Plan Vivo Technical Specification for Forestry Plantations for sustainable Wood Production

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1. Summary

This document is the revised Plan Vivo technical specification for small-scale plantations in the settler areas of the Cochabamba Tropics, the Province of Ichilo in the department of Santa Cruz, Northern La Paz, and Western Beni.

Carbon estimates for forest plantations are based on the approved CDM small-scale methodology AR-AMS0001 vs5 (annex 1). After many years of operations, the growth curves have been revised for most species based on monitoring data from the plantations established under the project.

Ex-ante carbon calculations are calculated according the *long-term average carbon stock approach* and is calculated over a 40-year crediting period.

All activities are embedded in a proper land use planning system. If land use can be improved, agriculture will become more efficient and the deforestation due to traditional method of slash and burn can be reduced. In addition, more land can be officially registered and once identified and categorized, this land and its use will be protected.

This technical specification refers to one of the project activities, which is the establishment of plantations for sustainable wood production. A brief description of the proposed land use type under this technical specification can be seen in Table 1.1

Table 1.1: summary of activity under TS-FP

Title	**Type of activity**	**Objectives**	**Brief description**	**Target areas / groups**
FP	Forestry Plantations for sustainable wood production	Income improvement Environmental benefits	Only native tree species will be planted, except for the naturalised *Tectona grandis*, which will be planted only on a small scale. The native tree species proposed are: *Aspidosperma macrocarpon, Buchanavia sp, Cedrela fissilis, , Calophyllum brasiliense, Centrolobium tomentosum, Dipteryx odorata, Guarea rugby, Schlizobium amazonicum, Stryphnodendron purpureum , Swietenia macrophylla, Tapirira guianensis, Terminalia amazonica, Terminalia oblonga, Virola flexuasa* Trees are planted in small sectors of one single specie after concluding a site selection process, matching tree requirements with site conditions, only in a few cases more than one tree-specie is planted per sector, the species *swietenia macrophylla* and *cedrela fissilis* might be planted with about 50 trees per hectare in plantations with other species, this to avoid the attack of *Hypsipyla grandella.*	Farmers participating in the project

Long-term average GHG removals per hectare and per tree species over the validation period of 40 years are shown in Table 1.2 below. These data are based on long-term measurements of tree growth in permanent sample plots established according the monitoring protocol.

Table 1.2: Long-term average carbon over a 40 years crediting period. New/ adjusted values are provided (based on long-term monitoring data) alongside previous/initial carbon levels (used in the previous technical specification)

Growth class	Scientific name	Common name	Rotation	Above and Below Ground GHG removal (tCO2e/ha) adjusted	Above and Below Ground GHG removal (tCO2e/ha) initial	Monitoring result
Fast	Schizolobium amazonicum	Serebo	13	254	248	Adapted
Fast	Stryphnodendron purpureum	Palo yugo	13	269	263	Confirmed
Medium	Calophyllum basiliense	Palo maría	25	288	215	Adapted
Medium	Centrolobium tomentosum	Tejeyeque	25	302	231	Adapted
Medium	Guarea rusby	Trompillo de altura	22	313	386	Adapted
Medium	Tapirira guianensis	Palo román	22	282	303	Adapted
Medium	Tectona Grandis	Teca	25	248	217	Adapted
Medium	Virola flexuasa	Gabún	25	203	203	Confirmed
Slow	Buchenavia oxycarpa	Verdolago negro de pepa	35	234	234	Confirmed
Slow	Dipteryx odorata	Almendrillo	35	277	277	Confirmed
Slow	Terminalia amazonica	Verdolago negro de ala	30	278	278	Confirmed
Slow	Terminalia oblonga	Verdolago amarillo de ala	35	228	228	Confirmed

The ex-ante estimate of net anthropogenic GHG removals for the different species per ha is the result of:

Long-term Average net GHG removals MINUS ***The sum of Long-term average Negative removals*** MINUS **the *sum of average net baseline GHG removals*.**

In Table 1.3 the long-term average net GHG removals for each baseline type per tree species is given,. These adjusted values are provided (based on long-term monitoring data) alongside previous/initial carbon levels (used in the previous technical specification).

Table 1.3: Ex-ante estimate of net long-term average anthropogenic GHG removals per hectare over a 40-year crediting period.

			Net Average GHG removal (CO2e/ha) over crediting period per baseline				
Growth class	Scientific name	Common name	Grassland	Grassland with trees	Annual crops	Perennial crops	Status
Fast	Schizolobium amazonicum	Serebo	251	251	254	248	Adapted
Fast	Stryphnodendron purpureum	Palo yugo	267	267	269	266	Confirmed
Medium	Calophyllum basiliense	Palo maría	286	286	288	284	Confirmed
Medium	Centrolobium tomentosum	Tejeyeque	300	300	302	299	Adapted
Medium	Guarea rusby	Trompillo de altura	310	310	313	308	Adapted
Medium	Tapirira guianensis	Palo román	279	279	282	278	Adapted
Medium	Tectona Grandis	Teca	246	246	248	244	Adapted
Medium	Virola flexuasa	Gabún	202	202	203	201	Confirmed
Slow	Buchenavia oxycarpa	Verdolago negro de pepa	233	233	234	232	Confirmed
Slow	Dipteryx odorata	Almendrillo	276	276	277	275	Confirmed
Slow	Terminalia amazonica	Verdolago negro de ala	277	277	278	276	Confirmed
Slow	Terminalia oblonga	Verdolago amarillo de ala	227	227	228	226	Confirmed

2. Scope of the Technical specification

2.1 Eligible land types

Arbolivia's requirements for tree planting activities are:

- Smallholder owned land
- Land on which trees will be planted should have secure land tenure as stated in paragraph 3.1.2
- Tree planting should not adversely affect food security or the short term income security of the participating farmers, see PDD section 3.5
- No negative environmental impacts should occur as a result of tree-planting, see PDD section E
- Trees will be planted only on deforested land as defined by the DNA of Bolivia.

The following paragraph outlines the procedure adopted in order to demonstrate whether land deforested 10 years prior to the proposed reforestation activities is eligible.

2.1.1 Procedure to demonstrate eligibility for reforestation activities

Forest definition used in Bolivia is as follows:

- A minimum area of 0.5 hectare
- A minimum tree crown cover of 30 %
- Trees that potentially reach a height of >4 m.

The procedures used to decide whether land is to be included within the ArBolivia project are those used for CDM Afforestation and Reforestation project activities (http://cdm.unfccc.int/EB/035/eb35_repan18.pdf). The only exception is that a different date of deforestation has been used. In the eligibility procedures of the UNFCCC, areas for reforestation activities are only eligible if can be demonstrated that these areas were deforested prior to the 31st of December 1989. For this project, and in compliance with the Plan Vivo standard, this has been changed to 10 years prior to the date on which planting in a specific area commenced.

Land eligibility is demonstrated by classified LANDSAT 5-TM from the year 2000 and 2001.

Step 1: A non-supervised classification of the Landsat images is made.
Step 2: Major land use and land cover types within the portfolio area, even those with no potential for an A/R CDM project activity (dense tropical forest), are identified for the purpose of training in Remote Sensing image analysis.
Step 3: Field data gathering in transects on land cover units and land use units:

   i. Description of land cover, using classification criteria established by the ENCOFOR project, vegetation type, biomass estimation measured in sample plots, height of vegetation, vegetation density, crown cover;
   ii. Defining in the field whether the area is currently eligible;
   iii. Description of land use;
   iv. Measuring land unit boundaries: by GPS with a positional accuracy of 10 m or less.

Step 4: As a result of the above steps, three types of area are distinguished:

   1. Areas not eligible
   2. Eligible areas

3. Areas which may be eligible, but which need a more detailed analysis due to a lack of prior Remote Sensing (RS) analysis and defined characteristics of the vegetation in this area. In these cases, additional site visits are carried out with the objective of gathering the following data:
    a. Actual land cover
    b. Statement from the farmer on historical land-use and land cover, going back to 10 years from the proposed planting date - if vegetation had regrown, which according to the forest definition should be considered to be forest, the farmer should clarify whether this vegetation was removed with the specific intention of establishing reforestation activity.
    c. Field indicators, which prove that the area is used as agricultural land. This can be proven by an evaluation of historical land use as stated by the farmer and the existence of indicator species. Different pioneer species are good indicators of how many times vegetation has been cut down for cropping purposes and how many times it has been left as fallow land. This shows that the land is part of an agricultural system even though, at some stage, during the period between deforestation and the start of the project, fallow land existed that met the forest definition.

2.2. Land Use Types for which the activities will be developed

To be eligible for AR-AMS0001, the project must occur on grasslands or croplands, and <10% of the total surface project area may be disturbed as result of soil preparation for planting.

In compliance with the eligibility criteria, land use types on which the proposed activities are applicable are:

- Annual crops[1]
- Degraded grassland
- Degraded grassland with trees
- Cropland: perennial crops in their final stage of production

Specific plantation design and choice of tree species depends on site selection as described in paragraph 4.3.

[1] *The production systems of annual crops in the project area are based on the traditional practice of slash and burn. The fast loss of soil fertility limits the production of annual crops per year. Generally after a rotation of rice and maize, the land is left fallow, allowing the regeneration of pioneering vegetation and thus the recovery of soil fertility. The mentioned "annual crops/fallow land" refer to this production system.*

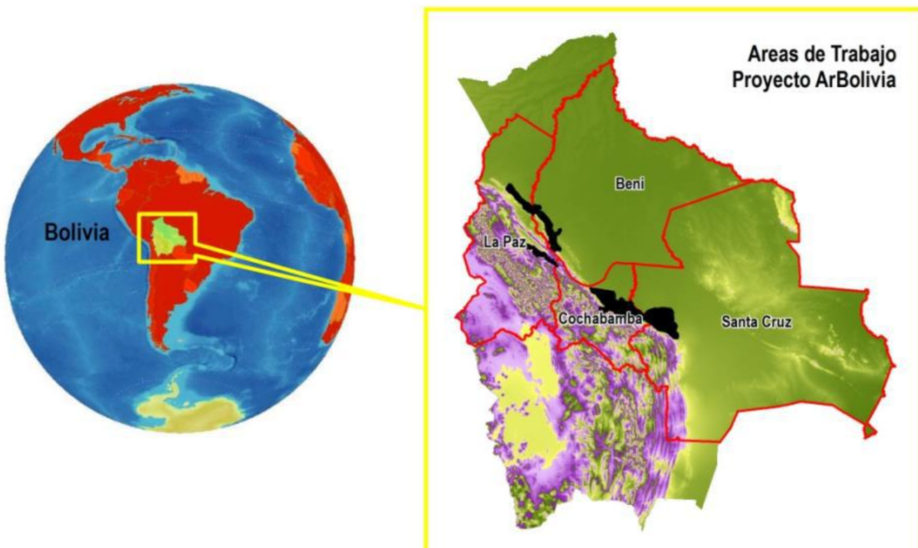
3 Baseline

3.1 Description of the project area

3.1.1 Location of project area

The Plan Vivo activities will be implemented in the settler areas of the Cochabamba Tropics, the Province of Ichilo in the department of Santa Cruz, Northern La Paz, and Western Beni. See map Figure 3.1

Figure 3.1: Project areas



Within these four departments the projects implement its activities in 13 municipalities. (See Table 3.1)

Table 3.1: Municipalities in which project activities take place (per department)

Dep. Beni	Dep. La Paz	Dep. Cochabamba	Dep. Santa Cruz
Reyes	Ixiamas	Chimoré	Buena Vista
Rurrenabaque	San Buenaventura	Entre Rios	San Carlos
San Borja		Puerto Villarroel	San Juan
		Shinahota	Yapacani

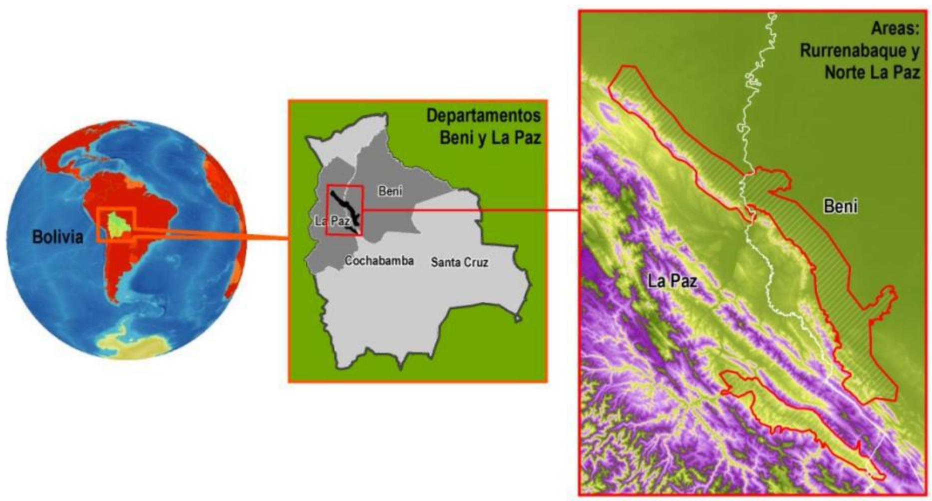
The project areas are all located at the foot of the Andes mountain range within the Amazon River basin. All project areas have in common that they have similar ecological characteristics and all project areas are settler areas. The settler areas have been a destination for migrants coming from the High Valley and Altiplano regions of Bolivia since the 1930s. This migration has intensified during recent decades due to increasing poverty, the “coca boom” and the deterioration of the mining and agricultural economic bases that have traditionally supported the people of the Bolivian highlands. Smallholders own 95% of the land in the portfolio regions. The sizes of the properties vary, but they are on average 20 hectares per family and are usually 100 by 2,000 m in the Cochabamba Tropics, and 25 to 50 ha in the other regions. Only few farmers have land less than 20 ha. The settlers are organised into syndicates of 20 to 60 farmer families. Approximately 5 syndicates form a “central”, which in turn belongs to a federation.

Tree planting activities in the first phase took place exclusively on lands deforested prior to 1990 (UNFCCC eligibility criteria), but in the roll-out phase this will be on land deforested 10 years prior to the start of the reforestation activity.

For organisational purposes the project areas are divided into three main zones:

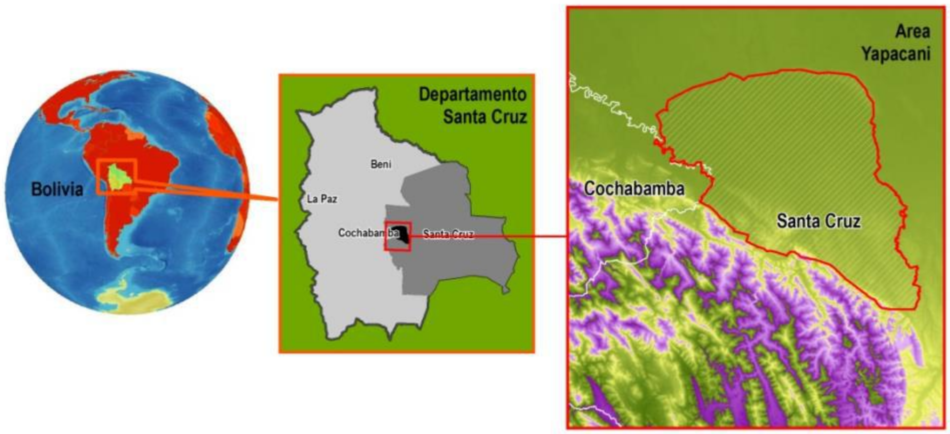
Rurrenabaque
The Rurrenabaque area comprises the province of José Balivian in the department of Beni and the province of Abel Ituralde in the department of La Paz. It is located near the national parks of Madidi (La Paz) and Pilon Lajas (Beni) and contains the municipalities of Rurrenabaque (Beni), San Borja (Beni), San Buenaventura (La Paz) and Ixiamas (La Paz). See map Figure 3.2.

Figure 3.2: Location of the “Rurrenabaque” area



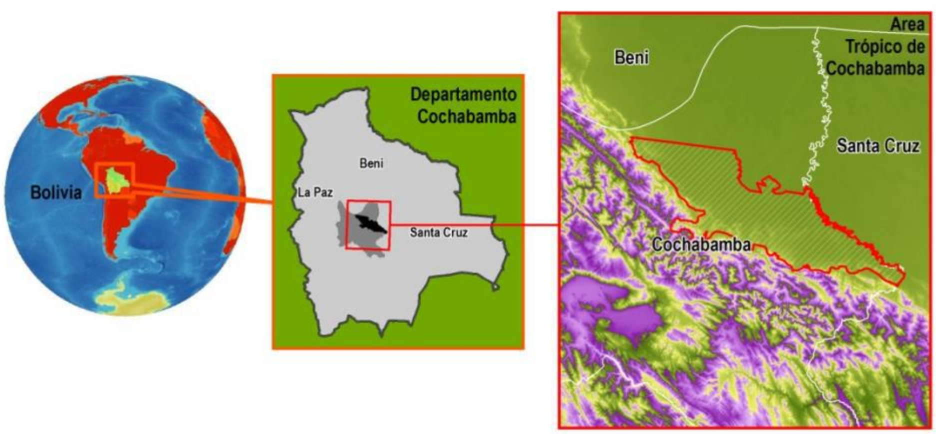
Ichilo Province.
This is situated in the department of Santa Cruz, bordering the Amboro National Park to the south. It contains the municipalities of Yapacani, San Juan, San Carlos, Buena Vista. See map Figure 3.3.

