirements Pay farmers for performed activity target using the technology platform
Forest Institute (INAFOR)	High	High	N	Weekly	Regional Administratives (call or visit)	N/A	INAFOR Offices	Forest plantations must be legally registered	Plantations are registered with INAFOR; Help shape legislation so that farmers can more easily register forest plots
Government (Climate Office, MARENA)	High	Low	N	Monthly	Public Officials (call/email)	N/A	Ministry Offices	Project exceeds forest carbon policy and legislation	Project registers forest polygons with the national carbon registry
Municipalities	High	High	N	Monthly	Mayors (Call/visit)	N/A	Village/ Town Office	Receive taxes Environmental targets	Project pays local tax; Participates in trainings and events for general public
Universities (UNA, UNAM)	Low	High	N	Bi-Monthly	Principal Investigators (Email/call)	N/A	Farms Video Calls	Students need to gain practical experience; Directly apply innovations	Project accepts student interns; Project tests biochar in real farming context
Donors (BANPRO, GIZ)	High	High	N	Monthly	Donor Staff (e-mail/call)	N/A	Office; Video Calls	Want to meet social and climate targets of their fundings schemes	Project provides ongoing monitoring via the technology platform and reports outcomes annually
Farming Associations (Foganic, Conagan)	Low	High	Y	Monthly	Association Directors (call/visit)	limited transport; Gender dynamics	Farms, Villages	Need to improve their sustainable practices and income	Project gives presentation and recruits new farmers on an ongoing basis

E2 Community-led implementation

Community-led implementation is a guiding principle and is imperative in the success of this project. The process leading up to preparation and registration of *plan vivos* are led by farmers and supported by field technicians. Eligible farmers (section C3 'Land tenure) who voluntarily choose to participate in the project take a leading role in designing and carrying out interventions on their lands based on their preferences and the technical advice from the field technicians. Technicians visit eligible farmers and discuss with them the project interventions they are interested in and the areas where farmers envision interventions will take place.

Table 4 shows the applicability conditions against which the field technicians will evaluate the area(s) selected by the farmer. The applicability conditions have been identified as key factors to ensure the success of each intervention type and therefore farmer benefit. Only if the general characteristics of the farm match with the applicability conditions of the chosen intervention will farmers proceed to create hand-drawn maps of their farms (*plan vivos*) and the signing of PES agreements. Through the drawing exercise, farmers discuss and identify their property's boundaries, current and previous land used for cultivating crops or pasture, existing water sources for irrigation (e.g., wells, nearby rivers), as well as areas with cultural or biological significance, and the final location of the planting area(s). These maps also illustrate where farmers want project interventions to take place so that these activities don't interfere with their livelihoods.

Table 4. Applicability criteria for project interventions

Criteria	Mixed-Species Forest Plantations	Silvopastoral Planting	Coffee Agroforestry
Elevation	Intervention area is 1400 masl. or lower.		Intervention area is between 500 masl. and 1,700 masl.
Accessibility	Farm is accessible via car, truck, or panel van for delivery of inputs etc.		
	Area of intervention is 150m or more from a body of water (e.g., river, lake)		

Distance to Water Body	that presents a flooding risk[1], and from access areas planted for timber extraction (trees that are close to a water body are considered resource protection areas under national forest law).		
Size of Intervention Area	Intervention has a minimum size of 1.5 hectares.[2] If the land is used for subsistence farming, no more than 25%[3] [4] of the total farmland area can go towards the project.	Intervention has a minimum size of 3 hectares. If the land is used for subsistence farming, no more than 25% of the total farmland area can go towards the project.	Intervention has a minimum size of 0.6 hectares.

After the *plan vivos* are created with the farmer, the field technicians create a profile for the farmer in the Taking Root technology platform using the mobile app, upload photos of the *plan vivos* to the farmer's profile and proceed to map the parcel(s) of land (i.e., intervention area(s)) using the mobile app so records of both the *plan vivos* and a GIS version of the area to be intervened are recorded.

[1] Flooding risk is defined as bodies of water that are known to move or overflow and are at an elevation similar to or higher than the intervention.

[2] The intervention may consist of the sum of smaller areas that are located within the same property.

[3] When creating the *plan vivo,* Taking Root also collects the area of participant's farmland to assess their eligibility against the eligibility percentage requirement.

[4] If a participant sells a portion of their non-project land after signing a PES contract, no action will be taken against the participant, even if their project to non-project land ratio is now greater than 25%. Instead, Taking Root assumes any increased risk from farmer drop-outs.

E3 Community-level project governance

Community involvement in decision-making

Smallholder farmers are the principal decision makers in this project and are involved in project decision making at different levels and project stages as illustrated in Table 5 below. Farmers make key decisions about project interventions and goals with the technical and operational support provided by APRODEIN and Taking Root. In return, they receive access to markets and carbon finance from the project coordinator (Taking Root), and continuous administrative support, training and education from the local reforestation partner (APRODEIN). Farmers are ultimately responsible for project success, as they are the ones that tend to the trees and practice forest management as part of PES agreements.

Table 5. Overview of project decisions fully led by participant farmers

Project decisions led by farmers and participating communities	Project design	Project implementation	Project revision*
To inform design of interventions	X		X
To participate in the project		X	
To select interventions for their farms		X	
To participate in local enterprises (e.g., biochar)		X	
To sell products to Taking Root (e.g., coffee, tree thinnings and shavings to produce wood products) for commercialization		X	
To conduct sustainable management (e.g., thinning, harvest of fuelwood and timber) according to technical recommendations		X	
To request implementation of new project interventions (technical specifications)			X

*Every 5 years. See **Figure 3.***

Community-based grievance system and recording

The project provides a robust and multi-channel grievance mechanism for participating farmers and other stakeholders. The project ensures that the grievance mechanism:

- Is accessible to all stakeholders at any point in the project cycle
- Addresses any applicable social, environmental, economic or cultural incidents that occur in the project
- Is not an economic or time burden for participating farmers
- Allows transparent, fair and timely resolutions of grievances
- Provides all documents and communications in the local language

1. Creating awareness of the grievance mechanism

To provide farmers and other stakeholders with the opportunity to submit a grievance, they must first be aware of the mechanism. The project publicizes the grievance mechanism in the following ways:

- Multiple posters - Posted in all of APRODEIN's offices describing the grievance mechanism and how to submit a grievance.
- Informational one-pager - Given to each participating farmer, this document contains details on the grievance mechanism and is also made available online.
- Community meetings - Farmers are reminded at all community meetings of the grievance mechanism and are given an opportunity to submit grievances after the meeting itself using a digital tablet on site.
-

2. Delivering a grievance

To enable farmers and other stakeholders across the project to submit a grievance easily, the project has developed a multi-channel approach for farmers to deliver their grievances to a grievance database. The following are the technology channels in which a grievance can be submitted:

- Pre-filled email, which is received by a generic APRODEIN email inbox and entered into the grievance database by an impartial administrative assistant.
- Project Specific Google Form which automatically logs the grievance in the database.

Each channel can be easily accessed without the need of APRODEIN staff by scanning a customized QR Code included on the posters and on the informational one-pager. In cases where the stakeholder is illiterate or not technically savvy, an impartial administrative assistant at any of APRODEIN's offices will be available to assist them in accessing and filling out a grievance through his or her preferred channel. In all cases, the farmer can submit the grievance anonymously if they are not interested in being contacted directly with a solution.

3. Steps for submitting and resolving a grievance

The following are the steps from the grievance submittal to resolution:

1. Farmer submits a grievance to APRODEIN through one of the two channels mentioned above.
2. The grievance is automatically logged (or entered by the administrative assistant from the APRODEIN email inbox) into the grievance database and Taking Root and APRODEIN are automatically notified.
3. In response to the grievance received, APRODEIN contacts and works with farmers and (if necessary) Taking Root to address the grievance.
4. The grievance resolution is documented in the grievance database.
5. If no solution is encountered by APRODEIN staff, escalation occurs and the APRODEIN Director will be notified of the grievance. (In this case, steps 3-4 are repeated.)
6. If a solution cannot be found after an escalation within APRODEIN, Taking Root's Reforestation Partnerships Director will be notified to find a resolution to the grievance. (In this case, steps 3-4 are repeated.)

The project allows at maximum a 2-week turnaround time for all grievances that do not escalate. All escalated grievances should be addressed within a year after reception on the grievance database.

Roles and responsibilities

- The administrative assistants at APRODEIN's offices are designated to help participants to submit and oversee the grievance cases. Administrative assistants are best suited to handle grievances as they have minimal daily interaction with the field technicians and farmers, so they can be seen as impartial intermediators.
- The Director of APRODEIN, under the supervision of Taking Root's Reforestation Partnerships Director, will be ultimately responsible for ensuring that each grievance is addressed and resolved.

Details on the grievance database

The grievance database exists online in a spreadsheet format on a platform controlled and secured by Taking Root and the APRODEIN leadership team. A summary of grievances and its resolution from the database is available under request and to the auditor during verifications.

Alignment with Nicaraguan government grievance mechanisms

The previously described grievance mechanism has been designed taking into consideration the grievance mechanism developed by the Nicaraguan Ministry of the Environment (MARENA, 2019).

Part F: Ecosystem Services & Other Project Benefits

F1 Net carbon benefits

The following section describes the calculation for the net carbon benefits for each project intervention. Table 6 summarises the carbon benefits per hectare for each project intervention over the project crediting period (50 years). The underlying calculations in this table come from the technical specifications described in Part G.

Table 6. Project intervention carbon benefits (t CO_2e/ha)

Formula Guide	1	2	3	4	2-(1+3+4)
Project Intervention	**Baseline carbon benefits**	**Project intervention carbon benefits**	**Expected adjustment from leakage**	**Risk buffer of 15%**	**Net carbon benefits**
Mixed Species Forest Plantations	12.3	364.9	0	52.9	**299.7**
Silvopastoral	12.3	238.1	0	33.9	**191.9**
Coffee Agroforestry	13.6	255.1	0	38.3	**203.2**

F2 Livelihood benefits

Table 7 outlines the expected livelihood benefits of the project. Farmers that participate in the project gain short, medium, and long-term value, both economic and environmental. The tree planting activities on participants' farms provide payments for ecosystem services in the short term. In the medium term, participants benefit from subsistence harvest or sale of fuelwood and other agroforestry products (e.g., coffee, fruits, etc.); and in the long term, participants benefit from improved and diversified farming systems, and the selective harvest and sale of high-value timber.

Table 7. Livelihood benefits

Food and Agricultural Production	Farmers have access to more diversified agricultural production (including alternative food sources from fruit crops), restored soils, improved pasture, and more resilient and productive farming systems
Financial Assets and Incomes	Farmers receive payments for ecosystem services and access to markets for high-value agricultural and forest products
Environmental Services	The planted forests provide farmers with an improved and more resilient ecosystem, helping them adapt to climate change, and promote soil nutrient cycling, water regulation, shade cover, higher biodiversity and increased carbon uptake
Energy	Tree pruning and thinnings from forest management are used as fuelwood
Timber & NTFPs	Farmers inform the selection of native tree species to include the most optimal high-yielding coffee trees, fruit-bearing trees and high-value timber trees within their regional context
Land Use & Tenure	Optimize land use planning on farms by implementing more sustainable farm management plans (*plan vivos* and tree planting and maintenance

Security	activity plans)
Use Rights to Natural Resources	Farmers obtain the legal rights to harvest and trade timber with the support of the project technicians who educate farmers on their rights and responsibilities as owners of the established plantations and help them register their plantations via INAFOR
Social & Cultural Assets	The project promotes a shift in thinking around trees as a crop that can be used to diversify people's livelihoods and income sources, instead of removing trees from the landscape. Training and technical experience also creates more stability in peoples' lives, therefore supporting well-being. This project also promotes job creation and environmental education.

Potential negative impacts

The project strives to avoid any negative impacts on vulnerable participants or non-participants of the project. However, we mention below two potential negative socioeconomic impacts identified as well as the mitigation measures incorporated into the project to minimize them:

1. The project limits participation to farmers who possess secure land tenure which can create inequalities for interested farmers that are not able to prove land tenure.

Mitigation measure: Although farmers without secure land tenure are not considered eligible for the project, APRODEIN supports interested farmers in this situation to help them gain eligibility (see details in section E1.)

2. Reduced planting density of coffee cash crops for project participants (those establishing coffee agroforestry interventions, more details in section G1) relative to non-participant coffee producers.

Mitigation measure: Coffee is considered a high value cash-crop which historically has been planted in the region as full-sun coffee monocrops. The project only supports the establishment of less dense coffee plantations (shade coffee model) which incorporates shade tree species within the participant's farms to improve the climatic resilience and biodiversity of these plantations. Although the direct revenue from less dense coffee plantations might be comparatively lower than for more traditional monocrop coffee farmers, the planting design incorporates tree species that provide additional economic benefits such as timber, fuelwood, or fruit production. These forest products can be sold at an equitable price to BOSNICA or in alternative markets (see more information on BOSNICA in section I1). The three species selected help ensure that participant farmers do not lose value by integrating shade trees but rather increase their climate resilience, soil health, and farm biodiversity in comparison with traditional coffee producers.

F3 Ecosystem & biodiversity benefits

Table 8 outlines how the project interventions provide a variety of ecosystem and biodiversity benefits through planting native tree species in the landscape, which will contribute to the creation of habitat for biodiversity, as well as the recovery of soil and water services in the project area (see section D3).

Table 8. Ecosystem and biodiversity impacts

Project Interventions	***Mixed-Species Forest Plantations, Silvopastoral Planting, Coffee Agroforestry***
Biodiversity Impacts	Increase forest cover, and thus, wildlife habitat using native species.
Water/Watershed Impacts	Prioritizing critical watersheds for planting reduces the probability of flooding in the wet season and increases water retention in the dry season. Planting of trees creates more complex and well-established root systems which results in better soil water retention and infiltration and replenishes surface and groundwater storage. This results in better drought and flooding resilience.
Soil Productivity/ Conservation Impacts	The selected project interventions all use a variety of nitrogen-fixing trees that nourish the soil, increasing soil microbial populations, while adding forest cover and reducing erosion. This helps to generate healthier and more fertile farmland and pastures.
Other Impacts	Reforestation activities help retain air humidity and reduce particulate matter in the air, especially in the dry season. It also increases CO2 sequestration and oxygen production.

Part G: Technical Specifications

G1 Description of interventions

Intervention: Mixed-Species Forest Plantations

This intervention involves the planting and intensive management of multi-purposed mixed-species forest plantations on specific portions of farmers' lands. Tree species were selected through public consultations with farmers and technical experts. Moreover, the final selection of five tree species (*Albizia saman, Swietenia humilis, Gliricidia sepium, Bombacopsis quinata, and Caesalpinia velutina)* was informed by the experiences of the initial participants of the project who reported them as the best combination. See more details about selected species in Annex 8, Table 1.

Figure 4 illustrates the planting design for this intervention which alternates rows of three fast-growing species that are also nitrogen-fixing (*Gliricidia sepium, Caesalpina velutina, Albizia saman*) and hardwood species (*Bombacopsis quinata, Swietenia humilis*). The fast-growing species are planted in rows with 1.5 metres distance between trees. The hardwood species are planted with 3 metres distance between each tree. The distance between the fast-growing and hardwood rows is 3 metres. The resulting planting density is 1,667 trees per hectare (1,111 fast-growing species trees and 556 hardwood species trees per hectare). The selected spacing between tree rows allows enough space for the shoots of the fast-growing species to grow back for a second harvest before being entirely crowded out by the timber species. The selection of the hardwood species includes variable growth rates and crown shapes allowing for variable thinning before the entire stand reaches maturity.

This planting design will provide farmers with an early harvest of the fast-growing species for fuelwood, biochar production, and wood for posts and fences for rural construction, while supporting nutrients fixation in the soil. In turn, the hardwood species will be a source of timber for farmers to sustainably extract from year 26.

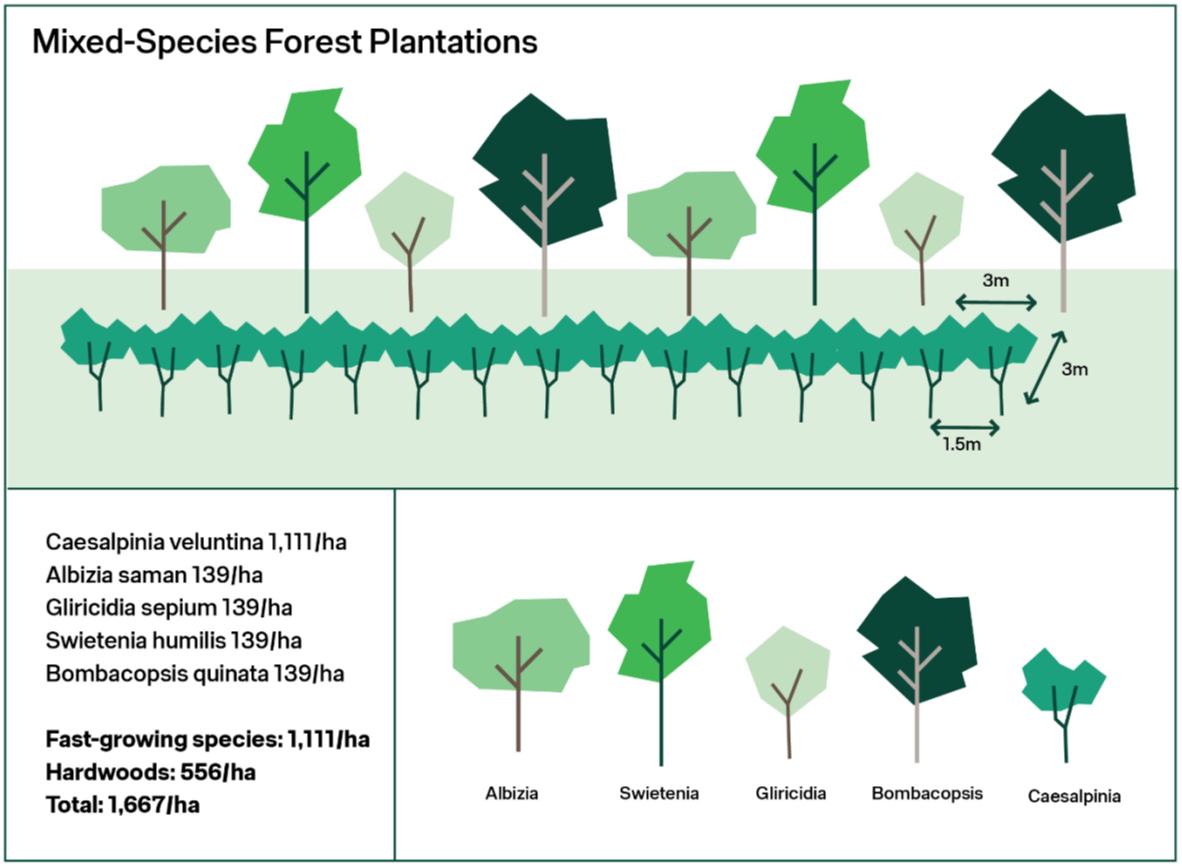

Figure 4. Plantation layout for mixed-species forest plantations.

Intervention: Silvopastoral Planting

Figure 5 illustrates the planting design for this intervention, which presents an alternative production system that integrates trees and improved pasture with livestock. For this planting design, trees from a pool of species that were selected by technical experts and farmers (see Annex 8) are planted at 5 x 5 x 5 metre spacing where *Bombacopsis quinata* and *Swietenia humilis* trees are alternated at equal density with *Caesalpina velutina* trees in between. The resulting planting density is 400 trees per hectare (200 *C. velutina*, 100 *S. humilis*, and 100 *B. quinata* per hectare). Scheduled thinnings of the fast-growing nitrogen-fixing *Caesalpina velutina* trees will provide farmers with fuelwood, and wood for posts and fences, leaving behind a young stand of high-value timber species (*Bombacopsis quinata, Swietenia humilis).* Since all three species coppice well, new trees will regenerate as older ones are removed, always keeping the stand semi-forested.

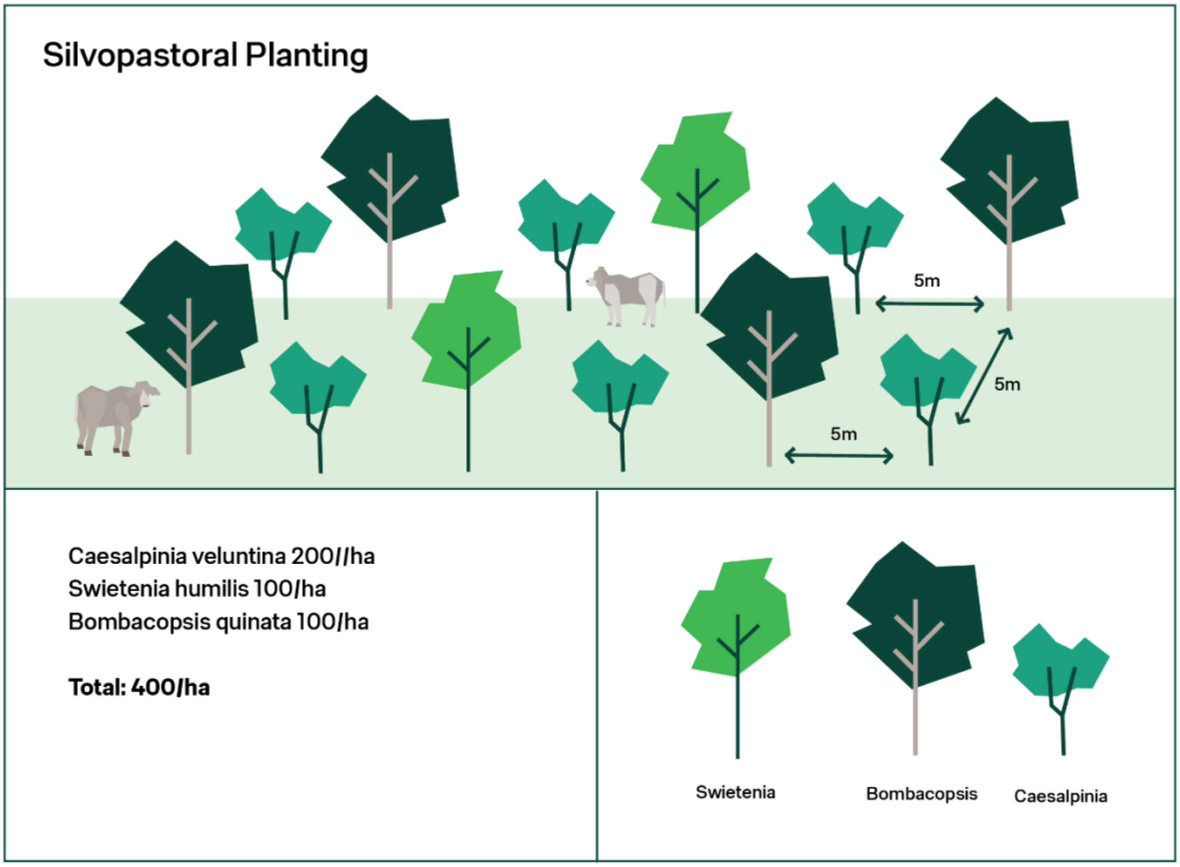

Figure 5. Plantation layout for silvopastoral planting.

Intervention: Coffee Agroforestry

The coffee agroforestry intervention consists of a four-strata coffee agroforestry system as illustrated in Figure 6. The system has a density of ~3,827 trees per hectare. The first stratum consists of coffee plants (or small trees) planted at a density of 3,000 - 4,000 coffee trees per hectare. These coffee trees (*Coffea arabica)* are the primary economic driver for this intervention as they act as an annual cash crop that starts to produce in the third year after planting. The second stratum consists of *musaceae* (banana) at densities determined by farmers. The third stratum consists of a variety of fruit trees (based on farmer preference) that are planted at a density of 16 trees per hectare, providing food crops for consumption and sale while providing partial shade for the coffee. The fourth stratum consists of a mixture of native tree species providing a diverse canopy for partial shade, wildlife habitat and carbon sequestration. These trees occupy the upper level of the canopy and are planted at a density of 138 trees per hectare. See Annex 8, Table 2 for a full list of tree species that can be used in this intervention for the third and fourth strata.

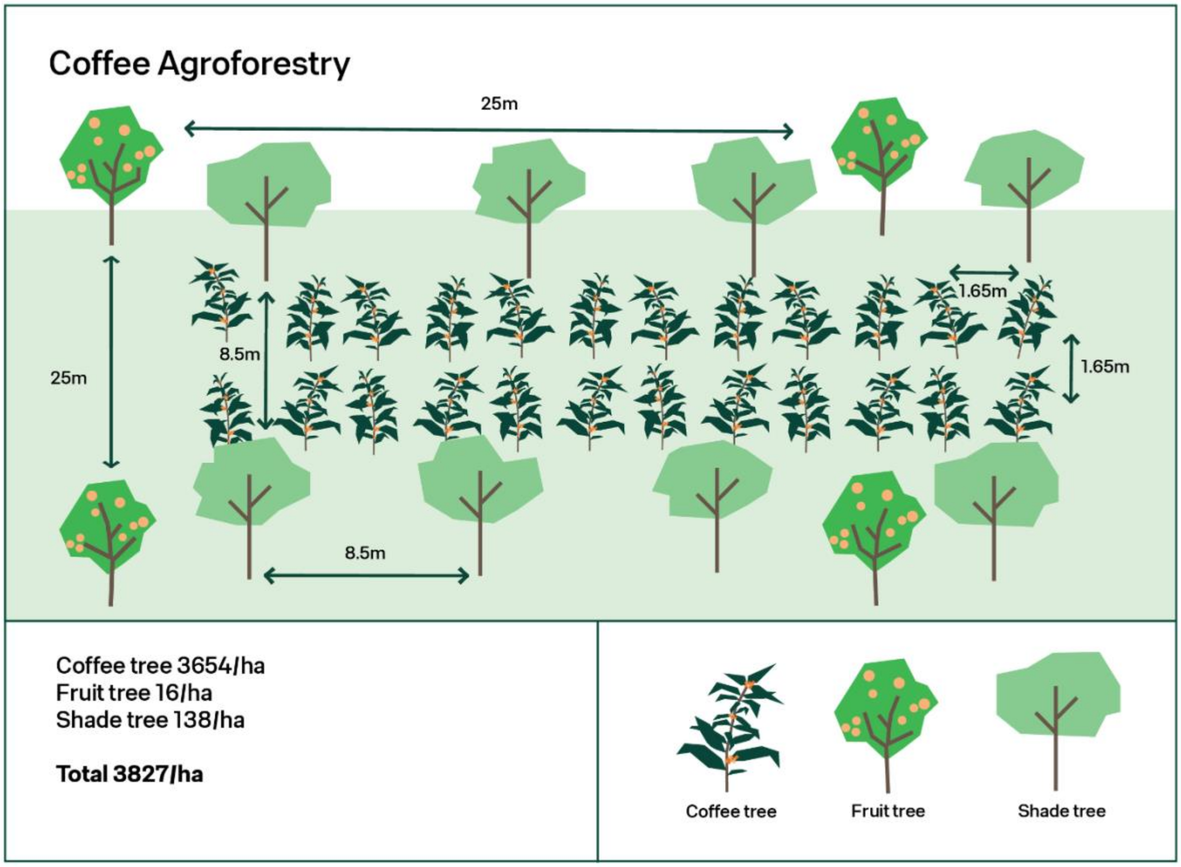

Figure 6. Plantation layout for coffee agroforestry.

The coffee trees for this intervention consist of new varieties that are resistant to *Hemileia vastatrix*, a fungus known as leaf rust. Leaf rust thrives under rising temperature conditions increasingly common due to climate change and has ravaged coffee plantations in Nicaragua and across Central America, crippling production and threatening the livelihoods of millions who depend on the coffee industry (Bacon et al. 2021). Despite the increasing availability of leaf rust resistant cultivars, the speed of re-planting in coffee producing countries with improved varieties has generally been slow. Therefore, a primary focus of this technical specification is promoting the adoption of coffee varieties that are resistant to leaf rust but that also produce high yields that command attractive market prices.

Description of activities

After participating farmers select the type of intervention for their farm, and create their *plan vivos* (see section E2) they are supported with the development and implementation of a tree planting and maintenance activity plan tailored to their selected interventions. This activity plan is included in their PES agreement. It serves to ensure proper establishment and management of project interventions. The activity plan for each intervention has been designed through a consultation process among various stakeholder groups, and regional experts. It serves as the minimum standard required for the program to be effective and farmers to be successful in establishing the interventions.

