Technical Specifications for Agroforestry Systems in Temperate and Tropical Climate Areas
Based on SHAMBA v1.1 Methodology

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The Scolel'te Program

Scolel'te, "the growing tree" in Mayan tseltal language, is a program for sale of carbon capture ecosystem services through reforestation and sustainable forest management activities. It has operated within the Land Use, Land Use Change and Forestry (LULUCF) category in the voluntary carbon market since 1997. With more than two decades in operation, it is the most experienced program of its kind worldwide. Furthermore, it is a pioneering initiative in the commercialization of Forestry Carbon Credits that are certified under an international standard in Mexico.

Through the Scolel'te Program, the Ambio Cooperative works alongside rural villages in southeastern Mexico. The program aims to mitigate climate change and promote social wellbeing by strengthening local capabilities and promoting forestry, agroforestry and community-based sustainable forest management. This is done from an integrated approach to land management and community participation, with the aim of developing sustainable livelihoods.

Intervention area

Scolel'te has an intervention area of 8,946.5 hectares[1], distributed in several regions of Chiapas and Oaxaca. Both states have a critical importance in ecological and cultural terms, given their representation of indigenous peoples and their high rates of terrestrial biodiversity.

Background of the program

Scolel'te began operations in 1994 as a feasibility study to assess the potential for carbon capture in the rural communities of the state of Chiapas. It also aimed to understand the socioeconomic factors that influence in the sustainable management of natural resources. In 1997, the project accomplished its first sale, joining the Voluntary Market. Based on this initial experience, the Plan Vivo System was further developed.

[1] According to the Scolel'te Annual Report 2016.

Objective

The general objective of the Scolel'te program is to contribute to climate change mitigation and to social wellbeing through the strengthening of local capabilities and the promotion of forestry, agroforestry and community forest management. This is to be achieved using a landscape management approach and community participation, in order to achieve sustainable livelihoods in Mexican rural communities.

Implementers

Scolel'te – *Natural Resources Management and Carbon Capture*- is led by the Ambio Cooperative, which coordinates the activities with rural communities.

Activities

Scolel'te promotes a set of activities, which include forestry, reforestation, agroforestry, conservation, protection and restoration of forests and rainforests, using native tree species with a sense of cultural relevance in the regions where the program is implemented.

Carbon sequestration takes place by establishing and maintaining agroforestry and forestry systems, divided in two climatic regions and six intervention models.

Forest and Agroforestry Systems for Template Areas	**Agroforestry Systems for Tropical Areas**
– Improved fallow – Living fence – Forest Restoration	– Taungya – Improved fallow – Living fence – Improved shade-grown coffee
– Community forest management	

Impacts

Scolel'te aims to strengthen the diversified and sustainable management of natural resources, according to the particular requirements of the communities involved. In addition to the PES (Payment for Ecosystem Services) that participants receive, the program generates socio-environmental co-benefits, such as local training in forest management, seedlings collection, nurseries, pruning, climate change awareness, and fire management, among others. These benefits also extend to the provision and better understanding of medicinal plants, fuelwood, timber and other non-timber forest products, all of them with ecosystem and market value.

Reforestation activities are carried out with native endemic species. This allows for the permanence of natural habitats for flora and fauna that are considered vulnerable from a conservation perspective.

Technical specifications for Scolel'te

Summary

Two technical specifications are presented for the Scolel'te program. One is suited for a temperate climate, which includes three agroforestry systems, and another for tropical areas with four agroforestry systems. They are all designed for the geographic region of the State of Chiapas, located in southeastern Mexico.

The most representative forest species are cedar (*Cedrela odorata*), pink poui (*Tabebuia rosea*) and mahogany (*Swietenia macrophylla*) for tropical regions, as well as pinus (*Pinus sp.),* oak (*Quercus sp.)* and cypress (*Cupressus sp*.) for temperate areas.

The figures presented in this document come from research conducted since 1997 by different academic institutions, from the SHAMBA Tool software (developed by the Edinburgh University) and from the monitoring data, which has been accumulated in more than 20 years of continuous operations. The Technical Specifications are based on the **Shamba Methodology v1.1** which was approved by the Plan Vivo Foundation as an Approved Approach in 2017.

With its activities, Scolel'te aims to provide medium and long-term benefits to improve agriculture and forestry yields, protect soil and crops, as well as supply timber and firewood for rural families. This aims to reduce pressure on areas that are conserved or have a status of protection.

The activities described in these technical specifications are only eligible for smallholder farmers with sufficient land for planting trees. Lands must be within the program geographical area, as defined in the *Project Design Document (PDD and on page 9)* and the participating households must demonstrate that the program activities are not in conflict with their own productive activities, such as subsistence farming.

Scolel'te is a long-term program with carbon credits issued **ex-ante** for a 40-year crediting period for temperate areas and a 40-year crediting period for tropical zones[2]. It is based on a contractual period of 10 years, considering the monitoring and follow-up activities scheduled for the first ten years of the program. Harvesting will be implemented once the trees have reached the appropriate physical conditions. Throughout the project period, it is expected that the families obtain benefits from firewood, fruits and other ecosystem services.

The **SHAMBA software** (described in the next section), developed by a research team at the University of Edinburgh, was used to estimate carbon sequestration rates for a set of variables such as the forest species, the agroforestry system and the project lifespan. Estimations are based on combined measurements of the carbon pools within above ground and below ground biomass.

[2] The years calculated in the technical specifications have considered both the technical aspects and the Mexican National Legislation (which regards the temporality of land use rights and land tenure).

A summary of the carbon estimations can be found in the following chart.

Chart 1: Summary of net and saleable tCO_2.

Technical specification	System	Sink tCO_2/ha	Baseline tCO_2/ ha	Net benefits tCO_2/ha	Risk buffer[3] (10%) tCO_2/ha	Saleable tCO_2/ha
Temperate climate*	Improved fallow (FOR-ACME-TEMP)	802.81	666.11	136.71	13.67	**123.04**
	Living fence (AF-CERVI-TEMP)	559.49	488.11	71.38	7.14	**64.24**
	Forest Restoration (FOR-REST-TEMP***	1187.29	770.0	417.29	125.19	**297.1**
Tropical climate**	Taungya (AF-TAUNG-TROP)	540.00	330.30	209.70	20.97	**188.73**
	Improved fallow (FOR-ACME-TROP)	532.19	341.31	190.88	19.09	**171.79**
	Living fence (AF-CERVI-TROP)	415.92	315.62	100.30	10.03	**90.27**
	Improved shade-grown coffee (AF-CAFE-TROP)	514.50	378.01	136.49	13.65	**122.84**

* Projected to 40 years with a single rotation for tropical climate.
** Rotation after 20 years for tropical climate, two periods.
*** As a result of COVID-19, it is currently not feasible to collect data from field sites. Instead, data collected in 2010 and 2011 are applied with very conservative assumptions on growth rates to calculate preliminary emission estimates. Once travel restrictions are lifted, up to date field data be collected and further updates made to the technical specification.

[3] For the forest restoration system, 30% buffer is considered.

The SHAMBA tool

The Small-Holder Agriculture Monitoring and Baseline Assessment (SHAMBA) tool is a simple system to assess greenhouse gas flux from the land used in tropical areas. It can be used to undertake a baseline assessment and continual monitoring of small-scale agriculture. The tool has been reviewed and approved by the Foundation and the Plan Vivo Standard, and it is currently being used in Plan Vivo projects. The tool is under continuous improvement by the team of tropical lands at the University of Edinburgh, in association with several users and sponsors.

Shamba Methodology v 1.1 is described in detail here. Default values were taken from the model description. All model parameters are summarized in the section 'Biomass calculations' (p. 21). Shamba default values are used per the methodology (v 1.1) except for wood densities and growth rates for different tree species which are summarized in the 'species analysis' sections in the separately provided carbon calculations.

With this background, the SHAMBA tool was used to update the technical specification of the Scolel'te Program. The field data was taken from 95 plots of the different agroforestry systems already created in the Program. The plots were 20 years old.

The field data collected at each sampling plot included: The tree's diameter, height, age, condition of health, and the local and scientific identification of each species measured. This information was provided alongside a general description of the current site (type of vegetation, land use, type of agriculture), and a description of the previous management of the plots (before the establishment of the agroforestry system), such as the use and application of agrochemicals and fertilizers. All this information was inputted into the SHAMBA tool, to be analyzed and updated for the Scolel'te specifications.

Intervention and activities of the Scolel'te Program

Scolel'te's intervention area is mainly in the state of Chiapas, located in southern Mexico. It encompasses 21 municipalities distributed in the physiographic regions of the Chiapas Highlands , Sierra Madre de Chiapas, Mountains of the North, Mountains of the East and Depresión Central. A group of the communities registered in the program is within the jurisdiction of a federal protected area, such as Montes Azules, Naha-Metzabok, La Sepultura, La Frailescana, El Ocote, Sumidero Canyon National Park and El Triunfo.

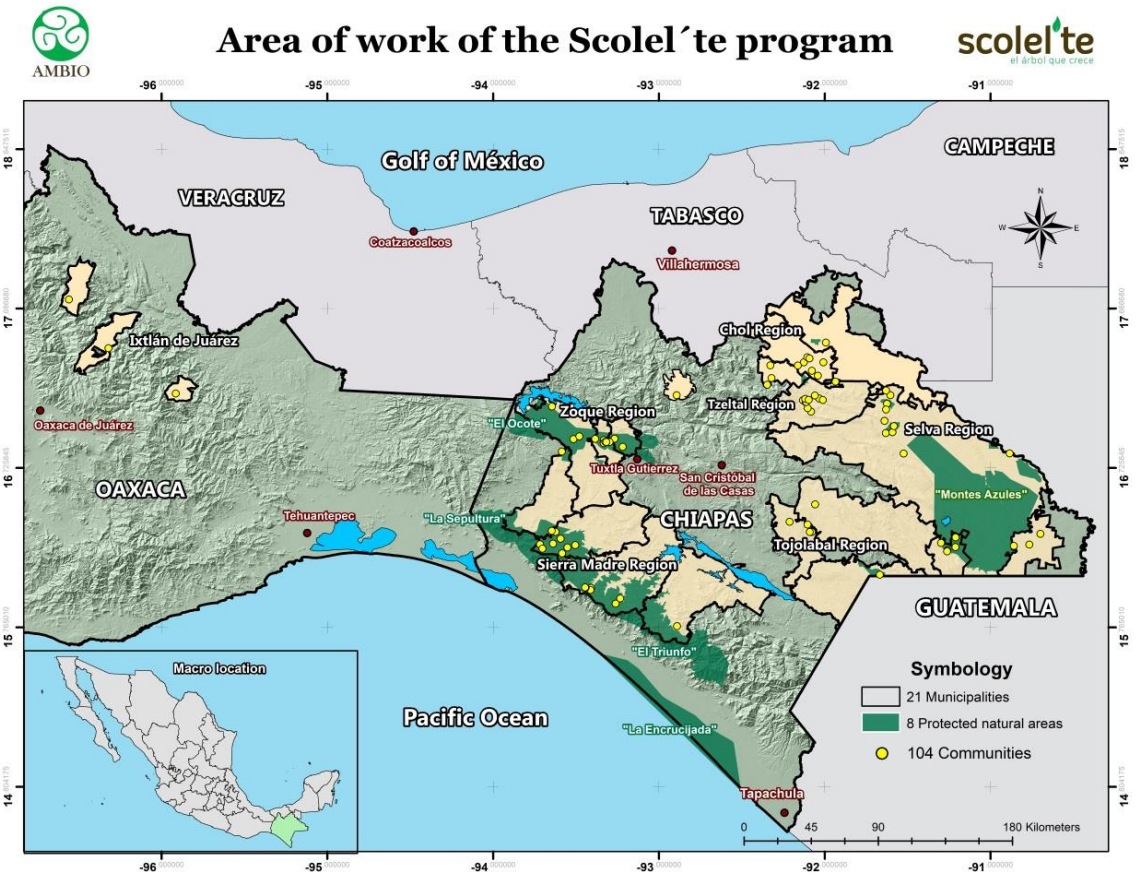

Figure 1. Communities and working area of the Scolel'te Program

(Source: Cooperativa Ambio).

Technical specifications

General

The technical specifications guide the implementation of reforestation, agroforestry and forest management activities of the Scolel'te Program.

In addition to estimating the carbon sequestration across the project lifespan, these specifications justify the socioeconomic and environmental benefits linked to the sustainable management of the land use interventions, as proposed in the 'Plan Vivos'. The activities described in these technical specifications are applicable only for smallholder farmers or communities with potential land for planting trees and implementing forest restoration.

Scolel'te's technical specifications are implanted on degraded and/or deforested land that has previously been used for agricultural activities. Participants have to demonstrate the legal possession of land and that the project activities won't lead to familiar or communitarian conflict. Furthermore, during the planning stage, it must be validated that the project actions will not affect subsistence farming.