Figure 3.3: Location of the "ichilo" area



Cochabamba Tropics
The Cochabamba Tropics region lies in the department of Cochabamba, bordering the Carrasco National Park to the south. It contains the provinces Chapare and includes the municipalities of Villa Tunari, Tiraque, Shinahuota, Carrasco, Chimoré, Puerto Villarroel and Entre Rios. See map Figure 3.4

Figure 3.4: Location of the "Cochabamba Tropics" area



3.1.2 Recording of site information

For all sites, land tenure and actual land use is recorded. In the Table 3.2 an example is given of a report on land tenure, and current land use. Information for all individual participants in the project is stored in the database.

Table 3.2: Data on land tenure and land use for the plantation areas

Planting areas in the Small-scale CDM AR project activity	Unique ID of planting areas	Municipality	Community	Name/Surname	Status of land ownership	Surface (has)	Actual land use
1	SCZ-ICH-SCS-14S-12-S2-P1	San Carlos	14 DE SEPTIEMBRE	Catari Mamani Gregorio	Notarized certificat	1.0	Annual crops/fallow land
2	SCZ-ICH-SCS-14S-27-S1-P1	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.5	Annual crops/fallow land
3	SCZ-ICH-SCS-14S-27-S1-P2	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.5	Annual crops/fallow land
4	SCZ-ICH-SCS-14S-27-S1-P3	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.5	Annual crops/fallow land
5	SCZ-ICH-SCS-14S-27-S1-P4	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.5	Annual crops/fallow land
6	SCZ-ICH-SCS-14S-27-S3-P10	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.5	Annual crops/fallow land
7	SCZ-ICH-SCS-14S-27-S3-P7	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.5	Annual crops/fallow land
8	SCZ-ICH-SCS-14S-27-S4-P6	San Carlos	14 DE SEPTIEMBRE	Arancibia Miranda Crispin	Provisional title	0.2	Annual crops/fallow land

(In the digital version, click twice to obtain the complete set of data)

Examples of specific areas identified for planting or those which have already been planted are shown on Sicirec´s website: http://dss.sicirec-bolivia.org/mapa/index.html

The geographical coordinates of the boundaries of each of the sites where project intervention will take place (project sites) will be, and have been, determined by GPS (with positional accuracy of 10m). All parcels have a unique identification code, generated automatically by the database system of the project.

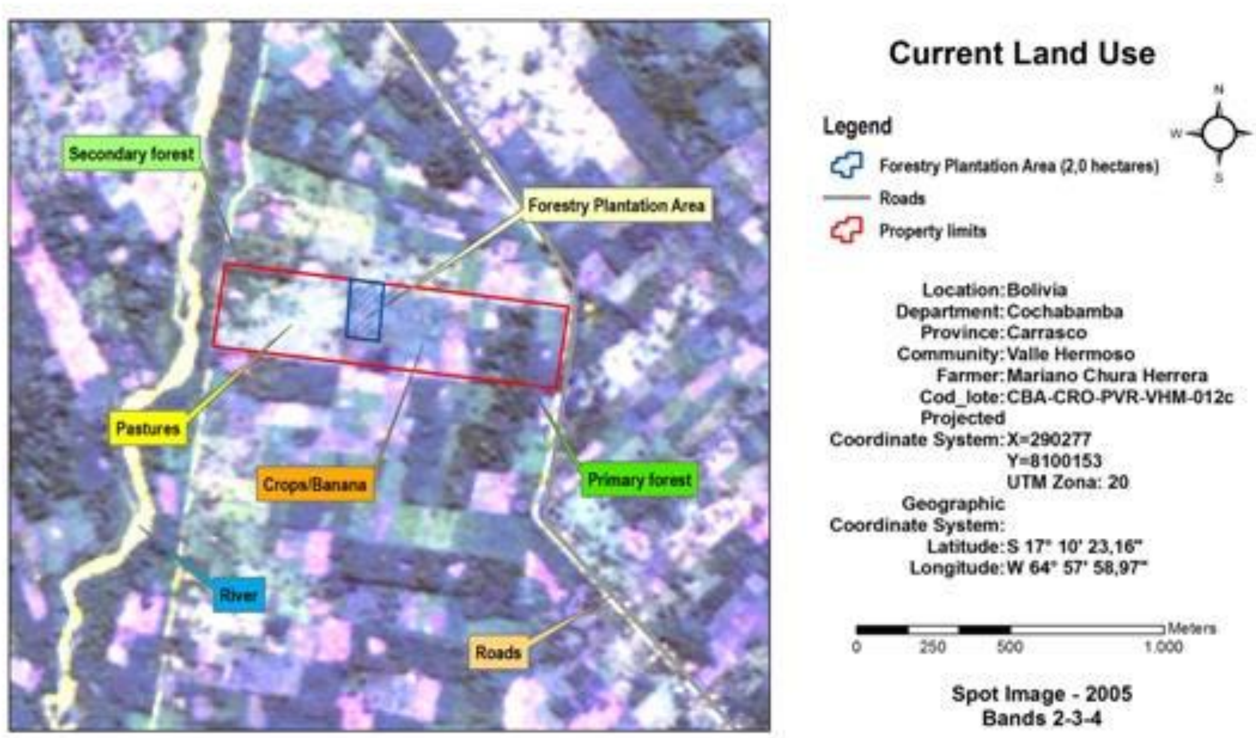
Examples of coordinates in UTM-WGS84 of the different parcels where small-scale A/R CDM project activity will take place are shown in Table 3.3. The complete set of data is available on request.

Table 3.3 Example of coordinates for planting areas

Planting areas in the Small-	Unique ID of planting areas	Easting	Northing
1	SCZ-ICH-SCS-14S-12-S2-P1	409069	8103033
		408964	8103066
		408986	8103153
		409088	8103126
		409069	8103033
2	SCZ-ICH-SCS-14S-27-S1-P1	410635	8104127
		410420	8104195
		410425	8104215
		410640	8104150
3	SCZ-ICH-SCS-14S-27-S1-P2	410469	8104405
		410473	8104421
		410769	8104336
		410765	8104321

An example of one farm with a parcel selected for the reforestation activity is shown in the Figure 3.5.

3.5. Example of farmers parcel and the selected area for the plantation



3.1.3 Site description

3.1.3.1 Biophysical characterization

From a biophysical perspective, the portfolio area is quite uniform; the terrain is relatively flat, the precipitation and temperature patterns do not fluctuate significantly and the soil texture and depth remain relatively homogeneous throughout. The Andes mountains are located immediately south of the portfolio area. The rivers flow in a north-easterly direction. The portfolio area ranges in elevation from 250 to 450 meters above sea level. More than 75% of the area has a slope angle of less than 5%.

3.1.3.2 Land cover / land use

Farmland in the portfolio area comprises a heterogeneous mix of different land cover and land use types. Each of these classes exhibits unique biomass accumulation curves through the course of its rotation, as agriculture crops shift within the land use system. In Table 3.4 and Figure 3.5a and b, the land cover types are shown.

Table 3.4: Land cover types in the program area.

Actual Land cover type	Surface (Ha)	Surface (%)
Primary forest	961,160	53.9
Secondary vegetation/fallow	295,019	16.6
Crops	328,223	18.4
Pasture land	134,806	7.6
Water	62,535	3.5
Total	1,781,742	100.0

Fig. 3.5a Veg. cover in the Rurrenabaque area

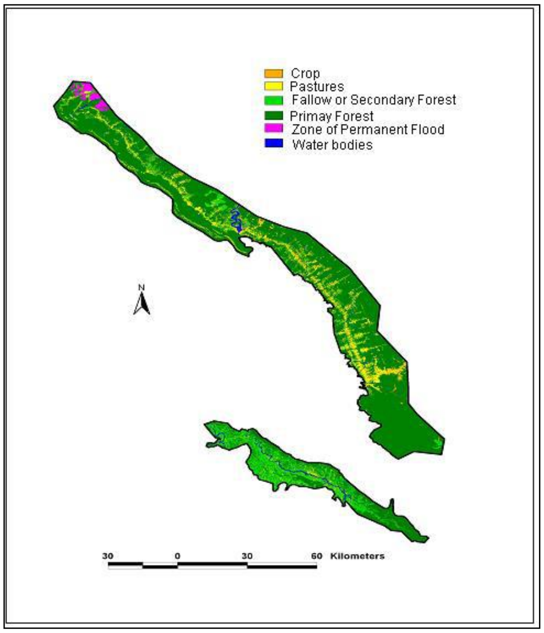
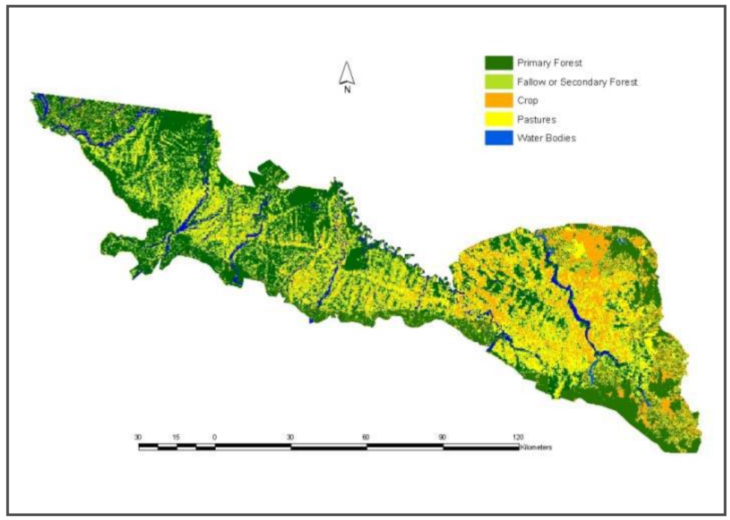


Fig. 3.5b Veg. cover in the Cochabamba and Ichilo area



The most common types of agricultural land use in the portfolio area are:

- Cattle grazing for beef and milk production
- Annual cropping (rice, maize, cassava)
- Perennial cropping (banana, palm heart, papaya, pineapple, citrus)

3.1.3.3 Ecosystem

Biogeographical zonation

According to the bio-geographical zonation of Bolivia, the Cochabamba Tropics and Ichilo province belong to: Biogeographic province of Acre and Madre de Dios (South West Amazon), Sector biogeographic Amazon Andean foothill. District A.5. biogeographic district Amazon Chapare and A.3. bio geographic district Amazon Alto Beni, Characterised by the following species: *Aspidosperma rigidum, Astorcaryum murumur, Attalea phalerata, Brosimum acutfolium, B. lactescens, Cariniana estrellensis, Cedrela odorata, Celtis schippi, Cetrolobium ochtryxylum, Clarisia biflora, C.racemosa, Coussapoa ovalifoloa. C. villosa, Erythrina poeppigiana, Guarea macrophylla, Iriartea detoidea, Leonia glycicarpa, Porcelia steinbachii, P. ponderosa, Poulsenia armata, Pourouma cecropiifolia, Protium opacum, Pseudolmedia laevis, P. macrophylla, Ruizodendron ovale, Sloanea guianensis, Socratea exorhiza, Spaattosperma leucanthum, Swietenia macrophylla, Tabebuia serratifolia, Tapura acreana, Terminalia amazonica, T. oblonga, Trichilia pleeana, Thrihis caucana* (Navarro, 2002[1]).

Rare endangered species

The project sites are poor in the variety of flora and fauna, however on most farms near to the planting areas residual primary forests with a high variety of fauna and flora do still exist. The project area as a whole contains a wide variety of fauna, including avifauna and aquafauna. Inhabitants of the region have reported a decline in the number of animals and fish, due to hunting, fishing and the destruction of their natural habitat.

The following mammal species have been reported in the project areas by people from the communities: jochi pintado (*Agouti paca*), jochi colorado o calucha (*Dasyprocta* sp.), chichilos (*Saimiri sciureus*), taitetú (*Tayassu tajacu*), parabas (*Ara spp*), loro cenizo (*Amazona farinosa*), venado o huaso (*Mazama americana*), tropero (*Tayassu pecari*), anta (*Tapirus terrestris*) y oso hormiguero (*Tamandua tetradactyla*). All of these species except the jochi pintado and the jochi Colorado are protected under CITES. People from the communities have also reported a decline in all mammal species due to the conversion of forest to crop- and pasture land in the portfolio area. In other words, natural habitats for these species have already been, and continue to be, lost. Another reason they give for the decline of these species is pressure from hunting.

3.1.3.4 Climatic conditions

As shown in Figure 3.5a and b, there are six climate stations within the portfolio region. Monthly rainfall and temperature are shown in Figures 3.6a and 3.6b respectively. Average annual rainfall is highest in the La Jota station with an average of 4449 mm, with most precipitation falling between the months of November and March. Going further to the north and east, the average annual rainfall decreases to 1725 mm. The average annual temperature is 24.7°C, with temperatures ranging between 6 °C and 39 °C. Temperature declines during the dry season.

Fig 3.5a Meteorological climate stations in Rurr. area.

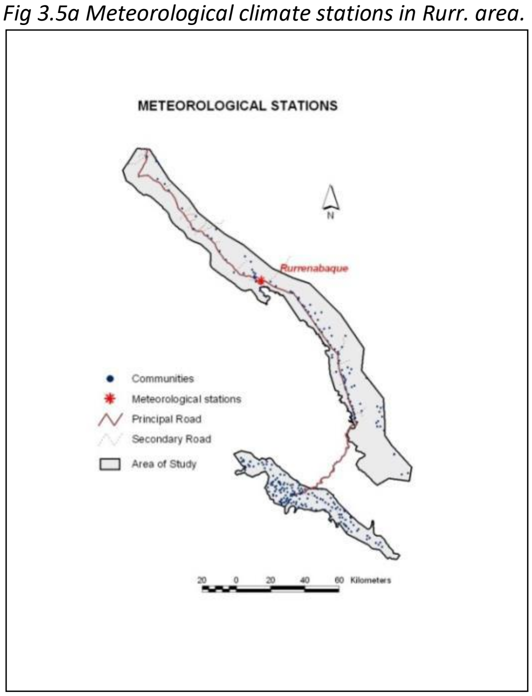
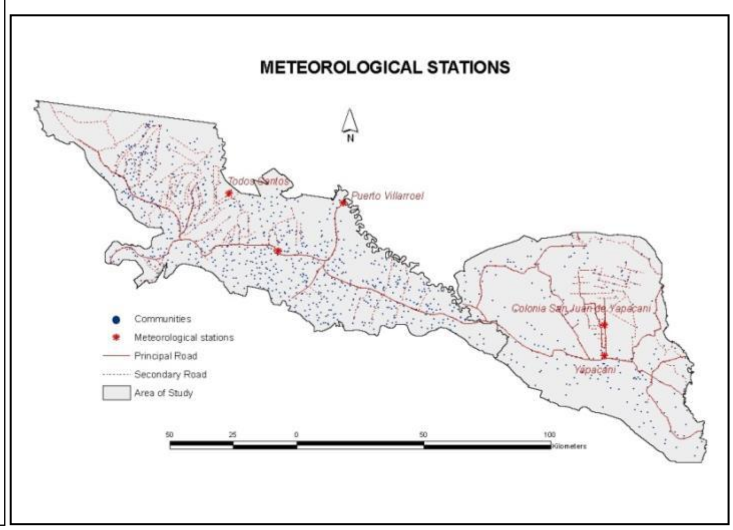
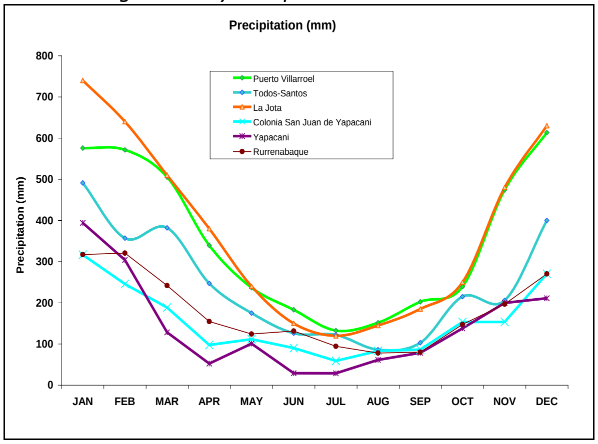


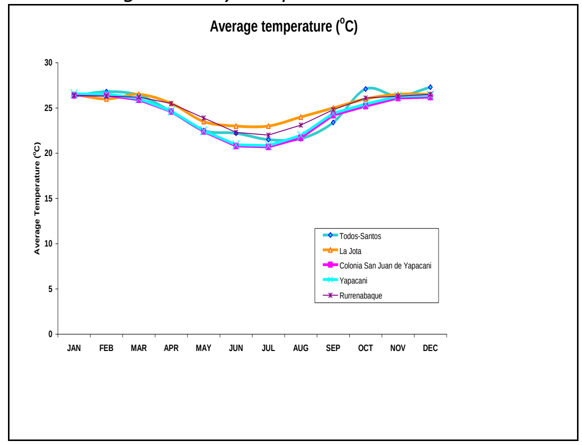
Fig 3.5b Meteorological in Cochabamba and Ichilo area



3.6 a. Average Monthly Precipitation



3.6 b. Average Monthly Temperature



Source: FAO, 2003

3.1.3.5 Flood occurrence

In the northern and eastern (see map Figure 3.7a&b) part of the portfolio area, flooding may occur with a frequency of 1 to 2 times a year, for a period of less than 5 days. In the site selection procedures, this is taken into account and tree species will be selected according to their resistance to flooding.