Compliance with the activity plan is a major component that forms part of the PES agreements that farmers voluntarily sign with Taking Root. Payments are based on the successful and verified implementation of the activity plan. Table 10 below summarizes the activities for each intervention that farmers must fulfill annually during the 10-year plantation establishment period. At the end of year 10, the tree stands are considered ‘free to grow’ and farmers are no longer monitored for silvicultural activities.

Table 9. Activity plan with farmers under PES agreements

<table>
<tr><th>Year</th><th>Mixed-Species</th><th>Silvopastoral Planting</th><th>Coffee Agroforestry</th></tr>
<tr><td rowspan="6">1</td><td>Establish Nurseries</td><td>Establish Nurseries</td><td>Establish Nurseries (coffee + shade trees)</td></tr>
<tr><td>Fencing + Clearing + Prepare Land for Planting</td><td>Fencing + Clearing + Prepare Land for Planting</td><td>Clearing + Prepare Land for Planting (establish flat holes for coffee seedlings - terrazas)</td></tr>
<tr><td>Planting</td><td>Planting</td><td>Planting</td></tr>
<tr><td rowspan="3">Weeding: 1,2 & 3</td><td rowspan="3">Weeding: 1,2 & 3</td><td>Weeding: 1,2 & 3</td></tr>
<tr><td>Fungicide: 1,2 & 3</td></tr>
<tr><td>Fertilizer: 1, 2 & 3</td></tr>
<tr><td rowspan="6">2</td><td>Establish Nurseries</td><td>Establish Nurseries</td><td>Establish Nurseries (coffee + shade trees)</td></tr>
<tr><td>Re-Planting</td><td>Re-Planting</td><td>Monitor flat holes for coffee seedlings (revivir terrazas)</td></tr>
<tr><td rowspan="4">Weeding: 1&2</td><td rowspan="4">Weeding: 1&2</td><td>Re-Planting</td></tr>
<tr><td>Weeding: 1,2 & 3</td></tr>
<tr><td>Fertilizer + Fungicide + Sun Protector (as needed)</td></tr>
<tr><td>Pruning (as needed to control shade)</td></tr>
<tr><td rowspan="2">3</td><td colspan="2" rowspan="2">Repeat Activities from Year 2</td><td>Weeding: 1,2 & 3</td></tr>
<tr><td>Fertilizer + Fungicide + Sun Protector (as needed)</td></tr>
</table>

			Pruning (as needed to control shade)
4	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
	Pruning	Pruning	
5	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
			Coffee Harvest
6	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
	Thinning	Pruning	Coffee Harvest
7	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
			Coffee Harvest
8	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
	Thinning (optional)	Thinning (optional)	Coffee Harvest
9	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
	Thinning (optional)	Thinning (optional)	Coffee Harvest
10	Weeding: 1	Weeding: 1	Repeat Activities from Year 3
	Pruning	Pruning	Coffee Harvest
11-50	Sustainable maintenance of the intervention		

1. <u>Nursery establishment</u>

Based on the selected farm area and chosen project intervention, field technicians help farmers to produce the seedlings that farmers need to grow their trees and the most suitable nursery system. Field technicians evaluate if the seedlings can be grown on site (when there is a water source, often a well, in the farm to ensure irrigation of in-farm nurseries during the dry season) or if the seedlings need to be grown in the project's central nurseries and then delivered to the farm (when no irrigation is possible in-farm during the dry season).

Figure 7. An in-farm nursery

As much as possible, the project tries to collect seeds from the local communities but purchases additional seeds externally as needed to guarantee the annual project seed requirement.

In-farm nurseries:

The project implements a quality protocol in collaboration with farmers to help them grow high-quality seedlings on their own land. The protocol encompasses both material provisions and training to ensure the successful establishment of nurseries and the cultivation of seedlings. The following are the high-level steps of the protocol:

1) The field technicians support farmers to identify optimal areas on their land for the setup of the nurseries and train them on land preparation procedures such as weeding, site leveling, and installing barriers to prevent entry of animals.
2) The project uses a calculator tool to determine optimal quantities of seeds, bags, and soil necessary for any given project intervention on a farmer's land. The calculations are based on hectare size of interventions and farm location (dry or wet region).

3) A field technician delivers the materials to the farmer. Farmers might decide to get labour support for the establishment of the nursery. Field technicians often help farmers to find labourers when requested and they are invited to the training.

4) Farmers receive instructions on how to gather soil from their own land (mixing sand from riverbeds, on-site soil, ash and/or manure). Seedling bags are filled with soil and placed in 1x1m nursery beds that are established on flat ground or terraces, each with a capacity to fit 265 bags. The nursery beds are separated by wooden pegs and wire and labelled according to species and by number of seedlings. The soil-filled bags are regularly irrigated for 5 days prior to planting the seeds for optimal germination conditions (soil temperature and soil consistency). The field technicians offer advice to farmers on the ideal sequence of planting the seeds to account for their varying germination times.

Timing of these activities:

The timing of nursery activities is tailored according to the unique climatic conditions of the region. Depending on the area within the country and its rainy season's start date and length, seeds are sown in the nurseries from January to March. Seedlings are grown for about 3 months until they reach an approximate height of 30 cm. Field technicians also train farmers in irrigation schedules and techniques for pest management to ensure robust growth of the seedlings. When trees have reached the required height and once regular rainy conditions start, seedlings are planted in the pre-selected intervention areas.

Figure 8. One of CommuniTree's central nurseries

Central nurseries:

The project runs central nurseries that serve as focal points of assistance for farmers whose lands do not favour the establishment of in-farm nurseries (e.g., due to lack of a water source) and to supply farmers with back-up seedlings should they need extra plants to complete their planting designs. Central nurseries follow the same quality protocol as the in-farm nurseries. The central nurseries' operations are adjusted annually based on current demand. APRODEIN staff employ planning tools and weekly progress updates to track activities in the central nurseries such as procurement of seeds and delivery of seedlings to farmers by project technicians.

2. Tree planting

Farmers perform planting with labour support and training from field technicians. The following activities describe the planting process:

2.1 Fence building and clearing

Before planting, intervention areas are fenced off to prevent livestock from grazing and trampling on the seedlings. The plots are also cleared of grasses and small shrubs to support the successful growth of the new seedlings and reduce resource competition.

2.2 Planting

After the intervention areas are fenced and cleared, farmers and support staff (labour) are trained to carry out the following activities during the planting season:

- Site demarcation - A rope with knots or tags at uniform distances is used as a measure to signal where the trees will be planted according to the technical specification.
- Digging holes - A hole slightly larger than the rootstock of seedlings is dug where each seedling needs to be planted.
- Tree planting - The seedlings are carefully removed from the nursery bags and planted in the holes according to the technical specification's planting design. Each seedling is planted at ground level (or a little deeper) so that water accumulates around the seedling.

Figure 9. Site demarcation

Figure 10. Hole digging

Figure 11. Tree planting

For coffee agroforestry, two special practices are implemented for planting:

1. Biochar, a charcoal made from pyrolyzed wood material (produced by the project from pruning and thinning materials from the project's farmers), is added to the holes where coffee is planted (0.5 pound of biochar is added to each hole) to improve the soil's nutrients and water holding capacity.

2. If planting is done in steeper terrain (common at high elevations), planting requires a preliminary preparation of the land which consists of establishing small flat holes or trenches (*terrazas*) perpendicular to the direction of the slope where the coffee and shade seedlings are planted to reduce water runoff and prevent erosion and the soil from washing off (see Figure 11).

Figure 12. Coffee planting in steeper terrain (*terrazas*

2.3 Re-planting

Re-planting of seedlings is done in years 2 and 3 as needed to counter the expected natural seedling mortality for the three technical specifications. Re-planting ensures that interventions are established according to specific tree density defined in the planting design of each intervention type. Technicians will support farmers to assess their re-planting needs at the beginning of years 2 and 3 during farm visits.

Re-planting can be also recommended and performed after year 3 as needed, if a clear deviation from expected tree and stand growth is identified by field technician visits or remote sensing monitoring (for more details see section K1)

3. Tree maintenance (silviculture)

The planted forest areas are intended to remain permanently forested under sustainable forest management. Farmers are trained, technically supported, and closely supervised by the project's field technicians on a continuous basis for 10 years. After that, the intervention is established, and the frequency of field visits decreases to one or two visits a year to provide technical assistance and supervision. When the plantation approaches maturity near year 25, the management regime will progressively shift towards sustainable stand management. During this period, the larger trees will be selectively harvested. Natural regeneration will also be encouraged in the Mixed Species Forest Plantations and Silvopastoral planting interventions. This model ensures that farmers perform adequate maintenance of their trees to ensure the successful establishment and development of their plantation until it is mature and stable. The following section describes the silviculture activities that all participant farmers are expected to conduct for tree maintenance over the project.

3.1. Weeding

Regular weeding is performed across all three project interventions whereby any competing grasses, bushes, shrubs, and lianas are removed from a 2 m circular area around each tree so that intended targets for tree growth can be met. During the first 2-3 years of tree growth, multiple rounds of weeding are performed, followed by annual weeding activities in the remaining 7-8 years until interventions are fully established (see Table 10 above).

3.2. Pruning

Once the seedlings have been planted, thinning and pruning activities take place for optimal growth and survival. For timber species, the lateral branches of the lower two-thirds of the tree are cut to encourage upward growth. All pruning activities are carried out during the dry season with sharpened tools to avoid damaging the trees as much as possible. This helps to avoid pests and diseases. Pruning schedules are based on the tree height (rather than age) and are as follows:

- First pruning - When trees are 5-6 metres tall. The branches of the lower two metres of the tree should be removed to help minimize knots
- Second pruning - Takes place when the trees reach between 8 and 9 metres, and the branches from the lower 4 metres of the tree are removed
- Third and final pruning - When the trees reach 12 metres, and the lower 7 metres are freed of side branches

3.3. Thinning

Periodically, the planted trees are thinned to increase available resources and to make room for the roots and crown of the remaining species to grow larger and stronger. Thinning is a selective process which begins approx. 6 years post planting (depending on type of intervention). Trees which are growing crooked, or showing signs of illness or damage, are targeted for thinning. The proposed thinning schedule is as follows:

- First thinning - In year 6 when trees should have reached a height between 6-8 m. Trees to be thinned are those trees showing the characteristics mentioned above.
- Second thinning - A second thinning can occur in year 8 or 9. The best trees (higher diameter, straight trunk with minimal branching) are identified, and the nearby competing non-optimal trees are removed to facilitate the growth of the most valuable timber trees.
- Third thinning - Occurs in year 15, following the same logic and methodology as the second thinning.

This schedule may vary on a case-by-case basis depending on parcel growth, shade cover and carbon sequestration. We consider each farm on an individual basis and take into account the perspective of both the farmers and technicians of the project to make an optimal management decision.

3.4. Harvest

Farmers have the option to harvest the first mature hardwood trees for timber production in year 26. The mature trees will be harvested at a rate comparable to the long-term growth rate of the stand. The overall volume and carbon stocks fluctuate around the long-term average. Starting in year 26, 45 m^3 of wood products per hectare can be selectively cut from the stand every 5 years. (See Annex 10 - Additional Carbon Forecasting Modelling and Results). Harvests can be used for subsistence or sold however the farmer chooses.

3.4. Coffee maintenance

Establishment of coffee agroforestry systems involves technical training on the best coffee management practices to increase yield, and control for pests and disease such as leaf rust. Additional coffee management involves treatment as needed of the coffee seedlings with fertilizers, fungicides, and sun protectors (see Table 10 for the frequency of these additional activities). The measures ensure that farmers have a high-quality product for better market access and can also sell the coffee at a higher price.

G2 Additionality and environmental integrity

There are several constraints facing the project region that make this project highly additional. Regional land use practices in Nicaragua in recent decades have shown the lack of financial incentives, ecological integrity, and investments in innovation that would establish reforestation as a competitive land use option. Institutional, as well as economic and cultural barriers, prevent farmers from accessing the necessary resources to successfully grow trees without risking their livelihoods. To this date, there exist no official incentives and legislative support for farmers to grow trees for the market and participate in PES.

Table 10 outlines the barriers which would have prevented the project interventions from taking place in the absence of the project. The associated mitigation measures have also been identified.

Table 10. Project barriers and mitigation measures

Type of Barrier	Description of Specific Barriers	Mitigation Measures
Economic/ Financial	The project targets rural areas with high rates of poverty. The majority of smallholders do not possess the financial means to invest in the acquisition of inputs and materials to grow trees on farmland.	The project will give farmers access to finance so that they can face the initial investment required for participation in year 1. A portion of the total payment they are eligible for (up to 20%) will be issued to farmers during year 1 to help them produce or acquire inputs or resources (e.g., labour support, wire fencing, etc.) needed to establish their plantations. Such pre-payments will be deducted from their annual payments.

Technical	Smallholder farmers in the project area rarely possess the technical training that is required to sustainably manage a forest and collect data on tree growth over time, which is a requirement for annual reporting and certification of carbon credits.	The project matches farmers with field technicians that provide training and support on an on-going basis. Project field technicians are in turn regularly trained on sustainable land management and monitoring of tree growth using Taking Root's science-based carbon monitoring approach via its mobile app to report monitoring activities and data.
Institutional	There is a lack of marketing mechanisms that rewards smallholders to grow trees for the market. In Nicaragua, it is illegal to harvest trees and sell them on the market without registering the land as a forest plantation. The law is geared towards large plantations. Smallholders are largely unaware of the process and lack the technical expertise to perform bureaucratic processes with the government.	The project will play an active role in creating favourable market access by improving efficiency and manufacturing (e.g., making biochar, processing wood into high value crafts and timber products) and by helping to create new markets (e.g., selling biochar as a growth enhancer in the national market, exporting wood crafts internationally). Through participation in the project, all farmers have their plantations registered with the government. The project supports all farmers to register their plantations via INAFOR and has worked closely with them to keep the registration process easy and affordable.

Ecological	Nicaragua is already experiencing the effects of climate change in the form of lower and disrupted rainfall patterns during the wet season, which leaves many smallholders with limited access to water resources and therefore limited opportunities to make their land profitable and productive. Seedling production that makes the establishment of farm plantations possible have limited growth periods often coinciding with the dry season (January-April) when they heavily depend on water. This represents a barrier for farmers in the drier regions of the country for accessing this type of land use.	The project considered water as a key ecological barrier in selecting species and developing planting designs with farmers and experts. The planting designs for the project interventions take into consideration the specific precipitation conditions of the project area and are based on highly technical knowledge and years of regional experience to help farmers overcome those barriers. The project produces seedlings in central nurseries for farmers who are interested in participating but who lack access to water for seedling production during the dry season. Seedlings are delivered to these farmers when the rainy season starts for them to plant them when water is available.
Social	Smallholder farmers' lands are often in remote locations that lack access to infrastructure, which often limits the farming practices they are able to develop or establish on their land given the limitations to transport and/or haul equipment or inputs to their farms.	The project delivers materials for in-farm nursery establishment, plantation fencing, tools for tree maintenance, and maintains community nurseries to supply farmers with seedlings.
Cultural	Tree planting is not part of the	The project will reverse the low-

	cultural heritage of most smallholder farmers in the project region. For generations, they have been taught to remove forests to increase yield on their farms. Reversing prevailing perspectives on trees as productive land use that can provide diverse forest products with value on the market is not conducive to farmers' cultural beliefs and norms in the project area.	productivity stereotype surrounding trees on farmland through leading by example (e.g., workshops, storytelling, farmer to farmer communication), and providing continuous education and training so that forests will be viewed and harnessed by smallholder farmers as a competitive form of land-use.

The project area cannot have been negatively altered before joining the program with the intention of receiving carbon credits. To become a participant in this program, farmers must demonstrate that they own the land for agriculture, which are the most recent and current uses of their land and that the intervention of the area selected will not interfere with their subsistence farming practices (see applicability criteria in section E2 Community-led implementations).

Relevant laws and regulations

The relevant existing laws and regulations are a) the National Constitution (1987, revised 2014), b) the Forest Law (No. 462), and c) the Environmental and Natural Resources Law (No. 217).

In Nicaragua, carbon rights are associated with property rights. The farmers that participate in the project have secure land tenure, and, as such, own the rights to the carbon (Art.5 of the Constitution). They can transact their carbon rights internationally, either through a private sector mechanism (Art. 2, Law No. 462; Art. 57, Law No. 217) or via the government (EO No. 21-2018) but they must report the areas planted. To that effect, the government issued an executive order (EO No. 06-2021) that requires projects to register the forest carbon polygons with the Climate Secretariat of the Presidency (SCCP), also known as the 'Climate Office'.

Within the institutional framework of the Climate Office, a dedicated subcommittee specializing in the Mitigation of GHG Emissions has been established as per Presidential Decree No. 06-2022. This subcommittee serves as the focal point for the acceptance and scrutiny of applications submitted by carbon project developers seeking to obtain official letters of non-objection for their undertakings within the national jurisdiction.

Projects falling under the reforestation category must follow a process overseen by the National Forest Institute (INAFOR). This involves the assessment of the project as delineated within the government's specifically designed template for Project Idea Notes (PINs). The Government PIN asks for a detailed description of the project, including location of project activities, project interventions, and carbon quantification methodologies used. INAFOR will evaluate the PIN, requesting amendments and clarifications as necessary, and conduct a field visit to corroborate activities described in the PIN. Once the project review culminates, INAFOR will advance its recommendations to the Climate Office of the Presidency where the National Committee for the Mitigation of GHG Emissions makes a final decision on the issuance of the letter of non-objection.

As of the most recent revision of this PDD, in line with the above requirements, Taking Root, in partnership with APRODEIN, has completed the submission of a Government PIN for the project. Currently, both organizations are immersed in a constructive feedback loop with INAFOR to address any potential clarifications and are working toward finalizing the review procedure to expedite the scheduling of a site visit.

The technical specifications of the project are recognized under the Forest Law (Art. 44, 47, and 58 of law No.462). There is no legal obligation as such for smallholder farmers to declare forest parcels on their private lands with the National Forest Institute (INAFOR). However, if farmers wish to practice tree harvesting and derive commercial benefits from tree plantations, they must list their parcels with the National Forest Registry and follow sustainable management practices under the INAFOR guidelines (Art. 16). The smallholder farmers that participate in this project register their parcels with direct support from the project to do so. Registration comes with a number of tax benefits, including a 50% property tax reduction, full refund of import taxes on special machinery and sawmill equipment, and up to a 100% reduction in income tax upon proof of investing in reforestation activities and the extension of areas planted (Art. 38).

Planned project interventions exceed current laws by putting in place sustainable management practices for each project intervention, detailed in the description of activities (section G1 Technical Specifications).

Other projects in Nicaragua

Nicaragua does not currently have projects underway that match the size and scope of the CommuniTree Carbon Program (8k hectares, 2.2M credits issued as of 2022). In its latest program report, The Forest Carbon Partnership Facility (FCPF) of the World Bank, which works with the government on the implementation of REDD+, identified the project as the only currently active forest carbon program of significance in the country (FCPF, 2019:318). Nicaragua launched its REDD+ strategy in 2018 (EO No. 21-2018). Under the strategy, one project is currently at the planning stage. The project is located in the North Caribbean Coast Autonomous Region and targets emissions reductions in the amount of 11 million tons over a 5-year period. The REDD+ program also targets departments within Nicaragua's Central and Pacific regions.

However, it should be mentioned that there have been small projects outside the accounting area that have ventured into forest carbon markets. *Fundación DIA* and *Across Forest* both run reforestation initiatives with smallholders in the Pacific and Southeastern Regions of the country and have issued 8,198 and 57,033 carbon credits respectively via The Gold Standard. There is also a native bamboo reforestation initiative, Ecoplanet Bamboo, active in the Atlantic Coast which has issued a total of 24,473 credits via Verra.

To avoid double counting, the project will comply with requirements that demand reporting of forest carbon polygons to the Climate Office (as per EO No. 06-2021). As can be seen in Annex 3, contracts with farmers are specified such that any stated amount of carbon rights cannot be sold via other projects.

G3 Project period

The certified project has grown since it was first established in 2010 and intends to increase its scale across the project area by recruiting new farmers in perpetuity (see section I4 'Project management'). Every year, farmers are recruited and enter a 50-year project cycle, as specified in the PES agreement. The cycle starts by choosing an intervention and creating the *plan vivos*, followed by planting, silvicultural activities, and monitoring tree growth targets over the course of 10 years, after which the plantation can be considered established.

Carbon quantification is based on the average carbon sequestered over a 50-year crediting period for which farmers commit themselves to maintain and protect their interventions and during which tree growth continues to be monitored via remote sensing. Each intervention will be registered, mapped, and monitored with the Taking Root technology platform to create a reliable database where verification of tree growth and carbon sequestration is recorded along the project life cycle (for more details on monitoring see section K1).

G4 Baseline scenario

The CommuniTree project conducts carbon baselines before the project interventions occur to measure the ex-ante carbon stock in the landscape. This is to ensure that carbon modelling only reflects the additional carbon benefits and that there is no double counting when measuring the project intervention carbon stock. The following section describes the carbon pools included in the baseline, the baseline methodology, the baseline results, and a narrative of the baseline condition for all project interventions.

Carbon pool choices

Table 11 outlines the various carbon pools considered for the baseline for each project intervention and justifies their exclusion when relevant.

Table 11. Carbon pools and emission sources quantified in the baseline

Type	Applicable to Planting Design *			Reason for Exclusion
	MSFP	SP	CA	
Carbon Pool				
Wood biomass (where DBH >= 5 cm)	x	x	x	
Wood biomass (where DBH < 5 cm)				Costly to measure with only a minimal increase in carbon benefits.
Non-woody biomass				Difficult and costly to measure with only a minimal increase in carbon benefits.
Litter biomass				Expected to increase as a result of program activities, but difficult and costly to measure with only a minimal increase in carbon benefits.

Deadwood biomass				Expected to increase as a result of program activities, but difficult and costly to measure with only a minimal increase in carbon benefits.
Emission source				
Burning of biomass				Burning of biomass for the purpose of site preparation when necessary in the project. The controlled burns are targeted at small bramble bushes, which impede planting activities. Taking Root has modeled that ~.06 t/CO2e per hectare emissions occur due to biomass burning. We therefore exclude this pool as this is less than 5% of total carbon benefits of any planting design. Please refer to the following calculator[5] for the biomass burning calculations.
Emissions from nitrogen fertilizer			x	
Burning of fossil fuels				The project uses fossil fuels for its operations. This use includes motorcycles and trucks for technician and seedling transport. While transport emissions are significant, we offset these emissions through the purchase and retirement of the equivalent amount of PVC offsets. Taking Root calculates and reports these emissions in the Annual Report.

** MSFP = Mixed Species Forest Plantations, SP = Silvopastoral, CA = Coffee Agroforestry*

[5] https://www.dropbox.com/scl/fi/36vmeud6pz9ivs3s5pgyz/Taking-Root-Biomass-Burning-Calculator.xlsx?rlkey=8upbdsrwftlqasd6ia6hrxvlf&dl=0

Carbon baseline methodology

The project calculated the project baseline using the CDM tool: "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" (UNFCC, 2013).

The baseline carbon stock was calculated as follows:

$$C_{BSL,t} = C_{TREE_{BSL,t}} + C_{SHRUB_{BSL,t}} + C_{DW_{BSL,t}} + C_{LI_{BSL,t}}$$

Where:

t = Year of the baseline measurement;
$C_{BSL,t}$ = Baseline carbon stock;
$C_{TREE_{BSL,t}}$ = Baseline carbon stock in tree biomass (AGB + BGB) within the project boundary;
$C_{SHRUB_{BSL,t}}$ = Carbon stock in baseline shrub biomass within the project boundary;
$C_{DW_{BSL,t}}$ = Baseline carbon stock in dead-wood biomass in the project boundary;
$C_{LI_{BSL,t}}$ = Carbon stock in baseline litter biomass within the project boundary.

As per Table 11, only the baseline carbon stock in trees with a DBH of greater than 5 cm was considered. To calculate the tree biomass carbon pool, the CommuniTree project first determined a non-forested stratum in the project landscape. This stratum is representative of the areas where the project intervention is performed.

Defining the strata

For the initial carbon stock, the landscape was stratified into forested and non-forested strata, which were further subdivided into non-forested stratum at low elevation for the Silvopastoral and Mixed Species Forest Plantation and non-forested stratum at higher elevation for Coffee Agroforestry.

See Annex 9 for an in-depth methodology for calculating the plot sample size, identifying the location of the plots, and tree data entry in those plots.

Calculating the biomass in the strata

CommuniTree uses the following methodology to calculate the average carbon stock per hectare of the trees in the eligible strata.

To calculate the aboveground biomass (AGB_t) for each measured tree, the project uses an allometric equation developed for dry tropical forests with annual precipitations > 900 mm (Brown, 1997).:

$$AGB_t = exp\,(-1.996 + 2.32 \times ln\, ln\,(DBH_t))$$

Where:

AGB_t = Aboveground Biomass of Tree t in kilograms;

DBH_t = Diameter at breast height of Tree t in centimeters.

The below ground biomass for the trees is calculated by multiplying the AGB by the AGB to BGB Conversion Factor (*CF)* (IPCC, 2006)

$$BGB_t = AGB_t \times CF$$

Where:

BGB_t = Belowground Biomass in kilograms of Tree *t*;

CF = 0.56 when AGB < 20 tonnes per ha or;

CF = 0.28 when AGB > 20 tonnes per ha.

Tree Biomass (TB_p) of the plot was calculated by:

$$TB_p = \sum_1^t (AGBt + BGBt)$$

Where:

TB_p = Total tree biomass of the plot in kilograms

The total tree biomass results of each plot were expanded to a per hectare basis using the following expansion factor calculation:

$$EF = \frac{10000}{A}$$

Where:

EF = Expansion factor;

A = Corrected Area of sub-plot in m^2

Where:

A has been corrected considering the slope of the plot using the following formula:

$$A = pi \times (L_s \times \cos(S))^2$$

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;

pi = The mathematical constant.

By taking the steepest slope, the carbon in each sample is overestimated. The principle of conservativeness specifies that when estimating GHG removals, the risk of overestimation should be minimized. It is considered conservative to (i) overestimate carbon stocks in the baseline, and (ii) underestimate carbon stocks in the forest-landscape restoration (FLR) activity (König et al. 2019, p.17). The expansion factor multiplied by the total calculated biomass of trees on the plot gives an estimate of the average biomass of all trees per hectare of land for each plot.

$$TB_{avg,p} = EF \times TB_p$$

Where:

$TB_{avg,p}$ = Average biomass (kg) of all trees per hectare per plot

The average carbon in the strata is calculated by averaging the sum of the biomass per hectare of all plots ($TB_{avg,p}$)

$$C_{Avg} = \frac{\sum_1^p \quad TB_{avg,p}}{tp}$$

Where:

C_{Avg} = Average total biomass in the strata

tp = Total number of plots

The climate baseline (tCO2e/ha) for the planting intervention is calculated by multiplying the average total biomass in the strata, by the carbon fraction (CCF).

$$CO2e_{Avg} = C_{Avg} * \ CCF$$

Where:

CCF = Carbon to CO_2 Conversion Factor of 3.67

Baseline conditions

The following section describes typical baseline conditions of the three project interventions for the CommuniTree project.

<u>1. Mixed Species Forest Plantation</u>

In much of the pastoral and agricultural land in the interior of Nicaragua, land-use commonly cycles from fields with bushy vegetation cleared for agriculture, to cattle pasture, then to fallow fields where bushy vegetation regenerates. This land use provides the perfect conditions for planting interventions as the landowners often have a surplus of underproductive land on which to plant trees. This project intervention targets these unproductive open fields under this cycle.

<u>2. Silvopastoral</u>

Same as for Mixed Species Forest Plantation.

3. Coffee Agroforestry

Much of the mountainous regions above 700 metres in Nicaragua are well suited for growing arabica coffees (*Coffea arabica*). To expand the productive coffee growing regions and plant more trees, the CommuniTree project targets de-forested or non-forested areas in these regions for the Coffee Agroforestry planting intervention.

In summary, for all three project interventions, the project will target areas of land with zero or close to zero biomass that are similar to the land-use cycles described in the sections above. By targeting these areas, the project can safely assume a similar baseline across the expanded project region without having to conduct new baseline surveys.

Over time, the baseline is assumed to stay constant, which is consistent with the conditions laid out in the CDM document "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" (UNFCCC, 2013).

History of baseline estimation in the CommuniTree project

To calculate the results above, three baselines were conducted in different regions of Nicaragua over various years as CommuniTree expanded (see project expansion in Table 22 - section I4).