These technical specifications are valid for a five-year period (from 2018 to 2023), in order to gather additional information as necessary for further feedback and update.

Technical specifications for Scolel'te

Two different technical specifications were developed for the Scolel'te Program, given the geospatial range of its intervention areas; one for temperate regions and a second for tropical areas.

The systems within each technical specification are the following:

Systems for temperate climate	Systems for tropical climate
– Improved fallow – Living fence – Forest restoration	– Taungya – Improved fallow – Living fence – Improved shade-grown coffee

The intervention model is applicable for both specifications, focused on the promotion of reforestation, landscapes restoration, sustainable forest management, and agroforestry in 21 municipalities in the state of Chiapas.

Ecology of the intervention species

Most common forest species in the program are *Cedrela odorata, Swietenia macrophylla, Tabebuia roseae, Diphysa robinioides, Calophyllum brasiliense, Pinus sp, Cupressus sp., Ceiba pentandra, Arborea cojoba, Tabebuia donell smithii, Pouteria sapota, and Mexicanum blepharidium*. All of these are native and have cultural and economic significance. This implies a high rate of physiological and ecological adaptation to the biophysical characteristics of the local environmental, allowing their proper development.

Plan Vivos management

Scolel'te provides an opportunity for smallholder farmers to access environmental markets through their own land management plans. The farmer carries out a planning exercise based on a land management plan (Plan Vivo), in order to assess the feasibility to participate in this market without affecting or obstructing his/her basic needs of alimentation. The planning action must also encourage direct and indirect benefits, such as firewood, timber, food and construction materials. The best way to achieve these objectives is by establishing agroforestry systems, rooted in local knowledge and traditions.

Another critical component of the systems established in Scolel'te is the direct correlation with biodiversity. This is because the presence of trees benefits the conservation of endangered populations of flora and fauna in the areas where the program operates.

Supplies

Plants production and acquisition

Plants are the main supply for the establishment of forestry and agroforestry systems. The program provides training and technical follow-up for nursery mamangement. In addition to securing high quality plants, community technicians and Ambio personnel collect seedlings in the areas of intervention.

These activities are scheduled with the aim to have plants in a good state of growth at the adequate time. Planting season is therefore aligned with rain patterns, between June and October in both climatic areas.

Project participants also request plants from federal and local institutions. The costs concerning seedling production can be covered by the program administration, in addition to seedlings produced directly by the communities.

Maintenance

The farmers enrolled in the Scolel'te programme are in charge of the maintenance of the trees. In most cases they implement silvicultural activities, planting trees and crops, weeding, crop harvesting, pruning and timber harvesting when the trees reach their optimal development.

The participation of family members is of critical relevance in these activities. External personnel are only hired when the farmer or the family cannot participate.

Central maintenance actions include:

Weeding

This concerns the elimination of weeds and grasses in the area for tree-planting, in order to avoid additional competition for nutrients and consequently improve tree growth. In the case of

improved fallows, weeding is done in the form of gaps, preferably from east to west, trying to leave residuals in the soil to promote its protection.

Plot measurement and delineation

Plot measurement and delineation refers to manual planting and aims to provide exact details in terms of spacing and density. Marked ropes, graduated rods and stakes are the main tools for measurement.

Holing and planting

Holing is carried out mainly in areas with a tropical climate. The activity refers to the opening of holes in the soil, with variable diameter and depth, to place the plants. The distribution of holing locations must be done as described in the technical specification. Depth and length must be the appropriate to allow the development of roots. For planting, there must be a careful management, trying not to damage the plant within its own bag or container. A stake is placed beside each on-site plant to reduce the risk of damage when subsequent weeding is performed.

Replanting

Replacement of dead plants takes places in the second year, after the initial planting period and during the rainfall season. An evaluation is undertaken one month after the replacement to assess the survival rate.

Weed management

This activity has a critical role in forest management, especially in the early stages of development (years 1 to 3). Undesirable weeds in the plots are manually removed. Weed management is implemented at least twice a year in order to minimize each tree's competition for nutrients and therefore secure optimal growth rates.

Pruning and shade management

This is a silvicultural practice for a selective removal of parts of a plant, like branches, buds or roots. Pruning has the objective to remove dead wood, avoid the malformation of the trunk (therefore controlling or directing growth) and improve the general health of the trees.

Sanitation and development pruning take place to ensure high quality timber, particularly during the first three years of establishment. Pruning has also an accelerative effect in growing rates and makes trees less susceptible to shoot borers *(Hypsipyla grandella),* especially in cedar and mahogany species.

Thinning

Thinning activities are designed to select the best individuals that provide high quality timber and higher rates of carbon sequestration. As the circumference of the trees increases, the requirement of resources such as nutrients and space also increases; otherwise the growing rates will diminish.

Thinning allows a better selection of individuals in the plots, which translates into a faster growing and an improved management by enhancing the quantity and distribution of the trees. By modifying density in the plots, smallholders registered in Scolel'te can influence in the growing, quality and health of the trees. Forest temporality and density are determined according to the particular management system.

Illness and pest control

Shoot borers of *Hypsipyla grandella* (Zeller) is one of the main forest pests, and in particular a threat to cedar (*Cedrela sp.*) and mahogany (S*wietenia macrophylla*), of the meliaceae family.

For the above, smallholders associated to Scolel'te, implement continuous monitoring actions on the health status of the reforestations, and in case of an illness or pest, they inform to the regional technicians, for the execution of actions for appropriate management and control, in collaboration with the Ambio Cooperative personnel.

Fires and droughts management

To minimize the risk of fire damage, the smallholders of Scolel'te open firebreaks to protect reforestations. To minimize the risk of damage from droughts, preventive weed management is applied after droughts.

Applicability conditions

Both technical specifications (temperate and tropical climate) fulfill all the conditions required under the Plan Vivo Standard. This includes the baseline conditions, the activities and inputs outlined, as well as the benefits for ecosystem services.

The *Technical Specification for Temperate Climate* has been designed for ecosystems with species of pinus (*Pinus sp.)*, oak (*Quercus sp.)*, and cypress (*Cupressus sp*.). Meanwhile, the *Technical Specification for Tropical Climate* encompasses ecological areas where the typical species are cedar (*Cedrela odorata*), maculis (*Tabebuia rosea*) and mahogany (*Swietenia macrophylla*).

Communities and farmers willing to participate in Scolel'te must demonstrate the legal possession of land with documentation endorsed by the National Agrarian Registry (RAN by its Spanish acronym) as well as other processes developed by the Ambio Cooperative to verify rights to land, such as community certificates, plot certificate and land titles.

Additionally, any interested families must be within the geographical scope of the program and must demonstrate that the proposed activities will not generate further conflict or competition with agricultural production.

Outlined activities in this document are only eligible for smallholders or communities who have available land for tree-planting (deforested zones, degraded lands or areas with previous agricultural land-use). Smallholders willing to be part of Scolel'te have to demonstrate that areas have not been deforested prior to joining the project.

Temperate Climate

Agroforestry systems for temperate climate can be implemented in areas where temperate forests are distributed around Mexico. These are located primarily in the north and south of Baja California, along the Western and Eastern Sierras, in the Neovolcanic Axis, the Northern Sierra of Oaxaca and in Chiapas.

Temperate forests are arboreal, sub-arboreal, or shrubby communities where pine trees, oaks and their associated ecosystems develop as a result of their climate and soil conditions.

For pine forests, and other similar ecosystems where pine trees predominate, the climate ranges from temperate (average annual temperature between 5 and 18 ° C) to semi-cold temperatures, present at higher altitudes. In the oak forests, and other similar ecosystems where oak trees predominate, some species of pine, the climate ranges between temperate and semi-warm temperatures (average annual temperature between 18 and 22 ° C) (INEGI, 2014, García, 2004)

In Chiapas, the temperate forests are in the Sierra Madre de Chiapas and the Central High Plateau regions (Alba et al., 2003 cites Miranda, 1952, Breedlove, 1981).

In Chiapas, *Pinus spp* and their associated ecosystems can be located at an altitude of 950-2800m (above sea level), under sub humid or rainy conditions (between 940-3250 mm per year). These regions also observe greater precipitation in the summer and a well defined dry season that extends across winter and spring (Cw and Cm climates according to the Köppen classification modified by García, 2004) (Alba et al., 2003).

The slopes can be from 10% to 75%. Although the direction of these slopes can vary, they are more commonly oriented to the north. The suitable soil types are cambisols, leptosols, luvisols, phaeozems, regosols, and umbrisols, among others. The species of Pinus in Chiapas that can develop in environments with higher humidity are *P. maximinoi*, *P. strobus var. chiapensis* and *P. oocarpa*. Meanwhile, the species that can develop in drier environments are *P. ayacahuite*, *P. devoniana*, *P. montezumae*, *P. pseudostrobus* and *P. tecunumanii* (Alba et al., 2003).

With respect to temperature, the species that can develop at higher temperatures (i.e. lower altitude) are *P. montezumae*, *P. oocarpa*, *P. pseudostrobus* and *P. strobus var. Chiapensis*. At lower temperatures (i.e. higher altitude), the more suitable species are *P. ayacahuite*, *P. devoniana*, *P. maximinoi* and *P. tecunumanii* (Alba et al., 2003).

Any agroforestry systems implemented in regions where there are predominantly oak-pine ecosystems should consider the species suitable for temperate or semi-warm, and sub-humid or humid climates (200-2500 mm per year). The terrain is mainly flat and oriented towards the north, south, east and west. The soils can be of the cambis, leptosols, luvisols, regosols, among others (INEGI, 2014).

The expected heights of the trees in the system can be from 8 to 35 m, especially when planting and/or regenerating *Pinus* and *Quercus species* In the Scolel'te area, the most common and important Quercus species for local use are *Q. segoviensis* and *Q. crispipilis*.

Plan Vivos or management agreements should consider the use of systems for the collection of firewood, medicinal plants, fruits or other that facilitate the adaptation of the system. Restrictions on grazing during the first few years should be considered for Plan Vivos or management agreements at the group or community level in order to avoid damage to establishing plants.

Tropical Climate

Agroforestry systems for tropical climate can be implemented in the areas where tropical forests are distributed in Mexico. These can be wet or dry tropical forests, depending on the availability of water, which gives rise to particular characteristics of structure, physiognomy and functioning (Koleff et al., 2012).

The humid tropical forests are found in the states of Veracruz, Guerrero, Oaxaca, Chiapas, Campeche and Tabasco. Meanwhile, the dry tropical forests are found in the states of Yucatan, Campeche, Central Veracruz and Central Chiapas (INEGI, 2014).

The suitable types of climate for the implementation of tropical agroforestry systems are the warm (average annual temperature above 22 ° C) and semi warm (average annual temperature between 18 and 22 ° C). With respect to rainfall, tropical agroforestry systems can receive rain throughout the year and rain in summer; sub humid systems have a dry season (Af, Am and Aw climates according to the Köppen classification modified by García, 2004).

Most tropical agroforestry systems develop at 1500 meters above sea level. They develop in different topographical and soil type conditions. They can develop in flat lands, on hills, slopes and ravines. The types of soil where they can be developed are: leptosol, luvisol, phaeozem, regosol, vertisol, umbisol, cambisol and fluvisol, among others (INEGI, 2014).

The species proposed for these systems are cedar (*Cedrela odorata*), mahogany (*Swietenia macrophylla*), bari (*Calophyllum brasiliense*), ramón (*Brosimum alicastrum*), and boxwood (*Cordia alliodora*). However, these may differ in their development depending on local climate characteristics (temperature and humidity) and soil quality. In the sites where these species are able to regenerate, a varied vegetation associated with these species, can include: *Tabebuia heterophylla*, *Ficus laevigata*, *Cecropia peltata*, *Crescentia alatya*, *Crescentia cujete*, *Bursera simaruba*, *Tamarindus indica*, *Cochlospermum vitifolium*, *Acrocomia mexicana*, *Andira inermis*, *Belotia mexicana*, *Bernoulea flames*, *Calophyllum brasiliense*, and *Cordia dodecandra*.

Plan Vivos or management agreements should consider the use of systems for the collection of firewood, medicinal plants, fruits or other that facilitate the adaptation of the system. Likewise, Plan Vivos or management agreements should consider regulating the entry of animals to the site that may damage the plants mainly in the first years.

Barriers to implement activities without the project

- Scarce economic options for smallholders in marginalized areas.
- Limited availability of forest species for the implementation of agroforestry systems.
- Different types of land tenure that normally hinder the participation of small-scale producers. Ambio supports smallholders with different kinds of programs.
- Small land areas (1-10 hectares), which limits the participation of small producers in some government programs.
- Too many requirements for admission to government programs. Ambio promotes the use of legal timber and design new official schemes that favor the development of agroforestry systems and their use by small producers.
- Market interest in the illegal wood and low prices generate low incomes for participants in community forest management, limiting their silviculture activities and the implementation of good practices.