Fig. 3.7a: Map of flooding risk in Rurrenabaque area.

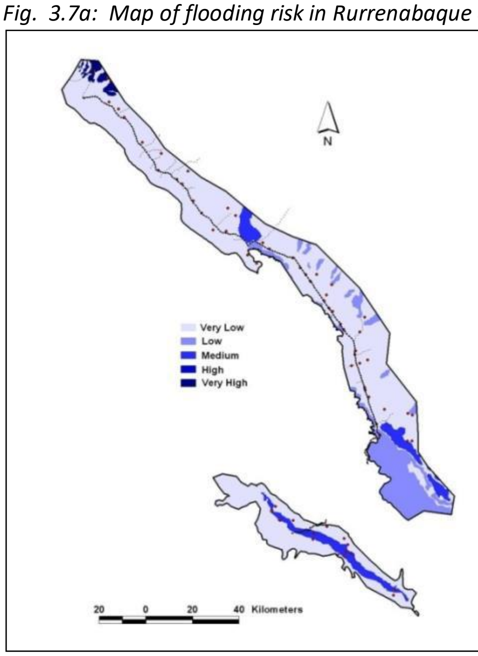
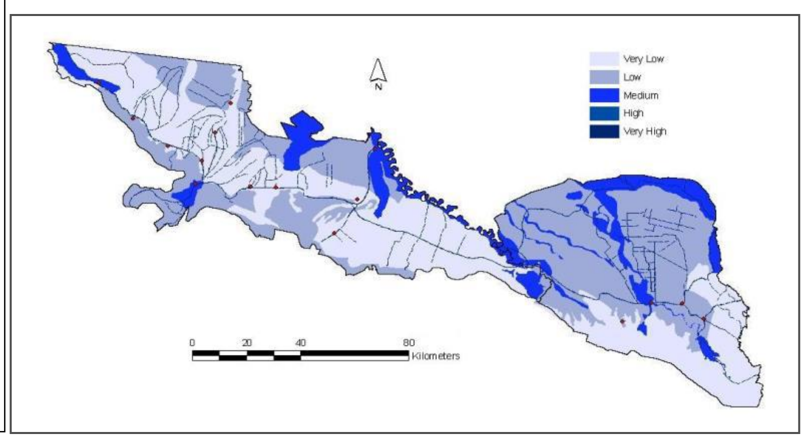


Fig. 3.7a: Map of flooding risk in Cochabamba and Ichilo area.



3.1.3.6 Other site conditions

Drought occurrence: July, August and September are the driest months in which generally no tree planting will take place. Once established, drought does not affect the development and growth of the trees.

There is no frost occurrence in the area.

Occurrence of other extreme events: Strong winds have been reported in the area with a frequency of 1 to 2 times a year. Plantation design, including wind breaks, will avoid major damage to plantations and infrastructure.

3.1.3.7 Soil and terrain conditions

The maps, Figure 3.8a & 3.8b delineate soil types using the Fertility Capability Classification (FCC) System. The FCC groups soils according to edaphic criteria that directly influence interactions between nutrient availability and plant growth. Map units; Table 3.5 represents the dominant soil type in this unit, which should be the soil type in at least 70% of the area. For the individual tree-planting areas, the scale of this map is not detailed enough, therefore for each individual planting area a soil classification is made, also based on the FCC system. A species-site matching assessment is completed based on the data obtained during this site selection process.

Figure 3.8a Soil map Rurrenabaque area

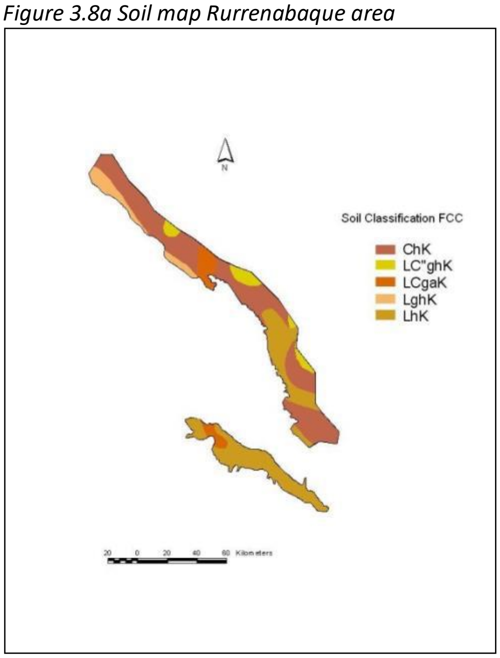
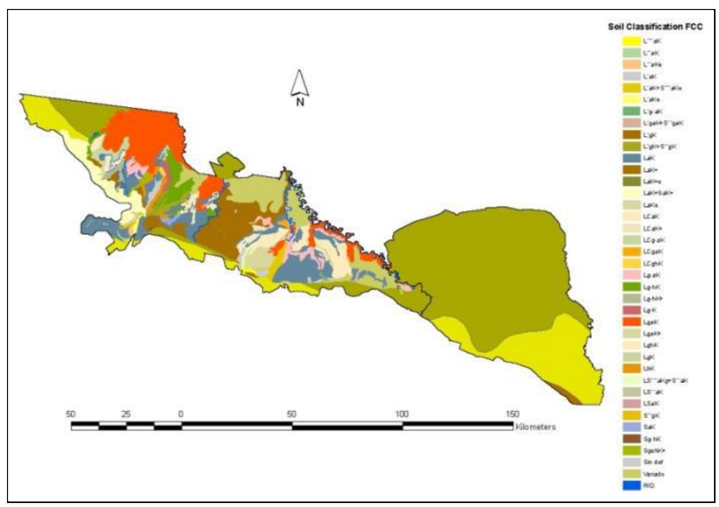


Figure 3.8b: Soil map of the Cochabamba and Ichilo area



Source: Based on Map of Soil Texture Classes (Monteith and Quiroga, 1993), a Soil map of Bolivia (ISRIC, 1995) and own field evaluations

In all areas, clayey and loamy soils prevail. Some areas to the north have a greater clay component, while the areas surrounding the central river bed are sandier. The FCC map indicates soil textures but also it indicates the deficiencies present in the soil. Within the area there are a number of factors influencing growth, the main limiting factors are:

- Aluminium toxicity: Within the entire area aluminium toxicity poses a limiting factor for plant growth.
- Gleying: Gleying and poor soil drainage is also a limiting factor in the north-eastern part of the area.
- Low cation exchange: The central area has a low cation exchange capacity.

- High rock density: High stone/ rock density can be found in some areas located along the southern border and along the rivers.

Table 3.5: Soil legend

Soil	Characteristics
L'"aK	Loamy soils, presence of >gravel, soils are presenting Aluminium saturation of the effective CEC, low potassium reserves.
L"aK	Loamy soils, presence of >35% gravel, soils are presenting Aluminium saturation of the effective CEC, low potassium reserves and low cation Exchange capacity (CEC)
L"aKe	Loamy soils, presence of >35% gravel, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and low Cation Exchange capacity (CEC)
L'aK	Loamy soils, presence of gravel, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves.
L'aK+ S'"aKe	Loamy soils over a sandy layer, presence of gravel in upper layer and high presence of gravel in sandy layer, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves, <10% weatherable minerals. Low Cation Exchange Capacity in the under layer.
L'aKe	Loamy soils, low presence of gravel, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and low cation Exchange capacity (CEC)
L'g-aK	Loamy soils, low presence of gravel and presence of some mottles <2chroma within 50 cm of the soil service, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
L'gaK+ S"gaK	Loamy soils over a sandy layer, low presence of gravel and presence of mottles <2chroma within 50 cm of the soil service, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves. <10% weatherable minerals. Sandy layer, has a high presence of gravel or coarse particles, and soil or mottles <2crhoma, Aluminium saturation>60%, low potassium reserves
L'gK	Loamy soils, low presence of gravel, with soil or mottles <2chroma within 50 cm of the soil service, low potassium reserves
L'gK+ S"gK	Loamy soils over a sandy layer. Upper layer with presence of gravel or coarse particles, with soil or mottles <2chroma within 50 cm of the soil service, low potassium reserves. Sandy layer has a high presence of gravel or coarse particles, and soil or mottles <2crhoma, low potassium reserves
LaK	Loamy soils, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
LaK+	Loamy soils, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and <10% weatherable minerals.
LaK+e	Loamy soils, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and <10% weatherable minerals and low cation Exchange capacity (CEC)
LaK+ SaK+	Loamy soils over a sandy layer, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves. <10% weatherable minerals.
LaKe	Loamy soils, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and low cation Exchange capacity (CEC)
Chk	Clayay soils, presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves
LCaK	Loamy to clayey soils, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
LCaK+	Loamy to clayey soils, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and <10% weatherable minerals.
LCg-aK	Loamy to clayey soils, presence of some mottles <2chroma within 50 cm, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
LCgaK	Loamy to clayey soils, presence of mottles <2chroma within 50 cm, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
LCghK	Loamy to clayey soils, presence of mottles <2chroma within 50 cm, presenting Aluminium saturation10-60% of the effective CEC, low potassium reserves
LC"ghK	Loamy to clayey soils, with high presence of gravel or coarse particles, presence of mottles <2chroma within 50 cm, presenting Aluminium saturation10-60% of the effective CEC, low potassium reserves
Lg-aK	Loamy soils, presence of some mottles <2chroma within 50 cm, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
Lg-hK	Loamy soils, presence of some mottles <2chroma within 50 cm, presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves
Lg-hK+	Loamy soils, presence of some mottles <2chroma within 50 cm, presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves and <10% weatherable minerals.
Lg-K	Loamy soils, presence of some mottles <2chroma within 50 cm, presenting low potassium reserves
LgaK	Loamy soils, presence of mottles <2chroma within 50 cm, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
LgaK+	Loamy soils, presence of mottles <2chroma within 50 cm, presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and <10% weatherable minerals.
LghK	Loamy soils, presence of mottles <2chroma within 50 cm, presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves
LgK	Loamy soils, presence of mottles <2chroma within 50 cm, low potassium reserves
LhK	Loamy soils, presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves
LS'"aKg+S"aK	Loamy soils with high content of sand over a Sandy layer, with high presence of gravel, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and low cation Exchange capacity (CEC), soil or mottles <2chroma are dominant within 50 cm of the soil surface , soils saturated with water during part of the year.
LS"aK	Loamy soils with high content of sand, with high presence of gravel, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves and low Cation Exchange capacity (CEC),
LSaK	Loamy soils with high content of sand, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
S"gK	Sandy soil with high presence of gravel, with soil or mottles <2chroma within 50 cm of the soil service, low potassium reserves
SaK	Sandy soils, soils are presenting Aluminium saturation >60% of the effective CEC, low potassium reserves
Sg-hK	Sandy soils, with low presence of soil or mottles <2chroma within 50 cm of the soil surface, soils are presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves
SgehK+	Sandy soils, with presence of soil or mottles <2chroma within 50 cm of the soil surface, low Cation Exchange Capacity (CEC) soils are presenting Aluminium saturation 10-60% of the effective CEC, low potassium reserves and <10% weatherable minerals

3.1.4 Site assessment

Each individual farm property will be assessed for the above-mentioned criteria, using forms 1, 2, 3, 4, 5, 6 (Annex 2). On this basis the most appropriate land type for the specific project activities will be selected, as well as selection of the most appropriate species.

3.2 Baseline methodology applied

The approved methodology AR-AMS0001/version 05 has been used.

This choice of methodology is justified because:

- The proposed activity is “grasslands to forested lands” and “cropland to forest land”;
- Project activities are implemented on lands where < 10% of the total surface project area is disturbed as a result of soil preparation for planting;
- The displacement of households or activities due to the implementation of the project activity is less than 50%;
- The displacement of grazing animals is less than 50% of the average grazing capacity of the project area;
- The proposed activity is not a de-bundled component of a larger project activity.

3.3 GHG sources considered in the baseline

According to AR-AMS0001/version 05, those project emissions that need to be taken into account are limited to emissions from the use of fertilisers.

Since the trees are planted on previous cropland, the farmers will be allowed to grow crops and use fertilisers as they did before the project activity started. However, in line with Annex 15A(b) of the EB22 report[2], this does not result in an increase in emissions compared with the pre-project activity and thus does not need to be counted as leakage.

3.4 Change in carbon stocks in the absence of the project

As mentioned in paragraph 2.2, project activities are developed on 4 different land use types:

- Annual crops
- Degraded grassland
- Degraded grassland with trees
- Cropland: perennial crops in their final stage of production

All 4 land use types are considered as different strata in the project. For all 4 strata, a separate baseline analysis is carried out, since change in carbon stocks in time might be different.

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[2] http://cdm.unfccc.int/EB/022/eb22_repan15.pdf:*(b)Pre-project GHG emissions by sources which are displaced outside the project boundary in order to enable an afforestation or reforestation project activity under the CDM shall not be included under leakage if the displacement does not increase these emissions with respect to the pre-project conditions. Otherwise, leakage for the displacement of pre-project activities is equal to the incremental GHG emissions compared with the pre-project conditions.*

3.4.1 Change in carbon stock per stratum

Annual crops

Annual crops are generally part of a slash and burn system in which the main crop is rice. After the rice harvest, the land will be used for a few months more for maize and after that, will become fallow land for several years. Since these lands have been part of such a system for a long time, they are becoming very poor and no significant crop production can be expected for the next 10 years or so. The fallow period is getting gradually longer over time. In all cases, the fallow period is not sufficient to allow the soil to recover and the level of fallow vegetation as well as agricultural production declines, leading to a further degradation of the soil.

In a few cases, trees are planted on land used for mechanized annual cropping. This type of agriculture can be found in the province of Ichilo. These lands have been used almost continuously for more than a decade and the use of agricultural inputs such as fertilizers and pesticides has increased over these years while yield has been reported to decrease (Sejas, 2008). Once the cost of these inputs exceeds the revenues received, farmers simply leave the area as waste land. No natural regeneration is expected since, after a few years of fallow, the farmer will use the land again for some marginal crop production. Land degradation will then continue.

Since multi-temporal satellite image analysis show an increase of agricultural land and a decrease in forest land. Pressure on land will continue, resulting in progressive degradation of productive soils.

Perennial crops

The perennial crops are predominantly full grown, low productive banana plantations, or citrus plantations at the end of their rotation, which are expected to show a decline in biomass in future rather than an increase. The changes in carbon stocks are therefore assumed to be zero. Once perennial crops are no longer productive or production is very low, farmers might let their cattle onto the land, resulting in a decline of biomass. Alternatively, they may leave the land for a few years more, after which they slash and burn the perennials and use the land for annual crops. In both cases natural regeneration is expected to be zero, since the farmer will continue to use the land for some marginal crop production, contributing further to the degradation of the land.

Grassland and Grassland with trees

In the project areas, the principal cause of degradation of pastures is bad management, which leads to extreme compaction of the soil, giving way to the gradual invasion of native grasses which end up choking and displacing the cultivated foraging species. Bad management can be caused by overgrazing or under grazing. According to Sejas and Espinosa (2007), the management in the zone consists of burning the pastures every 2 to 3 years in order to eliminate ticks and its eggs, and a burning every 4 to 5 years in order to renew and improve the pastures. The productive period of the pastures is generally considered to be about 20 years. Degraded pasture land is used as leisure areas or shelters.

The cause of degradation can be either overgrazing or under grazing. Overgrazing results in a significant deterioration of production and soil quality. Under grazing results in grassland with trees, since the partially abandoned and degraded grasslands are invariably invaded by shrubs and small trees. In the absence of the project, the most likely scenario is that these areas will be rehabilitated for grazing activities through burning, which means a further degradation of the soils and a decrease of biomass stock in time compared with the biomass which can be found currently in this land use type.

3.4.2 Most likely baseline scenario – Change in carbon stock in the absence of the project

It can be evidenced that, without intervention, carbon stocks would decline in future. The Project has assumed a conservative approach, assuming a static baseline.

This is in line with the applied baseline methodology AR-AMS0001-Section II.5.