- In 2011, the original baseline calculations for the San Juan de Limay area (Esteli Department) were performed for the Mixed Species Forest Plantation and the Silvopastoral planting intervention.
- In 2014, the baseline for the new area in Somoto (Madriz Department) was performed for the Mixed Species Forest Plantation and the Silvopastoral planting intervention.
- In 2016, the carbon baseline for the San Juan del Rio Coco area (Madriz Department) was performed for the Coffee Agroforestry Plantations planting intervention.
- For all areas post-2016 we will use the same average baseline results for any new areas provided they meet the same applicability conditions. See the next section for baseline results by planting intervention.

Baseline results

The carbon stock baseline is an area-weighted average of all eligible non-forested land: a mix between underutilized fields with busy vegetation, pastures, and agricultural land. The results of the baseline carbon stocks for all three project interventions are presented in Table 12 below:

Table 12. Baseline carbon results of non-forested land

Planting Intervention	Area (ha)	Above ground woody biomass (tC/ha)	Below ground woody biomass (tC/ha)	Total (tC/ha)	Total (tCO2e/ha)
Coffee Agroforestry (2016)	14,880	2.76	0.96	3.72	13.6
Mixed Species and Silvopastoral (2011)	26,459	2.60	0.75	3.35	12.3
Mixed Species and Silvopastoral (2014)	12,269	2.39	.69	3.08	11.3

Although the 2014 baseline has a lower baseline, in order to be conservative, Taking Root uses the higher value for baseline performed in 2011 - 3.35 (tC/ha) - to calculate the carbon benefits for both the Silvopastoral and Mixed Species Forest Plantation technical specifications.

To capture this scenario, the two eligible categories of vegetation (bushy vegetation and open-fields) have been considered as one land-use stratum (equal to the bushy vegetation value) for the baseline scenario. We have chosen this approach for parsimony and to be conservative.

G5 Ecosystem service benefits

The project has developed a carbon forecasting model to calculate the carbon benefits over the project period for all relevant planting designs. Each type of intervention has a carbon model which integrates a set of carbon pools. The following section describes the carbon pool choices for each design.

Carbon pool choices

Certain carbon pools are quantified for each planting design. Taking Root has selected the carbon pools that contain a significant amount of carbon or >5% of the total carbon benefits.

Table 13 describes the choice and justification for the carbon pools included and excluded in the carbon modeling and accounting.

Table 13. Carbon pool exclusion and inclusion criteria

Carbon Pool	Applicable to Planting Design*			Reason for Exclusion
	MSFP	SP	CA	
Above ground biomass (AGB)	x	x	x	
Above ground non-woody biomass				Expected to increase as a result of program activities, but difficult and costly to measure with only a minimal increase in carbon benefits.
Below ground biomass (BGB)	x	x	x	
Litter				Expected to increase as a result of program activities, but difficult and costly to measure with only a minimal increase in carbon benefits.
Soil				Expected to increase as a result of program activities, but difficult and costly

				to measure with only a minimal increase in carbon benefits.
Fertilizer emissions			x	
Harvested wood products - *Swietenia humilis, and Bombacopsis*	x	x		Note: Species not planted in Coffee Agroforestry planting design.
Harvested wood products - *Albizia saman*	x			Note: Species not planted in Coffee Agroforestry and Silvopastoral planting design.
Harvested wood products - *Caesalpina velutina and Gliricidia*				Expected carbon pool is minimal due to high volume processing factors for posts.

**MSFP = Mixed Species Forest Plantation, SP = Silvopastoral, CA = Coffee Agroforestry*

In addition, for each carbon pool, the project does not expect a significant decrease in any carbon stored or a significant increase in emissions stemming from each pool.

Carbon benefits forecasting methodology and inputs

This section describes the methodology for forecasting the carbon benefits potential of the trees planted in participating farms over the project crediting period.

Calculation of gross carbon benefits

For each planting design, the conversion of gross carbon benefits measured in the average carbon over the project period (C_{Avg}) to its CO_2 equivalent ($C02e_{Avg}$) is calculated as follows:

$$CO2e_{Avg} = C_{Avg} * CCF$$

Where:

CCF = Carbon to CO_2 Conversion Factor

See section F1 for a calculation on converting the gross carbon benefits to net carbon benefits for each planting intervention.

Average carbon stock

The average carbon benefits (C_{Avg}) (tC/ha) during the crediting period for each planting design is represented by the following equation:

$$C_{Avg} = C_{ABGB} + C_{AAGB} + C_{AHWP} - C_{AF}$$

Where:

C_{Avg} = Average net carbon benefits over the crediting period;

C_{ABGB} = Average carbon sequestered in below ground biomass of tree components over the crediting period;

C_{AAGB} = Average carbon sequestered in above ground biomass of tree components for all species over the crediting period;

C_{AHWP} = Average carbon stored in harvested wood products for all species over the crediting period;

C_{AF} = Average carbon emitted in the use of fertilizer over the crediting period.

The following sections further breakdown these components.

Average tree above ground biomass stock

The carbon in the above ground biomass (C_{AAGB}) (tC/ha) is calculated as follows:

$$C_{AAGB} = \frac{\sum_1^p \sum_1^t CF \times AGB_{tp} \times D_p}{n}$$

Where:

AGB_{tp} = Above ground biomass for species *p* at time t in kg;

D_p = The specific density of the wood of the species *p*;

CF = The constant representing the carbon fraction of dry biomass for tropical forests;

n = The project crediting period in years;

p = The total number of species in the planting design;

See Annex 10 for species-specific calculations of aboveground biomass.

Average below ground biomass of tree components

The carbon sequestered in the below ground biomass (C_{AAGB}) (tC/ha) is calculated as follows:

$$C_{ABGB} = C_{AAGB} \times R$$

Where:

R = The ratio of below ground biomass to above ground biomass for tropical dry forests.

Calculations for harvested wood products

The average carbon sequestered in the harvested wood products (C_{HWP}) (tC/ha) is calculated as follows:

$$C_{AHWP} = \frac{\sum_1^t \sum_1^p \left(C_{HWP_{tp}} + (C_{HWP_{(t-1)p}} \times k_p)\right)}{n}$$

Where:

k = Decay rate of species p;

$$C_{HWP_{tp}} = HWP_{tp} \times D_p \times CF$$

Where:

$$HWP_{pt} = V_{mpt} \times V_{hpt} \times PF_p$$

Where:

V_m = The standing volume per tree of merchantable timber of species p at year t;

V_h = The number of merchantable trees processed from species p at year t;

PF = Is the processing factor (the remaining volume after processing) of species p.

Calculations for fertilizer emissions

The average carbon emissions of fertilizer (C_{FE}) (tC/ha) is calculated as follows:

$$C_{FE} = \sum_{i=1}^{f} (V_f * EF_f)$$

Where:

V_f = Volume of fertilizer in tonnes;

EF_f = Emission factor of fertilizer

Parameters inputs

Table 14 describes the parameter inputs for the carbon benefits forecasting by project intervention. See Annex 10 for a further description of the parameters specific to the specific tree species AGB models.

Table 14. Parameter inputs carbon benefit forecasting

Description	Value	Reference
Wood Density (t/m3)		ICRAF Database
Swietenia humilis (MSFP, SP)*	0.718	""
Bombacopsis quinata (MSFP, SP)	0.428	""
Caesalpinia velutina (MSFP, SP)	0.722	""
Albizia saman (MSFP)	0.53	""
Leucaena leucocephala (MSFP)	0.59	""
Gliricidia sepium (MSFP)	0.67	""
Avocado Trees (CA)	0.5614	“”
Citrus Trees (CA)	0.59	FAO
Shade trees (CA)	0.602	Chave et al. 2006
Crediting Period (Years)	50	
Fraction of Carbon to Dry Matter	0.4928	IPPC, 2006
BGB to AGB Ratio		
AGB > 20t/ha (MSFP, SP)	0.28	IPCC 2006, Cairns et al. 1997
AGB <= 20t/ha (MSFP, SP)	0.56	""
AGB > 0t/ha (CA)	0.21	
Annual Rate of Decay (%)		
Wood Products (MSFP, SP)	2.30%	IPCC 2006
Fence Posts (MSFP, SP)	15%	Local Knowledge
Stem volume processing factors		
Sawnwood lumber (MSFP, SP)	0.35	Quirós et al., 2005
Posts (MSFP)	0.8	Internal Analysis
Fertilizer consumption (t/ha) (CA)		Recommendation by ECOM
Year 1(nursery)	0.003	""
Year 2 (after planting)	0.117	""
Other years	0.141	""
Fertilizer emission factor (CA)		""
Carbon to CO2 Conversion Factor	3.67	NA

**Where MSFP = Mixed Species Forest Plantation, SP = Silvopastoral,CA = Coffee Agroforestry*

Expected carbon benefits

The following Table 15 displays the carbon benefits from all pools for all three planting designs in the project.

Table 15. Carbon benefits (tC/ha) from project interventions

Carbon Pool (tC/ha)	MSFP	SP	CA
Aboveground Biomass	69.8	47.8	57.5
Belowground Biomass	19.6	13.5	12.1
Harvested Wood Products	10.2	3.7	0.0
Fertilizer Emissions	0.0	0.0	-0.02
Total	**99.5**	**64.9**	**69.6**

Where MSFP = Mixed Species Forest Plantation, SP = Silvopastoral, CA = Coffee Agroforestry

See Annex 9 for detailed graphs of the carbon uptake over the project period for each planting design.

Accounting for uncertainty

There is inherent quantifiable and unquantifiable uncertainty in any carbon forecasting modelling. To account for this uncertainty, Taking Root has taken various steps to provide conservative carbon benefit estimates. The steps are as follows:

1. The models explicitly exclude carbon pools that are expected to have net positive carbon sequestration benefits but are too costly to measure. These include pools for litter, soil, and above-ground non-woody biomass. See Table 15 for more information.
2. To minimize unquantifiable errors, the models use best practices such as allometric equations - instead of form factors - and up-to-date default values.
3. The forecasting models average the carbon benefits over the total project period instead of the rotation period. This approach leads to reduced and therefore more conservative carbon estimates.

G6 Leakage

Unintended losses in carbon stocks outside of a project area may result directly from project implementation, which can potentially undermine carbon credits from project activities (Vinca et al. 2018). These losses are otherwise known as leakage. This project calculates leakage as a percent discount from the total carbon benefits. After performing the following methodology, the project is at minimal risk of leakage. See the leakage methodology below.

Leakage methodology

The following approach was used to derive an estimated leakage discount factor for this project based on the following equations:

$$LD_{CP,a} = \frac{LE_{CP,a}}{PR_{a,t} - BR_{a,t}}$$

$$LE_{CP,a} = \sum_{1}^{p} (Arp_p * Prp_p * \Delta C_{a,p} * \frac{44}{12})$$

Where:

$LD_{CP,a}$ = Leakage discount factor in project area a;

$LE_{CP,a}$ = Potential net GHG emissions from carbon pools caused by activity shifting and/or market leakage from project area a (t CO_2 e/ha);

$PR_{a,t}$ = Expected net GHG removals under the project scenario for project area a (t CO_2 e/ha);

$BR_{a,t}$ = Total net GHG removals under the baseline scenario for project area a (t CO_2 e/ha);

Arp_p = Extent of project area that will experience reduced used, production or harvesting of wood, animals, agricultural crops or non-timber forest products p as a result of project activities (ha);

Prp_p = Reduction in production within the part of the project area that will experience reduced use, production or harvesting of wood, animals, agricultural crops or non-timber forest products p as a result of project activities, expressed as a proportion of production expected under baseline scenario;

$\Delta C_{a,p}$ = Potential reduction in carbon stocks per hectare from all eligible carbon pools that could occur as a result of displacement of use, production or harvesting of wood, animals, agricultural crops or non-timber forest products p as a result of project area a (t CO_2e/ha);

$\frac{44}{12}$ = Conversion factor from C to CO_2.

This approach is derived from the draft version of the Plan Vivo module "Calculation of Leakage Discount Factor in Plan Vivo Projects" from the 2022 Plan Vivo Standard.

Parameter inputs

The following Table 16 details the input parameters for the project.

Table 16. Parameter inputs for estimating leakage discount factor

Parameter Notation	Value			Justification	Section Reference
	MSFP	CA	SP		
	7.46	3.72	7.46	Baseline values	PDD Section G4
	0	0	0	No reduced production	PDD
	0	0	0	No reduced use	PDD
(tCO_2/ha)	7.46	3.72	7.46	Estimates from baseline scenario	PDD Section G4
(tCO_2/ha)	299.7	203.2	191.9	Estimates from project scenario	PDD Section G5

Where MSFP = Mixed Species Forest Plantation; CA = Coffee Agroforestry; SP = Silvopastoral Planting

Results

Following the approach for deriving the leakage discount factor, no leakage is envisioned from project implementation, since the parameters from Equation 2 were identified to be zero. This is because a significant proportion of land in the project area is underutilized in terms of production activities. Therefore, project activities are expected to enhance production in all the land use types considered.

The following gives the project's rationale by planting activity:

- Coffee Agroforestry **-** Incorporating trees in coffee plantations enhances production by providing shade, enhancing soil nutrients and retaining soil moisture, which helps to bolster resilience in the coffee production system. Such ecosystem benefits are expected to enhance production.
- Mixed Species Forest Plantations **-** Mixed species planting involving a mixture of multipurpose hardwood species and fast-growing firewood species returns degraded non-utilized land to productive use. For example, coppicing of nitrogen-fixing firewood species will provide much needed fuelwood while improving soil nutrients via soil nitrogen-fixing and litter fall.
- Silvopastoral Planting **-** Integrating trees on pastureland ameliorates the microclimate for animals while providing additional fodder to diversify animal feed, which enhances production. Additional ecosystem benefits include sustainable production of timber for fence posts and rural construction.

Leakage risk reduction

Apart from enhanced production from project implementation, which ensures that the risk of leakage is minimized, project participants are required to create individual farm management plans or *plan vivos* that demonstrate that sufficient land is available for their agricultural, silvopastoral or other land-use activities (see section E2).

Part H: Risk Management

H1 Key Risks

The following Table 17 outlines the key risks, their level of severity and how they are being mitigated by project interventions. The key risks are updated every 5 years.

Table 17. Description of risk types and their levels of risk

Risk Type	Risk Level (Probability)	Initial Situation	Mitigation measure
Unclear land tenure (carbon rights) and potential for disputes			
Land tenure	Low	Farmers can have privately owned land, but it is not often nationally registered	The project only accepts farmers that possess original documentation of land ownership (verified by a lawyer), or where the municipality can verify ownership through land title search
Potential for disputes with landless individuals	Medium	Some individuals do not own land	The project provides opportunities for landless individuals to be involved in project activities as workers (e.g., nursery building) and seasonal labour on neighbours' land

Disputes caused by conflicting land-use interests	Low	A significant portion of land is underutilized, but cattle often roam all over the place, which can destroy young trees	All projects are fenced in to avoid damage from roaming cattle or other animals
With inheritance to land, new land owner decides to not participate in project	Medium	Privately owned land usually possessed by the patriarch or matriarch of the family	Education to current and future inheritors on medium- and long-term benefits of the project. Continually educating on the importance of the project on the environment
Financial failure			
Project financial plan	Low	Budgets are reviewed annually to ensure financial projections and KPIs are reasonable and any variances in input cost can be explained. Quarterly budgets to actual reports are reviewed to ensure the project is staying on course. Additionally, all funds related to future farmers' PES are kept in separate guaranteed funds	Development of business plans (reviewed periodically) for economically viable management
Decrease in fuelwood and timber value	Low	Fuelwood and timber have high relative value	The project supports the diversification of chosen fuelwood and timber species from what is available in the market

Technical failure			
Technical capability of project coordinator	Low	Proven capacity to design and implement activities	The project only hires highly qualified staff and trains them on an annual basis
Poor selection of trees	Low	Farmers like to use species which are well adapted to the region	The project selected species based on regional experience, farmers' knowledge and technical advice
Management failure			
Management activities not carried out effectively	Low	APRODEIN has experience carrying out project activities	Taking Root's experienced project managers support APRODEIN staff to ensure optimal project implementation
Double-counting due to poor/bad record keeping	Low	Proper record keeping system in place	Transparent record-keeping procedures are documented combined with quality mapping of the project area and activities; the database is maintained with records of all carbon which is monitored and sold
Staff with relevant skills and expertise	Low	Staff are highly qualified	Careful selection of project staff and additional training is provided
Rising land opportunity costs that cause reversal of sequestration and/or protection			

Returns to producer and implementer stakeholders	Low	Opportunity cost of land is very low	Detailed financial analysis of project interventions. In addition to the payments for ecosystem services, the project is designed to provide high value products in the form of fuelwood, timber or coffee.
Introduction of new cash crop in region	Medium	Tobacco production, the latest cash crop in the region, has been banned in multiple municipalities	Appropriate land use planning through *plan vivos* allows diversified land use within farms
Political instability			
Land reform removes property rights	Low	Government currently in process of legalizing property	N/A
Social unrest	Medium	Economic hardship is generally dealt with by searching for employment in cities or other countries	Continuous process of community consultations to adapt the project operations to the social reality
Social instability			
Disputes caused by conflict of project aims or activities with local communities or organizations	Low	Project was built in consultation with other NGOs, the local community, and government	Participatory planning and continued stakeholder engagement over the project's lifetime
Participants lose interest in project	Low	High degree of desired participation by the communities	Project aims are aligned with farmers' needs

Devastating fire			
Forest fire	Medium	Forest cover in the area is minimal and isolated making it difficult for fires to spread	Frequent removal of fuel wood from project areas
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 farmers
Pests and diseases			
Incidence of tree crop failure from pests or disease	Medium	Mahogany (*Swietenia humilis)* is the only chosen species subject to insect attack by the shoot borer (*Hypsipyla grandella*.) These attacks are common and affect apical growth but rarely kill the tree when grown alongside multiple species.	Assessment of tree species, careful selection of tree species, strong diversification to minimize disease and pest spread.
Extreme weather events			
Drought	High	Becoming more common (1-2 every 10 years, especially during El Niño periods)	Replanting of trees as required, planting at the very beginning of wet season, selection of drought resistant species
Hurricane	Medium	Hurricanes occasionally hit the region	Replanting of trees as required

Floods	Low	Relatively infrequent (< 1 in 10 years)	Areas of interventions must be at least >150 m distance from a water body.
Geological risk			
Earthquakes	Low	Earthquakes occur above average, but not excessively often (the most recent earthquake was in 2014)	N/A
Landslides	Low	Landslides haven't caused much damage in the past	Projects don't take place in steep areas or shifting riverbeds

H2 Risk buffer

The risk buffer for the three interventions within the project is calculated at 11%, derived from the combined average score of the risk categories outlined in Table 18. To be conservative, we rounded up the risk buffer for the project's interventions to 15%. Risk categories are assessed based on the probability of risks occurring and their associated level of impact post interventions. For example, a risk such as a 'decrease in timber value' which is unlikely to occur and would have had a minimal impact on the project, receives a lower calculated risk score. The risk buffer is deducted from farmer PES payments to ensure that any uncertainties as a result of external or internal variables do not critically impact project outcomes. The risk buffer calculation is updated every 5 years.

Table 18. Risk buffer calculation

Risk Type	Probability (After Interventions) [P] Key: Low = .05, Medium = .1 High = .15	Impact (After interventions) [I] Key: Low = 1, Medium = 2, High = 3	Score = [I*P]
Unclear land tenure and potential for disputes			
Land tenure	Low P = 0.05	Medium I = 2	0.1
Potential for disputes with landless individuals	Medium P = 0.1	Low I = 1	0.1
Disputes caused by conflicting land-use interests	Low P = 0.05	Medium I = 2	0.1

With inheritance to land, new land owner decides to not participate in project	Medium P = 0.1	Medium I = 2	0.2
Financial failure			
Project financial plan	Low P = 0.05	High I = 3	0.15
Decrease in fuelwood and timber value	Low P = 0.05	Low I = 1	0.05
Technical failure			
Technical capability of project coordinator	Low P = 0.05	Medium I = 2	0.1
Poor selection of trees	Low P = 0.05	Low I = 1	0.05
Management failure			
Management activities not carried out effectively	Low P = 0.05	Low I = 1	0.05
Double-counting due to poor/bad record keeping	Low P = 0.05	Low I = 1	0.05
Staff with relevant skills and expertise	Low P = 0.05	Low I = 1	0.05
Rising land opportunity costs that cause reversal of sequestration and/or protection			

Returns to producer and implementer stakeholders	Low P = 0.05	High I = 3	0.15
Introduction of new cash crop in region	Medium P = 0.1	Low I = 1	0.1
Political instability			
Land reform removes property rights	Low P = 0.05	Low I = 1	0.05
Social unrest	Medium P = 0.1	Medium I = 2	0.2
Social instability			
Disputes caused by conflict of project aims or activities with local communities or organizations	Low P = 0.05	Low I = 1	0.05
Participants lose interest in project	Low P = 0.05	Low I = 1	0.05
Devastating fire			
Forest fire	Medium P = 0.1	High I = 3	0.3
Intentional burning of agricultural land	Medium P = 0.1	Low I = 1	0.1
Pests and diseases			
Incidence of tree crop failure from	Medium P = 0.1	Low I = 1	0.1

pests or disease			
Extreme weather events			
Drought	High P = 0.15	Medium I = 2	0.3
Hurricane	Medium P = 0.1	Medium I = 2	0.2
Floods	Low P = 0.05	Low I = 1	0.05
Geological risk			
Earthquakes	Low P = 0.05	Low I = 1	0.05
Landslides	Low P = 0.05	Low I = 1	0.05
Overall Score (average of risk types)			**.11**
Suggested risk buffer			**.15**

Part I: Project Coordination & Management

I1 Project organization structure

Table 19 summarizes the status and roles of the organizations that are involved in the project. As the project coordinator, Taking Root has been working in Nicaragua for over a decade in close collaboration with its local reforestation partner APRODEIN. Taking Root and APRODEIN are the co-owners of BOSNICA.

Table 19. Responsibilities of each organization involved in the project

Organization & Experience	Responsibilities
Taking Root *Purpose-driven company, federally incorporated in Canada*	***Project coordinator and applicant organization*** ● Develops technical specifications and certification documents ● Provides access to the Taking Root technology platform ● Provides project management and data quality control ● Generates carbon calculations ● Writes annual reports ● Does the project financial planning ● Manages administrative and marketing tasks ● Sells carbon credits
APRODEIN *Taking Root's reforestation partner in Nicaragua, registered as a non-profit organization*	***Technical operator and service provider (reforestation partner)*** ● Implements the project on the ground ● Recruits and informs farmers about the project ● Supports farmers to map and register their interventions with the government ● Provides continuous training for farmers to establish and manage their interventions

	● Manages central tree nurseries ● Monitors adequate management of the interventions to ensure farmers' compliance ● Carries out carbon monitoring using Taking Root's technology platform ● Pays farmers based on compliance
BOSNICA *For-profit (sociedad anónima), registered in Nicaragua, co-owned by Taking Root and APRODEIN*	***Commercial partner for forest products*** ● Buys forest products from participant farmers ● Manufactures high value wood-based goods (i.e, biochar, wood-crafts, coffee, etc.) ● Commercializes and creates national market for high value wood-based goods and subproducts

APRODEIN & Taking Root

Taking Root and APRODEIN are highly experienced organizations across forestry, smallholder economics, technology, and carbon financing. For over 10 years, the collaborative work of both organizations has demonstrated how to grow trees successfully with farmers to create carbon credits and sustainable livelihoods (see section I4 for an overview of the growth trajectory of the CommuniTree Carbon Program since the project started in 2010). APRODEIN has been able to increase its capacity and expand operations rapidly to improve farmers' livelihoods from a local to a national scope over this short period of time. In turn, Taking Root has gained international recognition and is currently developing and implementing forest rehabilitation projects with different reforestation partners in over nine countries to support smallholder projects.

BOSNICA

BOSNICA was created to generate additional forest product market opportunities for the project participants given the lack of a developed regional or national forestry products (timber and non-timber forest products) market in Nicaragua. BOSNICA is a for-profit company that acts as the commercial arm of the project to support the buying and commercializing of the forest products produced by the farmers from their interventions (e.g., pre-commercial thinnings, timber, and coffee) to create long-term added value for the participants. BOSNICA purchases the wood and coffee at a fair price to support farmers. In response to farmers needing a sustainable alternative to fertilizers, BOSNICA began manufacturing biochar. This local enterprise is meant to provide additional stability for farmers by providing another source of revenue beyond the project's payment period (10 years). Farmer revenue from BOSNICA is not counted as a PES farmer payment. Although farmers are not involved in the decision-making within BOSNICA, farmers remain the primary beneficiaries of BOSNICA's activities. BOSNICA makes decisions to improve the current and future livelihoods of project participants and their communities. These local enterprises are still in the early stages but present great socio-economic impact potential in the future with community participation and additional enterprises.

Stakeholder analysis

A detailed chart of identified stakeholders is presented in section E1.

I2 Relationships to national organizations

The project keeps the relevant national bodies informed on a continuous basis. APRODEIN's leadership team is in regular contact with ministries and key national organizations, such as the Ministry of Environment and Natural Resources (MARENA), the National Forest Institute (INAFOR) and the Climate Secretariat of the Presidency (SCCP) to inform them about the development and activities of the project. A detailed overview of the frequency and mode of this engagement can be found in the stakeholder chart that is provided in section E1 Community participation.

Taking Root, APRODEIN, and BOSNICA are privately funded and executed in partnership with smallholder farmers and therefore do not require approval by government authorities.

I3 Legal compliance

The project exceeds all the relevant laws and regulations in Nicaragua (see section G2 Technical Specifications). There are currently no activities taking place in the project that require any written approval by the government.

APRODEIN's leadership team keeps farmers informed on a regular basis of any potential policy changes that may affect forest management requirements or their carbon rights. The project also supports farmers with the mapping and registration of their tree plantations with the government (INAFOR and the Climate Secretariat of the Presidency) to guarantee their rights to sustainably use their tree plantations and their carbon rights.

Equal opportunities for employment

The project aspires to hire men and women in equal proportions. About half of APRODEIN's staff and Taking Root's international team are made up of women, many of whom are in management positions. Recruitment of local staff who will be employed in the project is done through job interview opportunities which are open to all qualified adults in the project area, regardless of their gender, ethnicity, religion, or sexual orientation.

Worker compensation and well-being

The project pays local staff well-beyond the national minimum wage, offers vacation in line with the requirement under the national labour code (Law No. 185), and provides a competitive benefits package, including private health insurance, travel expenses, cellphones, and English language training as per the requirements of each position. The project is currently in the process of passing an anti-bullying and harassment policy to further protect the rights of local workers and support their well-being.

14 Project management

Project timeline and scale

The project started in 2010 as a small-scale project in the municipality of San Juan de Limay (Department of Estelí) and since then it has expanded to be run nationwide as shown in Table 20. Today, CommuniTreeis the largest forest carbon initiative of its kind in Nicaragua recruiting new farmers and farmland across the country every year. The project plans to continue accepting new participants within the national boundaries in perpetuity while farmers continue expressing interest.

Table 20. Nationwide project expansion since 2010

Year	Country departments	Municipalities with farmland in the project	Percentage of municipalities within the project*
2010	1	1	0.6%
2014	2	2	1%
2016	2	4	3%
2020	9	38	25%
2021	14+1 Autonomous Region	71	46%
2022	15+1 Autonomous Region	100	65%

**Percentage estimated relative to the total amount of municipalities in the country (N=154)*

Project annual operations

Table 21 summarizes the project's annual operational cycle and all the activities implemented to establish new interventions and achieve the issuance of carbon credits. The annual operational cycle starts in January with the setting of annual targets and ends in February of the following year with the submission of the annual report which will trigger the issuance of the carbon credits.

At the start of every annual cycle, the project defines its annual operational targets based on the market demand for carbon credits identified by Taking Root, and the regional growth opportunities identified by APRODEIN. These annual targets will define an approximate number of carbon credits to generate (or saleable tCO_2) which translate toa target of hectares of land to be recruited, planted and monitored (via forest inventory) during the annual cycle, and a list of communities or regions in which recruitment of new farmers will be particularly focused based on interest expressed during the previous year. In line with these annual targets, the project develops a series of annual plans for the efficient implementation of the operational activities:

- Farmer recruitment and engagement plan (workshops, and visits to farmers and communities).
- Hiring and training plan for new (and established) field technicians.
- Procurement plan to source all required inputs for annual operations (seeds, planting and silviculture inputs, bags, wire, etc.)
- Monitoring plan to ensure tree growth monitoring via forest inventories in a) areas intervened in previous vintages, and b) new land intervened during that annual cycle.