Additionallity

The project has considered economic and environmental additionality. The first one relates to whether the activities would be possible without the income from the carbon credits, while the latter relates to whether GHG emissions reductions would have happened in project´s absence.

The activities promoted by Scolel'te are not the result of regulations or laws and would not be possible without financing from the sale carbon credits considering that the project works with smallholder farmers and marginalized communities.

Due to agroforestry's combination of tree planting, agriculture and forest restoration activities, these systems encourage the capture of CO_2 at levels that would not be observed in the usual scenario of agricultural and forest management. The program has overcome barriers, such as those mentioned previously, to allow the participation of people by simplifying entry requirements to the program. Additionally, the large portfolio of agroforestry systems allows adaptation to different environmental and social conditions.

Legal Background

The actions promoted by Scolel'te are compatible and are supported by the following legislation:

- General Law of Ecological Balance, chapter IV (instruments of Environmental Policy), section VII, relating to activities of preservation and restoration of the ecological balance and protection of the environment;
- The Law of sustainable rural development, chapter II, article 37, section XVI, relative to the Development of forms of use and improvement of natural resources, that increase environmental services and productivity in a sustainable manner;
- The Law of sustainable rural development, chapter IV (of sustainable productive reconversion), Article 57;

- The General Law of Sustainable Forestry Development (current text), Chapter I, of its Object and application, section IV, relating to the provision of environmental goods and services;
- The General Law of Sustainable Forestry Development (current text), Chapter I, sections XI and XXXIX, related to the promotion of sustainable forest management, adaptation to climate change, and the reduction of emissions from deforestation and forest degradation.

Contribution to NDCs (Nationally Determined Contributions)

The activities promoted by the Scolel'te Program contribute to the compliance of the goals of the Nationally Determined Contribution (NDC). Under the NDC, the country is committed to reduce greenhouse gas emissions by 22% (below BAU) by 2030. The NDC activities are: Increase carbon capture; reforest the upper, middle and lower basins, with special attention to the riparian zones and considering native species of the area; conserve and restore ecosystems to increase the ecological connectivity between Protected Areas, and other conservation schemes, through biological corridors and sustainable productive activities.

SHAMBA Methodology

The full SHAMBA model accounts for GHG benefits from changes in biomass, soil management, crops and fertiliser use. In this project **we only use SHAMBA to calculate the changes to biomass**. We also use the outputs from SHAMBA to calculate **carbon stored in harvested wood products (HWPs)** after thinning and harvesting. In our analysis of the SHAMBA outputs, positive numbers represent GHG removals.

Below follows an outline of the overall modelling approach, and a brief description of the assumptions and calculations made for calculating each of the carbon pools. For further details on the SHAMBA model, please refer to the SHAMBA methodology (https://shambatool.wordpress.com/outputs/). In addition to the species, stocking densities, growth rates and soil management activities specified elsewhere in this document, the full SHAMBA input values used to estimate the climate benefit for each intervention are documented and referenced in a separate Excel database for each intervention (available upon request).

Overall modelling approach

We employ an average carbon accounting approach to calculate the benefit from carbon in biomass and HWPs. First, we use the outputs of SHAMBA to calculate the net GHG benefit across pools (i.e. biomass, HWPs and soils) in each year over the project period, relative to the baseline for each pool. We then average this over the project period to give an average GHG benefit to $tCO_2e\ ha^{-1}$.

For the baseline scenario, GHG emissions or removals per hectare in year *y* are calculated as:

$$BE_y = BE_{SOy} + BEWB_y + BEHWP_y$$

For the intervention scenario, the calculation is identical:

$PE_y = PESO_y + PEWB_y + PEHWP_y$

Where for baseline (variables starting with B) and intervention (variables starting with P) emissions:

E_y is the GHG emissions under the scenario for year $_y$ (tCO_2e/ha);

ESO_y is the emissions from change in soil organic carbon stocks in year y of the scenario (tCO_2e/ha);

EWB_y is the emissions from change in woody biomass of trees planted through scenario activities in year y of the scenario (tCO_2e/ha); and

$EHWP_y$ is the emissions from change in woody biomass stored in harvested wood products in year y of the scenario (tCO_2e/ha).

The average net climate benefit (CB) for a project period is given by first summing the cumulative benefit from the difference between the baseline and intervention over the years y = 1 to y = d, then averaging this over d, where d is the accounting period:

$$CBd = \frac{\sum_{y=1}^{d} (BEy - PEy)}{d}$$

Where:

BE is the total emissions for the baseline scenario (tCO_2e/ha) over the accounting period

PE is the total emissions for the intervention scenario (tCO_2e/ha) over the accounting period

Biomass calculations

Biomass calculations relied on growth rates from a field inventory of existing agroforestry farms in the region, and on values from the literature. Full details, references, growth curves and model fit details are available in the Excel database for each technical specification. Biomass was estimated for all species using SHAMBA's implementation of the pan-tropical allometric equations from Chave et al. (2005), with equations for for dry or moist forests being used depending on the rainfall range for the appropriate ecozone in which the technical specification will be applied. Growth curves were based on the annual DBH increments specified below. The growth model was selected by SHAMBA from a variety of options (linear, exponential, hyperbolic and logistic) based on the model with the lowest mean squared error (MSE). For each of these species in these technical specifications, the logistic curve provided the best fit. Our modelling assumes that biomass from dead trees and branches will be removed from the system for fuelwood.

HWP calculations

A proportion of tree stems removed from the system during thinning and harvesting will be processed into HWPs (see table on thinning and harvesting), which will form a pool of stored

wood-based carbon separate from the biomass and soil pools modelled in SHAMBA. We calculated this for each of the interventions in this project using an IPCC Tier 1 approach (IPCC, 2006), as follows:

$$C_{HWP} = k \times (C_{harv} - C_{discard})$$

Where:

C_{HWP} is carbon in harvested wood products (HWPs)

K is decay rate of carbon HWPs, based on default value of 0.023% per year in IPCC (2006), which appears conservative relative to similar analyses in the tropics and elsewhere (Kürsten et al. 1993)

C_{harv} is amount of carbon in total harvested timber, from intermediary SHAMBA outputs on the biomass of stems per ha in each year of the project scenario, and information on thinning and harvesting regimes

$C_{discard}$ is amount of carbon in timber discarded during processing of timber, using value of 0.4 of C_{harv} based on conservative estimates from de Jong et al. 1996.

Chapter 1. Technical specification for temperate climate

The agroforestry systems (AFS) that are part of the Technical Specification for temperate climate are:

1. Improved fallow
2. Living fence
3. Forest restoration

System: Improved fallow (FOR-ACME-TEMP)

Management of secondary vegetation (fallow) for the production of timber, firewood and other products are done through the planting of *Pinus sp* and thinning to encourage the growth of naturally regenerating oak (*Quercus sp.).* This enrichment system is the most appropriate for sites with vegetation lower than 3 meters to reduce the number of thinning cycles in the gaps of the plantation. This system is also suitable for mature secondary vegetation lacking commercial species.

System: Living fence (AF-CERVI-TEMP)

Pine and cypress are the most common species for living fences. This system prevents erosion, runoff, serves as a windbreak, and offers protection for crops against the movement of animals and people. Besides the ecosystem services, these species offer a particular economic value through timber.

System: Forest Restoration (FOR-REST-TEMP)

This system is used for natural or assisted recovery of open areas that have been affected by natural or anthropogenic disturbances. The system restoration (FOR-REST-TEMP) is based on the improvement of the density of commercial trees in these areas.

It is performed by planting in open areas (reforestation) with Pinus sp, Cupressus sp, and Quercus sp. To aid natural regeneration, it is excluded from grazing. These species produce good timber and is commonly used for house construction, fuelwood, and trees of good form can produce high value timber for community forest management activities.

Activities to develop in Agroforestry Systems of Temperate Climate

Each system (AFS) involves tree-planting and the establishment of crops for forestry and agroforestry systems. In the following chart are detailed the specific activities for each particular system of temperate climate, as well as the number of trees per hectare and its maintenance activities.

Chart 1. Summary of the activities implemented under the technical specification for temperate climate

Agroforestry system	Trees established	Activities
Improved fallow (FOR-ACME-TEMP)	*Pinus sp* *Cupressus sp* *Quercus sp* From 700 to 500 trees per ha (7x2; 7x3 or 6x3 m) and a final density of 250 per ha (6x6 or 7x6 m)	**Establishment:** 1. *Terrain preparation:* no soil treatment is applied in this system. 1.1 Line drawing: lines are oriented for shade management, from east to west for better sun illumination. 1.2 Weed and shrubs cleaning, following a gap of 2 m width over the drawn lines. 1.3 Opening of strains of 30 x 30 x 30 cm of width, length and depth, although this can be variable according to the terrain conditions. 2. *Planting:* 2.1. Initial density of 700 to 500 trees per hectare (7x2; 7x3 or 6x3 m); final density of 250 trees per hectare (6x6 m or 7x6). 2.2. Planting method, root pruning and allocation of the plant at the center of the strain, leaving the stem at ground level. *3. Maintenance:* 3.1 Replanting: during the first 3 years after the establishment, the farmer has to replant to fulfill the objective of the system. 3.2. Weeding twice a year in the form of gaps. 3.3. Development and sanitation pruning. 3.4. Shade management of secondary species when the branches obstruct sunlight to the plantation. 4. *Harvesting* 4.1. First thinning in the year 15 after establishment, with a residual density of 280 – 240 trees per ha (6x6 m or 7x6). 4.2. Final harvesting when the trees reach the growing objective according to commercial standards. **Reestablishment**: the establishment of the plot once the trees were harvested for timber. However, this activity is not considered given the kind of ecosystem.
Living fence (AF-CERVI-TEMP)	Pinus *(Pinus sp.)* Cypress *(Cupressus benthamii)* Density: 133 trees per hectare	**Establishment** 1. *Terrain preparation* 1.1. Weeding. 1.2. Opening of strains of 30 x 30 x 30 of width, length and depth. **2.** *Planting* 2.1. Initial density of 133 trees per hectare (3 m) of the strain. **3. Maintenance**

Agroforestry system	Trees established	Activities
		3.1 Replanting: during the first 3 years after the establishment the smallholder has to replant to fulfill the objective of the system. 3.2. Weeding twice a year. 3.3. Development and sanitation pruning. **4.** *Harvesting* 4.1. No thinning. 4.2. Final harvesting when the trees reach the growing objective according to commercial standards.
Forest Management (FOR-REST-TEMP)	Pinus sp Cupressus sp Quercus sp From 280 to 240 trees per ha (6x6)	Establishment: 1. *Restoration:* 1.1. Involves the improvement of natural regeneration and reforestation with the intervention of the technical team. Fence construction to exclude livestock and fire breaches to reduce fire risk. 2. *Reforestation:* 2.1. Pine, cupressus sp seedlings in open areas of forest with a planting density of 3x3m (the initial planting density is higher than the final desired density of 250 trees per hectare). 2.2. Opening of holes for seedlings with the dimensions of 30x30x30 cm in width, length and depth to improve the conditions for the development of roots, aeration and drainage. 2.3. Weeds and shrub vegetation are cleaned in the plantation areas. 2.4. Root pruning and placing the plant in the center of the hole, leaving the neck of the plant at ground level. 3. *Maintenance:* 3.1. Weeding 2 times a year until canopy closure. 3.2. Pruning when the tree has bifurcations. 3.3. Depending on the land use patterns may be required maintenance of fences, fire breaks and community controls 4. *Thinning and Harvesting:* 4.1. At year 15, trees of good form should be retained and those of poorer conditions should be removed to leave final spacing of 6x6m 4.2 The harvest should take place in year 40. when the tree has completed its technical growth shift with commercial measures (> 40 cm dbh). 5. *Re-establishment:* 5.1 From 25 to 30 trees per hectare may be retained as seed trees when the main crop is felled to provide seed for the new crop. Regeneration should be maintained by regular weeding

Ecology of forest species of temperate climate

The following chart presents a description of the ecological characteristics of the representative forest species in Scolel'te for temperate climate.

Chart 2. Tree species used in temperate climate areas of the Scolel'te Program.