II-5 The most likely baseline scenario of the small-scale A/R CDM project activity is considered to be land-use prior to the implementation of the project activity, either grassland or croplands in which changes in carbon stocks are assumed to be zero, for grassland if:

And section II-6

II-6b If the carbon stock in the living biomass pool of woody perennials and in below-ground biomass of grasslands is expected to decrease in the absence of the project activity, the baseline net GHG removals by sinks shall be assumed to be zero. In this case, the baseline carbon stocks in the carbon pools are constant and equal to existing carbon measured at the start of the project activity.

Biomass in annual crops is ignored since it is considered transient.

The perennial crops are predominantly full grown, low yielding banana plantations, at the end of their rotation, which are expected to show a decline in biomass in future rather than an increase. Therefore, the changes in carbon stocks are assumed to be zero.

3.5 Quantification of existing carbon stocks per stratum

The baseline scenarios for the 4 different land use types show that changes in carbon stocks in all scenarios can be assumed to be zero. However, it is still necessary to quantify the carbon stocks for each stratum since due to project activity carbon removals will occur due to site preparation or canopy closure, which competes with the vegetation in the baseline.

For each stratum (grassland, grassland with trees, perennial crops and annual crops), the following calculations are performed as shown below.

Baseline net GHG removals by sinks are determined by the equation:

$$B(t) = \sum_{i=1}^{I} (BA(t)\, i + BB(t)\, i) * Ai$$

where:

- $B(t)$ = carbon stocks in the living biomass pools within the project boundary at time *t* in the absence of the project activity (t C)
- $BA(t)\, i$ = carbon stocks in above-ground biomass at time *t* of stratum *i* in the absence of the project activity (t C/ha)
- $BB(t)\, i$ = carbon stocks in below-ground biomass at time *t* of stratum *i* in the absence of the project activity (t C/ha)
- Ai = project activity area of stratum *i* (ha)
- i = stratum i (I = total number of strata)

3.5.1 For above-ground biomass

BA(t) is calculated per stratum *i* as follows:

*BA(t) = M(t) * 0.5*

where:

BA(t) = carbon stocks in above-ground biomass at time *t* in the absence of the project activity (t C/ha)

M(t) = above-ground biomass at time *t* that would have occurred in the absence of the project activity (t dm/ha)

0.5 = carbon fraction of dry matter (t C/t dry matter)

3.5.1.1 Stratum: Grassland

M(t=0) = M(t) = Mgrass + Mwoody

Mgrass = above-ground biomass in grass on grassland at time *t* that would have occurred in the absence of the project activity (t dm/ha) = 11 t dm/ha (Zomer et al., 2006)

Mwoody = no woody perennials in this stratum

M(t=0) = M(t) = 11 + 0 = 11 t dm/ha

Thus, Carbon stock in above ground biomass for Grassland is:

*BA(t) = M(t) * 0.5*

*BA(t) = 11 t dm/ha * 0.5= 5.5 t C/ha*

3.5.1.2 Stratum: Grassland with trees

M(t=0) = M(t) = Mgrass + Mwoody

With reference to Zomer et al. a Figure of 5.5 tC/ha (11 t dm/ha) was used for grassland and a Figure of 8tC/ha (16t dm/ha) was used for a mixture of pasture/bare soil/banana. These areas can also be defined as invaded pasture lands, or overgrown pastures or pastures with trees. A conservative approach was taken since recently overgrown pasture lands have relatively more grass which may disappear over time. Therefore, the highest carbon stock possible was taken, which is all the grass (11t dm/ha) + a high stock of carbon in shrubs or banana of (max 16tdm/ha). Once the shrub layer is fully developed, the grass layer will start to disappear and the shrub layer will take over. Consequently, the highest carbon stock in this case is the sum of grass and these shrubs.

Mgrass = above-ground biomass in grass on grassland at time *t* that would have occurred in the absence of the project activity (t dm/ha) = **11 t dm/ha** (extracted from Zomer et al., 2006)

Mwoody (t)= above-ground woody biomass of woody perennials at time *t* that would have occurred in the absence of the project activity (t dm/ha) = **16 t dm/ha** (extracted from Zomer et al., 2006)

M(t=0) = M(t) = 11 +16 = 27 t dm/ha

Thus, Carbon stock in above ground biomass for Grassland with trees is:

*BA(t) = M(t) * 0.5*
*BA(t) = 27 t dm/ha * 0.5= 13.5 t C/ha*

3.5.1.3 Stratum: Biomass in annual crops

Biomass in annual corps is ignored since it is considered transient.

3.5.1.4 Stratum: The perennial crops

M(t=0) = M(t) = Mgrass + Mwoody

Mwoody (per) (t) = above-ground woody biomass of perennial crops at time t that would have occurred in the absence of the project activity (t dm/ha) = **24 t dm/ha** (extracted from Zomer et al., 2006)

M(t=0) = M(t) = 0 + 24 = 24t dm/ha

Thus, carbon stock in above ground biomass for perennial crops is:

*BA(t) = M(t) * 0.5*
*BA(t) = 24 t dm/ha * 0.5= 12 t C/ha*

3.5.2 For below-ground biomass

BB(t) is calculated per stratum *i* as follows:

Because living biomass carbon pools are expected to be constant, the average below-ground carbon stock is estimated as the below-ground carbon stock in grass and in woody biomass; biomass in crops is ignored since it is considered transient:

*BB(t=0) = BB(t) = 0.5 * (Mgrass * Rgrass+ Mwoody (t=0) * Rwoody)*
where:
BB(t) = carbon stocks in below-ground biomass at time *t* that would have occurred in the absence of the project activity (t C/ha)

3.5.2.1 Stratum: BB Grassland
No reliable local studies of root-to-shoot ratios for grasses and woody perennials in grassland in Bolivia are known, therefore as a default the values listed in IPCC GPG Table 3A.1.8. sub-tropical/tropical grasslands in tropical moist and wet climates, which for grasslands is **1.58 tdm/ dm.**

*BB(t=0) = BB(t) = 0.5 * (Mgrass * Rgrass+ Mwoody (t=0) * Rwoody)*
*BB (grassland)= 0.5 * (11*1.58 + 0) = 8.69t C/ha*

3.5.2.2 Stratum: BB Grassland with trees
Over time, grassland is converted to fallow land with secondary woody vegetation. Without human disturbance, (which is not the case) this will become a secondary forest. With this in mind, the root to shoot

ratio should be less than 1.58 (IPCC default value) and more than the ratio for secondary forest (0.42 IPCC default value). Since no information currently exists and the areas are still far from being a secondary forest, we took a conservative approach, using for Rwoody the same value as for Rgrass.

*BB(t=0) = BB(t) = 0.5 * (Mgrass * Rgrass+ Mwoody (t=0) * Rwoody)*
*BB (grassland with trees)= 0.5 * (11*1.58 + 16*1.58) = 21.33 t C/ha*

3.5.2.3 Stratum: BB perennial crops

The basic perennial crops are banana and palm heart. Based on the literature available, a conservative root to shoot ratio of **1 tdm/ dm** is used.

*BB(t=0) = BB(t) = 0.5 * (Mgrass * Rgrass+ Mwoody (t=0) * Rwoody)*
*BB (perennials) = 0.5 * (0*1.58 + 24*1) = 12 t C/ha*

3.5.3 Overall baseline scenario

Four different strata are distinguished in the baseline. Carbon stocks for each specific baseline per stratum are summarized in Table 3.6.

Table 3.6: Existing carbon stocks per stratum

Stratum (i)	M(t)	BA(t)	r/s ratio	BB	BT
	tdm/ha	tC/ha		tC/ha	tC/ha
1. Grassland	11.0	5.5	1.58	8.7	14.2
2. Grassland with existing trees	27.0	13.5	1.58	21.3	34.8
3. Annual crops/fallow land	0.0	0.0		0.0	0.0
4. Perennials	24.0	12.0	1.00	12.0	24.0

where:

M(t) = *above-ground biomass at time t that would have occurred in the absence of the project activity in tons of dry matter per hectare*
BA(t) = *carbon stocks in above-ground biomass at time t in the absence of the project activity (t C/ha)*
r/s ratio = *Root/Shoot ratio*
BB = *carbon stocks in below-ground biomass in the absence of the project activity (t C/ha)*
BT= *total carbon stocks in below-ground biomass and above ground biomass in the absence of the project activity (t C/ha)*

4. Project activities and Management System

4.1 Reforestation activities

Reforestation activities will be carried out on land, which is at risk of becoming degraded due to inefficient land use practices. Once productivity falls significantly as a result of soil degradation, farmers move on to nearby forest areas.

The proposed activity contributes **to sustainable development** by introducing an Integrated Land Use system, which seeks to improve the efficiency of land use practices over the entire farm, whilst also taking into account the current and future needs of the farmer family. Sustainable crop and timber production will generate income in the short, mid, and long-term.

Tree species selection for specific sites is based on site evaluations according to protocols developed by the project (annex 3). Tree selection depends on proven suitability for the specific site conditions and purposes of the trees species in the (agro) forestry systems (timber production, shade, soil improvement, etc).

Plantations for sustainable wood production: Only native tree species will be planted, except for *Tectona grandis*, which will be planted only small scale and on flat, well-drained soils, therefore avoiding any negative impacts. The tree species proposed for this project can be found in Table 4.1, additional to this plantation might be mixed with a maximum of 50 plants of the species: *Cederela fissilis* and, *Swietenia macrophylla.* These high valuable species are only planted in very small numbers due to their sensitivity to diseases and attacks of the *Hypsipyla grandella*, which can be avoided by planting these species in very low densities.

Table 4.1: proposed tree species for the ArBolivia project

Nr	Scientific name	Common name
1	Aspidosperma macrocarpon	Jichituriqui
2	Buchenavia oxycarpa	Verdolago negro (pepa)
3	Calophyllum basiliense	Palo María
4	Centrolobium tomentosum	Tejeyeque
5	Dipteryx odorata	Almendrillo
6	Guarea rusby	Trompillo de altura
7	Schyzolobium amazonicum	Serebo
8	Stryphnodendron purpureum	Palo yugo
9	Tapirira guianensis	Palo román
10	Tectona grandis	Teca
11	Terminalia amazonica	Verdolago negro (de ala)
12	Terminalia oblonga	Verdolago amarrillo de ala
13	Virola flexuasa	Gabún

In almost all cases trees, are planted in blocks, these blocks are distinguished as separated sectors with their own unique waypoint (identification code). For each sector, all relevant site data are stored both in paper files and in the database. This data includes; site quality characteristics, historic and actual land use, coordinates, species planted, number of trees, plantation development, growth rates, and management activities executed. Sectors with the same characteristics belong to a stratum. For each stratum single species tree-growth will be monitored by measuring permanent sample plots.

Project strata are defined based on:

1. Tree species planted
2. Former land use (grassland, grassland with trees, annual and perennial crops)

4.2 Integrated Land Use Planning

All activities are embedded within a comprehensive land use planning system. If land use can be improved, agriculture will become more efficient and the deforestation due to traditional slash and burn methods can be reduced. In addition, specific land use will be officially registered and specific areas will be registered as protected areas. The land use plan is based on the elaboration of the field forms annex 2 (forms 1, 2, 3, 4, 5, 6).

Integrated land use planning is based on major land use planning, i.e. the most intensive use of land units considering the carrying capacity according biophysical criteria. Farmers participate in the process of gathering of date and in the preparation of the final documents.

The reforestation activities must be embedded in the integrated land Use Planning order to mitigate the risk of forest plantations conflicting with short term income or food security.

Tree species choice, depends mainly on the following three factors:

- **Site selection:** Species have to match with site characteristics. Therefore, the decision of which tree species will be planted is made after the site survey is completed.
- **Availability of seed:** Genetic material of almost all species is recalcitrant, which means it cannot be stored and has to be distributed to the nurseries within a very short period. Since these seed can´t be stored, and the harvest fluctuates from year to year due to nature of the specie and the climatic circumstances, the availability of seeds from some species varies. As a consequence, the supply of plant material per specie might vary across years.
- **Farmer's opinion**: Farmers are partners within the project and they take the final decision on tree species considering the two previous points.

4.3 Technical support and review:

Species-site matching

Protocols for trees species and site selection are used as established by the Cetefor foundation (annex 3).

Tree species selection for specific sites is based on site evaluations and depends on proven suitability for the specific site conditions and function of the trees species in the (agro) forestry systems. The functions include, amongst others, timber production, shading and nitrogen fixation.

<u>Step 1: Selection of potential sites for reforestation activities</u>

Site selection and the potential for reforestation is defined together with the smallholder, taking account of the current and future needs of the farmer family and the biophysical characteristics of the area. This phase results in an integrated farm plan (PIF). Based on this plan and the eligibility criteria area, the planting location of the trees will be defined.

Step 2: Matching site and species
For these sites, tree species selection is based on site evaluations, using the species-site selection and plantation design procedures developed by the CETEFOR foundation (annex 3).

Species selection
The site selection criteria ensure that the species most appropriate to the specific site are recommended. Account may also be taken of the owner's preference in terms of the type of production and the goals of the plantation. Table 4.2 shows the species used in this project and their individual characteristics. The design of each plantation is formulated using this table.

Table 4.2: Species requirements

Species		pH	Drainage					Texture					Illumination	
Scientific name	**Common name**	pH-tolerance	Free	imperfect	Poor	Tolerates Flooding	Soil depth	Sandy	Loamy	Clay	Soil fertility	Soil compaction	Light	Shadow
Aspidosperma macrocarpon	Jichituriqui	L - M	f	nt	nt		ne	t	f	nt	ne	t	e	nt
Buchanavia sp	Verdolago negro de pepa	M	f	t	t	t	ne		f	t				t
Calophyllum brasiliense	Palo maría	L - M		t	t	t							nty	e y
Cedrela fisillis	Cedro	M	e	nt	nt	nt	f				f	nt	em	e y
Centrolobium tomentosum	Tejeyeque	L - M	f	t	nt	nt	f		f			nt	e	nt
Dipteryx odorata	Almendrillo	L - M	f		nt		f		f		ne		e	nt
Dipteryx sp	Almendrillo amarillo	L - M	f		nt	t			f		ne		e	nt
Guarea rusby	Trompillo de altura		f	t	nt	nt	f	f	f	nt			e	nt
Hymenaea courbanil	Paquio	L	f	t	nt	t					f			e y
Schlizobium amazonicum	Serebo	L - M	ne	t	t	t		ne	ne	ne	ne	nt	e	nt
Stryphnodendrum purpureum	Palo yugo	L - M		t	t	t		ne	ne	ne	ne	t	t	f
Swietenia macrophylla	Mara	M	f	t	nt	nt	f		f		f	nt	em	e y
Tabebuia sp.	Tajibo		ne	t	t	t		f	f					e y
Tapirira guianensis	Palo román	L - M	f	t	t	t			f				t y	tj
Tectona grandis	Teca	M	f	nt	nt	nt	e		f		f	nt	e	nt
Terminalia amazonica	Verdolago negro de ala	M	f	nt	nt	t	ne	f	f				e	nt
Terminalia oblonga	Verdolago amarillo	L - M		t	t	t	ne		f					t
Virola flexuosa	Gabún	L		t	t	t							nty	e y

L = Low	*f = favourable*	*ne = not very demanding*	*e y = demanding when young*
M = Medium	*t = tolerant*	*e = demanding*	*t y = tolerant when young*
H = High	*nt = not tolerant*	*em = demanding on maturity*	*nty = no tolerant when young*

Source: Cetefor 2007 and np field data Sicirec Bolivia ltda

Plantation design and forest management system

Based on site characteristics, species requirements and the production criteria of the farmer and forestry experts of Sicirec Bolivia ltda (the project developer), the plantation will be designed according to protocols developed by the project.

All plantations will be managed according to a management plan and adjusted periodically in line with evaluations of the plantations by project staff. Specific silvicultural and forest management tasks will be set in discussion with the farmer. The forest plantations will be harvested in the future, but a forest management system will be adopted that minimises CO_2 emissions (by minimising clear-cutting) and thereby maximises carbon sequestration and the plantations' average carbon storage capacity. This will be achieved by applying a poly-cyclic harvesting system. However, until now, the specific poly-cyclic harvesting system has not been not fully developed, since plantations have yet to reach a suitable age for this harvesting method to be applied. Therefore, a conservative approach has been used when calculating the average carbon storage over time, by basing it on a mono-cyclic harvesting system. Sicirec Bolivia ltda expects to have sufficient data available to propose the specific polycyclic system for each specie by the year 2022. Due to the conservative approach currently undertaken, it is believed that the estimated average GHG emission reductions will substantially increase when this polycyclic system is applied.

Nursery techniques
Seed collection is carried out by the project's Plant Production Unit. Seed sources are registered sources, and selected according to specific characteristics for quality. Since Sicirec Bolivia ltda has control over the seed sources, nurseries and the distribution of plants to the plantation site. As such, monitoring of the chain from seed tree to planting in the field is guaranteed.