According to this annual planning, the project starts implementing the project activities on the ground to achieve the annual targets as shown in Table 21.

Table 21. Project annual operational cycle

Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Project Annual Target Setting & Planning	X													
Hiring and Training Technicians		X						X						
Farmer Recruitment	X	X	X											
Nursery Establishment (and farmer training)	X	X	X											
Tree and Carbon Monitoring (old vintages, years -3, -5, -10)			X	X	X									
Planting new areas (and farmer training)					X	X	X	X						
Tree Maintenance (and farmer training)		X	X	X					X	X	X			
Tree and Carbon Monitoring (new interventions)									X	X	X			
Farmer Payments		X			X				X			X		
Data Analysis for Annual Report												X	X	
Submission of Annual Report		X												X

Project record keeping

The project keeps a record of key project data using the Taking Root technology platform. This includes keeping records of farmer data and documentation such as PES agreements, *plan* *vivos*, data consent forms, but also georeferenced polygons of all project intervention areas, and all monitoring data (tree and carbon monitoring) acquired by technicians from all project intervention areas during the project life span. The platform also supports record keeping of all training visits done by field technicians to farmers and proof of all payments disbursed to farmers. Throughout the project, field technicians working directly with the farmers will record and upload all this information onto the platform using Taking Root's mobile app. This data is then validated and serves as the basis for the issuance of the verified carbon credits generated via the submission and approval of the annual report to Plan Vivo.

For more details on the Taking Root technology platform database, see Annex 4. Project records are backed up at least once per week through an automated system that stores an image of our database on a secure third-party cloud provider in a separate storage service.

Business development and marketing

The Taking Root Commercial Department handles business development and sales. MARKIT transactions are handled through the Finance and Shared Resources Department of Taking Root (see section I6 for Marketing).

I5 Project financial management

Disbursement of PES funds

The project uses a distributed payment schedule to farmers over a 10-year period to create a stable income flow for farmers until their interventions are established and they can benefit significantly from their own forest products. A clear description of the total payment amount and the payment system is included in the PES agreements.

Within these 10 years, a series of sub-payments within each payment year are triggered based on completion of the tree planting and maintenance activities plan (confirmed by technicians) and achievement of their tree growth monitoring targets. (See further details about monitoring in section K1.) Distributing payments over the year (up to 4 times per year) and over a 10 year period based on a clear activity plan and incremental tree growth and carbon targets serves as an incentive to encourage farmers to continue with the program while ensuring the successful establishment of their interventions. It also helps them face some of the major costs associated with the establishment of the plantation in the initial years.

Funds for PES payments for each annual cycle are transferred from Taking Root's office in Canada to Nicaragua, where APRODEIN disburses payments to farmers via cheques. In most cases, farmers will visit the nearest APRODEIN office to collect their carbon payments (the organization runs six offices across the country), but farmers can also request their assigned technicians to bring the cheque to their farms if they do not have the means to visit any of the project offices. A copy of all payments disbursed is saved in the Taking Root's technology platform.

Financial plan

At the start of each annual cycle, an annual budget is presented by APRODEIN and approved by Taking Root to cover the operational costs associated with the implementation of the annual activities planned to achieve the annual targets. Revenue from the sales of carbon credits and all additional grant funding is held by Taking Root. APRODEIN is responsible for managing operating costs and performing disbursement of farmer payments. Taking Root provides oversight for all financial transactions, as well as performing regular audits. Sixty percent of the revenue that Taking Root receives from the sale of carbon credits from a specific vintage goes toward the *Community Fund* for that vintage, and the remaining 40% goes towards project operations (*Operations Fund*). Figure 15 provides a breakdown of funding allocation.

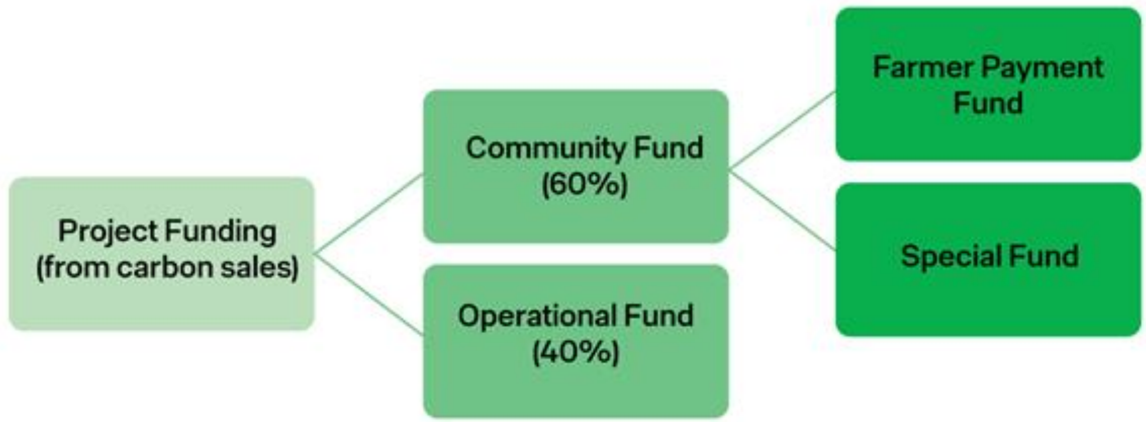

Figure 13. Breakdown of the allocation of funding resources

The Community Fund

The Community Fund receives 60% of the total revenue from the sale of the carbon credits from each vintage and it captures funding to be entirely allocated to farmers. It is essential to the project that farmers receive the majority of the revenue from the sale of carbon credits. Farmers will not grow trees on their land if doing so does not improve their livelihoods. Carbon revenues provide the initial incentive that farmers need to start growing trees, helping to unlock the value that they can receive through the sale of forest products as their forests mature. In this sense, the Community Fund acts as a catalyst for all the other forms of value that trees can provide to farmers.

The Community Fund is divided into two different pools of funding:

- The *Farmer Payment Fund*, and
- The *Special Fund*

The *Farmer Payment Fund* is entirely directed to disburse payments to farmers meeting tree growth annual targets and activity plans as per the PES agreements. This fund is the direct payment to farmers for successfully generating carbon credits.

The *Special Fund* captures the difference between the agreed carbon price stated in the PES agreements signed by farmers (based on carbon sales projections) and the final sales price of a given vintage. These additional funds are still entirely used to support the cost of project activities directly benefiting farmers such as the cost of maintenance of the central tree nurseries, and the purchase of equipment for project activities (e.g., pruning scissors, watering cans, etc.) that are given to farmers as needed to perform their tree planting and maintenance activity plan. CommuniTree provides these material inputs instead of cash payments as the project can:

- Purchase the nursery materials in bulk bringing significant cost savings to the farmers, and;
- Provide dedicated resources and capital to facilitate the purchase and transport of bulk quantities of seeds and tools for the nurseries.

The Operational Fund

The project's entire operations are funded via the remaining 40% of the carbon credit sale price of each vintage (the *Operational Fund*) so that the majority of the funds can be used to pay farmers directly. These operational costs include everything that is described in this document from certification and planning costs, marketing and sales, farmer engagement and recruitment, technician training, nursery management, silvicultural training, monitoring, reporting, financial and operational audits, technology, and administration.

Beyond the revenues generated through the sale of carbon credits, the project actively seeks out other forms of funding to cover project costs so that it can maximize carbon revenues for farmers. This includes securing institutional funding, grant funding, and other co-funding opportunities. By using a blended finance model, the project has been able to drastically scale its impact. The most recent grant information is outlined in Annex 2.

I6 Marketing

Taking Root focuses on building its brand to establish itself as a leader in tropical reforestation with smallholder farmers. Brand awareness is built through continued regular communications throughout the year. These include monthly blogs and thought pieces, monthly newsletters and other media, including videos and interviews from the project to showcase the work being done and Taking Root's Approach.

The client base that Taking Root targets with its marketing activities consists of a suite of international carbon retailers, as well as corporates looking to offset their carbon footprints.

All clients receive regular updates from Taking Root's marketing department. Updates contain media files, including photos and videos of various tree-planting activities, and interviews with farmers and staff. In addition, the Taking Root technology platform grants clients unparalleled access to activities and impacts from the project in near real time. Clients receive a project impact report at the end of each year.

Taking Root establishes a marketing plan on an annual basis. Marketing plans consider Plan Vivo certificates and sales targets for the year, key partner and client requests, market dynamics and specific marketing deliverables. The marketing plans prioritise direct communications with partners and corporate clients to continue building and growing relationships, while enabling further brand awareness. Based on developing a series of high-level marketing objectives, these are then broken down into a timeline of specific pieces of content and stories from the project, which are compiled and delivered across Taking Root's channels throughout the year. Taking Root monitors these activities to understand which materials and content are most engaging and impactful to further hone its marketing strategy on an on-going basis.

I7 Technical support

The project provides technical support and capacity development to participating farmers on an ongoing basis. Training is provided by field technicians that visit farmers regularly (from an average of 15 visits in year 1, to 3 visits in year 10), holding in-farm training sessions, giving technical and legal advice to successfully register and use their forest, monitoring the interventions and sharing project information with the farmers. The technicians are directly employed by APRODEIN. They are recruited from the diverse local communities within the country, so they understand the different regional farming realities and are connected to the farming communities. Where possible, technicians are hired based on preliminary experience in forestry and/or agriculture, and receive in-house training on the use of Taking Root's technology platform and how to deliver high-quality services to the farmers in the project. Technicians work out of APRODEIN's six offices that are located in different regions of the country (Somoto, San Juan de Limay, San Juan de Río Coco, Boaco, Santo Tomas, and Diriamba).

Part J: Benefit Sharing

J1 PES agreements

Procedures for entering PES agreements

As outlined in section I, each year the project sets and approves the annual operational targets based on expectations for demand and supply for carbon removals. Demand is assessed based on conversations with buyers, and supply is assessed based on technicians' projections regarding the number of farmers interested in participating in the project for the coming year. The outcome of this agreement is translated to a recruitment target for the year for new PES agreements.

Once a recruitment target has been agreed upon by Taking Root and APRODEIN, Taking Root then engages in selling activities of carbon credits to secure the funding for newly recruited farmers. For over a decade, Taking Root has proven its ability to meet its funding targets, often surpassing expectations in both volumes and price. Besides Taking Root's historical record, the recent rapid growth of the carbon market has also caused market demand to outpace supply, reducing the risk of potential funding inadequacies.

The recruitment of farmers to enter into PES agreements works as follows. Recruitment technicians approach the mayors and regional government offices in municipalities where the project seeks to expand its activities that year. With the help of these local officials, farmers in the area have the opportunity to listen to presentations where field technicians explain the project and present the details of the PES agreements. At the end of these informative consultations, farmers can leave their contact information for field technicians to arrange follow-up visits based on a first come first serve basis. In addition, participants are recruited into the program on a first come first serve basis contingent on sales targets for the year. Since Taking Root has historically been supply constrained, we have never had to turn down an interested and eligible participant.

PES agreements are signed with farmers if they meet the eligibility and applicability requirements. The eligibility and applicability assessment ensures that PES agreements are signed with farmers that own their land, have sufficient land available and choose an intervention that is adequate to their farm's characteristics, and that the project interventions do not take away from subsistence activities (see sections C3 Land tenure and E2 Community-led implementations). Prior to signing, field technicians explain in detail each section of the contract and answer any question that the farmer may have.

The PES agreement largely describes three main elements; Taking Root's/APRODEIN's commitments to support the farmer, the farmer's commitments to follow through with the project, and details concerning the consequences of non-compliance. More specific information included in the agreement is detailed below. Refer to Annex 3 to view an example of a PES agreement for each project intervention.

PES Agreements are written in Spanish (the local language) and include the following details:

1. Details describing the amount of land dedicated to each planting intervention(s).
2. The quantity of carbon credits the farmer will produce from each area of intervention, the price per tCO2, and the total payment to be expected over the contract period.
3. The expected payments and payment periods.
4. A description of tree planting and maintenance activities to be carried out by the farmer every year according to the selected intervention.
5. The tree growth targets to be achieved and confirmed via monitoring every year.
6. A clause to ensure that farmers do not enter into any other PES agreement for the same land within their farms.
7. A clause to ensure that the agreement is passed onto a pre-designated party (guarantor) if the original farmer cannot continue with their agreement.
8. Details of payment adjustments for low performance.
9. Details on the deduction of the risk buffer.

Alongside the cash incentives of entering a PES agreement, the project actively supports farmers to successfully reach their targets through regular in-farm training and technical assistance. APRODEIN validates successful project activities via monitoring, described in section K1.

Farmers enter PES agreements according to the principle of FPIC (free, prior, and informed consent):

- Free - Farmers are not pressured, coerced, or manipulated by the local/national government nor the project in entering a PES agreement. There are no laws which enforce participation.
- Prior - Before entering a PES Agreement, field technicians present the project (including the explanation of contracts and required activities) in community consultations and workshops which allows farmers to voice their opinions and ask questions during the early stages of project development.
- Informed - Consultations and subsequent farm visits are also an opportunity for farmers to learn about the project's benefits, activities, and objectives before joining the program in a transparent way. All documents are available in the local community's language.
- Consent - Once farmers have a complete understanding of the project's objectives and potential impacts, they will have the opportunity to accept or reject the project by voluntarily entering or not entering a PES agreement.

J2 Payments & benefit sharing

Disbursement of funds to farmers is done over the 10-year period based on predetermined farmer performance targets that are specified in the PES agreements. These include activity targets for performing specific planting and silvicultural activities and tree growth targets, each of which follows separate monitoring processes. Tree growth targets are assessed via forest inventory monitoring activities performed by field technicians. Tree growth monitoring occurs 4 times per farm over the contractual period (further details in section K). Silvicultural activities are a function of the work that needs to be done by the farmer to meet each year's tree growth targets, and they are assessed via farm visits by field technicians (see sections G1 and I7 for further details). All information related to the monitoring of silvicultural activities and tree growth monitoring via forest inventory is supported via Taking Root's mobile app and technology platform, where data is stored and evaluated, and records are kept from field visits, including field technicians uploading geo-tagged pictures to demonstrate activity results on each farm.

Payments to farmers are made using the following annual process:

1. Each farmer is assigned a field technician. After farmers sign a PES agreement, they are entitled to a maximum payment of their first year's budget based on completing the silvicultural activities prescribed by the field technician.
2. The field technician communicates to the farmer the activity plan (also detailed in the PES agreement) required for the optimal establishment of the trees and the achievement of the tree growth or carbon contractual targets based on the selected intervention (Table 10 - section G1).
3. The field technician and the farmer agree on a payment for each activity based on the state of the parcel. This budget should be inferior to the annual budget.
4. The field technician requests the agreed upon budget from their regional coordinator, who then confirms the availability of funds. The regional coordinator determines whether the request is reasonable based on the 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 the budget.

5. The regional coordinator passes the signed request for funds form to the administration department, which does a final review against the allocated annual budget and issues the cheque(s) for that amount in the farmer's name.
6. The field technician reviews the completion of the farmer's activities and records the results, including a geo-tagged picture, into the Taking Root technology platform via the mobile app. After each completion of each prescribed activity is confirmed, the technician approves the payment and gives the farmer the cheque or tells the farmer that payment can be collected at the nearest project office. Should the activity not be completed, the farmer's payment is not approved, and the cheque is not released.
7. If the annual tree growth target of year 1 is met based on the result of the tree growth (forest inventory) monitoring at the end of the year, a new budget is made available for the following year to reach the next tree growth target. If the contractual target is not met, the farmer is put under review and the technician makes a judgment call to decide whether they believe the farmer is likely to succeed via replanting in the following year. If they fail on the second round, they are removed from the program and new land is recruited as a substitute.

Note that only during the first year, farmers who express lack of funds to cover the cost of pre-planting activities (i.e., nursery establishment, land preparation and fencing of the area) for Mixed Species or Silvopastoral interventions can receive up to 20% of their total eligible payment as a prepayment (or *adelantado*) from the project to help them access to the capital needed to meet the cost of planting activities. This prepayment often includes a portion in cash and a portion in kind (i.e., wire for fencing the area of interventions.) This prepayment is deducted over the 10 year payment period in a proportional manner to the percentage of the total payment the farmer is eligible to receive every year. Farmers who receive this prepayment but fail to meet their activity and tree growth targets are removed from the program and will be expected to return the prepayments received to the program.

Payments and benefit sharing for farmers using the Coffee Agroforestry intervention is designed somewhat differently to account for higher upfront establishment costs. The Community Fund payments are used as collateral against below market rate loans offered by BOSNICA. These loans are used to cover the higher cost of establishment and are paid back over time through future coffee sales. Farmers can either choose to sell the coffee to BOSNICA that will offer above market prices - due to its sustainability attributes - or sell the coffee elsewhere if they can get a better price. When farmers repay the loan, farmers start receiving the Community Fund payments based on meeting targets.

To ensure equity, the PES agreements in this project are designed to give each farmer the same price per credit, and per vintage (program entry year or planting year). The conditions of benefit sharing are outlined in the PES agreements and are verbally communicated to the farmers before signing.

The contractual value of certificates (tCO_2) listed in the PES agreements is based on the expected average carbon sales price for that vintage. Since the actual average carbon sales price cannot be finalized until the following year once the certificates have been issued and the sale realized, PES agreements only provide a conservative estimate of the expected sales price. The difference between the carbon sales prices listed in the PES agreement and the realized sales prices at the end of the year becomes a surplus available to farmers via the Special Fund (see I5 Project financial management). This system ensures that the project honours the contractual value with farmers as per the individual PES agreements, while stocking the Special Fund from which project participants benefit collectively.

Part K: Field Monitoring

K1 Ecosystem services benefits

The project has a robust field monitoring protocol in place for tracking tree growth and silvicultural activities. The goals of the monitoring protocol are to:

- Estimate the delivery of ecosystem services, notably carbon sequestration for buyers;
- Estimate the tree density and composition of the interventions to inform appropriate management interventions for underperforming parcels;
- Estimate long-term timber supply for forest product processing planning;
- Develop a rich data set on intervention growth and interactions to inform and continuously improve decisions based on adaptive management.

Taking Root's monitoring approach is split into two categories:

1) Monitoring of silvicultural activities (i.e., tree planting and maintenance) carried out by the farmers against the prescribed activity plan (Table 10 - section G1), and;
2) Monitoring of tree growth and carbon sequestered carried out by project technicians using formal forest inventories against the project intervention carbon models.

Delivery of ecosystem service payments to the participants is dependent on successfully meeting monitoring targets for both silviculture activities and forest inventories. See further details in section J.

The following sections describe the methodology for tracking project activities and forest inventory.

Monitoring of silvicultural activities

This type of monitoring is performed through technician field visits to verify that the silvicultural activities needed to reach tree growth targets have been completed according to the prescribed activity plan agreed with the farmer (Table 10 - section G1). The inspection of silvicultural practices occurs multiple times a year throughout the intervention establishment period (years 1-10). During their visits, field technicians visually determine whether activities such as planting, replanting, pruning or thinning have been performed as described in the activity plan (included in the PES agreement) and instructed during previous training sessions and farm visits.

This type of monitoring is quick, effective, low cost, and highly tailored to the farmer's and plantation's particular needs. For example, if a particular parcel does not need thinning one particular year, no thinning will be prescribed.

During the first years, the visits are frequent (up to 17 times in the farmers' first year) and decline over time as trees take root and require less maintenance. Technicians record their visits using Taking's Root mobile app and upload a picture as evidence that the activity was performed before releasing payments.

See a list of silvicultural activity annual targets per year for each type of intervention in Table 10 (section G1.)

Monitoring of tree growth

Tree growth is measured in all project interventions through forest inventories. These inventories serve to verify that the interventions are on track to meet carbon sequestration targets as determined in the PES contracts, and for reporting to clients, funders, and certification bodies. The methodology followed for this monitoring is highly standardized and rigorous.

The tree inventories are performed in years 1, 3, 5, and 10 of a parcel's entry into the program. After year 10 and until the end of the crediting period, a sustainable forest management approach is evoked. Using remote sensing data, project stand growth and volume is monitored to ensure that it aligns with the carbon model projections. If there is significant underperformance, field technicians will be informed and intervene.

Taking Root harnesses the Taking Root Approach: *Automating Forest Carbon Quantification* (Taking Root, 2021) and the Taking Root technology platform to create sampling frames for the forest inventories. To do so, the user enters the expected plots per hectare (i.e., density) and the plot size. The platform algorithm then calculates the plot distribution using a fixed grid with a random start. See section 6.2 in *Automating Forest Carbon Quantification* for a description of how the Taking Root technology platform sets up the sampling frame. See section 6.3 of the document for a description of how the project collects tree measurements in the field.

The following are the inputs used in the platform by technical specification.

Table 22. Inventory parameters by technical specification

	Mixed-Species Forest Plantations	Silvopastoral Planting	Coffee Agroforestry
Plot radius (m)	7	7	10 (2 subplot for coffee plants only)
Plot shape	Circular	Circular	Circular
Plots per hectare	6	6	6

These plots are temporary in nature. While the plots' geospatial coordinates stay fixed over time, there are no stake plots installed during the forest inventories, so GPS error introduces a level of uncertainty to locate the exact placement of the plot year over year.

In 2023, Taking Root performed an extensive analysis to ensure that the sampling density is appropriate for a 90/10 confidence interval as per the Taking Root Approach. The analysis covered the monitoring data from three recent vintages (2016, 2017, and 2018) to ascertain that they exhibit a confidence interval of less than 10% for the project level carbon estimates. These years were selected as they epitomize a more mature stand base than recent plantings. Table 23 delineates the results. All years provide results within our confidence level, evidencing that the inventory parameters from Table 22 are appropriate. The python code for the analysis is available in the link in this footnote[6].

6 https://www.dropbox.com/scl/fi/pfta312wgry7mj8sniap2/confidence_interval_estimation_notebook.ipynb?rlkey=n2sn10ntbnmyaio2hnr1apyyj&dl=0

Table 23: Results demonstrating the adequacy of the sampling design.

Vintage (Year)	Carbon Estimate (tCO2/ha)	Error Proportion of Mean (%)
2016	45.34	5%
2017	55.51	8%
2018	51.01	9%

Technician training

To conduct the forest inventories, field technicians record tree data (i.e., tree species, tree diameter at breast height and/or tree height) from all trees within the parcel's monitoring plots generated by the Taking Root technology platform. Tree data is then uploaded directly to the platform via the mobile app. With this data, the platform automatically calculates basic metrics for each parcel (or parcels) including trees per hectare and stand basal area. The Taking Root technology platform allows field technicians to harness a simple and streamlined approach to gather and systematically record field data efficiently.

Field technicians are trained by APRODEIN to conduct systematic, high-quality forest inventories using a combination of technical and practical approaches. The following training is given to each technician to ensure success in field inventories:

- Using the Taking Root mobile app to find plots and enter tree data on those plots
- Using forestry tools for tree measurement such as a diameter tape
- Setting up sampling plots using the Taking Root Approach: *Automating Forest Carbon Quantification* (Taking Root, 2021)
- Using logic and sound judgment for how to measure trees according to their location in the plot, their height, and environmental variation (e.g., sloped terrain, crooked trees, etc.)
- Identifying common tree species

When fully trained, one technician team consisting of a team lead and a field technician can complete around 3.5 ha/day. This average may fluctuate depending on parcel management unit type, parcel terrain and distance, and if it is the first year of monitoring. This team has the ability to monitor approximately 77 ha per month assuming 22 working days. As the typical monitoring season lasts for 4 months (May to August), Taking Root needs approximately 3.25 teams per every 1,000 hectares in the project.

Field technicians trained by the project are in charge of performing the forest inventories. In addition, the inventory is performed alongside the participating farmer so that they have a clear understanding of their performance. In the past, technicians would informally communicate monitoring results to farmers (i.e., verbally.) In 2023, Taking Root launched a new formal system consisting of a written document delivered to farmers summarizing the results of monitoring and the subsequent technical recommendations if needed.

The document, to be signed by the farmer and the technician after its review, includes the following:

- The monitoring date;
- The results of the monitoring;
- The target to be met depending on parcel's age; and,
- The recommendations provided by the technician based on the comparison between results and target to be met.

Field technicians deliver this document to the farmer after each monitoring event and explain the technical recommendations in more detail to make sure the farmer is equipped to follow them appropriately. A copy of the signed document is then uploaded to the Taking Root technology platform to save a record of the communication with the farmer.

The field technicians are ultimately responsible for ensuring farmers meet their contractual parcel growth targets. To ensure success, field technicians give hands-on assistance and best-practice recommendations to those farmers underperforming against their parcels' growth targets.

Table 24 details the planting intervention growth targets which are measured against the data from the forest inventories. These target values are aligned with the planting intervention carbon forecast models. Where there are two targets in a single year (e.g., trees planted and parcel median height), both targets must be met for the parcel to pass monitoring.

Table 24. Planting intervention growth targets

Year(s)	Target(s)		
	Mixed Species	Silvopastoral	Coffee Agroforestry
1	1100 TPH	300 TPH	134 TPH
3	1100 TPH & median height of trees in parcel > 1.3 m	300 TPH & median height of trees in parcel > 1.3 m	134 TPH
5	2.59 BAHA	0.16 BAHA	1.95
10	14.46 BAHA	3.58 BAHA	6.33

Where: BAHA = Basal Area (m^2 /ha) and TPH = Trees planted (trees/ha)

Community involvement in monitoring activities

Monitoring activities to assess farmers' achievement of the silvicultural activities and tree growth targets are performed by APRODEIN's hired and trained technicians. Technicians are hired from the local community, creating training, jobs, and opportunities for people from the community who are not farmers. Farmers do not perform the monitoring activities to maintain the integrity and objectivity of the monitoring data. Self-monitoring would create a conflict of interest in the context of performance-based payments.

Although farmers do not perform monitoring, they are often present while monitoring activities are being conducted. During this time, technicians take the time to answer farmer's questions and inform them on how and why monitoring takes place. This allows the farmers who are interested in learning about monitoring to become involved in this process. For more ways which farmers are involved in decision-making and project activities, refer to section E3 and G1 respectively.

K2 Socio-economic impacts

The project improves Nicaragua's socio-economic status through specific project activities. These activities are monitored using the following socio-economic proxy indicators:

Table 25. Project socio-economic indicators

Indicator	Unit of Measurement	Monitoring Plan
Money Paid to Farmers	Cash paid per year (USD$)	Receipts for monthly payments are issued and recorded by Taking Root's accounting department. Payment transactions are also documented on the Taking Root technology platform. Reporting is done annually.
Jobs Created	Number of people employed per year	Employment is monitored continuously by Taking Root and APRODEIN. Employment contracts are processed via Taking Root's accounting department. Reporting is done annually.
Training Delivered	Number of annual farm visits	Project staff and technicians routinely visit farmers for training and support. Training visits are recorded in the Taking Root technology platform. Reporting is done annually.

The above indicators are considered for the following reasons:

- Money paid to farmers - Cash payments for ecosystem services result in higher income. With a higher income, local people can improve their livelihoods. The project specifically tracks the number of new participating communities and smallholder families, and the total payments which were issued to them. PES serves as a proxy indicator for socio-economic well-being.

- Jobs created - Employment creates stability. With secure jobs, local people can save money, which in turn can positively affect their living conditions. The project specifically monitors the percentage of temporary workers who are landowners, the percentage of temporary female workers, and total employment created. Jobs created serve as a proxy for socio-economic well-being.
- Training delivered - Through the tree planting activities, participating farmers learn how to manage their lands sustainably and more productively, which can help them improve their business and income. The project specifically monitors the number of training workshops delivered to community members in farms every year. Training provided serves as a proxy for socio-economic well-being.

K3 Environmental and biodiversity impacts

The project supports the following biodiversity indicators:

Table 26. Project biodiversity indicators

Indicator	Unit of Measurement	Monitoring Plan
Land Reforested	Hectares reforested	The three indicators are being assessed using the monitoring process described in section K1
Trees Planted	Number of trees planted	
Diversity of Trees	Number of native tree species planted	

The above indicators are considered for the following reasons:

- Land reforested - With the establishment of tree plantations it becomes possible to implement sustainable resource use, watershed management, and land use planning in areas that suffered from environmental degradation. Land reforested serves as a proxy for improved ecosystems and biodiversity.
- Trees planted - Planting activities result in increased forest cover, which is a prerequisite for a number of benefits described in section F3, including rehabilitation of wildlife habitat, increased water and nutrient retention, and improved air quality. Trees planted serve as a proxy for improved ecosystems and biodiversity.
- Diversity of trees - With the planting of tree species that are native to the region, benefits to water, soil, and habitat are optimized. Diversity of trees serves as a proxy for improved ecosystems and biodiversity.