Scientific name	Common name	Botanical description
Pinus sp	Pinus/Ocote	Evergreen, with an abundant ramification that provides a cylindrical-pyramidal shape to the canopy. Cells in leaves, trunk and branches are organized through channels for photosynthesis and resin accumulation. Between 2 and 5 needle-shaped leaves form groups around brachyblasts. Unisexual flowers in strobilus or cones. Male cones are in the terminal extremes of the branches, with ovoid shape and a central axis with inserted helical scales, each one with two pollen repositories.
Pino chiapensis	Chiapas pine/Ocote	Tree of 20 to 35 m height, with potential up to 50 m and diameter from 60 cm to 1 m. Trunk with widespread fissures and extended branches. Leaves are disposed in fascicles of five agglomerates in the extremes of the twig, resembling tufts. They measure from 8 to 12 cm length, of light green color, slightly yellowish. This species presents cones or woody pines, loose and ranging from 10 to 23 cm length. Seeds are inside the cones and reach maturity between August and October.
Cupressus benthamii	Cypress/Ciprés	Tree or robust arborescent shrub, evergreen, from 10 to 30 m height (up to 40 m), with a diameter at breast height (DBH) of 60 cm (up to 1 m). With a conic canopy and dense shadow. Leaves in the form of scales with sharp apex, imbricated, have near 2 mm length and 1 mm width, of bluish green tone. Straight trunk and slightly ascending extended branches.
Quercus sp.	Oak/Encino	The distribution of Quercus genus comes from mountainous regions of temperate climate. Quercus can be found as part of coniferous forests, mixed forests, mesophilic mountain forests. They are species intolerant to the shade.
Cupressus lusitánica	Cypress/Ciprés	Tree or robust shrub, from 10 to 30 m height (up to 40 m), with a DBH of 60 cm (up to 1 m). It has a straight trunk and slightly extended branches upward. Greyish to reddish-brown bark, fibrous in consistency, divided into irregular and narrow plates. It is a specie of rapid growth. Presence of leaves throughout the year. Intolerant to shade and sensitive to competition from weeds and insect damage. It has good quality timber, used for sawing and carpentry.

The species described above are the predominant in the systems outlined in the Chart 2. However, these are usually complemented with local species, preferred by the program participants, since they cover the needs of wood, shade, construction poles, and fruits, among others. They also strengthen the system in biological and ecosystem terms.

Local species of trees used in Scolel'te

Local name	**Genus**
Laurel	*Nectandra*
Aguacatillo	*Ocotea*
Ciprés	*Cupressus*
Onté	*Nectandra*
Pajul'te	*Mosquitoxilum*
Chalúm	*Inga*
Liquidámbar	*Liquidámbar*
Wilil or árbol del tule	*Taxodium*

See Annex 1 for modeled values

Chapter 2. Technical Specification for Tropical Climate

The agroforestry systems implemented under the *Technical Specification for Tropical Climate* are:

1. Taungya
2. Improved fallow
3. Living fence
4. Improved shade-grown coffee.

System: Taungya (AF-TAUNG-TROP)

Taungya is an intervention model for the establishment of an agroforestry system associated with annual crops. These crops provide additional income in the first years, while the trees receive the benefit of the maintenance that is done to the crops. The plantation density is lower than a commercial plantation, so the establishment cost is reduced. After 3 or 4 years, the trees provide enough shade to the crops and the system continues as a normal plantation, leaving aside the establishment new crops. This system is suitable for high rainfall areas where competition for water is not a problem.

System: Improved fallow (FOR-ACME-TROP)

Management of secondary vegetation (fallow) for the production of wood, firewood and other products through the improvement induced by the plantation of cedar (*Cedrela odorata*), pink poui (*Tabebuia rosea),* mahogany *(Swietenia macrophylla)* and other forest species with economic and cultural value.

System: Living fence (AF-CERVI-TROP)

In the management of living fences, the techniques are focused in the establishment and the maintenance of the arboreal components, since the interaction with crops or animals is not so obvious or as intense as in other systems. Living fences represent a productive space that is generally underutilized with low value species. Their creation can serve as reforestation and offer some services such as protection against the transit of animals and people to the crops, prevent erosion, runoffs and act as a windbreak curtain.

System: Improved shade-grown coffee (AF-CAFE-TROP)

Coffee is traditionally established in shaded spaces and, in most of the cases, it covers several needs for the coffee families. For Scolel'te, coffee is intercalated with timber trees, such as cedar (*Cedrela odorata*) and mahogany (*Swietenia macrophylla*). This increases the potential for carbon sequestration, minimizes the effects of price fluctuations and the effects of pests, in addition to obtaining extra benefits for the production such as meeting the optimal conditions of shade that

coffee crops require. The diversity of shade with commercial trees promotes the conservation of biodiversity and the provision of ecosystem services.

Activities to be developed in the Agroforestry Systems established in Tropical Climate

The following chart details the specific activities to be developed by system, such as the number of trees established per hectare and the central maintenance activities to increase its permanence.

Chart 3. Summary of the activities implemented under the technical specification for tropical climate

Agroforestry system	Established trees	Activities
Taungya **(AF-TAUNG-TROP)**	Cedar *(Cedrela odorata)* Mahogany *(Swietenia macrophylla*)	**Establishment** **1.** *Terrain preparation:* 1.1. Clean of weeds and shrub vegetation. 1.2. Corn or multi-cropping (milpa) sowing, attending to the cultural practices of the farmers. 1.3. Opening of strains with the dimensions of 30 x 30 x 30 cm of width, length and depth. 2. *Planting:* 2.1 Initial planting density of 667 to 333 trees per hectare (3x5 to 3x10 m) and final density of 250 trees per hectare. 3. *Maintenance:* 3.1. During the first 3 years of establishment, it is important that the smallholder carry out the replanting of the plot, to achieve the goal of trees for the system. 3.2. Weeding twice a year. 3.3. Sanitation and development pruning, in the presence of pests *(Hypsipyla grandella)* or when the tree stops being attacked by plague. 4. *Harvesting* 4.1. First thinning in year 10 after establishment, with intermediate harvesting of timber products, leaving a residual density of 400-300 trees/ha. 4.2. Second thinning in the year 15 after establishment, leaving a residual density of 250 trees/ha. 4.3. Final harvesting, when the trees reach the growing objective according to commercial standards. **Reestablishment:** Restart the taungya system using regeneration induced by planting in the sequence described above.
Acahual mejorado (FOR-ACME-TROP)	Cedar *(Cedrela odorata)*	**Establishment:** 1. *Terrain preparation* 1.1 Tracing lines, oriented from east to west to capture the greatest amount of light available during the day.

Agroforestry system	Established trees	Activities
	Barí (*Calophyllum brasiliense*) Ramón (*Brosimum alicastrum*) Bojón (*Cordia alliodora*) Mahogany (*Swietenia macrophylla*)	1.2 Clean of weeds and shrub vegetation in gaps of 2 m wide over the traced lines. 1.3. Opening of strains with dimensions of 30 x 30 x 30 cm of width, length and depth. In case of plants coming from a germination tray, the soil should be loosened well, following dimensions of 10x10x20 cm. 2. *Planting* 2.1. Initial density of 700 to 500 trees per hectare (7x2; 7x3 or 6x3 m) and final density of 250 trees per hectare (6 x 6 m or 7x6). 3. *Maintenance* During the first 3 years of establishment, it is important that the farmer carry out replanting actions, in order to achieve the goal of trees for the system. 3.2. Weeding twice a year in the form of gaps. 3.3. Development and sanitation pruning. 3.3. Shade management. 4. *Harvesting:* 4.1. First thinning in the year 10 after establishment, leaving a residual density of 400-300 trees/ha. 4.2. Second thinning in the year 15 after establishment, leaving a residual density of 250 trees/ha. 4.3. Final harvesting, when the trees reach the growing objective according to commercial standards. **Reestablishment:** Restart of the system using regeneration induced by planting in the sequence described above.
Living fence (AF-CERVI-TROP)	Cedar *(Cedrela odorata)*	**Establishment:** 1. *Terrain preparation:* 1.1. Weeding. 1.2. Opening of strains with dimensions of 30 x 30 x 30 cm of width, length and depth. 2. *Planting* 2.1. Initial plantation density of 133 trees per hectare (3 m). 3. *Maintenance:* 3.1. Replanting: During the first 3 years of establishment, it is important that the smallholder carry out replanting actions, to achieve the goal of trees for the system. 3.2. Weeding twice a year. 3.3. Sanitation and development pruning in case of the *Hypsiphyla* plague or when the tree has responded by throwing new shoots. 4. *Harvesting:* 4. 1. No thinning is made. 4.2. Final harvesting, when the trees reach the growing objective according to commercial standards.

Agroforestry system	Established trees	Activities
		Reestablishment: Restart of the system using regeneration induced by planting in the sequence described above.
Improved shade-grown coffee (AF-CAFE-TROP)	Cedar *(Cedrela odorata)* Mahogany *(Swietenia macrophylla)*	**Establishment:** 1. *Terrain preparation:* 1.1. Opening of strains with dimensions of 30 x 30 x 30 cm of width, length and depth. 1.2. Initial plantation density of 10x10m in the coffee crop with 5m of spacing for living fences, making a total of 180 trees per hectare. 2. *Maintenance* 2.1. Replanting: During the first 3 years of establishment, it is important that the smallholder carry out replanting actions, to achieve the goal of trees for the system. 2.2. Weeding twice a year. 2.3. Sanitation and development pruning in case of the *Hypsiphyla* plague or when the tree has responded by throwing new shoots. *3. Harvesting:* 3.1. No thinning is made. 3.2. Final harvesting, when the trees reach the growing objective according to commercial standards. **Reestablishment:** Restart of the system using regeneration induced by planting in the sequence described above.

Ecology of forest species of tropical climate

The following chart offers a description of the ecological requirements of the dominant forest species in the agroforestry systems managed in the Scolel'te Program and employed in the tropical climate regions.

Chart 4. Tree species used in tropical climate areas of the Scolel'te Program.

Scientific name	Common name	Botanical description
Cedrela odorata	Cedro/cedar	Deciduous tree, from 20 to 35 m (up to 45 m) tall, with a large, rounded, robust and extended crown or flattened canopy. Alternate, paripinnate or imparipinnate leaves, from 15 to 50 cm, including the petiole; composed of 10 to 22 opposite or alternate leaflets from 4.5 to 14 cm long by 2 to 4.5 cm wide, lanceolate or oblong.
Swietenia macrophylla	Caoba/mahogany	Evergreen or deciduous tree, from 35 to 50 m (up to 70 m) in height, with a diameter at breast height (DBH) from 1 to 1.8 m (up to 3.5 m). Open and rounded canopy shaped like an umbrella. Alternate, paripinnate or sometimes imparipinnate leaves, from 12 to 40 cm long including the petiole; with 3 to 5 pairs of leaflets, from 5 x 2 to 12 x 5 cm, lanceolate or ovate, very asymmetric, with an entire margin.
Swietenia humilis	Caobilla	Deciduous tree of medium size, between 10 to 20 meters high, with an irregular canopy; its distribution goes along the Mexico Pacific Coast (from the northwest in Sinaloa to the south in Chiapas) and Central America.
Tabebuia roseae	Maculis/Pink poui	Deciduous tree, from 15 to 25 m (up to 30 m) in height, with a diameter at breast height of up to 1 m. Stratified and convex canopy. Straight trunk, sometimes slightly grooved. Sympathetic branch. Fissured and suberized external cortex, compact in appearance, with longitudinal fissures that intertwine forming a reticulum; externally of dark gray to yellowish brown. Internally of light color to pink cream, fibrous, with bitter to bittersweet flavor.
Diphysa americana	Guachipilin	A tree that reaches a height of 15 m; in places with fertile soils it can reach up to 22 m and a DBH of 30 to 50 cm. It branches from the middle of its shaft; its cup is extended and irregular. The trunk of the youngest individuals have a large number of long vertical cracks of strong yellow color.
Calophyllum brasiliense	Barí/Guanadi	Deciduous tree, from 20 to 30 m (up to 45 m) in height and a diameter at breast height from 40

Scientific name	Common name	Botanical description
		to 60 cm (up to 1.3 m). Rounded, extended and dense canopy. Deciduous tree, simple and opposite leaves, sheets of 6 x 2.5 to 14 x 5.5 cm, elliptical or oblong, glabrous, coriaceous, with an entire margin; dark green and bright beam, underside of lower green color; abundant secondary veins.
Terminalia amazonia	Canshan	Large tree, up to 50 m in height (typically 20-35 m) and 1.5 m in DBH. Mature trees typically have large prawns, with clean and cylindrical shafts at heights of up to 20 m. Trunk: quite straight, gray-brown, with vertical fissures. Small leaves (2-4.5 cm long), simple, pointed, with full margins. They are concentrated in the tips of the branches.
Ceiba pentandra	Pochota/Ceiba	Giant tree, one of the largest in tropical America, deciduous, from 20 to 40 m (up to 70 m) in height, with a diameter at breast height of up to 3 m, measured on the tubular roots. Rounded or flat, very broad canopy (with coverage up to 50 m).
Enterolobium cyclocarpum	Parota/Orejón/ Guanacastle	Large and striking, deciduous tree, from 20 to 30 m (up to 45 m) in height, with a diameter at breast height of up to 3 m. Hemispheric cup. The foliage is abundant, giving the broad cup a wider than high form. Free of competition for light and it can reach large diameters.
Tabebuia donell smithii	Guayacán/Primavera	Tree that reaches up to 30 m in height, with irregular crown and normal diameter of up to 60 cm, with straight trunk, scarce, thick and ascending branches, pyramidal canopy. Rough trunk of gray to dark brown color, with vertical and deep cracks, which form wide plates of dark brown color.
Juglans pyriformis	Nogal/Walnut	Tree up to 25 m tall, deciduous, without spines or latex. Straight trunk, up to 90 cm in diameter, without buttresses. Cup rounded, scattered, composed of thick and ascending branches. Imparipinnate and rarely paripinnate leaves, with 17 to 29 leaflets sub-opposite or alternate, lanceolate to oblong-lanceolate, from 3.8 to 16.2 cm long by 1.1 to 4.8 cm wide; with the entire margin or sawed.
Cordia alliodora	Bojón/Salmwood	Deciduous tree, from 7 to 25 m (up to 40 m) in height with a diameter at breast height of up to 90 cm. Small, narrow and open canopy, which allows the passage of a lot of light. Alternate, simple leaves; blades from 4.5 to 17 cm long by 2 to 5 cm wide. Its trunk forms a very straight

Scientific name	Common name	Botanical description
		cylinder (shaft), sometimes with basal, thin buttresses. Upright and extended branches, whorled at the top.