For plant production, genetic material is used according to the standards and regulations previously developed by the CETEFOR Foundation, Sicirec Bolivia and the National Institute for Innovation and Forestry (INIAF).

Site preparation
New sites will be prepared to enhance the early growth and development of the planted seedlings. To achieve this, the area around the planting spots will be weed free before planting. Additionally, planting holes of 20 cm deep and 20 cm wide on cropland, and 35 cm deep and 30 cm wide on pastureland, will be dug prior to planting. It is believed that, from this process, CO_2 emissions will not be significant due to the low soil disturbance caused by this form of site preparation.

Tree Planting
Planting distances will be such as to maximize stand development for timber production: The norm is 3.0 m x 3.0 m (1,111 plants per hectare) or 3 x 4 m (833 plants per hectare) according to tree species and specific site conditions. Accurate alignment of planting lines and spacing within the lines is important for subsequent tending operations. After site preparation, the plants will be delivered to the farm and planted within 2-3 weeks of delivery. Although there is no pronounced dry season, planting will usually be undertaken between November and May. After this period, the plantation quality and survival rate will be monitored to determine whether any replanting is necessary. Where survival is less than 90%, replanting will be carried out in in July. Whilst planting and replanting can be undertaken in other months, it is not recommended due to higher risks of mortality.

Tending and weed control
Weed control, especially in the first few years, is crucial for growth, survival rates and quality of the plantation. Weed control will be manual and no herbicides will be used to avoid damage to the plantations and the environment.

Thinning and pruning
Thinning and pruning of the plantations will be important to ensure that they maximise the proportion of large stems with clear timber. The purpose of thinning is: i) to focus the growth of the stand on the most vigorous stems and ii) to reach the targeted final product diameter as soon as possible. The objective of pruning is to produce high quality timber. Thinning and pruning regimes depend on species and the growth rates achieved in the project area. The impact of thinning and other silvicultural measures on carbon sequestration is accounted for in the quantification of the actual net GHG removal by sinks. The impact of pruning is accounted for by application of a reduced biomass expansion factor (1.4 for all tree species).

Harvesting
Although these forest and agro-forestry plantations will be harvested in the future, a forest management system will be introduced to minimize CO_2 emissions and maximize CO_2 sequestration. The application of a polycyclic harvesting system in forest plantations will guarantee a relatively high average carbon storage

capacity. As explained previously, this system will be developed in 2022, at which point the plantations will be nearing a suitable age for polycyclic harvesting.

Wind
The potential risks from extreme winds are examined during species selection. If a specific plantation is deemed to be subject to extreme winds (as no natural wind barriers exist), the risk will be mitigated through creation of wind breaks and selection of specific wind-resistant species.

Fire control
Fire risks exist since it is common for farmers, within the project regions, to apply the practice of burning old pastures to promote the renewal of pasture. This could cause fire in the plantations if no mitigation measures are taken. To reduce the risk of fire the following measures are taken:

1. Capacity building in the community regarding the control of renewal (burning) of pasture lands;
2. Fire breaks between pastureland and the newly established plantations (10-20m);
3. Removal of dry weeds and other vegetation in the most delicate areas of the plantations.

Animal control:
There is risk of plantation damage from animals since most farmers manage husbandry (cows, pigs and chickens) for their livelihood income. In order to protect forestry plantations from cattle or pig invasions that can generate enormous damage especially during the initial stage, protective fencing will be placed around the planting sites. The famer is obliged to fence the area identified while the project supports the farm household with a maximum of 1000 meters of barbwire per hectare.

Pest control
By applying appropriate site selection and good silvicultural management procedures, the risk of pests and diseases will be minimized, since pest and diseases usually occur in stressed crops. However, the project area will be routinely assessed for any pest and disease problems that may arise. If pests or diseases appear, these will be controlled by using organic products and, in a worst-case scenario, chemical control methods may be used as a last resort, but only after careful consideration of the environmental impacts.

5. Quantification of carbon services

5.1 Crediting period

The crediting period is 40 years from 2007. Credits will be claimed ex-ante. This option has been selected on the basis that neither the communities nor the project coordinator have sufficient funds to carry out the ongoing reforestation activities without up-front funding.

Payments to the farmers are made during this crediting period. These payments are not directly related to carbon offsets but, instead, are based instead on the satisfactory execution of specific forest management activities, as described in section G of the PDD.

5.2 Estimation of the project's net GHG removals by sinks

The actual net GHG removal by sinks relates only to the *changes* in carbon pools for the project scenario.

GHG removals due to project activities are estimated per stratum (grassland, grassland with trees, perennial and annual crops) for each of the different tree species and for each plantation design.

Total carbon stock for the project scenario at the starting date of the project activity (t=0) is the same as for the projection of the baseline carbon stock (t=t), therefore, for each different tree species, for each different plantation design and per planting year:

$$N(t=0) = B(t=0)$$

Where:

N= *total carbon stock in biomass under the project scenario (tC/ha)*
B= *total carbon stocks in biomass under the baseline scenario (tC/ha)*

For all other years, the carbon stocks within the project boundary at time t ($N(t)$) will be calculated as follows:

$$N(t) = \sum_{i}^{I} (NA(t)\, i + NB(t)\, i) * Ai$$

where:

N(t) = *total carbon stocks in biomass at time t under the project scenario (t C/ha)*
NA(t) i = *carbon stocks in above-ground biomass at time t of stratum i under the project scenario (t C/ha)*
NB(t) i = *carbon stocks in below-ground biomass at time t of stratum i under the project scenario (t C/ha)*
Ai = *project activity area of stratum i (ha)*
i = *stratum i (I = total number of strata)*

The long-term average GHG benefit (LA) is determined by dividing the expected total GHG benefit for the planned length of the rotation in years, by 2. This is done for each of the species. This is a conservative approach, since management is not aiming on a monocyclic system, with a final clear cut at the end of the rotation, but aiming at a polycyclic system, therefore maintaining a significantly higher biomass than monocyclic systems.

5.2.1 For above-ground biomass

The following calculations are performed for each stratum:

NA(t) is calculated per stratum i as follows:

*NA(t) = T(t) * 0.5*

where:

NA(t) = carbon stocks in above-ground biomass at time *t* under the project scenario (t C/ha)

T(t) = above-ground biomass at time *t* under the project scenario (t dm/ha)

0.5 = carbon fraction of dry matter (t C/t dm)

T(t) = *SV(t) * BEF * WD*

where:

T(t) = above-ground biomass at time t under the project scenario (t dm/ha)

SV(t) = stem volume at time t for the project scenario (m^3 /ha)

BEF = biomass expansion factor (over bark) from stem volume to total volume (dimensionless)

WD = basic wood density (t dm/m^3)

- *BEF (Biomass expansion factor) = 1.5 and is based on the IPCC good practice guidance default value (*IPCC_-_GPG_ Default_values_Annex 3A1.10, Tropical BEF (over bark).
- WD (Wood density) is based on local sources or if these are absent on data extracted from international sources. Table 5.1 shows the basic wood density and sources used.

Table 5.1: basic wood densities and sources

Tree species	Wood density [g/cm³]	Source
Schyzolobium amazonicum	0.49	FAO/PAFBOL, 2002
Stryphnodendron purpureum	0.52	Brown, 1997
Aspidosperma macrocarpon	0.67	FAO/PAFBOL, 2002
Calophyllum brasiliense	0.55	FAO/PAFBOL, 2002
Centrolobium tomentosum	0.58	FAO/PAFBOL, 2002
Guarea rusby	0.52	Brown, 1997
Tapirira guianensis	0.60	FAO/PAFBOL, 2002
Tectona grandis	0.50	Brown, 1997
Virola flexuosa	0.44	Brown, 1997
Buchenavia oxycarpa	0.77	FAO/PAFBOL, 2002
Dipteryx odorata	0.91	FAO/PAFBOL, 2002
Terminalia amazonica	0.66	FAO/PAFBOL, 2002
Terminalia oblonga	0.75	FAO/PAFBOL, 2002

- *SV (stem volume)* estimates are based on DBH and height measurement data collected from the permanent sample plots established according the monitoring protocol, as described in section 7.

5.2.2 Carbon stocks for below-ground biomass

NB(t) is calculated per stratum *i* as follows:

$NB(t) = \quad T(t) * R * 0.5$

where:

NB(t) =	carbon stocks in below-ground biomass at time *t* under the project scenario (t C/ha)
T(t) =	above-ground biomass at time *t* under the project scenario (t dm/ha)
R =	root to shoot ratio (dimensionless)
0.5 =	carbon fraction of dry matter (t C/t dm)

The conservative default value for R, of 0.42 (secondary tropical and sub-tropical forest) of the IPCC´s good practice guidance for LULUCF, Table 3A.1.8 are used (annex 5)

5.3 Carbon loss due to plantation activity

Due to weeding within the plantation and eventual closure of the canopy, which increases the competition for light, the light-demanding grasses and perennials will disappear over time. This will result in some removal of carbon.

The level of removal is calculated using the same equations as for the planted trees:

$$N(t) = \sum_{I}^{I} (NA(t)\, i + NB(t)\, i) * Ai$$

In which

N(t) =	*total carbon stocks in biomass at time t under the project scenario (t C/ha)*
NA(t) =	*carbon stocks in above-ground biomass at time t under the project scenario (t C/ha)*
NB(t) =	*carbon stocks in below-ground biomass at time t under the project scenario (t C/ha)*
Ai =	*project activity area of stratum i (ha)*

The level of carbon loss is based on the existing biomass stock in the baseline scenario per stratum compared to the project scenario.

$N(t=0) = B(t=0)$

Where:

N=	*total carbon stock in biomass under the project scenario (tC/ha)*
B=	*total carbon stocks in biomass under the baseline scenario (tC/ha)*

This means, per stratum at the start of the project:

1. Grassland	*B(t=0) = N(t=0) = 14.19 tC*
2. Grassland with existing trees	*B(t=0) = N(t=0) = 34.83 tC shrubs and trees represents 20.64tC*
3. Annual crops/fallow land	*B(t) = N(t) = transient*
4. Perennials	*B(t=0) = N(t=0) = 24*

A summary of the above data is summarized in Table 5.2.

Table 5.2: Carbon stocks in the baseline

Stratum (i)	M(t)	BA(t)	r/s ratio	BB	Bt
	tdm/ha	tC/ha		tC/ha	tC/ha
1. Grassland	11.0	5.5	1.58	8.7	**14.2**
2. Grassland with existing trees	27.0	13.5	1.58	21.3	**34.8**
3. Annual crops/fallow land	0.0	0.0		0.0	**0.0**
4. Perennials	24.0	12.0	1.00	12.0	**24.0**

where:

M(t) = *above-ground biomass at time t that would have occurred in the absence of the project activity in tons of dry matter per hectare*
BA(t) = *carbon stocks in above-ground biomass at time t in the absence of the project activity (t C/ha)*
r/s ratio = *Root/Shoot ratio*
BB = *carbon stocks in below-ground biomass in the absence of the project activity (t C/ha)*
BT= *total carbon stocks in below-ground biomass and above ground biomass in the absence of the project activity (t C/ha)*

Weeding is one of the maintenance activities of the plantations and is carried out regularly until canopy closure is reached. After canopy closure, weeding intensity is reduced to a level in which undergrowth is not competing with the trees, which fundamentally means the removal of those plants considered “climbers”. The tree species Palo María, teak, almendrillo and verdolago show a relatively dense tree cover and almost no weeding is needed. So far, the applied initial tree stock/ha and distance between trees has resulted in reaching canopy closure within 4 years.

For the species mentioned, this is resulting in an under store where grasses and perennials have disappeared almost completely, but where existing shrubs and trees are still present. For species with a more translucent crown cover, it has been noticed that a significant amount of grasses, weeds and perennials survive. However, the portion of vegetation what will survive is relatively expensive to monitor, due to different species and baseline strata. Therefore, calculations are based on the conservative assumption that all undergrowth will disappear after 4 years. An exception is made for the stratum “grassland with existing trees” in this strata existing trees will be remained. The following conservative equation is used for the different strata:

1. Pasture *N (t=4) 0 tC*
2. Grassland with existing trees *N (t=4) = 20.64 tC*
3. Annual crops/fallow land *N(4) = transient*
4. Perennials *N(t=4) = 0*

In table 5.3. the carbon stocks/ha after site preparation are shown.

Table 5.3: carbon stocks/ha maintained after site-preparation

Stratum (i)	M(t) tdm/ha	BA(t) tC/ha	r/s ratio	BB tC/ha	B(t) tC/ha
1. Grassland	0.0	0.0	1.6	0.0	**0.0**
2. Grassland with existing trees	16.0	8.0	1.6	12.6	**20.6**
3. Annual crops/fallow land	0.0	0.0		0.0	**0.0**
4. Perennials	0.0	0.0	1.0	0.0	**0.0**

where:

M(t) = *above-ground biomass at time t that would have occurred in the absence of the project activity in tons of dry matter per hectare*
BA(t) = *carbon stocks in above-ground biomass at time t in the absence of the project activity (t C/ha)*
r/s ratio = *Root/Shoot ratio*
BB = *carbon stocks in below-ground biomass in the absence of the project activity (t C/ha)*
BT= *total carbon stocks in below-ground biomass and above ground biomass in the absence of the project activity (t C/ha)*

For the full project, the carbon loss per hectare is multiplied for the surface of the stratum:

I
*N(t) = (NA(t) i + NB(t) i) * Ai*
I

After *t=4* no extra loss of carbon which existed in *t=0* is expected.

Carbon loss is equally distributed over the first 4 years. Table 5.4 shows the carbon loss distributed over the first 4 years per hectare.

I
N(t) = (NA(t) i + NB(t) i)
I

Table 5.4: Carbon loss per ha per stratum (i) in tC/ha

Stratum	Year				Total loss
	1	2	3	4	
NA pasture	1.38	1.38	1.38	1.38	**5.50**
NB pasture	2.17	2.17	2.17	2.17	**8.69**
NA grassland with existing trees	1.38	1.38	1.38	1.38	**5.50**
NB grassland with existing trees	2.17	2.17	2.17	2.17	**8.69**
NA Perennials	3.00	3.00	3.00	3.00	**12.00**
NB Perennials	3.00	3.00	3.00	3.00	**12.00**

Where:

NA(t) = *carbon stocks in above-ground biomass at time t under the project scenario (t C/ha)*
NB(t) = *carbon stocks in below-ground biomass at time t under the project scenario (t C/ha)*
Ai = *project activity area of stratum i (ha)*

5.4 Net anthropogenic GHG removals

The ex-ante estimate of net anthropogenic GHG removals for the different species per ha is the result of:

Long-term Average net GHG removals *MINUS* **the *sum of Long-term average Negative removals*** MINUS **the *sum of average net baseline GHG removals*.**

Leakage = 0

Greater detail on this calculation is provided in section 8.1, with the results of this equation provided in section 8.3. For the entire project, actual net GHG removals are multiplied with the surface of each stratum.

6. Leakage

6.1 Risk of Carbon loss attributable to the project activity

The project is managed so as to avoid leakage, meaning that forestry production would not replace agricultural production. The risk of leakage or an unintended loss of carbon stocks outside the project boundary, attributable to the project activities is considered to be insignificant, for the reasons outlined below:

6.1.1 Displacement of households

There is no displacement of households due to the project, since only a small portion of the farmland is reforested. In fact, the project will actually serve to reduce the risk of migration from the area to nearby forest areas due to better land use practices. There is a current tendency for farmlands to become degraded through inefficient land use practices. Once productivity has fallen excessively as a result of soil degradation, farmers simply move to new areas of forest in the vicinity. The "Integrated Land Use" approach outlined above is intended to introduce efficient land use practices across the entire farm, whilst also taking into consideration the current and future needs of the farmer family. Sustainable crop and timber production will generate income in the short, mid, and long-term, a factor, which subsequently reduces the risk of farmers moving to other, e.g. forested, locations.

Information obtained from stakeholder meetings and a study done by Reijnierse (np) in 2019 shows that the displacement of pre-project activities are not causing deforestation attributable to the project activity.

6.1.2 Displacement of cropland:

Land deforested 10 or more years prior to reforestation had previously been subjected to a "slash and burn" system. After rice cropping, maize is normally planted, after which it is left fallow. In the first fallow period, it normally takes at least 4 years before the land can be used for agriculture again. After a second cultivation period, it takes at least 7 years before it can be used again for cropping and after that it takes approximately 10 years, even on the better soils, before land can be recovered. On the poorer soils this period can be up to 15 years. Moreover, crop production per hectare decreases as the fallow period increases. If the fallow period is not extended, crop yields fall even further.

On croplands established 10 years ago or more, and which are now in the second and third cycle, yields fall to 70% or less to of yield levels in the 1st cycle. On croplands established before 1990 and which are now in the 4th or subsequent cycle, the average annual crop yield falls to 50% or less of yield levels in the 1st cycle.