K4 Other monitoring

All monitoring for this project is described in sections K1-K3.

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Annex 1. List of key people involved with contact information

Annex 1 - Table 1. Key people involved in the project

Organization	Key Contacts Participant and Position	Nationality	Role(s)
Taking Root	Laura Morillas Director, Reforestation Partnerships info@takingroot.org	Spanish	Oversees project implementation and development
			Coordinates external project reviews and supervises creation of annual reports
			Develops and maintains relationships with international project funders
	Will Sheldon Director, Commercial will@takingroot.org	British	Leads all marketing and communications
			Manages and develops all carbon credit sales
APRODEIN	Elvin Castellon, Executive Director elvin@takingroot.org	Nicaraguan	Leads and coordinates on-going community engagement and project expansion
			Administers payments to producers
			Provides fiduciary responsibility to organization
	Elsa Damarys Gonzáles Operations Director elsa@takingroot.org		Oversees all operational components of the project
			Provides technical training for technicians

Annex 2. Information about funding sources

Taking Root is an independent purpose driven organization. An increasing number of individuals, private businesses and institutions in Canada form a diverse funding base to support the organization's ongoing activities, including the purchase of carbon certificates. Some financial support from the Canadian public sector was received in the form of grants and wage subsidies.

- During 2017 - 2019 fiscal years, Taking Root received funding from Catholic Relieve Services (CRS)
- During the 2020 fiscal year we didn't receive development funding for the project
- During the 2021 fiscal year, Taking Root received funding from ECOM Agroindustrial Corp. Ltd (ECOM), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and BANPRO
- During the 2022 fiscal year, Taking Root received funding from BANPRO, the Nordic Climate Fund (NCF), ECOM, and GIZ

Annex 3. Producer/group agreement template

PES Agreement for Coffee Agroforestry (English version):

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreemennt]

Reforestation and Payment for Environmental Services Agreement

Taking Root, located at 948 Homer Street, office 300, Vancouver, BC, V6B 2W7, Canada and represented by the Asociación de Profesionales para el Desarrollo Integral de Nicaragua (APRODEIN), located at kilometer 217, one block west, barrio Los Maestros, Somoto, Madriz, Nicaragua and the Producer [*Farmer name*] located in [*Community, Region]*, with ID number [*Farmer government ID*] have decided to subscribe to the terms of this Agreement.

Whereas the Producer 1) is the owner of the land(s) described in Table "A"; 2) agrees to abide by the conditions described in this agreement and the legal contract associated with this document; and 3) agrees to enter into this Agreement.

Section I - Taking Root via APRODEIN agrees to:

1. Provide technical services to the Farmer for he/her to achieve the reforestation and plantation management objectives on their plot as described in the Appendices.
2. To help the Farmer to commercialize the products produced in the part of its farm reforested under the modalities of this Agreement.
3. Facilitate financing with BOSNICA, S.A. to cover the costs of coffee plants and inputs necessary for the establishment of coffee agroforestry systems in the area(s) covered by this agreement.

Section II - The Farmer agrees to:

1. Carry out the management activities necessary to achieve the targets described in the Appendix. Failure to carry out these activities is considered a breach of the Contract (see Section III).
2. Not enter into another agreement for the sale of environmental services related to the same area of his/her farm covered by this agreement.
3. Care for and protect the part of his/her farm covered by this agreement so that it remains reforested until [*Parcel(s) entry year +50*] and follow APRODEIN's recommendations for harvesting and thinning of timber products until that year.
4. Allow access to Taking Root/APRODEIN technicians for plantation monitoring and supervision of maintenance activities in reforested areas.
5. Not to bring animals into the reforested area or plantation.
6. Transfer the benefits and responsibilities of this agreement to the buyer of his/her farm in case of selling the farm or to the Guarantor in case of not being able to continue with the agreement.
7. Give permission to Taking Root and APRODEIN to use certain personal and family information such as their names, pictures, videos, project financial information, farm information including geospatial information on their publicly accessible website and their partners' websites for the following purposes: marketing, to facilitate payments to the farmer and to promote the program. This information will be retained by the program, but the Farmer may revoke this consent without retroactive effect by clearly informing APRODEIN or Taking Root of his/her desire. Upon doing so, all personal information about the Farmer will be removed from public access.

Section III. Breach of the legal contract associated with this agreement.

1. In the event of a breach of this agreement for reasons other than weather, the breach measures detailed in the legal contract associated with this agreement will be applied.

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreemennt]

Signatures

Taking Root	APRODEIN
Kahlil Baker	**Elvin Castellon**
Signature and Name	**Signature and Name**
24 January 2022	*24 January 2022*
Date	**Date**
Excecutive Director	Legal Representative
Position	**Position**

Farmer	Guarantor
Signature	**Signature**
Date	**Date**
ID Number	**ID Number**

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreemennt]

Table A – Agreement Value

Parcel - Plan Vivo number	**Management Unit**	**Area**		**Tons of CO2**
		hectares	blocks	
PARCEL ID from tech platform	*Coffee Agroforestry*	*Area from Tech platform*	*=ha* 1.4232*	
PARCEL ID from tech platform	*Coffee Agroforestry*	*Area from Tech platform*	*=ha* 1.4232*	
Total				

Appendix - Agroforestry System: Shaded Coffee

Year	**Management activities target**	**Trees and carbon target**
1	Fencing, weeding, clearing, establishment of nurseries, planting trees, weeding and application of fungicide and fertilizer	134 árboles/ha
2	Establishment of nursery and replanting of trees as needed, weeding, pruning and application of fungicide, sun protection and fertilizer as needed.	
3	Weeding, pruning and as needed applications of fungicide, sun protection and fertilizer.	134 trees/ha
4	Weeding, pruning and as needed applications of fungicide, sun protection and fertilizer.	
5	Weeding, pruning, fungicide, sun protection and fertilizer applications as needed. Coffee harvesting.	Basal area= 1.95 m3/ha
6	Repeat Activities from Year 5	
7	Repeat Activities from Year 5	
8	Repeat Activities from Year 5	
9	Repeat Activities from Year 5	
10	Repeat Activities from Year 5	Basal area= 6.33 m3/ha
11-50	Sustainable maintenance of the intervention	

PES Agreement for Mixed-Species and Silvopastoral Plantations (English version)

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

Reforestation and Payment for Environmental Services Agreement

Taking Root, located at 948 Homer Street, office 300, Vancouver, BC, V6B 2W7, Canada and represented by the Asociación de Profesionales para el Desarrollo Integral de Nicaragua (APRODEIN), located at kilometer 217, one block west, barrio Los Maestros, Somoto, Madriz, Nicaragua and the Farmer [*Farmer name*] located in [*Community, Region*], with ID number [*Farmer government ID*] have decided to subscribe to the terms of this Agreement.

Whereas the Farmer 1) is the owner of the land(s) described in Table "A"; 2) agrees to abide by the conditions described in this agreement and the legal contract associated with this document; and 3) agrees to enter into this Agreement through which they will receive payments in exchange for the environmental services (i.e. tons of carbon sequestered by the end of this agreement, see Table A) resulting from their tree planting and maintenance activities.

This Agreement is not a donation contract. The incentives provided by Taking Root/Aprodein as a result of the signing of this Agreement are subject to the fulfillment of forest management activities as well as the fulfillment of monitoring targets as described in Section I.

Section I - Taking Root via APRODEIN agrees to:

1. Provide technical training, periodic supervision, and technical recommendations so that the Farmer can establish his/her plantation successfully and have the capacity to achieve the forest monitoring targets of his/her parcel that give him/her access to the incentives available by stage as described in the Table B of this contract.

2. Carry out all forest monitoring activities during the first ten years of this Agreement to confirm that the Farmer is achieving his/her targets as well as to communicate his/her results and corrective recommendations to the Farmer.

3. Pay the Farmer the incentive associated with the environmental services generated by his/her plantation if it is properly managed, as described in Table A. Said total incentive will be distributed throughout the period necessary to meet all forest monitoring targets, estimated at ten years, according to the incentive system described in Table B of this contract. The system works as described below:

    a. At the beginning of this Agreement, the Farmer has access to an initial fund for the preparation of his/her parcel and nursery (See funds available for this stage in Tables B and C) that he/she will receive as the forest management activities are confirmed by the Aprodein technician (See Table D). Once the proper performance of these tasks is confirmed by the technician, the Farmer gains access to the "Parcel in planting" fund with potential incentives for planting and clearing the newly seeded parcel (See funds available for this stage in Tables B and C).

    b. From planting, the Farmer must achieve a series of forest monitoring targets to access the next stage and the incentive fund associated with it until reaching the stage of "Parcel in production", where the Farmer is free to make use of his/her parcel sustainably (see more details in Table B).

    c. The distribution of the incentives by activity in each stage will be decided by the technician according to the specific needs of his/her parcel and in clear and early communication with the Farmer.

    d. If, at the time of forest monitoring, a parcel does not reach the forest monitoring target to move to the next stage, said parcel will enter a review period, and the Taking Root/Aprodein team will inform the Farmer of the necessary corrective actions to access more funds and in what period of time they must be carried out. If such recommendations are ignored, it is considered a breach of contract (See Section III).

    e. The fund available for each stage (Table C) represents the maximum fund to be received during that stage, but depending on the specific conditions of the parcel, the Aprodein technician may decide to reallocate part of the fund from one stage to a later stage. always with the sole objective of optimizing the development and establishment of the parcel according to its specific needs and in clear and direct communication with the Farmer.

:

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

f. Any Farmer whose parcel(s) reaches the "Parcel in production" stage by achieving the forest monitoring target of the previous stage ("Parcel established") must have received the full potential incentive associated with this Agreement. (Table A). The achievement of said goal will result in the payment of any incentive that has remained to be delivered from the previous stages.

4. Support the Farmer in the commercialization of the forest products generated in the parcel of his/her reforested farm under the modalities of this Agreement . The Farmer signing this contract keeps intact all his/her rights to the ownership of his/her land and the right to use any forest product associated with it (firewood, food, wood or any other product produced on it).

<u>Section II - The Farmer agrees to:</u>

1. Carry out management activities according to the recommendations of the project technicians and work to achieve the forest monitoring targets of each stage described in Table B. Failure to carry out these activities or non-compliance with the forest monitoring targets of each stage is considered a breach of the Agreement (see Section III).
2. Not to introduce animals into the reforested area established in conjunction with Taking Root/APRODEIN until guidance from the field technician is obtained.
3. Demonstrate, through an official document, that he/she is the owner of the land to be reforested to facilitate the forest registration process, as well as not sign any other Agreement for the sale of environmental services related to the same area of his/her farm covered by this Agreement.
4. Care for, manage, and sustainably make use of the parcel reforested as part of this Agreement up to *[Parcel(s) entry year +50]*, following APRODEIN recommendations for the sustainable use and thinning of timber products until that year.
5. Allow access to Taking Root/APRODEIN technicians for forest monitoring of the plantation and supervision of maintenance activities in the parcel(s) planted.
6. Use any wires received from APRODEIN as part of his/her incentive fund for the fencing and protection of the parcel planted as part of this Agreement.
7. Transfer the benefits and responsibilities of this Agreement to the buyer of his/her farm in case he/she sells the farm or to the Guarantor in case he/she is unable to continue with the Agreement.
8. Give permission to Taking Root and APRODEIN to use certain personal and family information, such as names, pictures, videos, project financial information, farm information, including geospatial information, on its publicly accessible website and its partners' websites for the following purposes: marketing, to facilitate payments to him/her, and to promote the program. This information will be retained by the program, but the Farmer may revoke this consent without retroactive effect by clearly informing APRODEIN or Taking Root of his/her desire. Upon doing so, all personal information about the Farmer will be removed from public access.

<u>Section III - Breach of the legal contract associated with this Agreement</u>

1. Continued non-compliance with technical forest management recommendations that, as a consequence, prevents any progress of the parcel through its development stages due to failure to meet forest monitoring targets (see Table B) is considered a breach of contract. Faced with this situation, Taking Root/APRODEIN will inform the Farmer of the termination of this Agreement and will not be obligated to make any incentive payments.
2. Farmers can seek re-entrance to the program by implementing the corrective forest management recommendations provided by his/her Taking Root/APRODEIN field technician using their own additional resources. To re-enter the program and receive further payments, his/her Taking Root/APRODEIN field technician will need to confirm that the corrective measures have been performed as instructed and that the Farmer will now be able to meet the forest monitoring target to reach the next stage of development in no more than one year after the event of non-compliance.
3. If the Farmer consistently breaches this Agreement for reasons other than weather or extreme circumstances,

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

or voluntarily chooses to withdraw from the project, the Guarantor may assume the responsibilities and benefits of the Agreement (see section 2-7).

4. If both the Farmer and the Guarantor fail to respond to the responsibilities of this Agreement and this Agreement is finally breached, Taking Root/APRODEIN will automatically withhold all further incentive payments associated with this Agreement, and the Farmer will be expected to return any form of compensation received from Taking Root/APRODEIN in exchange for the environmental services he/she will fail to achieve as a result of his/her lack of compliance. This ensures that resources are allocated towards active participants and project growth.

Section IV – Conflict resolution and the grievance mechanism

Farmers can submit confidential project grievances to report inefficiencies or problems related to the project. Examples of grievances to be reported are:

- Harm to the environment (i.e. issues relating to biodiversity)
- Harm to persons (i.e. conflicts between participants or project technicians and administrators)
- Harm to the integrity of the project (i.e. mismanagement of payments, materials, etc.)

Grievance forms can be submitted in the following ways:

- Google form (using the Survey QR Code below)
- E-mail (using the E-mail QR Code below)
- Visiting the local project office and requesting support to submit a grievance on their behalf (if the Farmer is uncomfortable with technology or writing).

If grievances are submitted including the Farmer's personal information, a member of staff will get in contact to seek a resolution when necessary. If grievances are reported anonymously, the project will take them into consideration for the improvement of the project design.

E-mail QR code

Survey QR code

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

Signatures

Taking Root	**APRODEIN**
Kahlil Baker	**Elvin Castellon**
Signature and Name	**Signature and Name**
24 January 2022	*24 January 2022*
Date	**Date**
Executive Director	Legal Representative
Position	**Position**
Farmer	**Guarantor**
Signature	**Signature**
Date	**Date**
ID Number	**ID Number**

:

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

Table A – Value of the Agreement

Parcela – *Plan Vivo* number	Management unit	Area (hectares)	Area (*manzanas*)	CO2 tons (gross)	Risk buffer (CO2 ton)	CO2 tons (net)	$ / CO2 ton (net)	Total potential incentive (USD)
Parcelo ID from the platform	*Mixed species*	*Area from platform*	*=ha* 1.4232*					
Parcel ID from the platform	*Mixed species*	*Area from platform*	*=ha* 1.4232*					
Total								

Table B. Parcel stages and requirements to access the incentive fund by stage, by management unit

Mixed Species

Stages	Forest monitoring year	Forest monitoring target at the end of each stage	Minimum technical confirmation for incentives*	% of contract value for incentives
Parcel (and nursery) in preparation			-Parcel cleared and fenced -Nursery ready and plants produced in plants to sow	19%
Parcel in planting	1 or 2	At least 1,100 living trees	-Parcel planted and regular weeding	34%
Vulnerable parcel	3	1,100 trees with a height of at least 1.3m	-Parcel planted and regular weeding	22%
Semi-established parcel	5	Parcel with basal area of 2.59 m3/ha (~1000 trees of 6 cm diameter)	-Regular weeding and pruning	20%
Established parcel	10	Parcel with basal area of 14.46 m3/ha (~ 720 trees of 16 cm diameter)	-Regular weeding and pruning	5%
PARCEL IN PRODUCTION	Plantation free to grow and in the production stage Sustainable use of the plantation with commercial and environmental objectives			0%
Total:				100%

** See more details on the specific activities that require technical confirmation for incentive in Table D*

Silvopastoral

Stages	Forest monitoring year	Forest monitoring target at the end of each stage	Minimum technical confirmation for incentives*	% of contract value for incentives
Parcel (and nursery) in preparation			-Parcel cleared and fenced -Nursery ready and plants produced in plants to sow	20%

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

Parcel in planting	1 or 2	At least 300 live trees	-Parcel planted and regular weeding	32%
Vulnerable parcel	3	300 trees with a height of 1.3m	-Parcel planted and regular weeding	25%
Semi-established parcel	5	Plot with a basal area of 0.16 m3/ha (~300 trees of 2.6 cm in diameter)	-Regular weeding and pruning	21%
Established parcel	10	Plot with a basal area of 3.58 m3/ha (~200 trees of 15 cm in diameter)	-Regular weeding and pruning	2%
PARCEL IN PRODUCTION	Plantation free to grow and in the production stage Sustainable use of the plantation with commercial and environmental objectivesa			0%
Total:				100%

** See more details about specific activities that require technical confirmation for incentives in Tabla D*

Table C. Value of maximum incentives to be paid by parcel stage

Stage	parcel (pv_1)	parcel (pv_2)	Total
Parcel (and nursery) in preparation	*$584.00*	*$438.00*	*$1,022.00*
Parcel in planting	*$1,080.00*	*$810.00*	*$1,890.00*
Vulnerable parcel	*$700.00*	*$525.00*	*$1,225.00*
Semi-established parcel	*$626.00*	*$469.50*	*$1,095.50*
Established parcel	*$155.00*	*$116.25*	*$271.25*
Total	*$3,145.00*	*$2,358.75*	*$5,503.75*

Table D. Detail of forest maintenance activities and associated incentives by stage

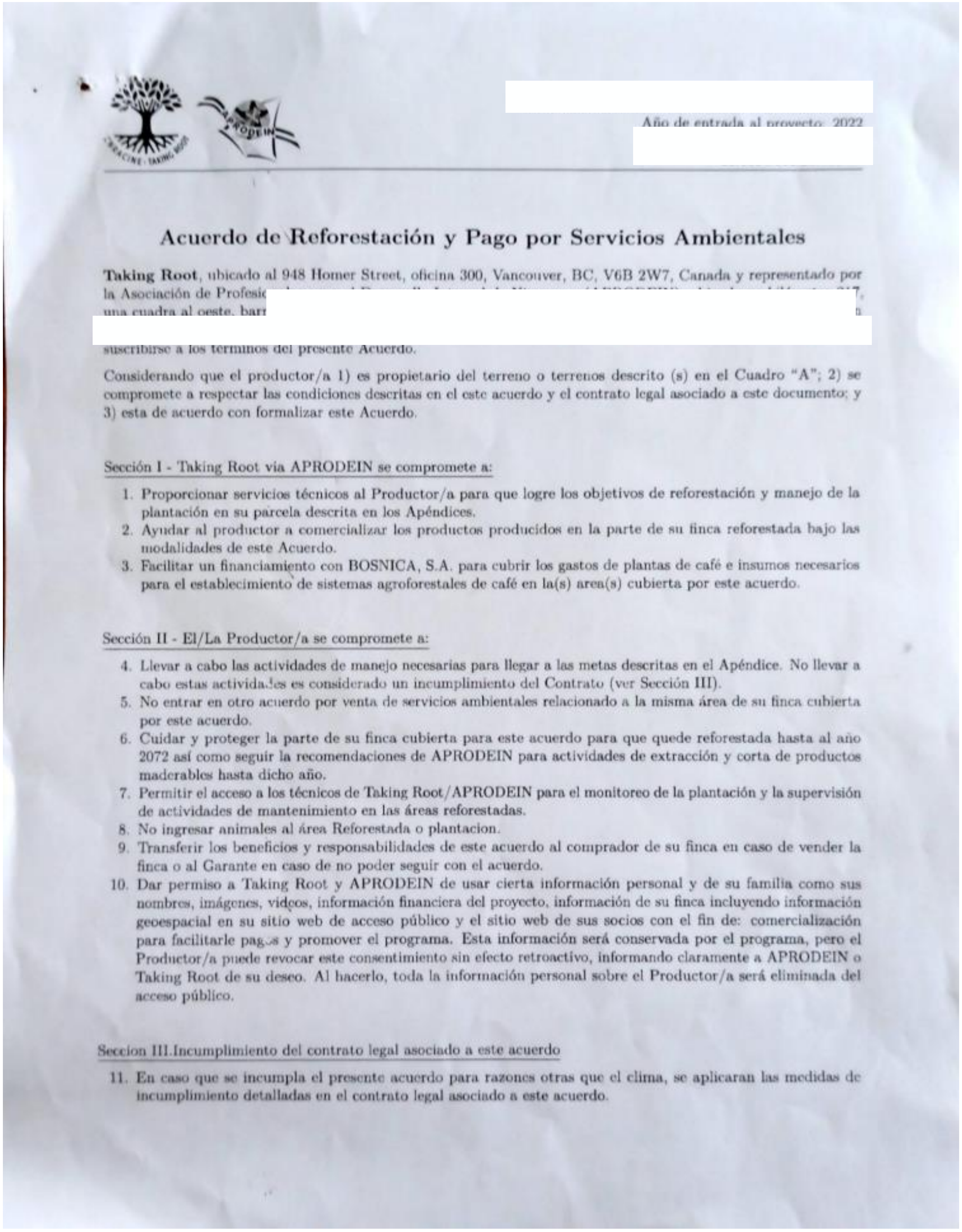
Parcel Stages	**Forest management activities (for reference)**	**Activities with potential incentive**
Parcel (and nursery) in preparation	Nursery – Soil sourcing	Yes
Parcel (and nursery) in preparation	Nursery - Filling bags	Yes
Parcel (and nursery) in preparation	Nursery - Bedding	No
Parcel (and nursery) in preparation	Nursery - Sowing seeds in nursery	Yes
Parcel (and nursery) in preparation	Parcel plating	Yes
Parcel (and nursery) in preparation	Parcel fencing	Yes (wire delivery)
Parcel (and nursery) in preparation	Nursery - Irrigation	No
Parcel (and nursery) in preparation	Nursery - Remove weeds	No
Parcel (and nursery) in preparation	Transport of plants to parcel(s)	Yes
Parcel (and nursery) in preparation	Reestablishment of nurseries for replanting (year 2) *according to mortality	Yes
Parcel in planting	Sowing - Hole	No
Parcel in planting	Sowing of plants in plot	Yes
Parcel in planting	Resowing of plants in parcel in year 2 (if necessary)	Yes
Parcel in planting	4 weedings after first planting	Yes (up to 4 weedings with incentive in this stage)
Vulnerable parcel	3 or 2 weedings per year	Yes (up to 5 weedings with incentive in this stage)
Vulnerable parcel	Annual pruning	No
Semi-established parcel	2 weedings per year in wet season	Yes (up to 5 weedings with incentive in this stage)

:

Farmer Name: *Example Example*
Farmer entry year to the Project: *XXXX*
Planting year: *XXXX*
[Parcel IDs included in the current PES agreement]

Semi-established parcel	Pruning when the trees reach between 2m and 4m in height	Yes (up to 2 prunings with incentive in this stage)
Semi-established parcel	Pre-commercial thinning(s) for sale (trees > 7cm thick)	No
Established parcel	Weeding every year	Yes (1 weeding with incentive in this stage)
Established parcel	Pruning every other year	Yes (1 pruning with incentive in this stage)
Established parcel	Pre-commercial thinning(s) for sale	No

Example of actual PES Agreement for Coffee Agroforestry signed (Spanish):



[redacted]

Año de entrada al proyecto: 2022

[redacted]

Acuerdo de Reforestación y Pago por Servicios Ambientales

Taking Root, ubicado al 948 Homer Street, oficina 300, Vancouver, BC, V6B 2W7, Canada y representado por la Asociación de Profesi[redacted] suscribirse a los terminos del presente Acuerdo.

Considerando que el productor/a 1) es propietario del terreno o terrenos descrito (s) en el Cuadro "A"; 2) se compromete a respectar las condiciones descritas en el este acuerdo y el contrato legal asociado a este documento; y 3) esta de acuerdo con formalizar este Acuerdo.

Sección I - Taking Root via APRODEIN se compromete a:

1. Proporcionar servicios técnicos al Productor/a para que logre los objetivos de reforestación y manejo de la plantación en su parcela descrita en los Apéndices.
2. Ayudar al productor a comercializar los productos producidos en la parte de su finca reforestada bajo las modalidades de este Acuerdo.
3. Facilitar un financiamiento con BOSNICA, S.A. para cubrir los gastos de plantas de café e insumos necesarios para el establecimiento de sistemas agroforestales de café en la(s) area(s) cubierta por este acuerdo.

Sección II - El/La Productor/a se compromete a:

4. Llevar a cabo las actividades de manejo necesarias para llegar a las metas descritas en el Apéndice. No llevar a cabo estas actividades es considerado un incumplimiento del Contrato (ver Sección III).
5. No entrar en otro acuerdo por venta de servicios ambientales relacionado a la misma área de su finca cubierta por este acuerdo.
6. Cuidar y proteger la parte de su finca cubierta para este acuerdo para que quede reforestada hasta al año 2072 así como seguir la recomendaciones de APRODEIN para actividades de extracción y corta de productos maderables hasta dicho año.
7. Permitir el acceso a los técnicos de Taking Root/APRODEIN para el monitoreo de la plantación y la supervisión de actividades de mantenimiento en las áreas reforestadas.
8. No ingresar animales al área Reforestada o plantacion.
9. Transferir los beneficios y responsabilidades de este acuerdo al comprador de su finca en caso de vender la finca o al Garante en caso de no poder seguir con el acuerdo.
10. Dar permiso a Taking Root y APRODEIN de usar cierta información personal y de su familia como sus nombres, imágenes, videos, información financiera del proyecto, información de su finca incluyendo información geoespacial en su sitio web de acceso público y el sitio web de sus socios con el fin de: comercialización para facilitarle pagos y promover el programa. Esta información será conservada por el programa, pero el Productor/a puede revocar este consentimiento sin efecto retroactivo, informando claramente a APRODEIN o Taking Root de su deseo. Al hacerlo, toda la información personal sobre el Productor/a será eliminada del acceso público.

Seccion III.Incumplimiento del contrato legal asociado a este acuerdo

11. En caso que se incumpla el presente acuerdo para razones otras que el clima, se aplicaran las medidas de incumplimiento detalladas en el contrato legal asociado a este acuerdo.

Año de entrada al proyecto: 2022
Año de siembra: 2022

Firmas

Taking Root	APRODEIN
Kahlil Baker	**Elvin Castellon**
Firma y Nombre	**Firma y Nombre**
24 de Enero de 2022	24 24 de Enero de 2022
Fecha	**Fecha**
Director ejecutivo	Representante legal
Posición	**Posición**

Productor/a	Garante
Firma	**Firma**
04/04/2022	04/04/22
Fecha	**Fecha**
Numero de Cedula	**Numero de Cedula**

[redacted]
Año de entrada al proyecto: 2022
[redacted]

Cuadro A – Valor del acuerdo

Parcela - numero de Plan Vivo	Unidad de Manejo	Área - hectáreas	Área - manzanas	Toneladas de CO2
[redacted]	Café con sombra	1.64	2.33	333.68
Total		1.64	2.33	333.68

Apéndice – Café con sombra

Año	Meta de actividades de manejo	Meta arboles y carbono
1	Cercado de la parcela, chapia, establecimiento de vivero, arboles plantados, limpia y aplicaciones de fungicida y fertilizante	134 árboles/ha
2	Establecimiento de vivero y replante de arboles según necesidad, limpia, poda y aplicaciones según necesidad de fungicida, protector solar y fertilizante	
3	Limpia, poda y aplicaciones según necesidad de fungicida, protector solar y fertilizante	134 árboles/ha
4	Limpia, poda y aplicaciones según necesidad de fungicida, protector solar y fertilizante	
5	Limpia, poda, aplicaciones según necesidad de fungicida, protector solar y fertilizante. Recogida de café.	Área basal= 1.95 m3/ha
6	Mismas que en año 5	
7	Mismas que en año 5	
8	Mismas que en año 5	
9	Mismas que en año 5	
10	Mismas que en año 5	Área basal= 6.33 m3/ha
11-50	Manejo sostenible del café con sombra	

Example of actual PES Agreement for the Silvopastoral Plantation signed (Spanish):

[redacted]
Ano de entrada al proyecto: 2022
[redacted]

Acuerdo de Reforestación y Pago por Servicios Ambientales

Taking Root, ubicado al 948 Homer Street, oficina 300, Vancouver, BC, V6B 2W7, Canada y representado por la Asociación de Profesional[redacted] términos del presente Acuerdo.

Considerando que el productor/a 1) es propietario del terreno o terrenos descrito (s) en el Cuadro "A"; 2) se compromete a respectar las condiciones descritas en el este acuerdo y el contrato legal asociado a este documento; y 3) esta de acuerdo con formalizar este Acuerdo.