Leakage and Uncertainty

Leakage risk

Leakage is considered any unintentional loss of carbon stocks that occur outside the project area that are a direct result of project activities. In the Scolel'te Program, activities are planned by smallholders to minimize the risk of leakage.

The expansion of agricultural activities has been identified as the main risk of leakage. However, the territorial limits are described in Plan Vivos, thus allowing the Scolel'te program not to affect the agricultural production of the participants. Leakage losses have been estimated in the calculus of carbon benefits.

For the Forest Restoration System the estimations applied are very conservative in assumptions on growth, due to the data from field sites were collected in 2010 and 2011 and COVID19 has made not feasible to collect new data from field sites. The main uncertainty associated with the SHAMBA input data for the restoration system are

1. Growth rates are from 2010-2011 Pinus from an area outside of the temperate forest zone. These growth rates are used for all of the temperate tech specs.
2. Mortality rate is entered into the SHAMBA model as "0.00%". This is based on the assumption that even though there is a mortality rate of 15% within the first 3 years, Ambio replaces the dead trees.
3. The percentage of dead branches and percentage of dead tree stems that remain on ground is estimated at 90% and 0% respectively by Ambio. No monitoring has been completed to confirm the accuracy of these estimates

After restrictions attributed to the coronavirus pandemic have been lifted, Ambio will collect growth rate data from plots within the intervention area and update for the data for the restoration system.

Leakage management

With support from the Ambio Cooperative, the Scolel'te project coordinates a team of regional and local technicians who have presence in the rural communities that are part of the program. The implementation of Scolel'te is based on planning and decision-making from the owners of the land, with the accompaniment and supervision of the technical staff of the Ambio Cooperative. These staff ensure that the proposed Plan Vivos don't generate conflict with the subsistence activities of the communities, which mainly consist of agricultural production for self-consumption.

The tree species used in the Scolel'te program are appropriate for the regions in which they are established. In addition, some of them are suitable for establishment in productive agroforestry systems.

Both technical specifications of the program (temperate and tropical, respectively) have developed forest and agroforestry systems to allow an optimal use of the land. They also

promote the improvement of agricultural productivity, in addition to allowing the establishment in diverse areas of land, therefore adapting to the needs of rural families.

The Scolel'te Program works with federal and state governmental institutions to promote actions that contribute to reduce the pressure on forests and rainforests in the state of Chiapas, Mexico. These actions strengthen the governance and the awareness, of those who live in rural areas, about the importance of conserving their natural resources; fostering sustainable economic strategies (e.g. beekeeping), production and the sales of handicrafts, as well as ecotourism.

A poor design and implementation of the carbon sequestration program could lead to the loss of ecosystem services. An example would be the conversion of forests (although degraded) into large-scale monoculture plantations, which would negatively affect biodiversity. Therefore, in order to avoid this, the systems and activities of the program under both technical specifications are only eligible for lands with agricultural, livestock and recovery use, as in the case of fallows (secondary vegetation).

The enrollment process for new participants to the Scolel'te Program depends on a field inspection. This is to verify that each site has the favorable characteristics to develop forestry and agroforestry systems, and that tree removal will not take place to plant new trees for the program.

In the Scolel'te Program, other reforestation activities are allowed, but only the systems established under the program which recorded documented geospatial references, are considered for carbon sequestration.

Leakage assessment for the Scolel'te program

The following table shows the potential risks of leakage identified by the participants within Scolel'te (smallholders, technical and administrative staff) and their mitigation measures.

Chart 5. Risk assessment of leakage and mitigation measures

Possible leakage risk	Risk level	Mitigation measures
Displacement of small-scale subsistence farming	Low	Each farmer (preferably with his/her family) develops a land use plan (Plan Vivo) which demonstrates that, upon entering the Program, he/she will not displace his/her agricultural activities, and that agricultural or livestock improvement will be part of the management objectives for tree planting. There will be monitoring of the territory and follow-up surveys of the smallholders on the progress of the activities of the program and their management commitments.

Increase in opportunity costs due to commercial agriculture	Medium	Empower smallholders to supplement their income through other sustainable productive activities, such as: honey production, handicrafts and ecotourism. Promote the access to sustainable markets to smallholders. Make tree plantation more profitable through carbon payments and market access. Increase community awareness of the role of ecosystem services in their own livelihoods.
Carbon emissions resulting from project management and travel during monitoring activities	Low	In general, it is insignificant. This is since the entry of new smallholders to the program, as well as the activities of capacity-building and monitoring, are planned in such a way that they have the least impact on carbon emissions.

Leakage monitoring

The main leakage threat identified for Scolel'te is the expansion of agricultural land for both subsistence (traditional milpa and livestock at family level) and commercial (oil palm) purposes. Therefore, the program will ensure that there is no conflict of interest in the relation to the amount of land available per producer or participating community.

The periodic inspection to ensure that there is no land-use change, derived from the lack of available land to cultivate, is part of the monitoring activities carried out at the plots registered in the program. In addition, continuous supervision takes place in cooperation with community and regional technicians, who make it possible to ensure that trees are not being cut in the intervention zones of the program and the surrounding areas.

Risk management

The Scolel'te Program has identified its main risks and mitigation measures through a risk assessment in participatory workshops. These workshops comprised of the farmer partners and communities, technical staff, as well as the administrative and managerial personnel of the Ambio Cooperative.

In order to secure carbon sequestration and the permanence of the registered plots, Scolel'te promotes best practices that result in greater productivity and improved land management, which include a thorough monitoring system and withholding a buffer of carbon credits. The following section describes the main risks that the program could face, and the measures planned to mitigate them.

Identification of risk areas

Risks to permanence

Risks of reversal are associated with natural catastrophes such as fires, droughts and floods. Similarly, although arboreal species are native to the implementation regions, they are at risk from pests and diseases, especially mahogany and cedar species.

To minimize these risks, Scolel'te invests in activities that develop and consolidate technical capacities for the management of the forestry and agroforestry systems of the program. These include fire management, capacity building and the promotion and strengthening of social organizations.

In addition, the program has the necessary resources to replace the trees that may have been affected by these phenomena and guarantee the objective of trees per plot established in their technical specifications.

Capacity building

Scolel'te focuses on generating sustainable, diversified and resilient systems that are a source of food and commercial products that are useful for the farmer and his/her family, such as firewood and timber. The smallholders of Scolel'te are continuously trained on better agricultural practices and sustainable management for their plots. Moreover, there are other activities that generate additional income, such as seed collection and plants production. The smallholder and his/her family members, with the technical support and supervision of the staff of the Ambio Cooperative, carry out all the activities required by the program.

The Ambio Cooperative promotes workshops and training on topics of interest raised by the producers themselves. Selective pruning, forestry, management of coffee plantations and fruit production through grafts, are among the main issues addressed.

Institutional presence and joint relationships

The process carried out by the Scolel'te Program is based on the direct interaction with smallholders who live in rural areas of the state of Chiapas. The Ambio Cooperative maintains its presence as an organization through its community technicians. These individuals represent Ambio with the smallholders, giving them confidence and allowing them to attend in first-hand the activities of the Program.

All activities within Scolel'te are planned by the landowners, and verified by the Ambio technical staff, in order to avoid any conflict over the spatial limits. In addition, for all the interventions of the program, the approval of the community authorities is requested.

The structure of carbon payments allows farmers to meet their needs in the short term. In the medium and long term, they benefit from other inputs generated in the plots, such as the production of honey, cultivation of edible herbs and medicinal plants, firewood collection, fodder

for animals, construction materials and handcrafts. These are used for family consumption or sold locally.

Sustainability of the Scolel'te Program Coordination

The Scolel'te Program is coordinated by Ambio Sociedad Cooperativa de Responsabilidad Limitada (S.C. de R.L.). This is a non-governmental organization (NGO) that aims to promote sustainable, comprehensive, and harmonious rural development in gender issues, culture and socioeconomic levels through the rational management of natural and environmental resources. It also aims to strengthen the local capacities of social organizations, rural communities and organized groups in southeastern Mexico.

To achieve its goals, the Ambio Cooperative collaborates with academic institutions, government agencies, credit institutions, civil associations, in addition to national and international NGOs. Through these collaborations, the cooperative supervises and implements natural resources management initiatives in southeastern Mexico, with a long record of demonstrated effective performance of its projects.

Performance-based payments

Although awareness and capacity building are carried out in a cooperative manner, each participant (owner of the plot) is paid according to his/her performance. The payment at each stage is structured to meet the agreed commitments; in this way, the participants are encouraged to provide the plantation with the relevant care to ensure its permanence.

Risk reduction

The Scolel'te program avoids the inclusion of high-risk sites, such as those with unclear land tenure rights or those known to be prone to natural disasters such as landslides, seasonal flooding, etc.

Both technical specifications apply to areas where landowners legally own land. The program is also based on local governance arrangements, through locally accepted mechanisms, in which the community authorities are aware of the commitments made, either by the community or as individuals.

Risk buffer

It has been considered that external factors that are beyond the control of the project or the smallholder could affect the performance of the program. To tackle these externalities, Scolel'te, sets aside buffer credits that could be used for force majeure events.

In case of external events that cannot be mitigated, a percentage of the overall carbon capture is set aside to make up for any potential shortfalls. According to the risk assessment, the Scolel'te risk buffer is equivalent to 10%, which is monitored and verified, but not saleable.

A 30% risk buffer is applied to the forest restoration activities based on an update run in 2020 with available inventory data as Covid-19 did not permit field work to take place. It is planned that data will be collected in 2021 at which point, the project will request to reduce the buffer.

Chart 6. Risk analysis for the Scolel'te Program.

Type of risk	Description	Management and mitigation measures	Severity/Impacts	Score
Environmental risks = Level of risk= Medium				
Wildfires	Uncontrolled use of fire for agricultural practices may cause forest fires. Change in climate cycles.	Firebreaks breaches; fire prevention campaigns in conjunction with municipal, state and federal governments. Training and equipment of fire brigades at community level.	Social and cultural aspects influence differently depending on the region. Natural Protected Areas have fire prevention and control mechanisms. Even in sites with high occurrence of fires where Scolel'te has plots, these are under control, since the smallholders perform continuous surveillance. Occurrence of fires is prevented collectively. Payment for Ecosystem Services (PES) promotes the prevention and control of fires. The National Commission of Natural Protected Areas (CONANP) supports the prevention of fires and promotes the opening of firebreaks. Presence of community agreements on no-burn and a system of fines and sanctions. Plots are clearly delimited, allowing each farmer to take care of his/her land.	0.5 Low
Pests and illness	Some tree species are prone to pests and diseases. When attacked, the trees delay their growth, wood quality and fork.	Pruning and forest management as pest prevention activities.	Cultural management to control the pest (spatial arrangements for species to be separated). Annual pruning and replacement of affected plants.	1.0 Medium
Droughts	Dry periods and change in weather patterns.	Replanting	It mainly affects new plantations (1 to 3 years), mostly in tropical areas (cedar).	1.0 Medium