Some farmers are using their cropland almost continuously by making use of fertilizers. In areas where fertiliser is used, soil degradation also continues and annual crop yield decreases, rendering the use of fertiliser uneconomic. It can be evidenced that activities, that are shifted due to tree planting can be absorbed by the surrounded lands because the level of foregone crop production is relatively small, Therefore, in accordance with AR-AMS0001/version 05 (28), leakage due to displacement of crop production is considered insignificant.

6.1.3 Displacement of pasture land:

Leakage on pastureland through shifting of activity will occur in less than 10% of cases, since the amount of cattle which may be moved to areas outside the project boundary is not significant. It can be evidenced that trees planted on pastureland will not cause deforestation, since the planted areas are only a small portion of the total degraded pasture land. Instead, the total pasture land on a farmer's parcel and the other surrounding areas, such as pasturing on the side of the road, are likely to receive the shifted activities (Knoblauch 2007, Sejas 2007). Therefore, in accordance with AR-AMS0001/version 05 (28), leakage due to displacement of grazing activities is considered insignificant.

Moreover, grazing systems and silvipastoral systems will only be implemented on roughly 5% of the project area. Therefore, in accordance with AR-AMS0001/version 05 (28), leakage due to displacement of grazing is considered insignificant.

6.2 Monitoring leakage and mitigation

As evidenced previously in section 6.1, leakage is not significant. However, potential leakage will nevertheless be monitored over time, by monitoring land use change. This monitoring may also demonstrate a positive effect or collateral carbon benefits.

In addition, measures such as the introduction of agroforestry systems and silvipastoral systems are also being implemented within the project area, avoiding even a minimum risk of displacement of activities due to the project's activities. These measures are summarized in Table 6.1.

Table 6.1: Mitigation measures to avoid leakage

Activity Type	Potential Leakage	Mitigation measures
Tree Planting	Tree planting might lead to displacement of household, farmers, and displacement of crop production and pasture land.	Integrated Land use Planning will ensure farmers have sufficient land for their crops, so generating income in the short-term. Tree planting is not competing with their income or food security in the short, mid and long-term.
		Introducing agroforestry systems, which are more sustainable over time than rice, yield higher incomes per hectare and per working day, and generate subsistence products for the farmer and their family.
		Improving grazing systems, introducing silvopastoral systems and improved pastures.

6.3 Risk management

Risk management is based on the establishment of a common responsibility and the shared interests between the farmers and Sicirec Bolivia ltda, through its project ArBolivia. The aim of the ArBoliva project is not only to motivate famers in a participatory process to plant trees, but also for Sicirec Bolivia ltda to form a true partnership with the farmers and for both parties to unite to form the ArBolivia project. In this way, the social risks will be minimized. In Table 6.2, a description is made of the main risks and the mitigation measures to minimize risks.

Table 6.2: Main risk factors

Permanence Risks	Level of risk (low/medium /high)	Management Measures	Level of risk (low/medium/high) after management measurements taken
Legal			
Conflicts land tenure	Medium	Verification of documents and by the community before starting the activities.	Low
Illegal tree cutting	Medium	Forest Committees in coordination with community authorities responsible for control. Registration of plantations in the municipality and National Forest Authority.	Low
Natural			
Drought	Low	No planting in July, August and September.	Low
Floods	Medium	Adequate site selection, site-specie match according to strict protocols.	Low
Wind fall	Low	Adequate site selection according strict protocols and introduction of wind breaks if necessary.	Low
Forest fires	Medium	Project and forest committees implement measures to reduce this risk.	Low
Social			
Encroachment of cattle	High	Fencing (the project provides barbed wire).	Medium
Lack of sufficient knowledge on natural resource management	Low	Sicirec Bolivia ltda monitors the level of knowledge and strengthen capacities among famers and the contracted (community-based) companies.	Low
Changes in ownership, not interested in trees, or farmers losing interest over the long-term	Medium	Involvement of community authorities, legal aspects, involvement of forestry committees can minimize these situations. The partial payments and the possibility of obtaining loans, using the plantations as a guarantee, will minimize the loss of interest as well and will motivate to manage the plantations well.	Low
Economic			
Wood will be used and cut before maturity, sold elsewhere	Medium	Forestry committees control illegal logging, consciousness program, and legal announcements, which makes it impossible to sell the wood elsewhere. The project will provide higher prices than on the local market, and payments for environmental services generate income and are therefore an incentive to leave the trees growing.	Low
Lack of cash flow within the project, during project life time	Low	Lack of cash flow might affect the quality and growth of trees, but since tree-growing is a shared activity between farmer and project, it is expected that this will not result in the complete failure of the plantations. On the other hand, the financing strategy is based on avoiding cash-flow shortage.	Low
Market driven payments for environmental services might not cover farmers´ costs	High	The level of payments to farmers for carbon credits is not market driven, but based on maintenance costs agreed on beforehand. Payments are related solely to compliance with the activities agreed and guaranteed by the project.	Medium

7. Monitoring

In order to be able to provide accurate and precise information on the results of the activities in terms of intervened areas, growth and development a comprehensive monitoring system is in place. Based on the PDD, the system and protocols have been implemented refined.

The monitoring and evaluation system of the ArBolivia Project has the following main objectives:

1. Facilitate effective Quality control and assurance through constant performance monitoring and evaluation of the productive process of ArBolivia
2. Impact monitoring and evaluation in terms of:
    a. Growth: Timber and biomass (carbon)
    b. Socio-economic
    c. Environmental

The monitoring process is an ongoing process that is standardized by operational procedures, technical criteria and indicators that permit verifiable and certifiable evaluations of the progress, extent and quality of the plantations and measurements of changes in carbon stocks.

Monitoring consists of four components:

1. Data collecting
2. Data processing and storing
3. Internal monitoring and evaluation
4. External verification

7.1 Decision Support System (DSS)

For data-processing and storing a web-based software has been established, which not only functions as a database but is also supporting data analysis and decision making. This Decision Support System is a useful tool, for the objective to 1) quality control and assurance. It informs the management in a timely manner and in sufficient detail of any discrepancies between planned developments and implemented activities, initial as well as ongoing, and what is actually happening in practice. The tool also provides recommendations of possible corrective options and methods for timely alerts for the usual pitfalls that are inherent in forestry projects. A further use is the establishment of practical criteria for decision making in respect of the thinning operations. At the other hand it supports to impact monitoring. Data on, growth and development of the plantations is all stored in the database and reports can be analyzed relatively easy.

A full description of monitoring procedures for plantation establishment and development, including field forms and the storing of data in a database, is described in the monitoring section and annex 5 of the PDD. The PDD manuals and protocols for monitoring can also be found in annex 6 of this document.

In this section the monitoring procedures for growth and development will be discussed more detailed.

7.2 Site selection, baseline evaluation (t=0)

The data described below will be gathered. To achieve this, data gathering forms are used (illustrated in annex 1). These forms take into account some important aspects such as location co-ordinates, height and other important data that we believe has an influence on the development of different species, such as:

Site description (Form 1)

- Location
- Ownership status
- Landscape
- Gradient
- Flood risk
- Frost frequency
- Fire risk
- Erosion risk
- Wind risk
- Preponderance of stones
- Drainage

Description of the proposed plantation design (Form 1)

- Use and implementation of fertilizers (if used)
- Type of experimental design
- Planting method
- Topography
- Site preparation before planting
- Types of pre-existing crops (before tree planting)
- Sketch of the plantation

Soil characteristics (Form 2)

- Texture
- Colour
- pH values
- Compaction
- Indicator of drainage
- Prevalence of stones
- Quality of organic matter
- Soil depth
- Gradient

7.3 Monitoring of establishment, tree survival and general growth data

Two to three weeks after planting, quality and stock will be checked to determine whether replanting of dead trees is necessary. Where survival is less than 90%, replanting will be carried out. After this first monitoring visit, periodic site visits will be carried out. This will include at least three visits during the first year, three during the second year, two in the third year and at least one annual monitoring visit in the years thereafter.

For monitoring purposes, mapping of the planted areas will be conducted by GPS to determine the polygon of the planting area. Surface will also be measured with a measuring tape.

The plantation will be assessed as well for plant development, plantation quality, weed control, pests and diseases. For these monitoring visits, field forms are used (see annex 1) and all this information is stored in the database of the Decision Support System (DSS), as referred to in paragraph 7.1.

7.4 Monitoring of tree growth (volume) and plantation development (t=t)

Monitoring of tree growth and development of the plantations per species, is done according a protocol summarized below:

GENERAL OBJECTIVE

- Determine wood volumes and above ground biomass during the whole crediting period

SPECIFIC OBJECTIVES

- Define the growth in wood volume, yield and development of the forestry plantations
- Define the increase of biomass within the forestry plantations
- Evaluate the quality of the site for each species
- Establish site indices and growth models
- Define the behavior of different species considering interactions with site and management.

These measurements will initially be carried out at least bi-annually. However, this frequency can be adapted according to the growth and development of different species. The main variables measured to assess this are provided in Form 3 of annex 1.

Growth and development characteristics 1 (Form 3)

- DBH (cm)
- Total height (m)
- Mortality
- Competition
- Light/shade
- Health

After the first thinning, other growth and development variables will be included, as described in Form 4 of annex 1.

Growth and development characteristics 2 (Form 4)

- Area of coverage
- Position and shape of the crown
- Form and stem quality
- Commercial height (m)

7.4.1 Installation of permanent sample plots

In order to gather reliable data on tree growth and development, permanent sample plots are established. Installation of permanent sample plots will be based on the strategy for forest sampling, which was developed by the School of Forest Science at the University San Simon in Cochabamba and the CETEFOR Foundation (Stilma, 2004). Based on this strategy, and in accordance with the monitoring section in the PDD, Sicirec Bolivia ltda developed a manual for monitoring in the ArBolivia plantations. This manual contains detailed guiding principles for monitoring within the ArBolivia project. Clear guidance for each process makes quality control and assurance possible. The full guide is available on request. Below the main principles are discussed.

7.4.2 Stratification

Each Tree species might respond differently for different types of site and therefore sample plots are established for different strata. Stratification for sampling is based on the following criteria:

A. Different geographic areas: Different zones might differ in climate, therefore it is ensured that plots represent the different zones
B. Strata: Vegetation strata is based on the vegetation cover before land preparation has been completed, i.e. at t=0
C. Tree species: For each of the tree species, plots are selected. For species of which the total surface planted is less than 5 hectares, direct measurements have been made
D. Age: Areas included in the selection process should have an age of at least 3 years.

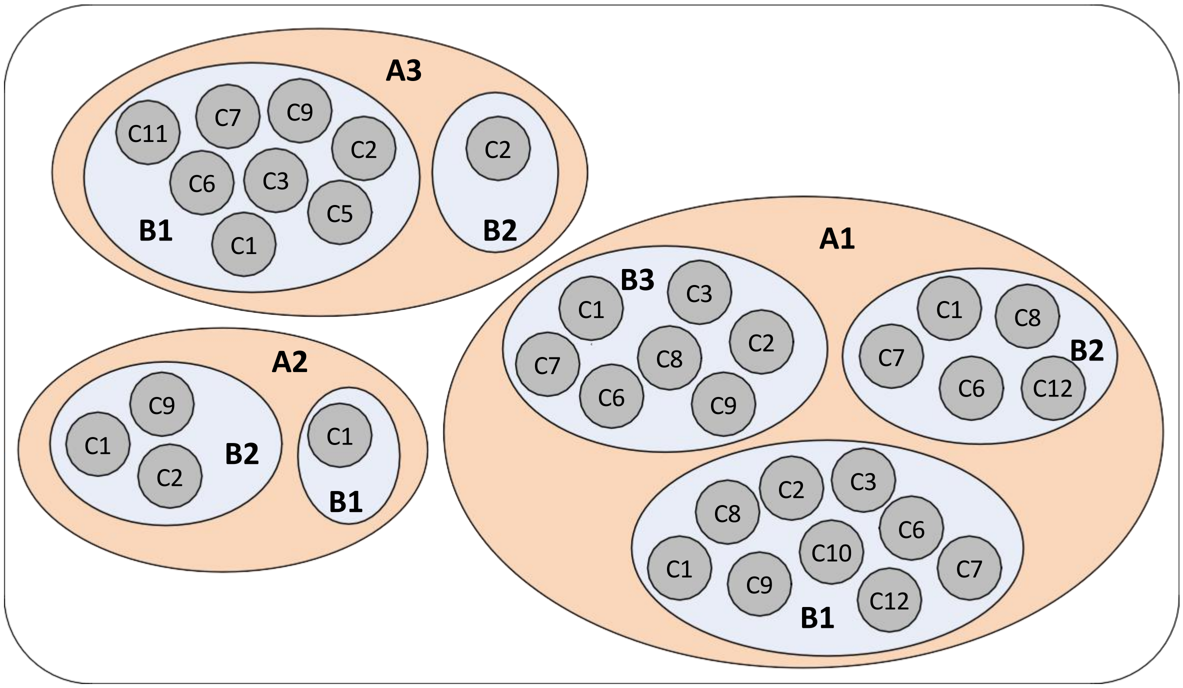
In Table 7.1, the criteria and indicators for stratification are shown. In addition to this, Figure 7.1 visualizes the different strata.

7.1: Stratification criteria for the distribution of Permanent Sample Plots

Strata	Level	Description	Remark
A) Area	3	A1) Ichilo (SCZ) A2) Trópico de Cochabamba (CBA) A3) Abel Iturralde, José Balivian (LPZ/BEN)	
B) Former vegetation cover	4	B1) Annual crops B2) Perennial crops B3) Grassland B4) Grassland with trees	Strata vegetation t=0
C) Tree specie	12	C1) Tejeyque *(Centrolobium tomentosum)* C2) Teca *(Tectona grandis)* C3) Verdolago negro de ala *(Terminalia amazonia)* C4) Verdolago negro de pepa *(Buchenavia oxycarpa)* C5) Verdolago amarillo *(Terminalia argentea)* C6) Palo Román *(Tapirira guianensis)* C7) Palo María *(Calophyllum brasiliense)* C8) Jichituriqui *(Aspidosperma macrocarpon)* C9 Almendrillo *(Dipteryx odorata)* C10) Serebo *(Schizolobium amazonicum)* C11) Palo yugo *(Stryphnodendron purpureum)* C12) Trompillo de altura *(Guarea rusbyi)*	Sum of the surface of a specific specie should be >=5 has
D) Age	4	D1) Year (oct 2011 - present)	First plantations established in 2007

Source: based on Bailly & Stilma, 2012

Figure 7.1 *Stratification for the selection of permanent sample plots*



Considering these stratification criteria, the proposed locations of permanent sample plots have been selected from the list of planted sectors with the RANDOM-function in EXCEL.

No significant differences have been found between growth per species in the different strata A and B.

Since the choice of species is based on site characteristics, no further stratification based on soil or vegetation characteristics is necessary.

7.4.3 Size and shape of the plots

In order to select the size of the plots, the following criteria are taken into account:

- ***Density of the plantation-*** Various studies on the size of experimental plots have been conducted and concluded that trials plots of 10-15 trees give sufficient precision with regard to relative growth, height and diameter. Based on this information a plot size of 15 trees is used, which takes into account the final projection of the plantation. In mixed plantations the number of trees is increased in proportion to the number of different species present in the plantation (Wright 1964 in Stilma, 2007).
- ***Numbers of clearings, which are realized in an entire rotation period-*** It is considered that between 2 and 5 thinnings will be carried out before the final harvest, depending on the rotation period of the tree species. Assuming 10-15 trees remain at the final harvesting stage; this means plots should contain 40 - 90 trees in the initial stage. Based on a tree density of 3x3 this means plots of 0.04 ha's for fast growing tree species and plots of 0.08 ha's for slow growing tree species.

The plots are rectangular or square in shape. This makes it easier with a simple mark to measure every year the same trees. It is important to know the exact surface of the sample plot; the 4 vertices have to be measured, respecting the spacing of the trees. In case of slopes corrections for surface have to be made.

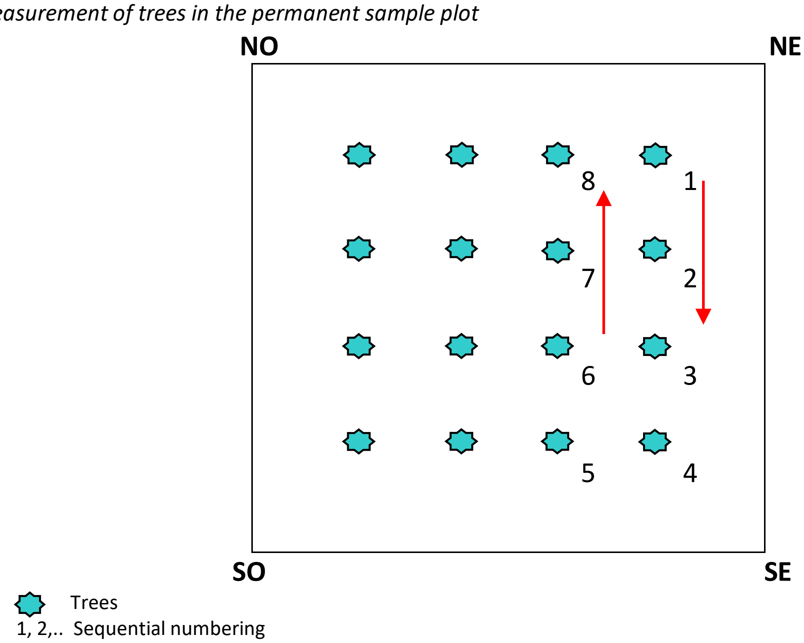
7.4.4 Demarcation and marking of plots

Account has been taken of the possibility that future measurements within the plots may be conducted by different technicians than those who conducted the initial surveys. In order to ensure that no mistakes are made, plastic tubes (1/2 or 1m) are used and are painted at the top to facilitate identification and to ensure future measurements with no errors.