Sección I - Taking Root via APRODEIN se compromete a:

1. Proporcionar servicios técnicos al Productor/a para que logre los objetivos de reforestación y manejo de la plantación en su parcela descrita en los Apéndices.
2. Ayudar al productor a comercializar los productos producidos en la parte de su finca reforestada bajo las modalidades de este Acuerdo.
3. Pagar al Productor/a el dinero descrito en el Cuadro A según el calendario de pago descrito en el Cuadro "B" cuando se hayan cumplido las metas descritas en el Apéndice Sistema Agroforestal - Silvopastoril según los resultados del monitoreo realizado por APRODEIN.
4. Si los resultados del monitoreo demuestran que se ha cumplido más del umbral de la meta, pero menos que la meta, se pagara 50% del pago correspondiente.
5. Si como parte de este acuerdo el productor ha recibido un pago por adelantado (ver sección 4), se deducirá de los pagos el monto del adelantado proporcionalmente al porcentaje de pago recibido cada año (ver Apéndice). Por ejemplo, si el pago a recibir en el año 2 es del 20% del total, dicho año se deducirá 20% del monto total del adelantado.

Sección II - El/La Productor/a se compromete a:

6. Llevar a cabo las actividades de manejo necesarias para llegar a las mestas descrito en los Apéndices. No llevar a cabo estas actividades es considerado un incumplimiento del Contrato (ver Sección III).
7. No entrar en otro acuerdo por venta de servicios ambientales relacionado a la misma área de su finca cubierta por este acuerdo.
8. Cuidar y proteger la parte de su finca cubierta para este acuerdo para que queda reforestada hasta al año 2072 así como seguir la recomendaciones de APRODEIN para actividades de extracción y corta de productos maderables hasta dicho año.
9. Permitir el acceso a los técnicos de Taking Root/APRODEIN para el monitoreo de la plantación y la supervisión de actividades de mantenimiento en las áreas reforestadas.
10. Usar cualquier pago por adelantado recibido de Taking Root/APRODEIN (ver sección 4) exclusivamente para cubrir los gastos asociados al establecimiento de la plantación forestal, que serán solo la construcción de vivero y chapia. Asimismo, si se recibiera rollo de alambre como parte de este pago por adelantado, dicho alambre deberá ser usado exclusivamente para la protección del área de plantación forestal.
11. Transferir los beneficios y responsabilidades de este acuerdo al comprador de su finca en caso de vender la finca o al Garante en caso de no poder seguir con el acuerdo.
12. Dar permiso a Taking Root y APRODEIN de usar cierta información personal y de su familia como sus nombres, imágenes, videos, información financiera del proyecto, información de su finca incluyendo información geoespacial en su sitio web de acceso público y el sitio web de sus socios con el fin de: comercialización para facilitarle pagos y promover el programa. Esta información será conservada por el programa, pero el Productor/a puede revocar este consentimiento sin efecto retroactivo, informando claramente a APRODEIN o Taking Root de su deseo. Al hacerlo, toda la información personal sobre el Productor/a será eliminada del acceso público.

[redacted]
Año de entrada al proyecto: 2022
Año de siembra: 2022
[redacted]

Seccion III.Incumplimiento del contrato legal asociado a este acuerdo

1. No ingresar animales al área Reforestada establecidas en conjunto con Taking Root/APRODEIN hasta obtener la orientación del coordinador técnico. En caso de que se incumpla, Taking Root/APRODEIN no está obligado a realizar ningún pago al productor.
2. Omitir las recomendaciones técnicas en las aras reforestadas se considera incumplimiento de contrato en caso de que se incumpla Taking Root/APRODEIN no está obligado a realizar ningún pago.
3. Si el Productor/a si se retira del programa esta obligado a: Reembolsar a Taking Root/APRODEIN la totalidad de los adelantados y pagos recibidos.
4. En caso que se incumpla el presente acuerdo para razones otros que el clima, el Productor/a debe: Reembolsar a Taking Root/APRODEIN la totalidad la totalidad de los adelantados y pagos recibidos. En caso de que el productor no cumpla con estas responsabilidades, el garante tomará las responsabilidades y los beneficios del acuerdo (ver sección 2-9)

Sección IV – Pagos Anticipados

Como parte de este acuerdo, el productor [redacted] recibió por adelantado la cantidad total de 420 dólares americanos, de Taking Root/APRODEIN. Dicho pago por adelantado se recibirá en forma de 0 rollo(s) de alambre por un valor de 0 dólares americanos y la cantidad de 420 dólares americanos en efectivo o cheque.

[redacted]
Año de entrada al proyecto: 2022
[redacted]

Firmas

Taking Root	APRODEIN
Kahlil Baker	Elvin Castellon
[redacted]	[redacted]
Firma y Nombre	**Firma y Nombre**
24 de Enero de 2022	24 de Enero de 2022
Fecha	**Fecha**
Director ejecutivo	Representante legal
Posición	**Posición**

[redacted]

Firma	**Firma**
05/04/2022	05/04/2022
Fecha	**Fecha**
[redacted]	[redacted]
Numero de Cedula	**Numero de Cedula**

Año de entrada al proyecto: 2022
Año de siembra: 2022

Cuadro A – Valor del acuerdo

Parcela - numero de Plan Vivo	Unidad de Manejo	Área - hectáreas	Área - manzanas	Toneladas de CO2	$ / tonelada de CO2	Pago total potencial (USD)
	Sistema Agroforestal - Silvopastoril	5.91	8.41111	1134.26		
Total		5.91	8.41111	1134.26		

Cuadro B – Lista de pagos potenciales máximo para todas las parcelas bajo este acuerdo

Año del pago		Total
2022		
2023		
2024		
2025		
2026		
2027		
2028		
2029		
2030		
2031		
Total		

[redacted]
Ano de entrada al proyecto: 2022
[redacted]

Apéndice – Sistema Agroforestal - Silvopastoril

Año	Meta de actividades de manejo	Meta arboles y carbono	Porcentaje de pago
1	Cercado de la parcela, chapia, establecimiento de vivero, arboles plantados y limpia	180 árboles/ha	25%
2	Establecimiento de vivero y replante de arboles según necesidad y limpia		20%
3	Establecimiento de vivero y replante de arboles según necesidad y limpia	180 árboles/ha	15%
4	Limpia y poda		10%
5	Limpia	Área basal= 0.16 m3/ha	0%
6	Limpia y poda		10%
7	Limpia		10%
8	Limpia		0%
9	Limpia y raleo opcional		0%
10	Limpia y poda	Área basal= 3.58 m3/ha	10%
11-50	Manejo sostenible del bosque		0%

Example of actual PES Agreement for the Mixed-Species Forest Plantation signed (Spanish):

[redacted]
Año de entrada al proyecto: 2022
[redacted]

Acuerdo de Reforestación y Pago por Servicios Ambientales

Taking Root, ubicado al 948 Homer Street, oficina 300, Vancouver, BC, V6B 2W7, Canada y representado por la Asociación de Profesionales para el Desarrollo Integral de Nicaragua (APRODEIN), ubicado en kilómetro 217, [redacted] suscribirse a los términos del presente Acuerdo.

Considerando que el productor/a 1) es propietario del terreno o terrenos descrito (s) en el Cuadro "A"; 2) se compromete a respectar las condiciones descritas en el este acuerdo y el contrato legal asociado a este documento; y 3) esta de acuerdo con formàlizar este Acuerdo.

Sección I - Taking Root via APRODEIN se compromete a:

1. Proporcionar servicios técnicos al Productor/a para que logre los objetivos de reforestación y manejo de la plantación en su parcela descrita en los Apéndices.
2. Ayudar al productor a comercializar los productos producidos en la parte de su finca reforestada bajo las modalidades de este Acuerdo.
3. Pagar al Productor/a el dinero descrito en el Cuadro A según el calendario de pago descrito en el Cuadro "B" cuando se hayan cumplido las metas descritas en el Apéndice Sistema Agroforestal - Especies Mixtas según los resultados del monitoreo realizado por APRODEIN.
4. Si los resultados del monitoreo demuestran que se ha cumplido más del umbral de la meta, pero menos que la meta, se pagara 50% del pago correspondiente.
5. Si como parte de este acuerdo el productor ha recibido un pago por adelantado (ver sección 4), se deducirá de los pagos el monto del adelantado proporcionalmente al porcentaje de pago recibido cada año (ver Apéndice). Por ejemplo, si el pago a recibir en el año 2 es del 20% del total, dicho año se deducirá 20% del monto total del adelantado.

Sección II - El/La Productor/a se compromete a:

6. Llevar a cabo las actividades de manejo necesarias para llegar a las mestas descrito en los Apéndices. No llevar a cabo estas actividades es considerado un incumplimiento del Contrato (ver Sección III).
7. No entrar en otro acuerdo por venta de servicios ambientales relacionado a la misma área de su finca cubierta por este acuerdo.
8. Cuidar y proteger la parte de su finca cubierta para este acuerdo para que queda reforestada hasta al año 2072 así como seguir la recomendaciones de APRODEIN para actividades de extracción y corta de productos maderables hasta dicho año.
9. Permitir el acceso a los técnicos de Taking Root/APRODEIN para el monitoreo de la plantación y la supervisión de actividades de mantenimiento en las áreas reforestadas.
10. Usar cualquier pago por adelantado recibido de Taking Root/APRODEIN (ver sección 4) exclusivamente para cubrir los gastos asociados al establecimiento de la plantación forestal, que serán solo la construcción de vivero y chapia. Asimismo, si se recibiera rollo de alambre como parte de este pago por adelantado, dicho alambre deberá ser usado exclusivamente para la protección del área de plantación forestal.
11. Transferir los beneficios y responsabilidades de este acuerdo al comprador de su finca en caso de vender la finca o al Garante en caso de no poder seguir con el acuerdo.
12. Dar permiso a Taking Root y APRODEIN de usar cierta información personal y de su familia como sus nombres, imágenes, vidèos, información financiera del proyecto, información de su finca incluyendo información geoespacial en su sitio web de acceso público y el sitio web de sus socios con el fin de: comercialización para facilitarle pagos y promover el programa. Esta información será conservada por el programa, pero el Productor/a puede revocar este consentimiento sin efecto retroactivo, informando claramente a APRODEIN o Taking Root de su deseo. Al hacerlo, toda la información personal sobre el Productor/a será eliminada del acceso público.

Año de entrada al proyecto: 2022

Seccion III.Incumplimiento del contrato legal asociado a este acuerdo

1. No ingresar animales al área Reforestada establecidas en conjunto con Taking Root/APRODEIN hasta obtener la orientación del coordinador técnico. En caso de que se incumpla, Taking Root/APRODEIN no está obligado a realizar ningùn pago al productor.
2. Omitir las recomendaciones técnicas en las aras reforestadas se considera incumplimiento de contrato en caso de que se incumpla Taking Root/APRODEIN no está obligado a realizar ningún pago.
3. Si el Productor/a si se retira del programa esta obligado a: Reembolsar a Taking Root/APRODEIN la totalidad de los adelantados y pagos recibidos.
4. En caso que se incumpla el presente acuerdo para razones otros que el clima, el Productor/a debe: Reembolsar a Taking Root/APRODEIN la totalidad la totalidad de los adelantados y pagos recibidos. En caso de que el productor no cumpla con estas responsabilidades, el garante tomará las responsabilidades y los beneficios del acuerdo (ver sección 2-9)

Sección IV – Pagos Anticipados

Como parte de este acuerdo, el producto recibió por adelantado la cantidad total de 50 dólares americanos, de Taking Root/APRODEIN. Dicho pago por adelantado se recibirá en forma de 0 rollo(s) de alambre por un valor de 0 dólares americanos y la cantidad de 50 dólares americanos en efectivo o cheque.

Año de entrada al proyecto: 2022

Firmas

Taking Root	APRODEIN
Kahlil Baker	**Elvin Castellon**
Firma y Nombre	**Firma y Nombre**
24 de Enero de 2022	24 de Enero de 2022
Fecha	**Fecha**
Director ejecutivo	Representante legal
Posición	**Posición**

Productor/a	Garante
Firma	**Firma**
07-04-2022	07-04-2022.
Fecha	**Fecha**
Numero de Cedula	**Numero de Cedula**

[redacted]
Año de entrada al proyecto: 2022
[redacted]

Cuadro A – Valor del acuerdo

Parcela - numero de Plan Vivo	Unidad de Manejo	Área - hectáreas	Área - manzanas	Toneladas de CO2	$ / tonelada de CO2	Pago total potencial (USD)
[redacted]	[redacted]istema Agroforestal - Especies Mixtas	0.46	0.65	137.59	[redacted]	[redacted]
Total		0.46	0.65	137.59	[redacted]	[redacted]

Cuadro B – Lista de pagos potenciales máximo para todas las parcelas bajo este acuerdo

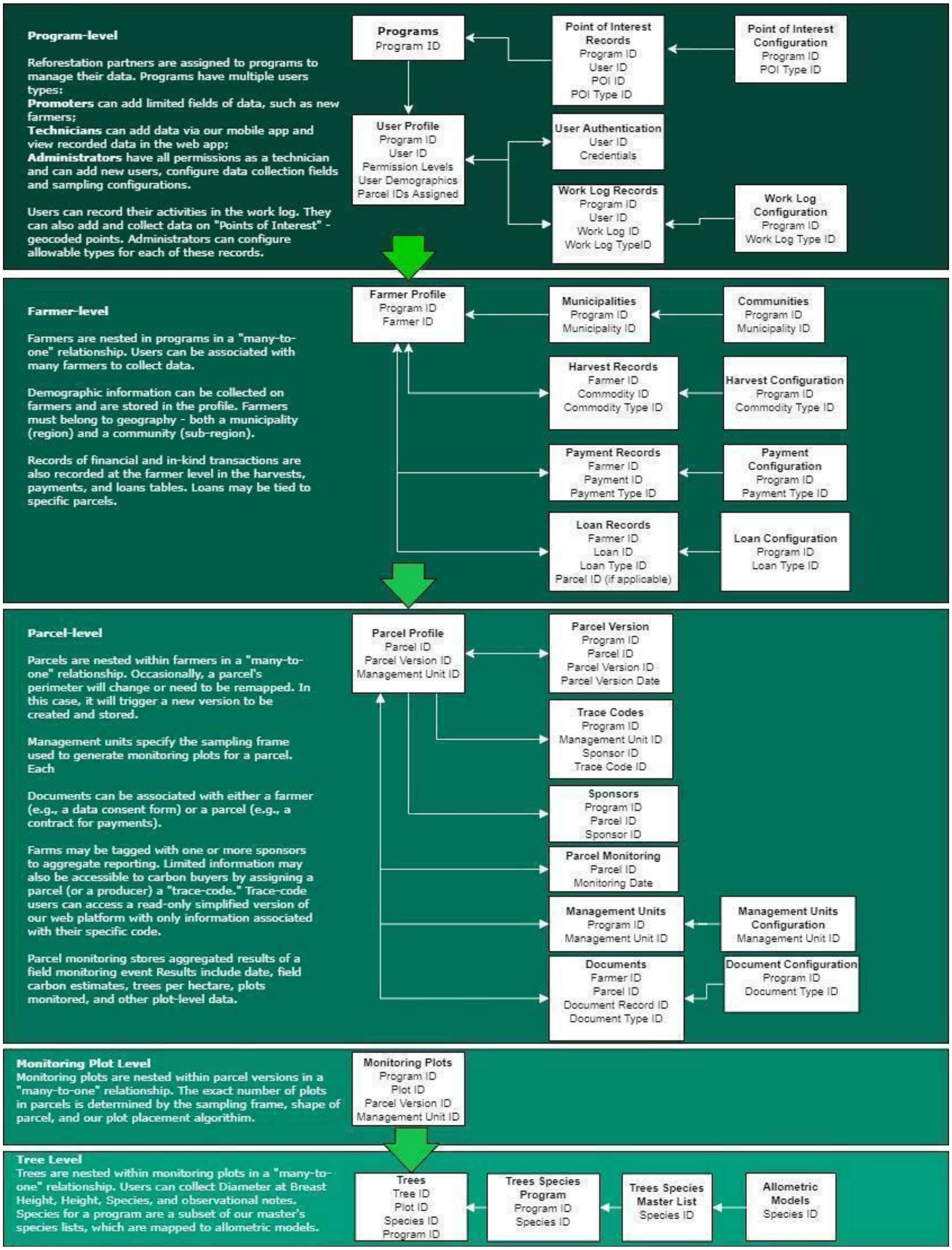
Año del pago	[redacted]1	Total
2022	[redacted]	[redacted]
2023	[redacted]	[redacted]
2024	[redacted]	[redacted]
2025	[redacted]	[redacted]
2026	[redacted]	[redacted]
2027	[redacted]	[redacted]
2028	[redacted]	[redacted]
2029	[redacted]	[redacted]
2030	[redacted]	[redacted]
2031	[redacted]	[redacted]
Total	[redacted]	[redacted]

[redacted]
Año de entrada al proyecto: 2022
[redacted]

Apéndice – Sistema Agroforestal - Especies Mixtas

Año	Meta de actividades de manejo	Meta arboles y carbono	Porcentaje de pago
1	Cercado de la parcela, chapia, establecimiento de vivero, arboles plantados y limpia	375 árboles/ha	25%
2	Establecimiento de vivero y replante de arboles según necesidad y limpia		20%
3	Establecimiento dè vivero y replante de arboles según necesidad y limpia	375 árboles/ha	15%
4	Limpia y poda		10%
5	Limpiar	Área Basal = 2.59 m3/ha	0%
6	Limpia y raleo		10%
7	Limpiar		10%
8	Limpia y raleo opcional		0%
9	Limpia y raleo opcional		0%
10	Limpia y poda	Área Basal = 14.46 m3/ha	10%
11-50	Manejo sostenible del bosque		0%

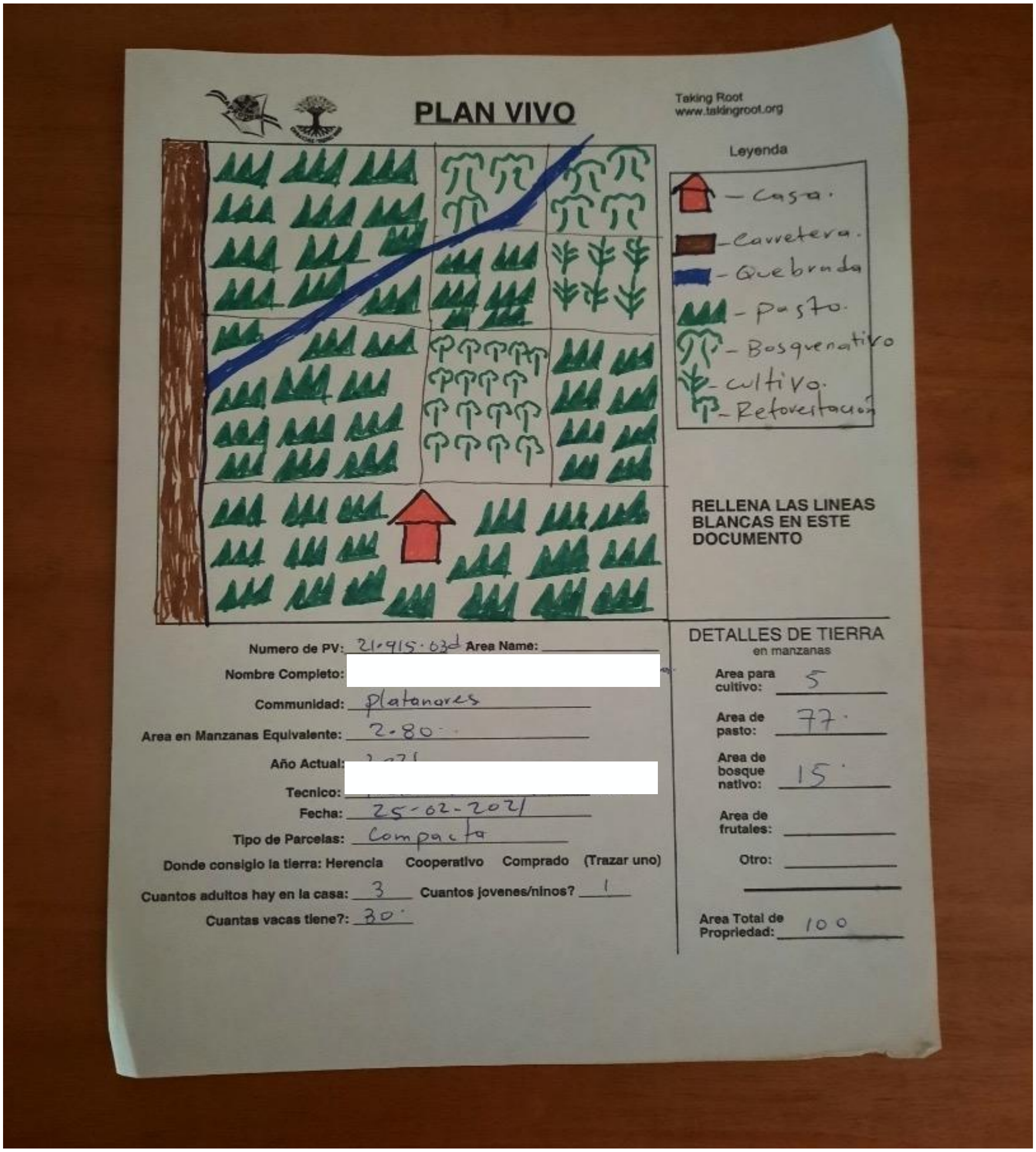
Annex 4. Database template



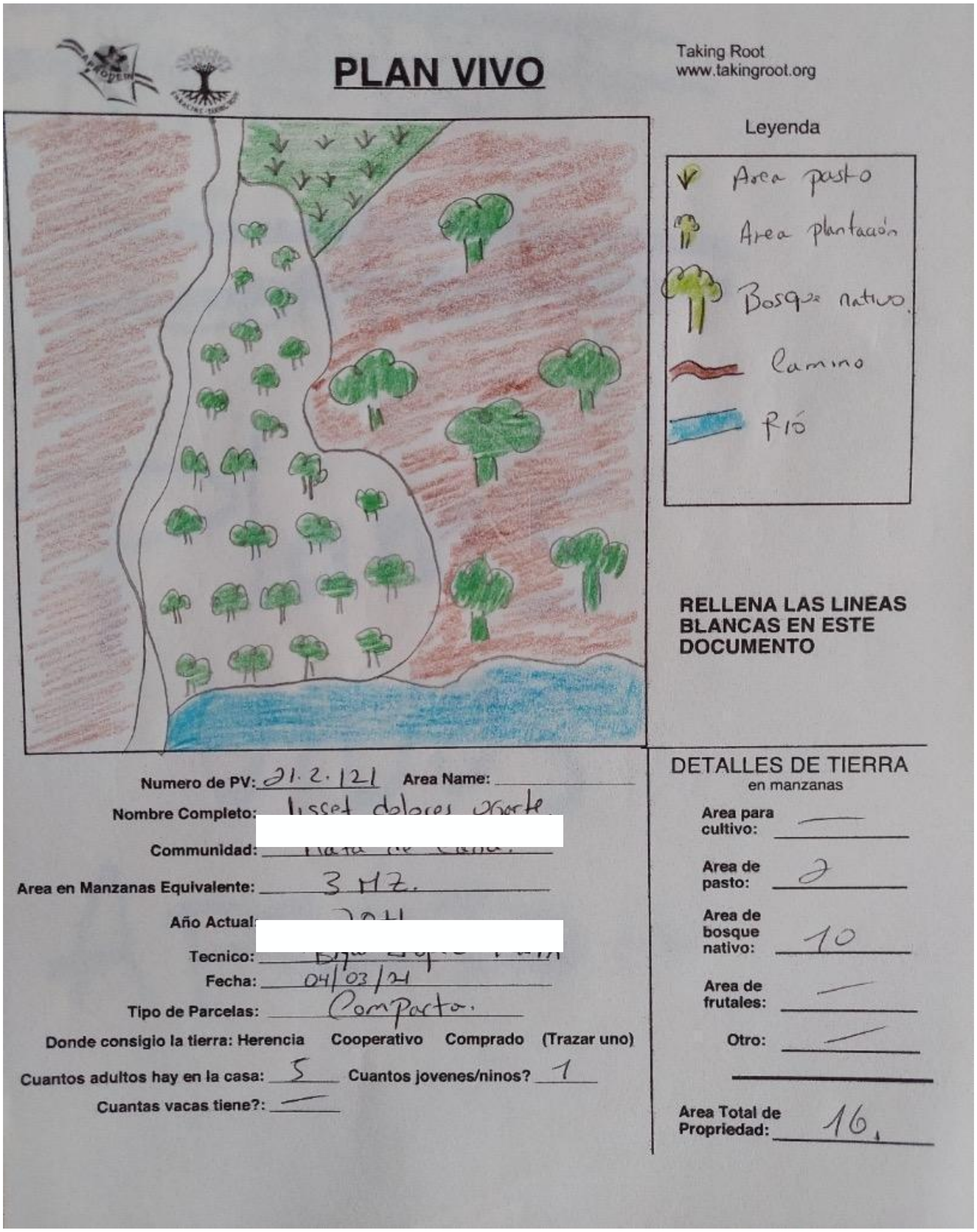
Annex 4 - Figure 1. Database schema of the Taking Root technology platform demonstrating how project data is being organized.

Annex 5. Example forest management plans/plan vivos

Figures 1, 2, and 3 are real examples of *plan vivos* collected from CommuniTree farmers in 2021.



Annex 5 - Figure 1. Plan vivo example



Annex 5 - Figure 2. Plan vivo example

Annex 5 - Figure 3. Plan vivo example

Annex 6. Permits and legal documentation

Not applicable

Annex 7.1 Evidence of community participation

These photos were taken during farmer recruitment activities for the year 2022. They show APRODEIN staff presenting to the community, introducing the project, explaining PES agreements, benefits and conditions; photos further show farm visits where farmers provide input and voice concerns.