Type of risk	Description	Management and mitigation measures	Severity/Impacts	Score
			Its impacts differ depending on the region.	
Social risks: Level of risk = Low				
Non-compliance and voluntary departure of farmers.	Lack of interest in continuing with the program.	Accompaniment and informed consent.	Constant information about the Program. Training and access to workshops and capacity building activities. Payments for carbon sequestration throughout the monitoring period of 10 years. Presence of community technicians.	0.5 Low
Increase in opportunity costs of other land uses, as opposed to government programs that promote livestock and other agricultural activities such as oil palm and conventional coffee production.	The offer of these activities could result more interesting for smallholders.	Accompaniment, awareness and informed consent.	Complementary training in forestry schemes. Increasing of the benefits of Scolel'te, by diversifying plots with fruit trees and other non-timber species.	0.5 Low
Economic and financial risk: Level of risk = Medium				
Supply and demand don't match	Increase in the number of plots registered in the program, but the lack of buyers makes it impossible to comply with the payments.	Conservative expansion of the program. Strengthening the sales area.	National Carbon Market (changes with companies) and the Mexican Carbon Standard. Interest from new participants in rural communities, but there are not enough buyers. Scenario of increased competition in the corporate environment. Promotion of business participation in forestry projects.	1.0 Medium
Risk of market dynamics: Level of risk = low				
Market failures	National fiscal reforms impact the payment structure.	Strengthening of the promotion and commercialization mechanisms of the carbon credits offered by the program.	The absence of markets, translates into no revenues for the program and consequently, the program could not continue operating. The lack of sales limits the purchase of necessary items for its development and implementation.	0.5 Low

Type of risk	Description	Management and mitigation measures	Severity/Impacts	Score
Technical risks: Level of risk = low				
Reduced adaptation of planted trees (due to rain cycles) and their sequestration potential.	Changes in rainfall patterns cause the planting season to be affected and trees do not survive.	Management by the local farmers Adequate use of tree species depending on the climatic region.	Survival rates are not reached, and replanting activities are not successful. Research on the new productive cycles of the managed species.	0.5 Low
The non-execution of relevant forest and agroforestry management activities.	That the farmers do not carry out the management activities planned for their plots with agroforestry systems.	Accompaniment, training and monitoring.	Perform pruning to ensure the growth of the trees. It is up to the farmers to carry out the management activities in their plots. Constant training and implementation of community exchanges to motivate farmers for management actions.	0.5 Low
Administrative risks: Level of risk = Low				
Impossibility to continue in the coordination of the program.	It is not perceived as a risk since the processes are consolidated within the operating organization and with the network of community and regional technicians. The administrative process is in continuous improvement.	Awareness, accompaniment, training and continuous capacity building.	There is a consolidated structure in technical, administrative and coordination processes.	0.5 Low
Risk definition Lower than 5 = 5% Greater than 5 = 10% Greater than 10 = 15%				6.5
Risk buffering				**10%**

* Risk analysis chart based on the project Management Institute methodology (PMI or PMBOK) for risk management, with a matrix of impact scales. Adapted to the results of the participatory workshop with partners and technicians of the Scolel'te Program, carried out in January 2018.

Monitoring

The monitoring for both technical specifications is based on estimating projected carbon benefits based on allometric models. It is assumed that carrying out the activities described here will result in the expected ecosystem services. Therefore, 1) the number of trees planted, 2) the area under management 3) the type of tree species planted and 4) the survival rates are monitored over a 10-year period.

Prior to the establishment of the agroforestry systems (AFS), each partner farmer prepares his Plan Vivo, in which he/she draws the surface that covers his/her property and indicates exactly where the trees of the program will be located (in addition to trees existing in his/her plot). During the revision of the Plan Vivos, the technical team of the Ambio Cooperative verifies that Plan Vivos represent the baseline status of the land to be enrolled in the program. Adjustments are proposed where necessary.

The technical team visits the site proposed by the smallholder and records their observations on the evaluation form. This procedure is carried out for each plot registered in the Scolel'te Program. Later the data of each plot is entered in a form with date and signature of both parties (farmer and Direction of the Ambio Cooperative).

Under no circumstance is it accepted that farmers cut trees in order to enroll in the Scolel'te Program. The technical staff of the program monitors the performance of the plots registered during the first ten years of the project. Each smallholder has an individual contract and a monitoring plan specifying the expected milestones, based on the growth rates in the carbon model and according to the AFS and its technical specification. The resources needed to carry out the monitoring include: GPS, clinometers, data sheets, digital cameras, clipboards, pens, measuring tapes, spray paints, tweezers and diametric tapes. Such equipment is used by highly trained personnel.

Chart 7. Monitoring plan for the Scolel'te Program

Year	Monitoring target	Monitoring indicators	Objectives
1	Establishment of at least 90% of the planned amount of trees.	Number (count) of established and living trees.	Establish the system in accordance with the technical specification and the Plan Vivo.
2	Evaluation of the survival of established trees. Target of 100%, considering replanting activity.	Number (count) of established and living trees.	Establish the system in accordance with the technical specification and the Plan Vivo.
3	Evaluation of the survival of established trees.	Number (count) of established and living trees.	Establish the system in accordance with the technical specification and the Plan Vivo.

Year	Monitoring target	Monitoring indicators	Objectives
	Target of 100% considering replanting activity.		
4	Survival of at least 85% of the whole plantation.	Number (count) of established and living trees.	Establish the system in accordance with the technical specification and the Plan Vivo.
5	Survival of at least 85% of the whole plantation.	Number (count) of established and living trees. Average height of the plot.	Evaluate the permanence of the system and the carbon capture scenario of it.
7	Survival of at least 75% of the whole plantation, considering thinning.	Number (count) of established and living trees. Average height of the plot. Average diameter of the plot (random sampling of 10% of plots)	Evaluate the permanence of the system and its carbon capture scenario, as well as the quality of the timber.
10	Survival of the plantation at least 65%, considering thinning.	Number (count) of established and living trees. Average height of the plot. Average diameter of the plot (random sampling of 10% of plots)	Evaluate the permanence of the system and its carbon capture scenario, as well as the quality of the timber.

Chart 8. Monitored variables in the Scolel'te Program

Variable	Resources	Justification
Species	Observation in the field and information gathering through the indicated format.	Evaluate that the species are native and in accordance with the environmental conditions of the sites.
Number of trees per hectare	Observation in the field and information gathering through the indicated format.	Evaluate the density of planted stands / trees and estimate tree requirements to replace non-surviving trees.
Diameter at breast height	Diametric tape through the indicated format.	Used to evaluate growth and performance (annual and average increases).
Height of the tree	Clinometer, through the indicated format.	Used to measure growth and development.
Physical condition of the tree	Observation in the field through the indicated format.	Evaluate the health of trees, since poor health will affect the achievement of goals and this can lead to the absence of payment.

Description of the monitoring

In year 0-1, reforestation activities start in each plot. From the planting date, in years 1, 2, 3, 4, 5, 7 and 10, the monitoring of the plots is carried out to verify the survival and general condition of the trees. The data of the number of trees planted, their spatial distribution as well as the size of the surviving trees are recorded in the monitoring format and registered in the program's database. This is later compared with the monitoring information from previous years and used to accredit the amount of carbon sequestered.

During the first 4 years of monitoring, the establishment of 85% to 100% of the system must be achieved. To quantify the establishment, monitoring includes the counting of all the trees per plot, their spatial distribution, average height and health of the plot.

A 90% compliance is established in the first year to have a homogenous plantation in both height and age, while the next 2 years will only be for replanting trees if necessary. For year 4, it is expected that at least 85% of the trees will be established in the plot, in accordance with the Plan Vivo.

From the monitoring of year 5, the permanence of the system is evaluated, considering 85% of the established objective as compliance. As in the previous monitoring, the total number of trees, as well as the average height and health of the plantation, are taken into account. Additionally, the percentage of species established in the plot is evaluated to obtain biodiversity indicators.

The monitoring of years 7 to 10, have the purpose to evaluate the permanence of the agroforestry system, by evaluating the number of trees and their average of height and health. The average overall diameter is monitored, to evaluate the carbon scenario over the next years and to identify the quality of existing wood.

Collecting data in the field through on-site monitoring is expensive and requires a considerable investment of time. For the above, the data of height, health and diameter of each agroforestry system, are gathered through samples. Depending on the agroforestry system, the number of

trees sampled is between 5% and 10% of the total trees in the plot. This is important in order to obtain a representative sample of all the trees of the program, since the trees can have different sizes due to ecological factors, spatial effect, physical conditions of the site, and their different planting dates.

Payment to smallholders

The smallholders enrolled in Scolel'te receive a monetary payment over the first ten years of the participation in the program. After the compliance with the agreed commitments has been verified, and once the smallholders achieve 100% of the activities corresponding to the monitoring year, these payments are disbursed. Those farmers that do not meet the objectives have the opportunity to take corrective actions and receive the carbon payment retroactively.

The goals for the first 10 years of implementation are described below:

Chart 9. Payment structure of the Scolel'te Program

Year	Performance indicator	Objective	% of carbon payment per hectare
1	Number of established and living trees.	Establish at least 90% of the planned amount of trees.	12%
2	Number of established and living trees.	100% of the established system, considering replanting	12%
3	Number of established and living trees.	100% of the established system, considering replanting	12%
4	Number of trees planted and height.	At least 85% of the agroforestry system initially planned.	12 %
5	Number of established and living trees. Average height of the plot.	At least 85% of the agroforestry system initially planned.	12%
7	Number of established and living trees. Average height of trees Average DBH of trees	At least 75% of the agroforestry system initially planned	20%
10	Number of established and living trees. Average height of trees Average DBH of trees.	At least 65% of the agroforestry system initially planned	20%

Update of the technical specifications

The Technical Specifications will be updated every five years, with further additional information obtained during the execution of the Program. This information will be retrieved from the monitoring, feedback of the participants and academic research carried out within the framework of Scolel'te. Likewise, the need for modifications in the technical specifications, whether for tropical or temperate climate, can take place, if there are changes in the needs of the smallholders, since these would adapt to the new environment and to the socio-environmental situation of the communities.

Socioeconomic impacts

Description of the social benefits

Small-scale forestry and agroforestry projects led by smallholders contribute to improving the living conditions in rural communities. The species selected for the Scolel'te Program are native and endemic. Due to their characteristics, they are adapted to the regions where the program is executed, as well as being trees with economic and cultural value that can be combined with crops that are usually for subsistence, mainly milpa (a corn crop alternated with squash, beans and others species).

The contribution of the trees and forest products to the livelihoods of the farmers is reflected mainly in the supply of firewood, food and construction materials. According to the Forest Stewardship Council[4], the ecosystem benefits that smallholders receive for an established plot have an impact on the support, provision and regulation of services derived from the forest. These include climate regulation, carbon sequestration, maintenance and conservation of the biodiversity, soil conservation and improvement of water quality.

Since the growth of the trees is gradual, while these capture carbon they also provide multiple services and products to the farmers. This can improve their food, income and their livelihoods security. Non-timber forest products act as a niche of opportunity for smallholders; to diversify their income through the commercialization of products derived from AFS.

The seven AFS covered by the tropical and temperate technical specifications are designed to be a relevant option adapted to the local needs and to the livelihoods of smallholders in rural communities. This is in addition to promoting native species with economic or cultural value, in conjunction with local strategies.

The implementation of the AFS will lead to an increase in the income of the smallholders from the sale of wood, and other forest products such as firewood, poles, medicinal extracts, palms, fruits, coffee, honey, etc. Furthermore, the activities of the program (site preparation, maintenance, nursery management, planting, etc.) provide temporary or seasonal employment.

On the other hand, trees play a critical role in agricultural production, since they increase the capacity of the soil to retain water and conserve the humidity of the planting sites. Trees also act

[4] Common Guidance for the Identification of High Conservation Values.

as windbreaks to protect crops and houses, help to prevent natural disasters and provide climatic regulation.

Furthermore, those trees distributed as live fences help to physically limit the properties of each smallholder and, in some cases, provide fodder for livestock. This occupies a large part of the activities of local communities in Chiapas.

The following are some social, economic and environmental benefits related to the participation of rural communities in the program, as well as other co-benefits from the establishment and long-term maintenance of the agroforestry systems promoted by Scolel'te.

Chart 10. Socioeconomic and environmental benefits of the Scolel'te Program.

Type of benefits: Derived from participation in the Scolel'te Program				**Type of benefits: Derived from the agroforestry systems**		
Financial	**Productive**	**Territorial**	**Social / Political**	**Ecosystem goods and services**	**Economic**	**Social**
- Permanent and temporary employment. - Household income. - Payments for ecosystem services. - Financial inclusion, savings and access to credit. - Installation of wood saving stoves. - Access to markets.	- Food and agricultural production. - Diversification of crops. - Diversification of the plots. - Improvement of local productive systems (production of milpa, beans, livestock or others).	- Ecosystem services. - Promotion of biological corridors. - Increase in crop yields. - Strengthening of community organization. - Territorial planning of land uses. - Prevention of land-use change.	-Strengthening of governance and social capital. - Collective community action. -Raised awareness on natural resources management. -Strengthening of social cohesion.	-Sustainable management of natural resources. -Supply of construction materials. - Promotion of native or naturalized species. - Decrease in muds and landslides. - Soil and runoff stabilization.	- Wood and non-timber forest products (including forest foods). - Supply of energy and materials. - Production of fruits and legumes for sale and self-consumption. - Production and sale of honey and sub-products. - Production and sale of medicinal plants.	-Capacity building. -Reduction in the extraction of firewood.