7.4.5 Measurement of the trees

Trees are measured using the following method: The technician will start in the North East point (NE) of the sample plot and carry out the measurement north - south – north. Trees are numbered according the sequence as shown in Figure 7.2.

Figure 7.2: Measurement of trees in the permanent sample plot



It is not necessary to put numbers on the trees but it is necessary to mark the place where the dbh is measured. Measurement of trees always has to follow the same sequence to avoid future errors.

Trees which are not planted, have been cut or have died, are all considered as dead trees. These trees will be assigned a code on the data sheets.

7.4.6 Number of plots

The acceptable level of precision for estimates of biomass stocks is set at +-20% of the mean at a 95% confidence level.
To evaluate variance and determine the number of sample plots necessary, initially data of 6 plots per stratum are used. Based on that the minimum number of plots per stratum is defined using the formula below.

$$n = \frac{(N \times s)^2}{\frac{N^2 \times E^2}{t^2} + N \times s^2}$$

Source: Pearson 2005

7.5 Wood and Carbon stock monitoring

Carbon stocks will be estimated for each stratum and multiplied by the surface of each stratum. The following equations will be used:

$$P(t) = \sum_{i}^{I} (PA(t)\, i + PB(t)\, i) * Ai$$

Where:
P(t) = carbon stocks within the project boundary at time *t* achieved by the project activity (t C)
PA(t) i = carbon stocks in above-ground biomass at time *t* of stratum *i* achieved by the project activity during the monitoring interval (t C/ha)
PB(t) i = carbon stocks in below-ground biomass at time *t* of stratum *i* achieved by the project activity during the monitoring interval (t C/ha)
Ai = project activity area of stratum *i* (ha)
i = stratum *i*

For above-ground biomass

PA(t) is calculated per stratum *i* as follows:

$$PA(t) = E(t) * 0.5$$

Where:
PA(t) = carbon stocks in above-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)
E(t) = estimate of above-ground biomass at time *t* achieved by the project activity (t dm/ha)
0.5 = carbon fraction of dry matter (t C/t dm)

E(t) will be estimated through the following steps:

Step 1: The diameter at breast height (DBH) or DBH and tree height will be measured
Step 2: Above-ground biomass (AGB) will be estimated using algometric equations, as follows:

Biomass expansions factors and stem volume as follows:

*E(t) = SV * BEF * WD*

Where:
E (t) = estimate of above-ground biomass at time *t* achieved by the project activity (t dm/ha)
SV = stem volume (m^3/ha)
WD = basic wood density (t dm/m^3)
BEF = biomass expansion factor (over bark) from stem volume to total volume (dimensionless)

$$SV(t) = \sum_{j}^{I} (g(t)\, j + PB(t)\, i) * i$$

$$SV(t) = \sum G * H(t) * FF(t)\, i + S/10000$$

SV(t) = stem volume (m^3/ha)
FF = Form Factor
G(t)= Basal Area (m^2/tree) at time t
S = surface sample plot (m^2)
$G = \pi/4*(dbh)^2$

A default *BEF of 1.5 proposed* by the IPCC good practice guidance (Table 3A1.10) for LULUCF is used in order to obtain a conservative estimate of total biomass.

SV will be calculated from on-site measurements using DBH, height and Form Factor (FF) per specie. FF is calculated based upon measurements, for each of the tree species, from reference stands.

Consistent application of *BEF* will be secured over total stem volume.

For below-ground biomass

PB(t) will be estimated for each stratum *i* as follows:

*PB(t) = E(t) * R * 0. 5*

Where:
PB(t) = carbon stocks in below-ground biomass at time *t* achieved by the project activity during the monitoring interval (t C/ha)
R = root to shoot ratio (dimensionless)
0.5 = carbon fraction of dry matter (t C/t dm)

Root to shoot ratios for the species concerned are not available. Therefore, the conservative default value of 0.42 (secondary tropical and sub-tropical forest) of the IPCC good practice guidance for LULUCF, Table 3A.1.8 are used.

7.6 Growth projections

Volume projections in time are based on Basal Areas and commercial height extracted from the data from permanent sample plots, which have been measured over time.

Measurements have taken place on an average every 2 years since 2011.

Data is, and will continue to be, processed as follows:

- **Step 1**: **Basal Area calculation**
  Basal Area data is derived from dbh measurement in permanent sample plots.

  BA (tree)= $1/4\pi * dbh^2$

  BA (plot) = ∑ BA (tree1….) in the plots

  This is converted into BA per hectare (m^2/Ha)

- **Step 2: Define growth projection in time for Basal Area**
  Measurements have then been repeated for the sample plots at different times. A regression analysis is carried out in order to project optimal growth of the trees when there is no competition from other trees. This so-called *trend line* is most reliable when its R-squared value is at or near 1. Therefore, the trend line with the highest R-squared value is chosen.

  For example:
  Data analysis of the Basal Areas of *Tectona grandis* show a best fit for a power model $y=1.5892X^{1.0136}$ in which y is BA at time t and x = t in years. For the best fit $R^2 = 0.6383$

  The basal areas analysis is based on the growth of each tree without considering competition with other trees. Whenever trees are competing with each other the Basal Area increment will be less than optimal and therefore a thinning regime is applied. Maximum Basal Area, for optimal growth is estimated to be $20m^2/ha$, which is considered to be conservative, given the relatively fertile nature of the sites.

Figure 7.3 shows an example for *Tectona grandis,* in which the remaining Basal Area in m^2/Ha and the cumulative Basal area (m^2/Ha) are shown. The cumulative basal area is the Basal Area of the remaining standing trees + the Basal Area of the trees extracted.

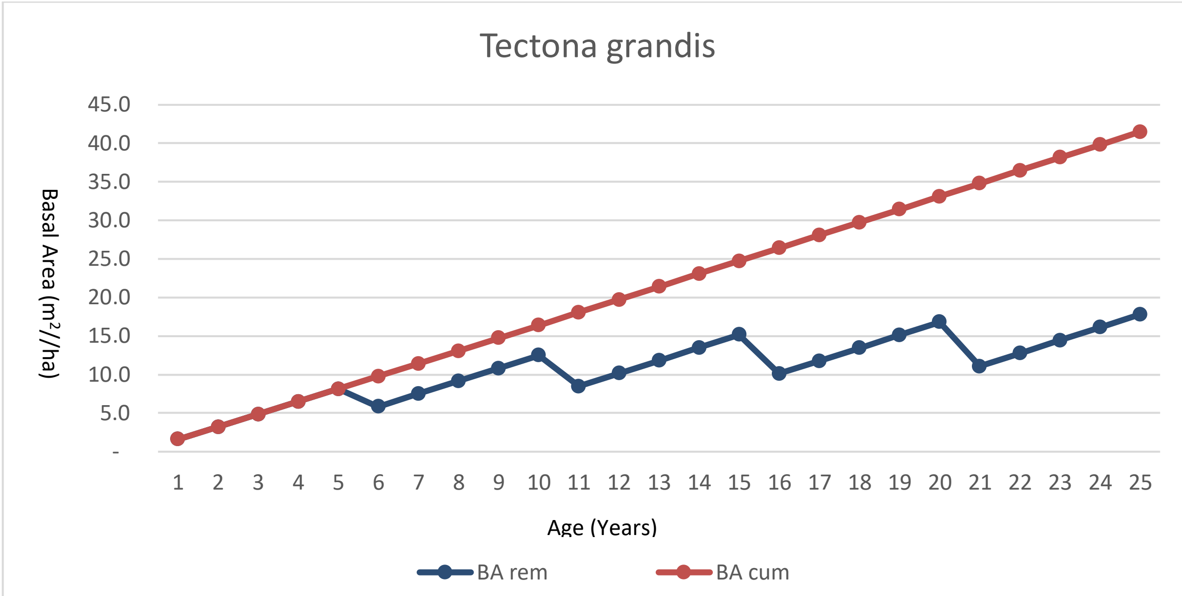


Fig 7.3: A graph illustrating the cumulative (BA cum) and remaining (BA rem) Basal Area in m^2/ha

Wood extracted due to thinning is not considered as a carbon pool since it cannot be monitored

Step 3: **Estimation of Height growth based on regression analysis.**
Similar to the Basal Area, a regression analysis is done for height growth. This is based on the height of the stem up to the crown, since in the field these measurements can be made more accurately than for total height. For example, for *Tectona grandis* the growth in tree height is best projected by the power model: $Y = 4.5772x^{0.4508}$

In Figure 7.4 the trendline for height over time is shown for *Tectona grandis.*

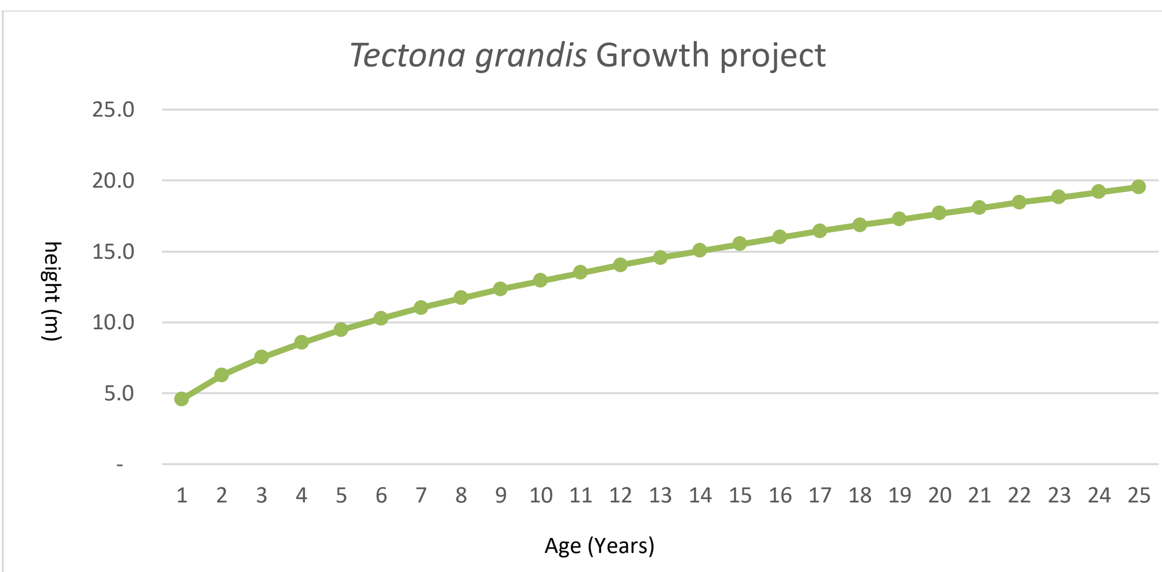


Figure 7.4: Tree height(m) in time is shown for Tectona grandis

Step 4: Form Factor
The form factor of the trees is calculated based on measurements of felled stems.

FFc = *The Form Factor of commercial volume is calculated for each species based on measurements of* harvested trunks from the plantations, whereas F = Vr/Vc, in which:
- *Vr= Real Volume of the trunk*
- *Vc = Volume of the cylinder using max diameter*

For teak the form factor is 0.7.

This is also the lowest ff-value founds amongst any of the native species planted and so this 0.7 value is also applied to the other native species until actual data from felled wood becomes available from future extraction.

Step 5: Stem Volume calculation
Different trend lines are fitted to the growth data for height and basal area respectively.

Volume is calculated using the following formula

SV(t) = Hc(t) * BA(t) * FFc

Whereas:

SVt = *Stem Volume of the tree stand at time t in m^3 per Hectare*
Hc= *Commercial Height – commercial height in meters of the measured trees in a sample plot.*
BA= *Basal area: The sum of the Basal area of all the trees in m^2 per Ha*
FFc = *The Form Factor of commercial volume of the stems*

Table 7.4 compares the project's model for Tectona growth with the best available literature (data from Pérez et al. (2005), which provides recorded growths for Tectona grandis plantations in Costa Rica) and shows clearly that our own estimations are very conservative. For a more detailed description of the model outputs for each species, please see Section 8.2.2.

Table 7.4: A comparison of Diameter at Breast Height (DBH), Basal Area (BA) and overall height for Tectona Grandis from the project's growth models and Pérez et al. (2005). Hstem = Height of stem from base to crown, Hd = Dominant Height

	DBH (m)			**BA (*m^2*)**			**Height (m)**		
Year	**Project**	**Literature**		**Project**	**Literature**		**HStem Project**	**Hd Literature***	
1	0.04			1.6			4.6		
2	0.06			3.2			6.3		
3	0.07			4.8			7.5		
4	0.09	0.12	0.12	6.5	5.8	6.4	8.6	9.4	9.4
5	0.10			8.1			9.5		
6	0.11			5.9			10.3		
7	0.12			7.5			11.0		
8	0.13	0.22	0.22	9.2	12.4	12.3	11.7	16.8	16.8
9	0.14			10.8			12.3		
10	0.15			12.5			12.9		
11	0.16			8.5			13.5		
12	0.18	0.30	0.30	10.2	13.8	15.4	14.0	22.2	22.2
13	0.19			11.8			14.5		
14	0.21			13.5			15.0		
15	0.22			15.2			15.5		
16	0.23		0.36	10.1		16.8	16.0		26
17	0.25			11.8			16.4		
18	0.27	0.38		13.4	17.3		16.8	27.5	
19	0.28			15.1			17.3		
20	0.30		0.40	16.8		21.5	17.7		28.7
21	0.31			11.1			18.1		
22	0.34			12.8			18.4		
23	0.36			14.4			18.8		
24	0.38	0.44		16.1	18.2		19.2	30.6	
25	0.40			17.8			19.5		

**Hcrown ≈ 0.65*Hd*

7.7 Summary of data to be collected for Carbon Stock Monitoring and Recording Frequency

Table 7.2 describes the data that is to be collected, or used, to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary, and resulting from the project. It also describes how this data will be archived.

Table 7.2: A description of data-type collected, collection frequency and storage method for carbon stock monitoring

Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
Location of the area where the project activity will be implemented	GIS system based on field surveys and satellite imagery	UTM WGS84 coordinate, X,Y,Z	(m)	once	100%	Electronic, pap er,	GPS is used
Ai – size of the areas where the project activity has been implemented for each type of strata	GIS system based on field surveys and satellite imagery	Ha	(m)	Yearly	100%	Electronic	GPS is used
Location of the permanent sampling plots	Project maps and project design	UTM WGS84 coordinate, X,Y,Z	Defined	5 years	100%	Electronic, paper (field form)	GPS is used to define exact location. This is registered in a data base and on a map
Diameter of tree at breast height (1.3 m)	Permanent plot	Cm	(m)	2 years	Each tree in the sample plot	Electronic (field forms)	Measure diameter at breast height (DBH) for each tree that falls within the sample plot and applies the size limit
Height of tree	Permanent plot	M	(m)	2 years	Each tree in the sample plot	Electronic, paper (field forms)	Measure height (H) for each tree that falls within the sample plot and applies to size limit
Total CO_2	Project activity	Metric tonnes	(c)	5 years	All project data	Electronic	Based on data collected from all plots and carbon pools

7.8 Data for monitoring of leakage

In compliance with the relevant methodology AR-AMS0001/version 05, monitoring is only needed in cases where leakage is considered significant. In this case leakage is not considered significant and it is therefore not necessary to be monitored. However, as mentioned in paragraph 6.1, potential leakage will nevertheless be monitored over time, by monitoring land use change. This monitoring may also demonstrate a positive effect or collateral carbon benefits. Land Use Change is monitored comparing the land use changes, with the actual situation, every 5 years period.

7.9 Procedures and Responsibilities

7.9.1 Data gathering and processing

Data gathering and processing of data from the permanent sample plots is undertaken by Sicirec Bolivia staff with the assistance of thesis students from the universities for forest science in Cochabamba and Santa Cruz and from various universities in Europe. The data gathering, processing and analysis is supervised by the internal monitoring unit of ArBolivia and the supervisors assigned by each university.

Data is stored in the data base. An application in the data base makes it possible to extrapolate the data of the permanent sample plots to the total volume of wood and biomass produced per species for each specific stratum and geographic area.

7.9.2 Quality control

Quality control is conducted by the Internal Monitoring Unit as described in section G.1 of the PDD. Once this process is completed, the whole process of data gathering, processing and analysis can be verified by an external entity.