Annex 7 - Figure 1: Community meeting in Boaco, 2022

Annex 7 - Figure 2: Community meeting in Matagalpa, 2022

Annex 7 - Figure 3: Field technician visiting a farmer in Nueva Guinea, 2022

Annex 7 - Figure 4: Community meeting in Rivas, 2021

Annex 7 - Figure 5: Meeting with farmers in Las Filas, 2019

Annex 7 - Figure 6: Training with farmers, Macuelizo, 2017

Annex 7.2. Interventions over time

Mixed species

Mixed species plantation pre-planting

Annex 7.2 – Figure 1

Photo: https://www.dropbox.com/s/qemn4xiaoz6uj2c/DSC07434.JPG?dl=0

Farmer: Maria gabriela Ramos

Parcel ID: 21.2.078.21.4.01

Entry date: 2021-02-09

Mixed species plantation in year 1

Annex 7.2 – Figure 2

Photo: https://www.dropbox.com/s/b03uzaaxrqgs2em/DSC07348.JPG?dl=0

Farmer: Milton Robleto

Parcel ID: 21.2.081.21.4.01

`

Mixed species plantation in year 5

Annex 7.2 – Figure 3
Photo:https://www.dropbox.com/s/gslj8nwkx9vesc7/2022_Denis%20Alexis%20Hernandez20220512_155018.jpg?dl=0
Farmer: Denis Alexis Hernandez Izaguirre
Parcel ID: 15.2.026.15.4.02
Entry date: 2017-11-10

Mixed species plantation in year 6

Annex 7.2 – Figure 4
Photo:https://www.dropbox.com/s/x6toqzrdlrun5x5/2022_Bernabe%20Blandon08705.JPG?dl=0
Farmer: Bernabe Blandon Perez
Parcel ID: 13.1.009.13.4.01
Entry date: 2016-06-09

Coffee Agroforestry

Coffee plantation pre-planting

Annex 7.2 – Figure 5

Name: Luisa Davidla & husband Luis alberto Tercero Altamirano

Community: El Pegador, Somoto

Entry date:2021-06-03

Parcel ID: 20.2.015.21.6.01

Coffee plantation after planting

Annex 7.2 – Figure 6

Photo: https://www.dropbox.com/s/8wprjryti82yzlg/20220126_130318.jpg?dl=0

Farmer: Guisella Hoyes Palma

Community: Las Sabanas

Parcel ID: 21.778.00f.22.6.01

Entry date: 2022-01-07

Coffee plantation in year 1

Annex 7.2 – Figure 7

Photo: https://www.dropbox.com/s/m06o00ojs8ul46l/DSC08038.JPG?dl=0

Name: Luis Alberto Tercero
Community: El Castillo_Las Sabanas_Somoto
Parcel ID: 20.2.015.21.6.01
Entry date: 2021-06-03

Coffee plantation in year 3

Annex 7.2 – Figure 8

Photo: https://www.dropbox.com/s/u8s36vdsnt9j3of/photo_2021-08-10_10-09-29.jpg?dl=0

Name: Jose Esteban Tercero Martinez
Community: Quebrada negra arriba / Murra
Parcel ID: 19.3.04e.19.6.01
Entry date: 2019-03-13

Silvopastoral

Silvopastoral plantation pre-planting

Annex 7.2 – Figure 9

https://www.dropbox.com/s/5fqvveul0pxw1z5/1632881978813.jpg?dl=0

Farmer: Juan Noe Tijerino

Community: El Aguacate - Boaco

Parcel ID: 20.2.0cd.20.3.02

Entry date: 2020-10-20

Silvopastoral plantation in year 6

Annex 7.2 – Figure 10

Photo: https://www.dropbox.com/s/iqqdzm2516cm2s0/DSC07975.JPG?dl=0

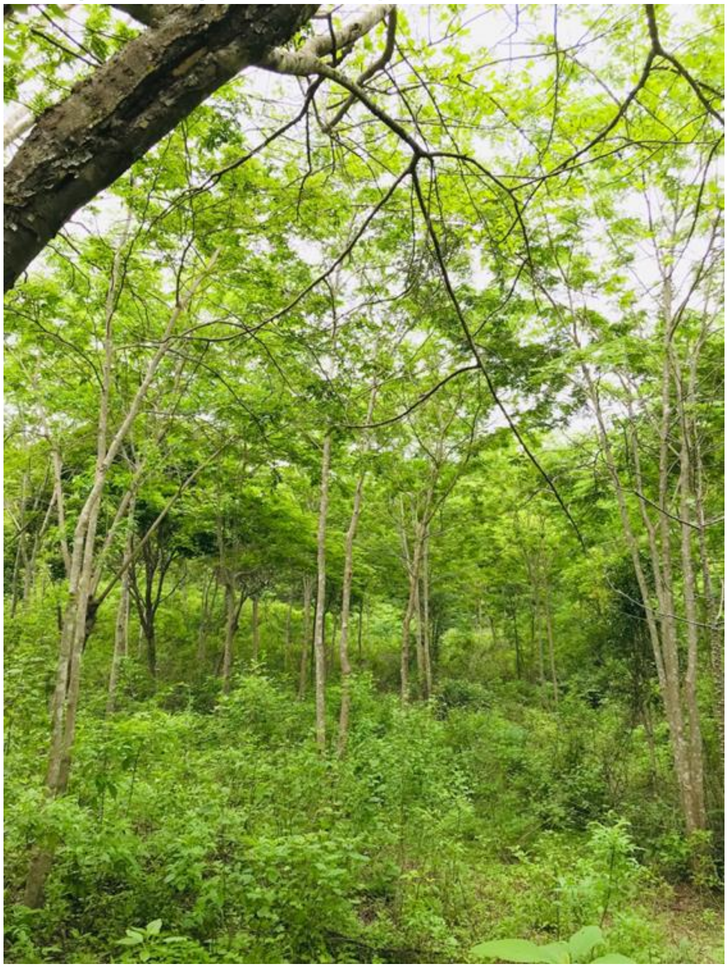
Farmer: Elvin Rene Pineda Roque

Community: Agua Calientes

Parcel ID: 16.2.f40.17.3.02

Entry date: 2016-11-29

Silvopastoral plantation in year 6



Annex 7.2 – Figure 11

Photo: https://www.dropbox.com/s/akt4n4uytoftxf2/IMG_9370.heic?dl=0

Farmer: Mario Alfredo Moncada Lopez

Community: Casco Urbano (Somoto)

Parcel ID: 14.2.023.14.3.03

Entry date: 2016-06-09

Annex 8. Technical specifications species information

Annex 8 - Table 1. Species information for Mixed Species Forest Plantations and Silvopastoral Planting

Name	Common Name(s)	Origin	Characteristics	
Bombacopsis quinata	Pochote, Spiny Cedar	Native	**Common names**: Pochote, Spiny Cedar **Family**: Bombacacea **Distribution:** Found naturally from Nicaragua to Colombia and Venezuela **Elevation:** 0-900 metres above sea level **Precipitation**: 800-2200 millimetres **Uses**: Timber	
Swietenia humilis	Caoba, Pacific Coast Mahogany, Honduran Mahogany	Native	**Distribution**: Found naturally from Mexico to Costa Rica **Elevation**: 0-1,200 metres above sea level **Precipitation**: 1100-1400 millimetres **Uses**: Timber	

Caesalpina velutina	Mandagual	Native	**Family**: Caesalpiniaceae **Distribution**: Dry regions from Southern Mexico to Northern Nicaragua **Elevation:** 50-1000 metres above sea level **Precipitation**: 400-1200 millimetres **Nitrogen-fixing:** Yes **Uses**: Posts, fences	
Albizia saman	Rain Tree, Genisaro	Native	**Family**: Mimosaceae **Distribution**: Mexico to Brazil **Elevation**: 0-1,300 metres above sea level **Precipitation**: 760-3,000 millimetres **Nitrogen-fixing**: Yes **Uses**: Posts, fences, fodder	
Gliricidia sepium	Madreado, Michigüiste	Native	**Family**: Fabaceae **Distribution**: Mexico to Colombia **Elevation**: 0-1,200 metres above sea level **Precipitation**: 500-3,500 millimetres; grows best between 900-3,500 millimetres/year **Nitrogen-fixing**: Yes **Uses**: Fuelwood, posts, fences	

Annex 8 - Table 2. Species information Coffee Agroforestry Planting

Name	Common Name(s)	Origin
Fruit trees (3rd stratum)		
Persea americana	Aguacate, Aguacate de montana	Native
Citrus limon	Limon real	Native
Citrus reticulata	Mandarina	Native
Mangifera indica	Mango	Naturalized
Citrus x aurantium	Naranja	Native
Shade trees (4th stratum)		
Annona squamosa	Anona	Native
Bixa orellana	Hachote	Native
*Bocconia arborea**	Mano de leon	Introduced
Bombacopsis quinata	Cedro pochote	Native
Byrsonima crassifolia	Lengua de toro, Nancite	Native
Cecropia obtusifolia	Guarumo	Native
Cedrella odorata	Cedar wood, Cedro real	Native
Cinnamomum triplinerve	Laurel	Native
Coffee arabica	Café	Introduced
Cordia alliodora	Palo de garabato	Native
Cordia dentata	Muneco, Tiguilote	Native
*Croton lechleri**	Sangre gado	Introduced
Cupania guatemalensis	Cola de pava	Native
*Daphnopsis americana**	Cuero de toro	Introduced
Erythrina berteroana	Elequeme	Native
Erythrina fusca	Bucaro	Native
Ficus aurea	Mata palo	Native
Ficus carica	Higuera, Iguera	Introduced

Ficus insipida	Chilamate	Native
Gliricidia sepium	Madero negro	Native
*Guaiacum officinale**	Varilla fina	Introduced
Guazuma ulmifolia	Guasimo	Native
*Hibiscus elatus / Talipariti elatum**	Majague	Introduced
Inga densiflora	Densely flowered Inga	Native
Juglans olanchana	Nogal	Native
Liquidambar styraciflua	Liquidambar	Native
Lonchocarpus yoroensis	Chaperno	Native
Lysiloma divaricatum	Quebracho	Native
Manilkara zapota	Cuernavaca, Manpas	Native
*Mariosousa heterophylla**	Palo blanco	Introduced
*Melicoccus bijugatus**	Limoncillo	Introduced
Pentaclethra macroloba	Guavilan, Lengua de vaca	Native
Perymenium grande	Tatascan	Native
Pinus caribaea	Pino	Native
Pouteria sapota	Sapote	Native
*Prunus salicifolia**	Capulin	Introduced
Psidium guajava	Guava blanca, Guava ne, Guayaba	Native
Quercus oleoides	Roble Encino	Native
Senna occidentalis	Pico de pajaro	Native
Sideroxylon capiri	Tempisque	Native
Spondias purpurea	Ciruela, Jocote, Siruela	Native
Swietenia humilis	Caoba	Native
Tabebuia rosea	Macuelizo	Native
Tabernaemontana donnell-smithii	Cojon de burro	Native
Tabernaemontana litoralis	Lechoso	Native
*Triplaris melaenodendron**	Tabacon	Introduced
Vochysia ferruginea	Areno	Native
*Yucca periculosa**	Izote	Introduced

Annex 9. Stratifying and measuring the landscape for baseline calculations

The following section describes the specific approach for selecting the baseline plots and measuring carbon in those plots. The approach is based on the Winrock International Sourcebook for Land Use, Land-Use Change and Forestry Projects (Pearson & Walker, 2005). An overview of the methodology is as follows:

- Stratification **-** The project boundary was stratified into non-eligible and one eligible vegetation cover classes.
- Required sample size **-** A pilot biomass survey was conducted to estimate the required sampling size within the eligible stratum. The eligible stratum was then sampled to estimate the initial carbon stock.
- Field measurements **-** Nested subplots were used to measure trees of varying sizes at varying intensities.

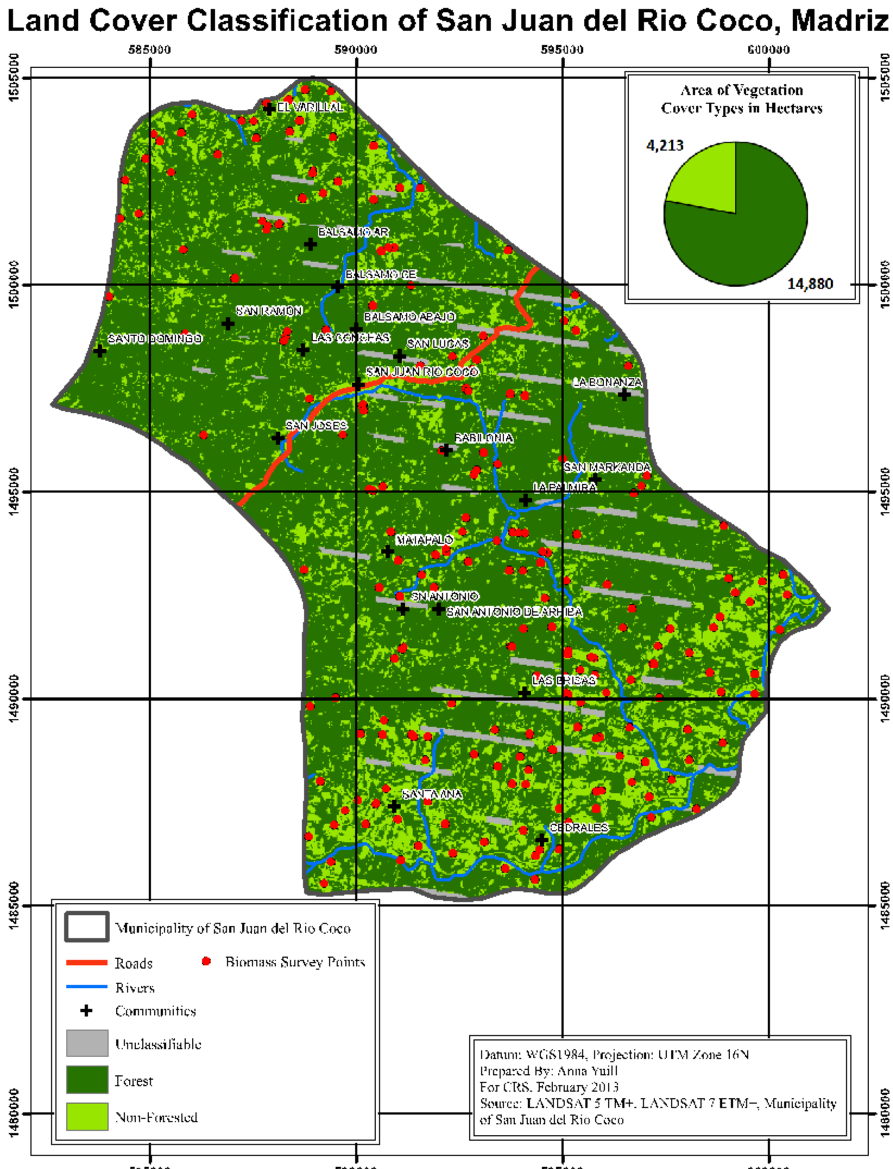
A description of the methodology is provided in the following sections:

Stratification

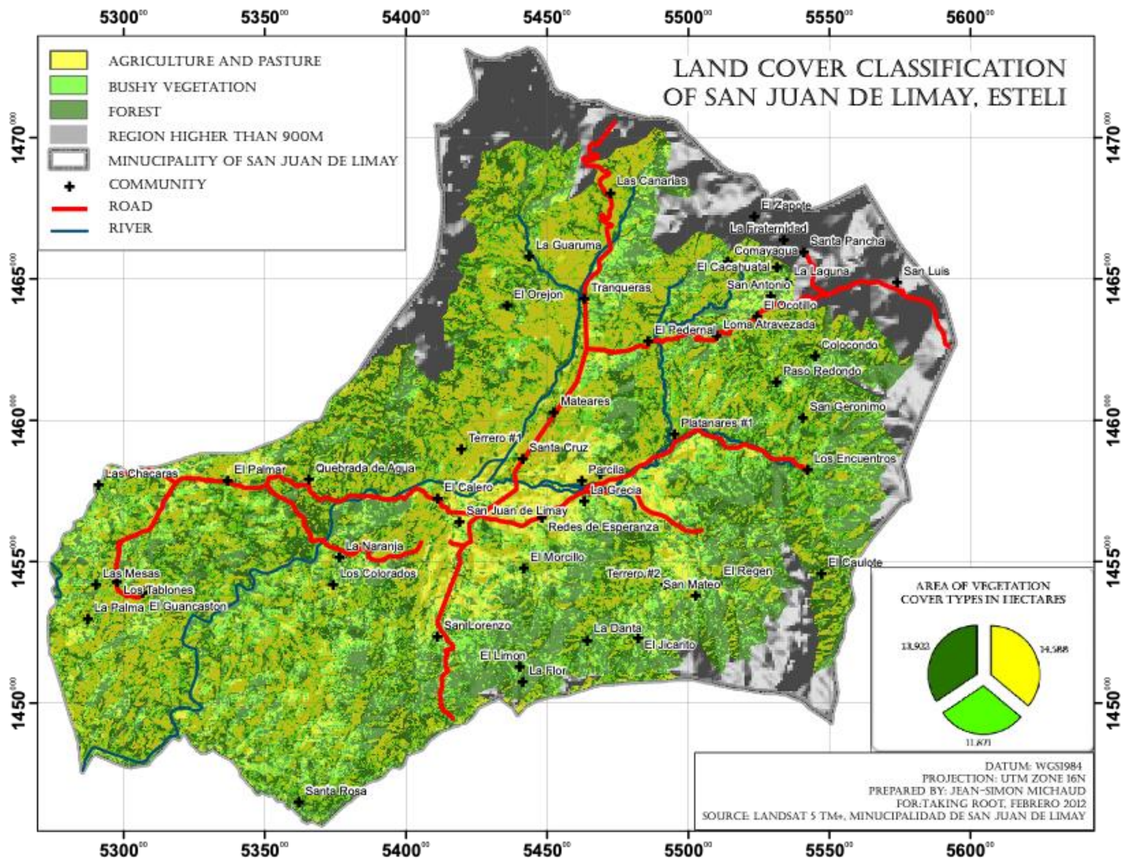
Two images, Landsat 5 TM+ and Landsat 7 EMT+ were acquired from the United States Geological Survey (USGS) website along with a digital elevation model (DEM). These two 30 metre spatial resolution images were selected based on the limited amount of atmospheric contamination (clouds and cloud shadows) and seasonality. Seasonality was an important consideration in choosing the images due to the significant atmospheric contamination over the humid and tropical latitudes, especially during the rainy season. For the San Juan de Rio Coco baseline, clouds and cloud-shadows were removed. The selected images and DEM were then layered into one image.

An unsupervised classification was then performed on the new image using ISODATA (Iterative Self Organizing Data Analysis Technique). ISODATA calculates the averages of the data then clusters the remaining data based on the minimum distance to other pixels with the same spectral signature. Using ISODATA, multiple classes were generated and then merged into two classes: forest and non-forest for the agroforestry intervention and bushy vegetation and open fields for the silvopastoral and mixed species forest plantation interventions. The merging of the classes into two was based upon imagery from Google Earth and the ground truthing of 50 randomly generated points during a pilot biomass survey. With the completed classification map, biomass survey points were randomly generated across the eligible classifications. Finally, the accuracy of the classification was evaluated after ground truthing by comparing the number of points that were classified correctly to those that were classified incorrectly.

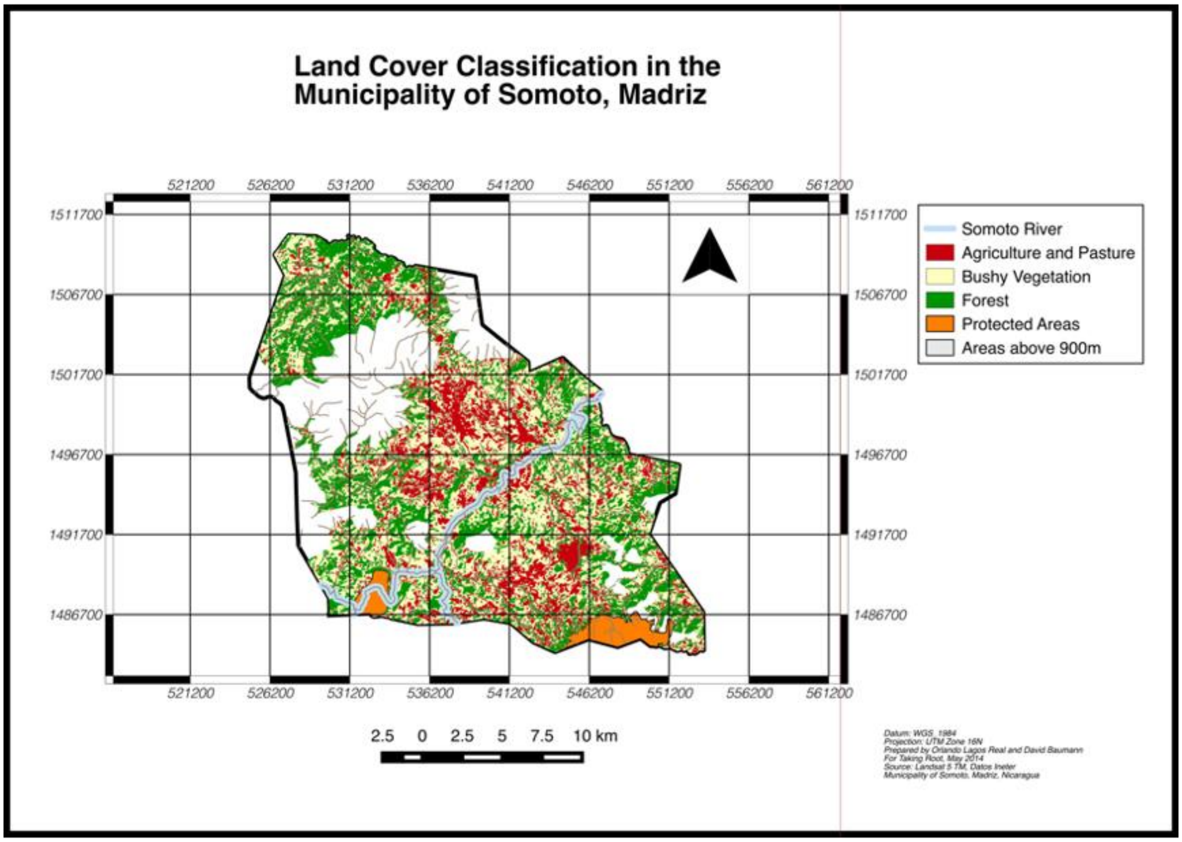
The final maps for the three baseline areas are illustrated in Figures 1-3 below.



Annex 9 - Figure 1. Land cover classification of San Juan del Rio Coco, Madriz



Annex 9 - Figure 2. Vegetation cover stratification below 900 metres for Limay



Annex 9 - Figure 3. Vegetation cover stratification below 900 metres for Somoto

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Determining required sample size

To determine the required sampling size, a pilot biomass survey was conducted for each baseline survey where biomass estimates were taken from randomly generated points within the eligible project area using the following 4 steps:

2.1) With the data acquired from the pilot survey, the average amount of carbon per hectare within that land-use classification was determined using the following equation:

$$\underline{y}_{ST} = \sum_{1}^{h} \left(\underline{y}_h \times W_h\right)$$

Where:

$\underline{y}_{ST}$= Estimate of the overall mean;

$\underline{y}_h$= Mean carbon value in metric tons of stratum h; and

W_h= Weight assigned to stratum h defined as:

$$W_h = \frac{N_h}{N}$$

Where:

N = Population of samples; and

N_h = Population of samples is stratum h.

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

$$L = L_s \times cos(s)$$

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.

The principle of conservativeness specifies that when estimating GHG removals, the risk of overestimation should be minimized. It is considered conservative to (i) overestimate carbon stocks in the baseline, and (ii) underestimate carbon stocks in the forest-landscape restoration (FLR) activity (König et al. 2019, p.17).

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

$$EF = \frac{10000}{A}$$

Where:

EF = Expansion factor;

A = Area of sub-plot in m^2

Using an allometric equation developed for tropical dry forests (Brown, 1997), with annual precipitations > 900 mm, the above ground biomass for each plot was calculated as:

$$AGB = (\frac{\sum_{1}^{t} \quad exp\, exp\, (-1.996 + 2.32 \ \times ln\, ln\, (DBH)\,)}{1000}$$

Where:

AGB = Aboveground biomass (t);

DBH = Diameter at breast height (cm);

t = Tree in the subplot;

1000 = Conversion of kg to tonnes.

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 hectare of land.

Below ground biomass was calculated by:

$$BGB = AGB * SRR$$

Where:

BGB = Belowground biomass (tC/ha);

AGB = Aboveground biomass (tC/ha);

SRR (Shoot to root ratio) = 0.56 when AGB < 20 t/ha and;

SRR (Shoot to root ratio) = 0.28 when AGB >= 20 t/ha.

The aggregate of above-ground and below-ground biomass were summed together using the following equation:

$$TC = CF * TB$$

Where:

TC = Total carbon (tC/ha);

TB = Total biomass (tC/ha);

CF = .49 (carbon fraction) (IPCC, 2006).

2.2) The variance in carbon per hectare was estimated using the following equation:

$$S_{\underline{y}_{ST}} = \sqrt{\sum_{i=1}^{h} \left(s_{\underline{y}_h}^2 \times W_h^2\right)}$$

Where:

$S_{\underline{y}_{ST}}$ = Standard deviation of the overall mean; and

$S_{\underline{y}_h}$ = Standard deviation of the mean of stratum h.

2.3) With these results, a Neyman allocation (also known as optimal allocation) was used to determine the minimum sample size required to meet the specified allowable error using a sampling without replacement approach. This allocation procedure was chosen because it considers 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:

$$n = \frac{t^2 \times \left(\sum_1^h \quad W_h s_{y_h}\right)^2}{AE^2 + \frac{t^2 \times \sum_1^h \quad W_h s_{y_h}^2}{N}}$$

and

$$n_h = \frac{W_h s_{y_h}}{\sum_1^h \quad W_h s_{y_h}} \times n$$

Where:

AE = Allowable sampling error;

n = Number of samples required;

s_{y_h} = Standard deviation of the sample of stratum h;

$s_{y_h}^2$ = Variance of the observations of stratum h; and

t = Student's random variable from *t*-distribution.

2.4) 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 were used and calculated as follows:

$$EDF = \frac{\left(s_{\underline{y}ST}^2\right)^2}{\sum_1^h \quad \frac{\left(\frac{N_h^2}{N^2} \times s_{\underline{y}h}^2\right)^2}{n_h - 1}}$$

Where:

EDF = Effective degrees of freedom

Field measurements

To calculate the baseline results, nested subplots of varying sizes were used within the sample plots to measure trees, according to Table 13 below. All trees with a diameter at breast height

(DBH) greater than 5 cm were measured and included in the survey. DBH of each tree was measured; plus, the height of one representative small, medium and large tree were recorded using a clinometer. Results from the biomass survey were scaled to estimate average carbon stock per hectare.

Annex 9 – Table 1. 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

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 southwest 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. All small trees in the small subplot were measured, all medium trees were measured in the small and medium subplot 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. This information, along with the local tree name, was noted in the data sheet along with the slope of the land at its steepest point.

Annex 10. Additional carbon forecasting modelling and results

Due to the different characteristics of the planting designs, there are some divergent approaches and parameters used to calculate the net carbon benefits between the planting designs. These approaches are presented in the sections below, separated by planting design.

Mixed Species Forest Plantation and Silvopastoral methodological considerations

Calculation of species above ground biomass

Bombacopsis quinata

Applies to: Mixed Species Forest Plantation, Silvopastoral

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

$$AGB_{Bombacopsis_t} = V_t \times BEF \times DBH_t$$

Where:

DBH_t = Diameter at breast height

V_t = Volume of the tree stem in m^3

BEF is the biomass expansion factor, which was estimated using the following equation (Avendano, 2008):

$$BEF = 3.23983 \times DBH^{0.45162} \times ht^{-0.67457}$$

Where :

DBH = The diameter of breast height in cm and

ht = The height of the tree in metres.

Published growth equations for *Bombacopsis quinata* from Costa Rican plantations exist; 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. 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 long as realistic and conservative values are used for the asymptote, the yield modeling 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* (Kanninen, 2003) so that DBH was capped at 42 cm and height was capped at 26 m. 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:

$$DBH_t = \beta_1 \times \left(1 - e^{\beta_2 \times t}\right)^{\beta_3}$$

Where:

t = Age in years; and

e is a constant representing the base of the natural logarithm.

The height equation is as follows:

$$ht_t = \beta_1 \times \left(1 - e^{\beta_2 \times t}\right)^{\beta_3}$$

Where:

ht = The height in meters and;

t = The age in years.

Stem volume (V) was estimated using the following model (Hughell, 1991):

$$ln\, ln\, (v) = -8.0758 + 1.2678 \times ln\, ln\, (dbh) + 0.9729 \times ln\, ln\, (ht)$$

Where:

v represents volume in m^3.

Caesalpinia velutina

Applies to: Mixed Species Forest Plantation, Silvopastoral

C. velutina is the species planted at the highest density of this technical specification and is scheduled to be harvested at an early age to provide a merchantable source of 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 the stand growth not meet expectations, individuals of *C. velutina* 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 allometric equation (Hurtarte, 1990):

$$ln\left(AGB_{caesalpinia_t}\right) = -2.708 + 1.6155 \times ln(DBH) + 1.1209 \times ln(ht)$$

Where:

AGB = Above-ground biomass in kilograms;

DBH = The diameter at breast height in centimeters and

ht = The height in meters.

The stem volume in m^3 can be estimated using the following equation:

$$ln(V) = -9.0215 + 1.4263 \times ln(DBH) + 1.1431 \times ln(Ht)$$

Where:

V = The stem volume in metres cubed;

DBH = The diameter at breast height in centimeters;

Ht = The height of the tree in metres.

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 68 permanent sampling plots (PSP) that were made available to the general public as part of the CATIE technical series. The PSPs originated from Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama, 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, 26 of which were added to the dataset.

The equation for height is as follows:

$$ln(ht) = -2.0144 + 0.9862 \times ln(t) - 0.00179 \times elev + 0.000187 \times precip + 0.005728 \times slope$$

Where:

ht = The height in m;

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.

The equation for height is as follows:

$$DBH = 2.22982 + 0.74529 \times ht - 0.00032 \times TPH - 0.000555 \times precip$$

Where:

TPH = The number of trees per hectare in the stand.