Socioeconomic impacts and mitigation strategies

Scolel'te seeks to minimize negative socio-economic impacts, based on its risk management assessment. The program is designed to be inclusive and to provide an opportunity for the participation of marginalized households. However, it is possible that some conditions or circumstances may unintentionally provoke unfavorable situations. The following chart identifies some of these, and describes the mitigation measures identified to decrease them:

Chart 11. Negative social impacts and potential control measures.

Potential risk	Impact	Control measures
Increase in the opportunity cost of the land.	Plantations such as oil palm and livestock may be more attractive to farmers, which can lead to a change in land use.	The program offers alternatives for production and use of resources at local level. There are agreements at the level of groups and communities, for the management of lands that are part of the Program. The use of the plots registered in the program is diversified, with the possibility of increasing the value.
Disinterest of smallholders, due to socioeconomic causes (e.g., migration, dedication to another economic activity)	Due to the lack of opportunities, smallholders decide to migrate from their communities to the cities or to work outside of the community.	Smallholders obtain direct and indirect benefits from the implementation of the AFS. Strategies are developed to maintain the smallholder´s interest in their plantations.
Inappropriate distribution of resources and benefits of the Program.	Unequal distribution of net income between communities and commercial entities, mainly due to asymmetric information. Due to land tenure structure, some gender groups may be disadvantaged.	Appropriate consultations with local communities and their representatives. Look for proposals to guide the distribution of benefits. Benefits shared with the community in general. Inclusion of provisions for marginalized groups.
Unequal inclusion of disadvantaged groups.	Because land tenure is predominantly by mature male, the participation of women and youth is diminished.	In recent years, Ambio has developed strategies and promoted the participation of women and young people in different activities developed by the program.
Intervention in local governance.	The intervention and implementation of the program can influence or limit the exercise of certain options by the smallholders, to manage their lands.	The limitations of land management are agreed upon with each community and the landowners.

Evaluations of socioeconomic factors and their impacts on the beneficiary population are some of the actions required to develop the technical specifications. Therefore, Scolel'te carries out interviews with the smallholders to understand the impacts that the program has on their livelihoods.

In addition to offsetting CO_2, the Scolel'te Program seeks to impact through AFS in the livelihoods of smallholders, with co-benefits such as:

- Larger income,
- Greater access to firewood and construction materials,
- Reduction of deforestation in natural protected areas,
- Diversification of productive activities.

Likewise, the smallholders will join activities for the strengthening of technical and managerial capacities that will generate access to local and national markets of wood, firewood, fruits, medicinal plants and fodder.

The establishment of nurseries and the production of seedlings will also provide additional income to rural communities. These are some of the indicators that the program documents during its implementation, as reflected in the Socioeconomic Impact Monitoring Plan outlined in Chart 13. All these indicators are monitored by the community and regional technicians of the program at the time specified in the participatory methods.

Chart 12. Socioeconomic monitoring

Characteristics	Indicator	Monitoring methodology	Frequency
Capitals of the community: social, human, financial, physical, cultural and political (Sustainable Livelihoods).	Number of participating families. Number of participating families with indigenous backgrounds. Number of women, youth and elderly people participating.	Semi-structured interviews	Bi-annual
Employment creation	Number of jobs created by the program (permanent and temporary). Number of community technicians. Identification of the destination of the economic resources received from the carbon sales. Total of carbon payments per producer and years of payments.	Information gathered by regional and community technicians. Database on the operation of the program.	Every 2 years

Characteristics	Indicator	Monitoring methodology	Frequency
	Number of male, female, young or elderly producers receiving carbon payments and years of payments.		
Gender equality	Number of enterprises owned by women. Number of trainings in which women, young people and the elderly participate. Number of work groups made up of women, young people and the elderly.	Activities (meetings, workshops, etc.) as described in the annual report.	Annual
Land tenure security	Number of families with property titles participating in the program.	Documentation that accredits the property.	Annual
Social capital	Number of farmer groups participating in the program and in activities to strengthen capacities and exchange experiences (men / women). Number of working and community groups. Number of community leaders strengthened.	Activities (meetings, workshops, etc.) as described in the annual report.	Annual
Social	Percentage of partner farmers that organize and participate in collective activities for the improvement of their community. Number of agreements of the working groups Number of productive practices, support and complementary training implemented from the management of the program, which contribute to capacity building.	Registry of collective activities carried out in the communities.	Annual

Environmental and biodiversity impacts

The technical team that integrates the Scolel'te Program visits the smallholders annual in order to monitor the registered plots. This provides information on the status of the reforestations and social, economic and environmental information that is of interest for the Program.

During these visits, information is gathered on: The species of trees planted, the presence of trees established by natural regeneration, and the presence of species that are in some category of risk[5]. Data is also collected on the number of trees planted, their spacing, the number and size of the surviving trees. This information is documented to generate the monitoring reports and information on the captured carbon.

The supply of wood provided by the Scolel'te´s AFS is an indicator of the reduction of threats to the protected areas where the program operates. For as long as possible, Scolel'te invests in biodiversity and watershed studies to evaluate its impact. This is in addition to generating information on ecosystem services and sustainable livelihoods. These studies are carried out by researchers and postgraduate students.

[5] According to the threatened species listed in the Mexican legislation (NOM059) and the IUCN Red List.

Chart 13. Biodiversity monitoring

Characteristics	Indicator	Monitoring methodology	Frequency	Implementer
Forest recovery of spaces with agricultural use.	Area (ha) of the plots reforested or managed sustainably by the Program. Average number of established plants per hectare. Number of AFS promoted. Number of community actions for the protection of water sources and number of water sources.	Survey of participating households.	Annual	Community and regional technicians.
Increase and protection of forest diversity.	Number of established tree species. Number of tree species reported in the IUCN Red List and NOM059. Number of productive practices implemented by the partners to adapt to climate change.	List of species recorded annually from the monitoring information and presented in the annual report.	Annual	Community and regional technicians.
Conservation of habitats for flora and fauna species.	Number of natural protected areas where the program operates.	Information registered in the annual report.	Annual	Community and regional technicians.
Creation and strengthening of biological corridors.	Number of hectares reforested in biological corridors.	Annual monitoring and report to the Plan Vivo Foundation.	Annual	Community and regional technicians.

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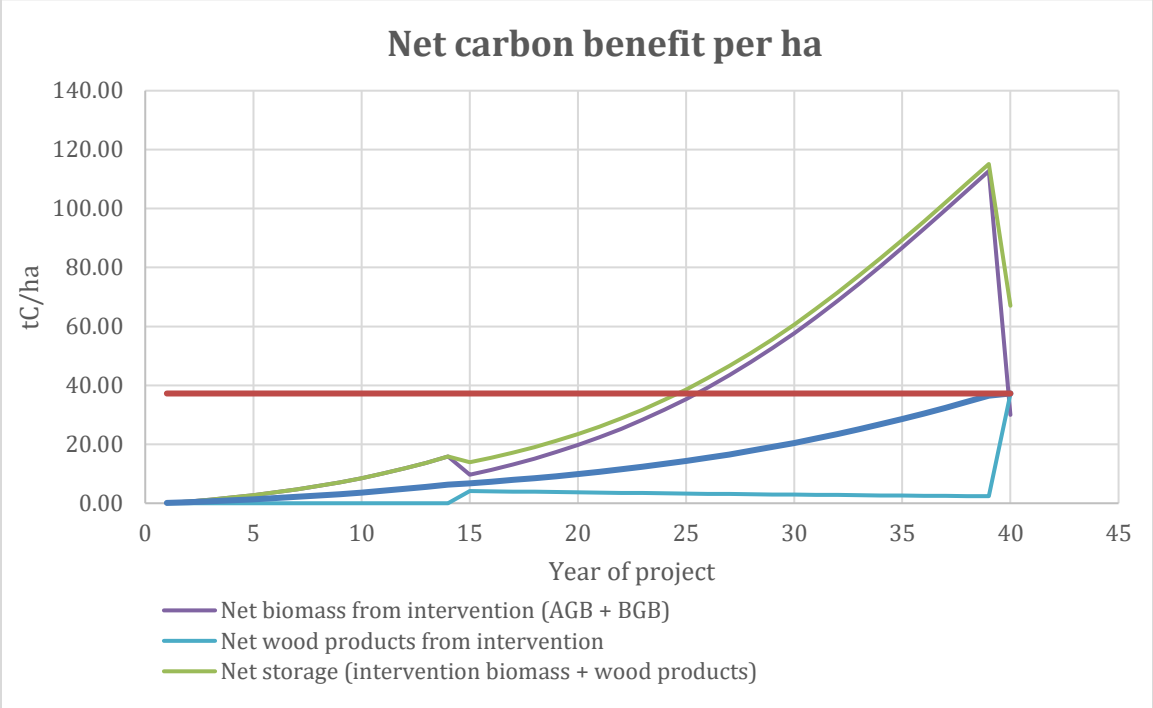
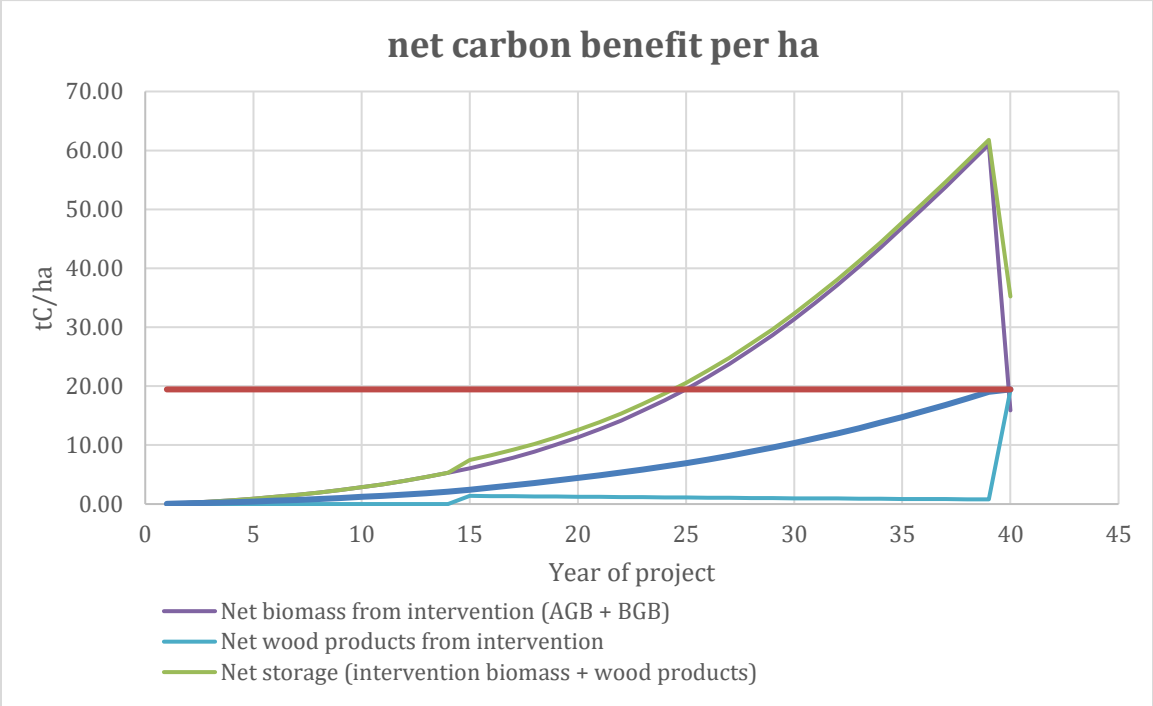
ANNEX 1