Swietenia humilis, Albizia saman and *Gliricidia sepium*

Above-ground biomass (AGB) for these three species was estimated using the following equation:

$$AGB_{t,p} = \left(BA_{t,p} \times ht_{t,p} \times FF_{t,p}\right) \times BEF_p \times D_p$$

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 (Hurtarte, 1990);

t is time measured in years;

p represents the species;

Basal area (BA) in m² is:

$$BA_t = \left(\frac{DBH_t}{200}\right)^2 \times \pi$$

Where:

π= the mathematical constant Pi whose value is equal to the ratio of any circle's circumference to its diameter;

Swietenia humilis

Applies to: Mixed Species Forest Plantation, Silvopastoral

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 cm and the maximum height was set at 20 m (again, well below the species potential). As such, the DBH equation was determined to be as follows:

$$DBH_t = \beta_1 \times \left(1 - e^{\beta_2 \times t}\right)^{\beta_3}$$

The height equation was determined to be as follows:

$$ht_t = \beta_1 \times \left(1 - e^{\beta_2 \times t}\right)^{\beta_3}$$

Albizia saman

Applies to: Mixed Species Forest Plantation

Albizia saman is rarely grown in plantations thus reliable growth information was difficult to obtain. Consequently, site-specific allometric equations were derived for height and DBH based on measurements taken from temporary sample plots within the community of San Juan de Limay using a full range of ages used in this forecasting exercise. Unfortunately, the trees measured were commonly open grown with no effect of stand density taken into account resulting in biased results. Individuals grown in the plantation will likely grow taller and narrower than forecasted.

Where:

$$DBH_t = 0.0311 \times t$$

$$Ht_t = 2.0344 \times t^{0.6601}$$

Gliricidia sepium

Applies to: Mixed Species Forest Plantation

Like *C. velutina, G. sepium* is scheduled for harvest at a young age so its carbon sequestration is excluded from the carbon modelling. The height prediction model for *Gliricidia sepium* is as follows (Hughell, 1990):

$$ln\ ln\ (Ht) = 0.1671 + \frac{-14.684}{t} + 0.9538 \times ln(SI)$$

Where:

SI = site index with a base year of 5 measured in m and t = age in months.

Since this planting design will take place in an area with no prior experience growing the species, the site index was assumed to be 5, which represents medium growth (Hughell, 1990).

Although there is much literature on the benefits of *Gliricidia sepium*, we were unable to find information on actual growth of DBH. Therefore, 80% of the DBH growth rate of *Leucaena leucocephala* was used, which is a conservative estimate. This is based on literature stating that *Gliricidia sepium* and *Leucaena leucocephala* are two of the most productive native biomass trees in dry zones of Central America (Stewart & Dunsdon, 1994). Internal field trials of *Gliricidia sepium* show the species growing just as tall as *Leucaena leucocephala* after one year of growth. The following is the equation used to calculate the DBH for any tree (t).

$$DBH_t = 1.825 \times t \times 0.8$$

Where:

t = Age of the tree in years;

0.8 is the conservative DBH growth rate modifier.

Values for timber processing factors

Applies to: Mixed Species Forest Plantation, Silvopastoral

When the trees are processed, only a minority of the stem is processed into long-lived timber products. For this program, a processing factor of 80% of the stem is used for posts, and 35% is used when larger stems are processed into sawnwood (Quiros & Chinchilla, 2005). This factor is taken from a study done in Costa Rica where trees with a DBH of 19 centimeters had a processing factor of 35% and those with a larger DBH had a higher factor. Although trees used for sawnwood in this program all have a DBH much larger than 19 centimeters at harvest, to be conservative, a constant factor of 35% is being used.

Values for decay rates of harvested wood products

Applies to: Mixed Species Forest Plantation, Silvopastoral

The rate of decay of harvested wood products is taken into consideration at a constant rate of 2.3% per year, (IPCC 2006) which is consistent with decay rates used in other publications for tropical agroforestry environments (Kursten & Burschel, 1993). The default value is appropriate because the majority of the sawnwood 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. This is wood that is decayed in the form of harvested wood products in the carbon modeling. As with carbon sequestration, the carbon stored in HWP of *C. velutina* and *G. sepium* are excluded from the carbon modeling.

Mortality considerations

Applies to: Mixed Species Forest Plantation, Silvopastoral

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

Shifting from plantation forestry to sustainable stand management in the second half of the project period

Applies to: Mixed Species Forest Plantation, Silvopastoral

When the plantation approaches maturity near year 25, the management regime will progressively shift towards sustainable stand management. From this point on, the carbon modeling shifts from a tree level model to a stand level model. A conservative growth rate of 9 m^3 per hectare per year is assumed with a harvest regime of 45 m^3 every 5 years (this is based on local professional knowledge and is a common figure for timber stand growth). The average density of the stand is assumed to be the average of the last species left in the stand, which is 0.57 g/cm^3.

Coffee Agroforestry methodological considerations

The following section provides the high-level methodology for modelling tree height, DBH and AGB. It also covers other aspects of the approach, including modelling stand growth and yield, setting the wood specific gravity and calculating emissions from fertilizers.

Modeling tree DBH

To estimate the growth and yield with only DBH, a Chapman-Richard function form was used, which is common in forestry given its flexibility and suitability to biological applications (Clutter, Fortson, Pienaar, Brister, & Bailey, 1983). Specifically:

$$DBH_{tc} = B_{1c}(1 - e^{-B2_c \times t})^{B3_c} + E_{tc}$$

Where:

$DBH_{t,c,}$ is mean DBH for cohort c at time t; t = time in years; e is the base of the natural logarithm, which is a constant = 2.71828; $ß_1$, $ß_2$ and $ß_3$ are fixed-effects parameters to be estimated; and $_{j,c}$ = error term of the equation.

It is important to note that this analysis was performed using cross-sectional data to make time-series inferences, thus biasing the results (Schabenberger & Pierce, 2002). This is because one does not end up modeling individual stands over time but rather a number of different stands of different ages without having information on some of the characteristics that might have affected a particular stand's growth trajectory. Nonetheless, this analysis provides the best estimate available for modeling growth and yield curves given the paucity of available time series data.

Modeling tree height

Height prediction models were used as proposed by (Staudhammer & LeMay, 2000)

$$Ht_c = 1.3 + \beta_{1c}\left(1 - e^{\beta_{2c} \times DBH^{\beta_{3c}}}\right) + \epsilon_c$$

Where:

Ht_c = average height of cohort c.

Calculation of species above ground biomass

Coffee trees

The coffee tree model used was developed by Segura, Kanninen and Suarez (2006). The model is specific to coffee and was developed in Nicaragua. Compared to other coffee biomass models available in the literature, this model is much more conservative with estimates of 20% to 66% of what other models predict (Schmitt-Harsh, Evans, Castellanos & Randolph, 2012).

Fruit and shade trees

For the fruit and shade trees, a general biomass model by Chave et al., (2005) is used as opposed to a species-specific model to account for the great diversity of tree species used and naturally regenerating in the coffee agroforestry systems. This general model is widely used for carbon modelling given its broad applicability. The model is specific to the climatic region of the project and allows for different tree densities. Segura, Kanninen and Suarez (2006) created allometric equations for coffee agroforestry systems in Nicaragua that we ultimately did not use for the following reasons: 1) shade cohort models were built using diameter at 15 cm as opposed to DBH, which is conventionally measured in the field of forestry and is the measurement used in this project; and 2) the shade cohort was modeled by combining fruit trees and shade trees, which are significantly different in size, thus biasing any model that doesn't use the same ratio of fruit and shade trees. Given this, the project uses a more general model for the region to account for the great diversity of tree species present in these coffee agroforestry systems.

Setting specific gravity (density of wood)

Given the variety of shade trees in this coffee agroforestry system, the density of wood was obtained by finding the average value among a variety of shade trees for the project's climatic region proposed by Chave et al. (2006). The density of fruit trees was obtained by averaging the species-specific values for citrus trees and avocado trees, as they are the most commonly planted fruit trees in the project area.

Modeling the growth and yield of the stand

Growth and yield of fruit trees and shade trees are highly dependent on management and different growth conditions. No species-specific models were available for this project region and therefore a new model was built in-house.

Growth and yield for coffee plants were built based on simple linear relationships of conservatively reported height and diameter at 15 cm in height of reported values in Segura, Kanninen and Suarez (2006) over an assumed 10 year rotation period.

The growth and yield modelling exercise was based on a DBH driven model from which height was derived. Nonlinear models were fitted using PROC MODEL of SAS version 9.3 and variables were tested for statistical significance using $\alpha = 0.05$.

Data was collected between the months of January and March 2013 from 30 coffee agroforestry systems. A variety of ages were purposely sampled across the municipality of San Juan de Rio Coco (SJRC). At each sampled location, nested subplots of varying sizes were used within the sample plots to measure trees using the same sampling plot types as the carbon baseline and described in Annex 9 - Table 1. Efforts were made to sample stands with the full variety of ages used for the proposed modelling exercise and to sample stands of homogenous ages. Unfortunately, few older stands were available with homogenous aged trees because farmers commonly established their coffee agroforestry systems progressively over time with remnant trees. To minimize the effects of really large trees from positively biasing the data within the time frame of this modeling exercise, trees with DHB > 50 cm were recorded as having a DBH of 50 cm.

Considerations in fertilizer emissions calculations

Coffee farmers in the coffee regions regularly use synthetic fertilizers to increase the productivity of their coffee, which emit greenhouse gas emissions (IPCC 2006). While CommuniTree does not provide farmers with synthetic fertilizers and promotes organic means of production, farmers are likely to use them. CommuniTree is also exploring using biochar as an organic fertilizer.

For the purposes of carbon modelling, the calculations assume that farmers will use the amounts recommended by technical best practices provided by Atlantic. This is almost surely a conservative assumption since farmers generally use substantially less given cash-flow problems. Furthermore, Taking Root intends to promote the use of organic methods such as biochar, which could even be carbon negative.

Parameters

The following Table 1 describes the parameter values for the equations in Annex 10.

Annex 10 - Table 1 - Parameter values for equations in Annex 10

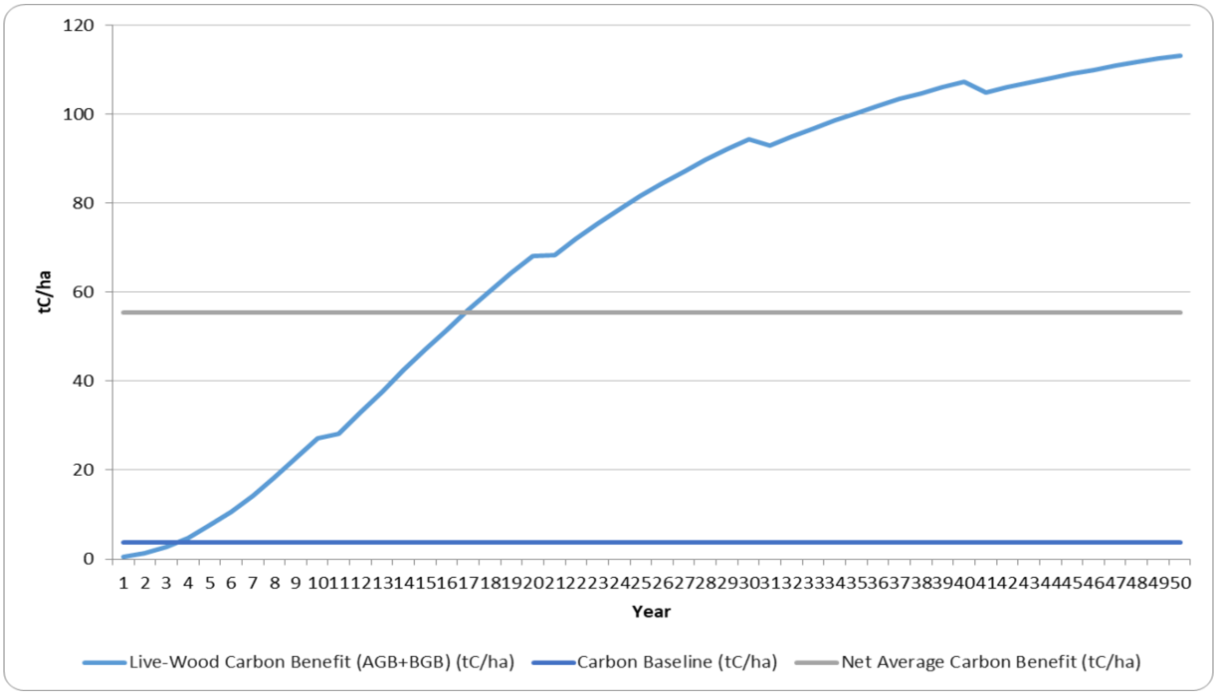
Description	Value	Reference
Biomass Expansion Factor		IPPC, 2006
Swietenia humilis	1.5	IPPC, 2006
Gliricidia sepium	1.5	IPPC, 2006
Albizia saman	1.5	IPPC, 2006
Annual Mortality	10%	Common Industry Assumption
Form Factor	0.5	Malik, A. (2002)
Stand Growth Rate (m3/ha)	9	Local Professional Knowledge
Site Index Variables (for Caesalpinia velutina)		

Annual Precipitation (mm)	1394	Internal GIS Analysis
Slope (degrees)	2	Internal GIS Analysis
Project Elevation (m)	400	Internal GIS analysis
Site Index	20.0611	Navarro, C. (1987)
Chapman-Richards Model		In-house model
b1 DBH	42	
b2 DBH	-0.16	""
b3 DBH	4.2	""
b1 height	26	
b2 height	-0.17	""
b3 height	1.6	""
Fruit Tree model (Coffee Agroforestry)		In-house model
b1 DBH	26.69	""
b2 DBH	-0.085	""
b3 DBH	0.599	""
b1 height	9.27	""
b2 height	-0.025	""
b3 height	1.392	""
Shade Tree model (Coffee Agroforestry)		In-house model
b1 DBH	49.54	""
b2 DBH	-0.0855	""
b3 DBH	1.17	""
b1 height	50	""
b2 height	-0.05266	""
b3 height	0.579	""

Where MSFP = Mixed Species Forest Plantation, SP = Silvopastoral,CA = Coffee Agroforestry

The following charts and tables display the baseline, net carbon benefits and average carbon benefits over the 50-year crediting period for each project intervention.

Coffee Agroforestry project intervention



Annex 10 - Figure 1. Carbon benefits from the coffee agroforestry planting design over the crediting period before baseline and risk buffer adjustments.

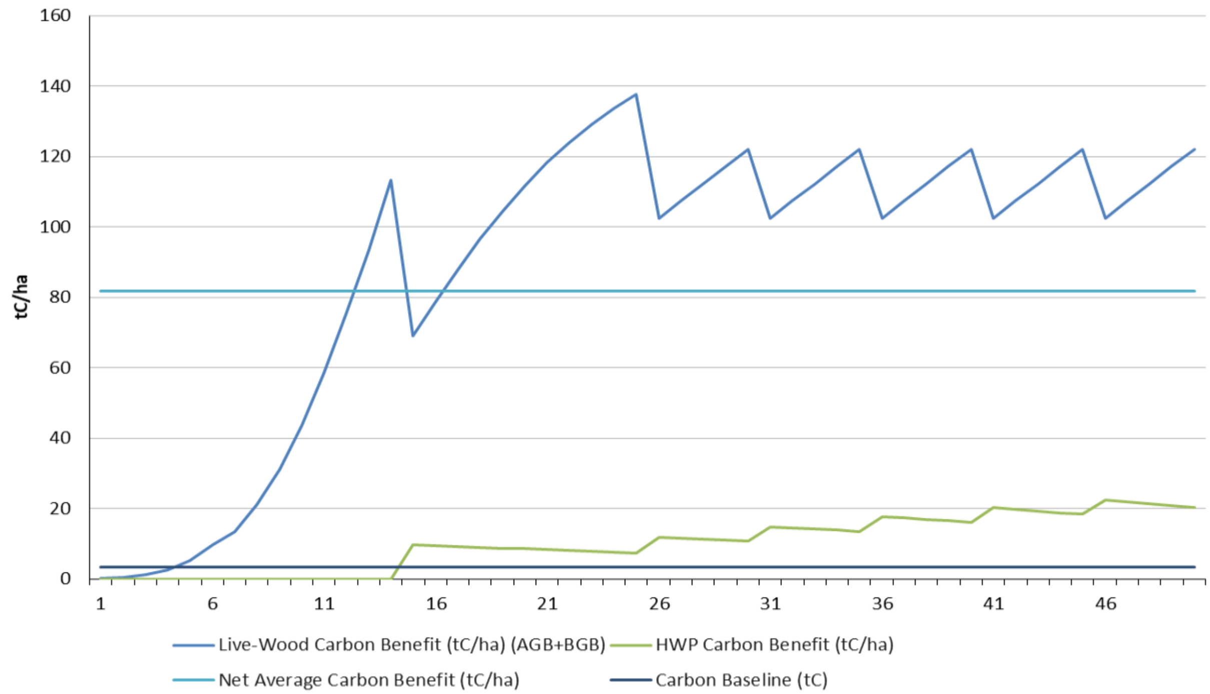
Annex 10 - Table 2 - Carbon pools and stand growth over the project lifetime - Coffee Agroforestry

Year	**Basal Area (m3)**	**Total AGB (tC/ha)**	**Total BGB (tC/ha)**	**Total fertilizer emissions (tC/ha)**	**Total Carbon Benefit (tC/ha)**
1	0.07	0.43	0.09	0.00	0.52
2	0.30	1.15	0.24	0.02	1.37
3	0.71	2.33	0.49	0.03	2.79
4	1.27	4.02	0.84	0.03	4.83
5	1.95	6.20	1.30	0.03	7.47
6	2.73	8.83	1.85	0.03	10.66
7	3.58	11.85	2.49	0.03	14.30
8	4.47	15.17	3.19	0.03	18.33
9	5.39	18.73	3.93	0.03	22.64
10	6.33	22.47	4.72	0.03	27.16
11	7.26	23.30	4.89	0.00	28.19
12	8.19	27.24	5.72	0.02	32.94
13	9.09	31.18	6.55	0.03	37.70
14	9.97	35.08	7.37	0.03	42.42
15	10.82	38.92	8.17	0.03	47.06
16	11.63	42.66	8.96	0.03	51.59
17	12.41	46.30	9.72	0.03	55.99
18	13.14	49.81	10.46	0.03	60.24

19	13.84	53.18	11.17	0.03	64.32
20	14.50	56.41	11.85	0.03	68.23
21	15.12	56.48	11.86	0.00	68.34
22	15.71	59.45	12.49	0.02	71.92
23	16.25	62.27	13.08	0.03	75.32
24	16.77	64.93	13.64	0.03	78.54
25	17.24	67.45	14.16	0.03	81.59
26	17.69	69.83	14.66	0.03	84.46
27	18.10	72.07	15.13	0.03	87.17
28	18.49	74.17	15.58	0.03	89.72
29	18.85	76.16	15.99	0.03	92.13
30	19.18	78.03	16.39	0.03	94.39
31	19.49	76.77	16.12	0.00	92.89
32	19.77	78.46	16.48	0.02	94.92
33	20.04	80.04	16.81	0.03	96.82
34	20.28	81.53	17.12	0.03	98.62
35	20.51	82.92	17.41	0.03	100.31
36	20.71	84.23	17.69	0.03	101.89
37	20.91	85.46	17.95	0.03	103.38
38	21.08	86.62	18.19	0.03	104.78
39	21.25	87.71	18.42	0.03	106.10
40	21.40	88.73	18.63	0.03	107.34

41	21.54	86.69	18.21	0.00	104.90
42	21.67	87.65	18.41	0.02	106.03
43	21.78	88.54	18.59	0.03	107.11
44	21.89	89.39	18.77	0.03	108.13
45	21.99	90.18	18.94	0.03	109.09
46	22.08	90.94	19.10	0.03	110.01
47	22.17	91.65	19.25	0.03	110.87
48	22.25	92.34	19.39	0.03	111.70
49	22.32	92.98	19.53	0.03	112.48
50	22.38	93.60	19.66	0.03	113.23

Mixed Species Forest Plantation project intervention



Annex 10 - Figure 2. Carbon benefits from the Mixed Species Forest Plantation planting design over the crediting period before baseline and risk buffer adjustments.

Annex 10 Table 3. - Carbon pools and stand growth over the project lifetime - Mixed Species Forest Plantations

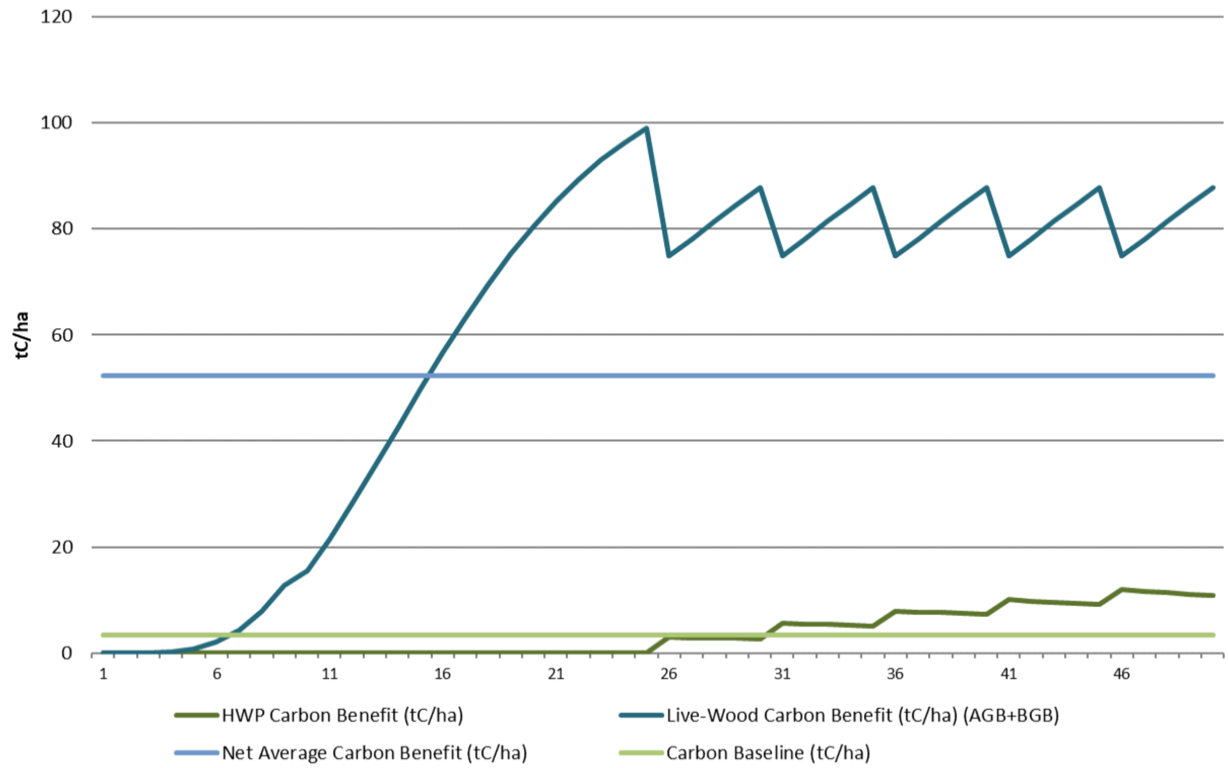
Year	**Basal Area** (m3)	**Total AGB** (tC/ha)	**Total BGB** (tC/ha)	**Total HWP** (tC/ha)	**Total Carbon Benefit** (tC/ha)
1	0.1	0.0	0.0	0.0	0.1
2	0.4	0.2	0.1	0.0	0.4
3	0.9	0.7	0.4	0.0	1.1
4	1.6	1.7	1.0	0.0	2.7
5	2.6	3.4	1.9	0.0	5.3
6	4.0	6.2	3.5	0.0	9.7
7	5.8	10.5	2.9	0.0	13.4
8	8.2	16.5	4.6	0.0	21.1
9	11.1	24.4	6.8	0.0	31.2
10	14.5	34.1	9.6	0.0	43.7
11	18.3	45.6	12.8	0.0	58.4
12	22.4	58.6	16.4	0.0	75.1
13	26.8	73.0	20.4	0.0	93.4
14	31.4	88.4	24.8	0.0	113.2
15	14.9	53.9	15.1	9.7	78.7
16	16.8	61.5	17.2	9.4	88.2
17	18.6	68.7	19.2	9.2	97.2
18	20.3	75.5	21.1	9.0	105.6

19	21.9	81.7	22.9	8.8	113.3
20	23.3	87.3	24.4	8.5	120.3
21	24.5	92.3	25.9	8.3	126.5
22	25.7	96.9	27.1	8.1	132.1
23	26.6	100.9	28.2	7.9	137.0
24	27.5	104.4	29.2	7.7	141.3
25	28.3	107.5	30.1	7.4	145.0
26	*	80.1	22.4	11.7	114.3
27	*	83.9	23.5	11.4	118.9
28	*	87.7	24.6	11.2	123.5
29	*	91.5	25.6	10.9	128.1
30	*	95.4	26.7	10.7	132.7
31	*	80.1	22.4	14.9	117.4
32	*	83.9	23.5	14.5	121.9
33	*	87.7	24.6	14.2	126.5
34	*	91.5	25.6	13.9	131.0
35	*	95.4	26.7	13.5	135.6
36	*	80.1	22.4	17.7	120.2
37	*	83.9	23.5	17.3	124.7
38	*	87.7	24.6	16.9	129.2
39	*	91.5	25.6	16.5	133.7
40	*	95.4	26.7	16.1	138.2

41	*	80.1	22.4	20.2	122.7
42	*	83.9	23.5	19.7	127.1
43	*	87.7	24.6	19.3	131.6
44	*	91.5	25.6	18.8	136.0
45	*	95.4	26.7	18.4	140.5
46	*	80.1	22.4	22.4	125.0
47	*	83.9	23.5	21.9	129.3
48	*	87.7	24.6	21.4	133.7
49	*	91.5	25.6	20.9	138.1
50	*	95.4	26.7	20.4	142.5

* Note from years 26-50, a sustainable forest stand management approach is undertaken. In these years, carbon sequestration is tracked as the primary metric for project success.

Silvopastoral Planting



Annex 10 - Figure 3. Carbon benefits from the Silvopastoral planting design over the crediting period.

Annex 10 - Table 4. Carbon pools and stand growth over the project lifetime - Silvopastoral Planting

Year	**Basal Area** (m3)	**Total AGB** (tC/ha)	**Total BGB** (tC/ha)	**Total HWP** (tC/ha)	**Total Carbon Benefit** (tC/ha)
1	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00
3	0.01	0.02	0.01	0.00	0.04
4	0.04	0.14	0.08	0.00	0.21
5	0.16	0.49	0.27	0.00	0.76
6	0.41	1.28	0.72	0.00	2.00
7	0.86	2.73	1.53	0.00	4.27
8	1.54	5.00	2.80	0.00	7.80
9	2.45	8.14	4.56	0.00	12.69
10	3.58	12.11	3.39	0.00	15.50
11	4.87	16.78	4.70	0.00	21.48
12	6.28	21.99	6.16	0.00	28.14
13	7.75	27.52	7.71	0.00	35.23
14	9.24	33.19	9.29	0.00	42.49
15	10.70	38.83	10.87	0.00	49.71
16	12.10	44.30	12.40	0.00	56.70
17	13.42	49.49	13.86	0.00	63.35

18	14.64	54.34	15.21	0.00	69.55
19	15.75	58.79	16.46	0.00	75.25
20	16.76	62.84	17.60	0.00	80.44
21	17.67	66.49	18.62	0.00	85.11
22	18.47	69.74	19.53	0.00	89.27
23	19.19	72.62	20.33	0.00	92.95
24	19.81	75.16	21.04	0.00	96.20
25	20.36	77.38	21.67	0.00	99.04
26	*	58.49	16.38	2.96	77.84
27	*	61.03	17.09	2.90	81.02
28	*	63.58	17.80	2.83	84.21
29	*	66.12	18.51	2.77	87.39
30	*	68.66	19.22	2.70	90.58
31	*	58.49	16.38	5.60	80.48
32	*	61.03	17.09	5.48	83.60
33	*	63.58	17.80	5.35	86.73
34	*	66.12	18.51	5.23	89.86
35	*	68.66	19.22	5.11	92.99
36	*	58.49	16.38	7.95	82.82
37	*	61.03	17.09	7.77	85.89
38	*	63.58	17.80	7.59	88.97
39	*	66.12	18.51	7.42	92.05

40	*	68.66	19.22	7.25	95.13
41	*	58.49	16.38	10.05	84.92
42	*	61.03	17.09	9.81	87.94
43	*	63.58	17.80	9.59	90.97
44	*	66.12	18.51	9.37	94.00
45	*	68.66	19.22	9.15	97.03
46	*	58.49	16.38	11.91	86.78
47	*	61.03	17.09	11.63	89.76
48	*	63.58	17.80	11.37	92.74
49	*	66.12	18.51	11.10	95.73
50	*	68.66	19.22	10.85	98.73

* Note from years 26-50, a sustainable forest stand management approach is undertaken. In these years, carbon sequestration is tracked as the primary metric for project success.