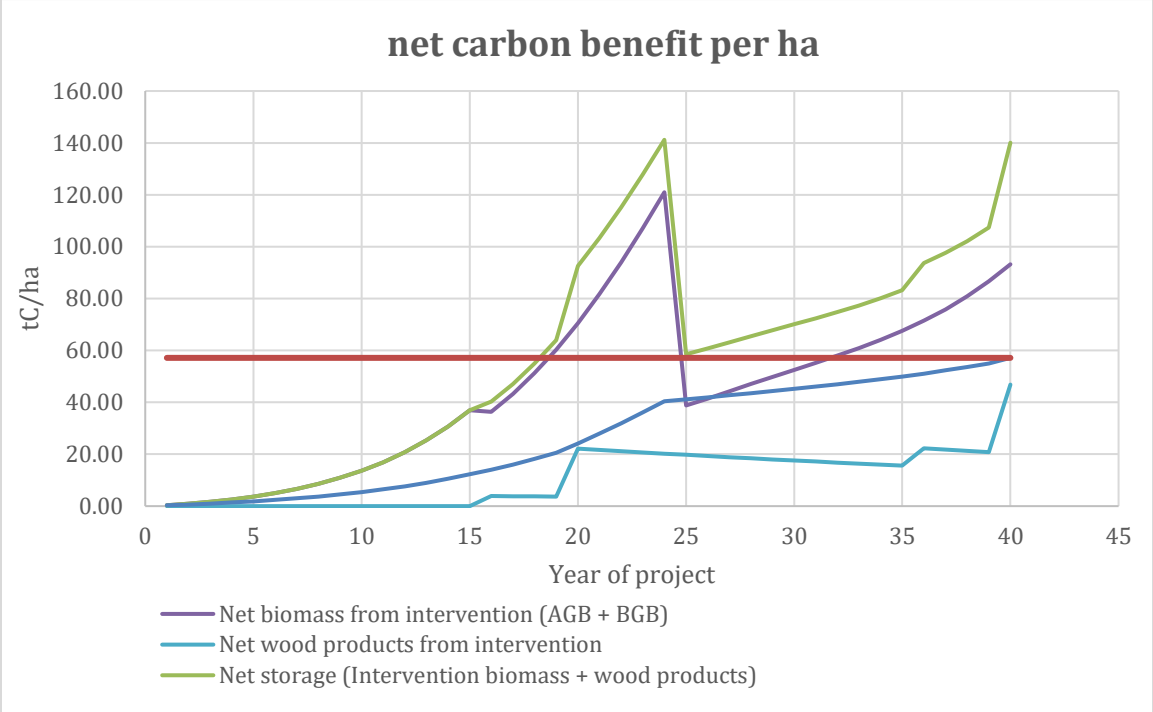
1. Subtropical Improved Fallow



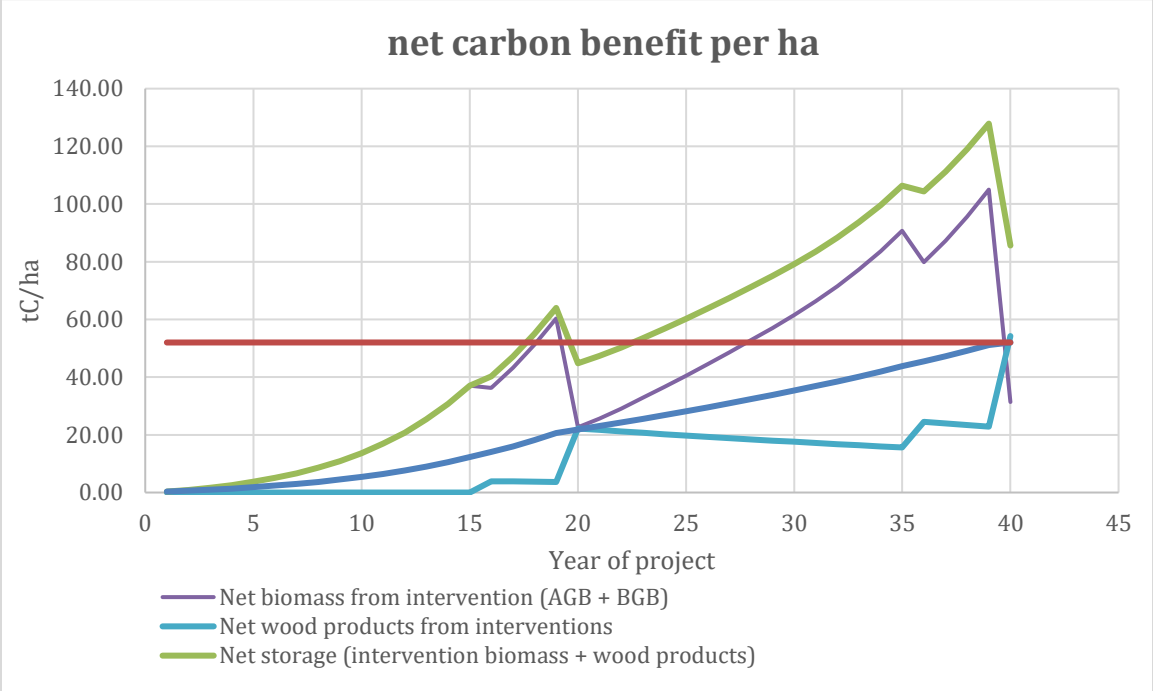
2. Subtropical Live Fence



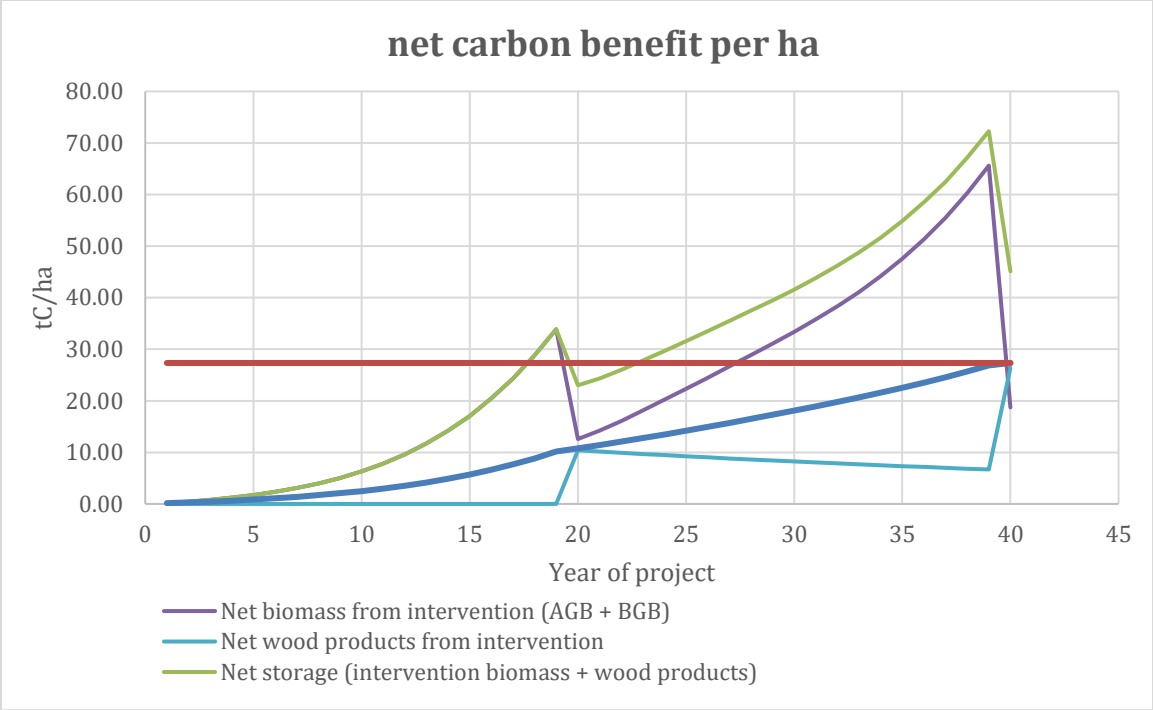
3. Tropical Taungya System



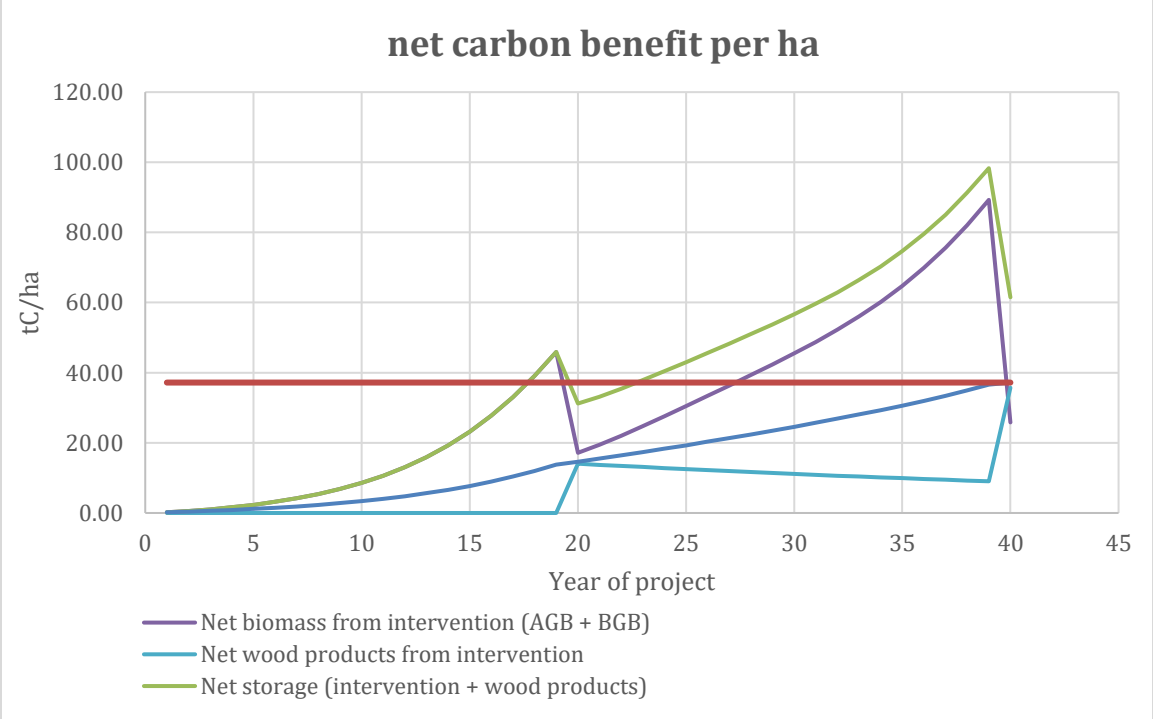
4. Tropical Improved Fallow



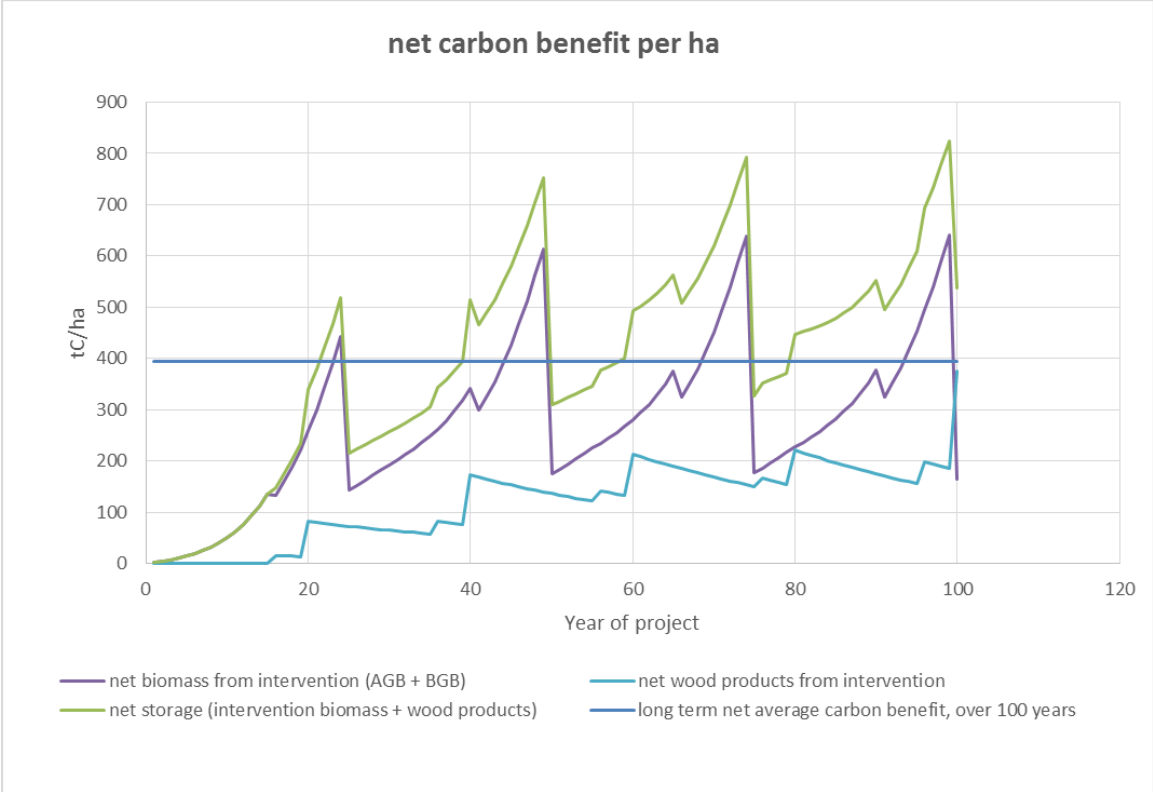
5. Tropical Live Fence



6. Tropical Improved Coffee



7. Forest restoration.


net carbon benefit per ha
900
800
700
600
500
400
300
200
100
0
tC/ha
0
20
40
60
80
100
120
Year of project
net biomass from intervention (AGB + BGB)
net wood products from intervention
net storage (intervention biomass + wood products)
long term net average carbon benefit, over 100 years