8. Monitoring results

When the project started in 2007, data on growth was based on measurements in uncontrolled plots in referential stands, measurements of individual trees, literature and expert knowledge. The monitoring data from the ArBolivia initiative has made it possible to measure dbh and tree height in representative permanent sample plots, from which accurate estimations of existing wood volumes can be deduced. Repeated measurements have made it possible to adapt the growth equations, specific to the project areas.

8.1 Growth data from Sample Plots

In Table 8.1, the number of plots per species is shown and if the result of the measurements has led to an adaption of the growth projections. For some of the species, additional data exists from non-permanent sample plots.

Growth projections have been adapted from the initial projections if these have been significantly different from the initial growth projections. Precision level should be less than 20%:

Table 8.1: Description of data collection from sample plots and whether this led to a change in growth rates

Specie	Common name	Permanent Sample Plots	Additional measurements non permanent Sample Plots	First year measured	Last year measurement	Total number of measurements	Total surface planted under PV (ha)	Result
Calophyllum brasiliense	Palo maría	21		2011	2018	52	44,4	adapted
Centrolobium tomentosum	Tejeyeque	43	18	2011	2018	123	100,8	adapted
Dipteryx odorata	Almendrillo	6	9	2012	2018	26	34,7	confirmed
Guarea rusby	Trompillo de altura	8	6	2011	2018	27	13,3	adapted
Schizolobium amazonicum	Serebo	2	2	2015	2018	5	8,1	adapted
Stryphnodendron purpureum	Palo yugo	3	9	2012	2018	21	14,2	confirmed
Tapirira guianensis	Palo román	12		2011	2018	37	15,6	adapted
Tectona grandis	Teca	13		2012	2018	33	75,2	adapted
Terminalia amazonia	Verdolago negro (ala)	5		2012	2018	16	5,8	confirmed
Terminalia oblonga	Verdolago amarillo (ala)	1	1	2012	2018	4	4,5	confirmed
Total		114	45				320,3	

8.2. Results per species

8.2.1 Form factor

Diameters on both the top and bottom of the wood stems is measured and the from factor is calculated for the species: *Centrolobium tomentosum (FF=0.80) , Schizolobium amazonicum (FF=0.87), Tectonda grandis* (FF= 0.70). For all other species a conservative value for the FF of 0.70 is used, since this is the lowest measured FF.

8.2.2. Growth projections

The equations derived from the measured dbh and height data have resulted in growth estimations as summarized for all species in Table 8.2. Growth projections for a crediting period of 40 years is shown in this table. It is important to mention that these are conservative projections, since a monocyclical silvicultural system is considered. However, in practice full plantation management will focus on a polycyclical system, which means much more biomass will be stored. The reason for this conservative approach is the lack of knowledge on natural regeneration of the different species. Sicirec Bolivia ltda is currently experimenting with natural regeneration and thus creation of multi-aged tree stands.

Table 8.2: Growth projection per species for standing wood volume (SW) and Extracted Wood (EW) Volume in m^3/hectare

Wood volume per hectare (m3)																								
Age in years	*Schizolobiu m amazonicum*		*Stryphnoden dron purpureum*		*Guarea rusby*		*Centrolobium tomentosum*		*Tectona Grandis*		*Calophyllum basiliense*		*Tapirira guianensis*		*Virola flexuasa*		*Dipteryx odorata*		*Buchenavia oxycarpa*		*Terminalia oblonga*		*Terminalia amazonica*	
	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW	SW	EW
0	0	0	0	0		0	0	0			0	0			0	0	0	0	0	0	0	0	0	0
1	2	0	13	0	0	0	2	0	5	0	0	0	0	0	16	0	8	0	8	0	8	0	12	0
2	15	0	28	0	1	0	7	0	14	0	5	0	2	0	33	0	16	0	16	0	16	0	24	0
3	41	0	48	0	2	0	15	0	25	0	10	0	5	0	49	0	24	0	24	0	24	0	36	0
4	41	28	73	0	6	0	24	0	39	0	19	0	12	0	50	15	32	0	32	0	32	0	48	0
5	69	0	102	0	12	0	27	9	54	0	30	0	22	0	67	0	40	0	40	0	40	0	60	0
6	105	0	95	41	16	4	39	0	42	27	43	0	26	11	83	0	36	12	36	12	36	12	72	0
7	147	42	129	0	30	0	53	0	58	0	35	23	43	0	99	0	44	0	44	0	44	0	84	0
8	197	0	168	0	49	0	69	0	75	0	51	0	66	0	90	26	52	0	52	0	52	0	64	32
9	126	0	210	0	50	0	65	22	93	0	69	0	95	0	106	0	60	0	60	0	60	0	76	0
10	157	0	180	77	81	0	83	0	113	0	90	0	92	39	122	0	68	0	68	0	68	0	88	0
11	191	0	226	0	122	56	102	0	80	72	68	45	131	0	139	0	76	0	76	0	76	0	100	0
12	227	0	276	0	113	0	123	0	100	0	91	0	178	0	120	35	63	21	63	21	63	21	112	0
13	266	266	13	0	172	0	101	43	120	0	116	0	140	93	136	0	71	0	71	0	71	0	124	0
14	2	0	28	0	243	0	123	0	142	0	144	0	197	0	152	0	79	0	79	0	79	0	105	31
15	15	0	48	0	214	195	147	0	165	0	113	61	263	0	169	0	87	0	87	0	87	0	117	0
16	41	0	73	0	308	0	172	0	113	124	144	0	204	136	144	41	95	0	95	0	95	0	129	0
17	41	28	102	0	0	0	139	59	135	0	176	0	282	0	160	0	103	0	103	0	103	0	141	0
18	69	0	95	41	1	0	164	0	159	0	212	0	0	0	177	0	83	28	83	28	83	28	153	0
19	105	0	129	0	2	0	191	0	183	0	150	100	2	0	193	0	91	0	91	0	91	0	165	0
20	147	42	168	0	6	0	220	0	208	0	186	0	5	0	163	46	99	0	99	0	99	0	136	41
21	197	0	210	0	12	0	175	75	140	180	226	0	12	0	180	0	107	0	107	0	107	0	148	0
22	126	0	180	77	16	4	204	0	165	0	268	0	22	0	196	0	115	0	115	0	115	0	160	0
23	157	0	226	0	30	0	235	0	190	0	0	0	26	11	212	0	123	0	123	0	123	0	172	0
24	191	0	276	0	49	0	267	0	217	0	5	0	43	0	229	0	131	0	131	0	131	0	184	0
25	227	0	13	0	50	0	2	0	244	0	10	0	66	0	245	245	104	35	104	35	104	35	196	0
26	266	266	28	0	81	0	7	0	5	0	19	0	95	0	16	0	112	0	112	0	112	0	208	0
27	2	0	48	0	122	56	15	0	14	0	30	0	92	39	33	0	120	0	120	0	120	0	220	0
28	15	0	73	0	113	0	24	0	25	0	43	0	131	0	49	0	128	0	128	0	128	0	232	0
29	41	0	102	0	172	0	27	9	39	0	35	23	178	0	50	15	136	0	136	0	136	0	244	0
30	41	28	95	41	243	0	39	0	54	0	51	0	140	93	67	0	108	36	108	36	108	36	256	256
31	69	0	129	0	214	195	53	0	42	27	69	0	197	0	83	0	116	0	116	0	116	0	12	0
32	105	0	168	0	308	0	69	0	58	0	90	0	263	0	99	0	124	0	124	0	124	0	24	0
33	147	42	210	0	0	0	65	22	75	0	68	45	204	136	90	26	132	0	132	0	132	0	36	0
34	197	0	180	77	1	0	83	0	93	0	91	0	282	0	106	0	140	0	140	0	140	0	48	0
35	126	0	226	0	2	0	102	0	113	0	116	0	0	0	122	0	148	148	148	148	-	148	60	0
36	157	0	276	0	6	0	123	0	80	72	144	0	2	0	139	0	8	0	8	0	8	0	72	0
37	191	0	13	0	12	0	101	43	100	0	113	61	5	0	120	35	16	0	16	0	16	0	84	0
38	227	0	28	0	16	4	123	0	120	0	144	0	12	0	136	0	24	0	24	0	24	0	64	32
39	266	266	48	0	30	0	147	0	142	0	176	0	22	0	152	0	32	0	32	0	32	0	76	0
40	2	0	73	0	49	0	172	0	165	0	212	0	26	11	169	0	40	0	40	0	40	0	88	0
Vol (max)	266		276		308		267		244		268		282		245		148		148		140		256	

The following sections provide greater detail on the growth models for individual species.

8.2.2.1 Growth Model - *Centrolobium tomentosum*

The output of the growth models for *Centrolobium tomentosum* are described in Table 8.3, with an illustration of this growth provided in Figure 8.1.

Table 8.3: The output of the project's growth model for Centrolobium tomentosum

Year	Basal Area (m^2)	Height (m)	Height Increment (m)	Form Factor	Basal Area Increment (m^2)	Basal Area Cumulative (m^2)	Thinning Percentage (% Basal Area)	Standing Volume (m^3)	Volume of thinning (m^3)
1	0.78	3.55	3.55	0.80	0.78	0.78		2	
2	1.74	5.25	1.69	0.80	0.97	1.74		7	-
3	2.80	6.59	1.34	0.80	1.06	2.80		15	-
4	3.92	7.75	1.16	0.80	1.12	3.92		24	-
5	5.09	8.78	1.04	0.80	1.17	3.81	0.25	27	9
6	6.29	9.73	0.95	0.80	1.21	5.02		39	-
7	7.54	10.61	0.88	0.80	1.24	6.26		53	-
8	8.81	11.44	0.83	0.80	1.27	7.54		69	-
9	10.11	12.22	0.78	0.80	1.30	6.63	0.25	65	22
10	11.43	12.97	0.75	0.80	1.32	7.95		83	-
11	12.78	13.68	0.71	0.80	1.35	9.30		102	-
12	14.15	14.37	0.69	0.80	1.37	10.67		123	-
13	15.54	15.03	0.66	0.80	1.39	8.44	0.30	101	43
14	16.94	15.67	0.64	0.80	1.41	9.84		123	-
15	18.36	16.29	0.62	0.80	1.42	11.27		147	-
16	19.80	16.90	0.60	0.80	1.44	12.71		172	-
17	21.26	17.48	0.59	0.80	1.45	9.91	0.30	139	59
18	22.73	18.05	0.57	0.80	1.47	11.38		164	-
19	24.21	18.61	0.56	0.80	1.48	12.86		191	-
20	25.70	19.15	0.54	0.80	1.50	14.36		220	-
21	27.21	19.69	0.53	0.80	1.51	11.11	0.30	175	75
22	28.73	20.21	0.52	0.80	1.52	12.63		204	-
23	30.26	20.72	0.51	0.80	1.53	14.16		235	-
24	31.81	21.22	0.50	0.80	1.54	15.70		267	

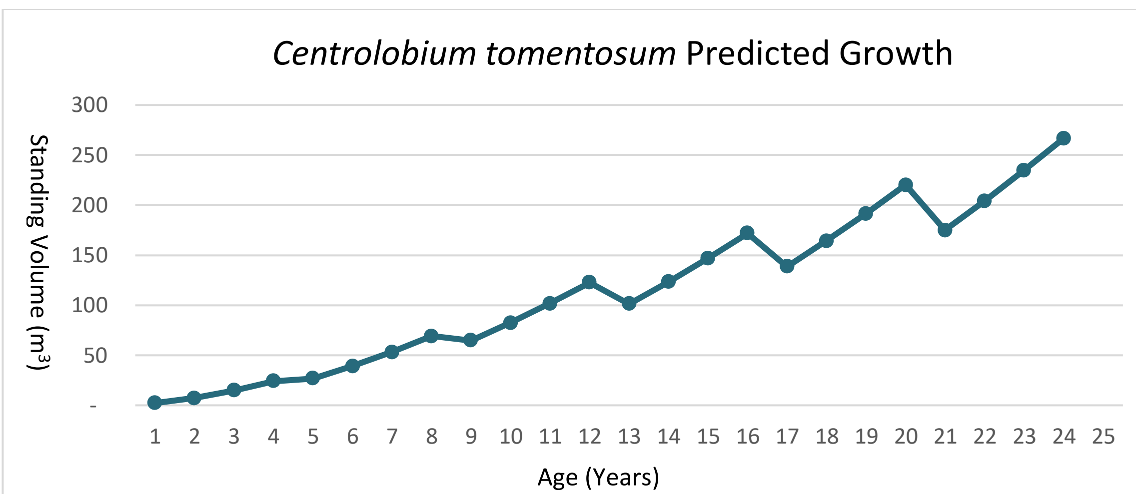


Figure 8.1: An illustration of the growth rate of Centrolobium tomentosum through predicted standing volume

8.2.2.2 Growth Model – Calophyllum brasiliense

The output of the growth models for *Calophyllum brasiliense* are described in Table 8.4, with an illustration of this growth provided in Figure 8.2.

Table 8.4: The output of the project's growth model for Calophyllum brasiliense

Year	Basal Area (m^2)	Height (m)	Height Increment (m)	Form Factor	Basal Area Increment (m^2)	Basal Area Cumulative (m^2)	Thinning Percentage (% Basal Area)	Standing Volume (m^3)
0	0.0	0.0	0.0	0.7	0.0	0.0		-
1	1.2	1.3	1.3	0.7	1.2	1.2		-
2	2.8	2.3	1.0	0.7	1.6	2.8		5
3	4.6	3.3	0.9	0.7	1.8	4.6		10
4	6.5	4.1	0.9	0.7	1.9	6.5		19
5	8.6	4.9	0.8	0.7	2.1	8.6		30
6	10.7	5.7	0.8	0.7	2.1	10.7		43
7	13.0	6.5	0.8	0.7	2.2	7.8	0.4	35
8	15.3	7.2	0.7	0.7	2.3	10.1		51
9	17.6	7.9	0.7	0.7	2.4	12.5		69
10	20.1	8.6	0.7	0.7	2.4	14.9		90
11	22.6	9.3	0.7	0.7	2.5	10.4	0.4	68
12	25.1	10.0	0.7	0.7	2.5	13.0		91
13	27.7	10.6	0.7	0.7	2.6	15.6		116
14	30.3	11.3	0.7	0.7	2.6	18.2		144
15	33.0	12.0	0.6	0.7	2.7	13.6	0.4	113
16	35.7	12.6	0.6	0.7	2.7	16.3		144
17	38.5	13.2	0.6	0.7	2.8	19.0		176
18	41.3	13.8	0.6	0.7	2.8	21.8		212
19	44.1	14.5	0.6	0.7	2.8	14.8	0.4	150
20	47.0	15.1	0.6	0.7	2.9	17.7		186
21	49.9	15.7	0.6	0.7	2.9	20.6		226
22	52.8	16.3	0.6	0.7	2.9	23.5		268

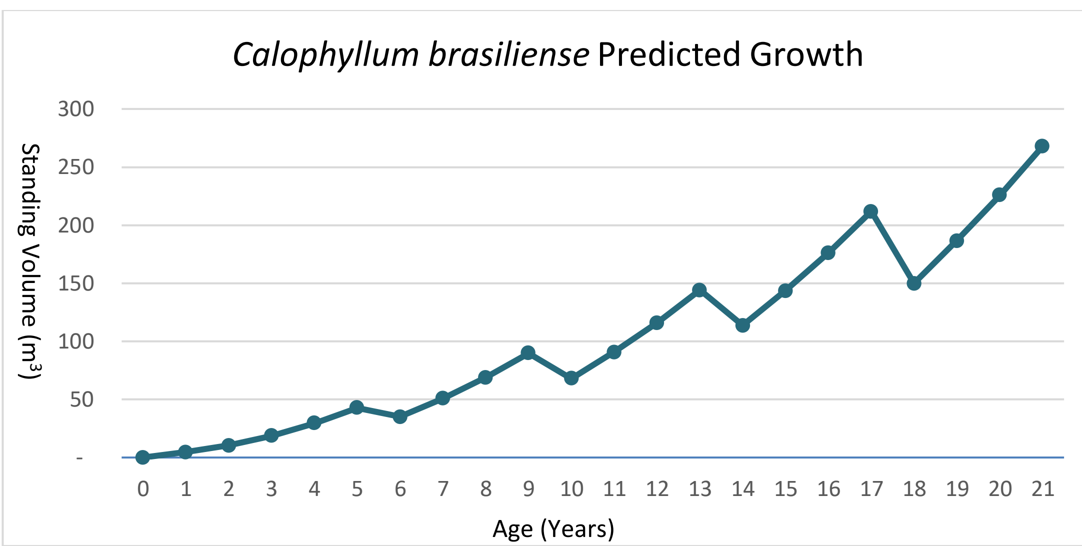


Figure 8.2: An illustration of the growth rate of Calophyllum brasiliense through predicted standing volume

8.2.2.3 Growth Model – *Guarea rusby*

The output of the growth models for *Guarea rusby* are described in Table 8.5, with an illustration of this growth provided in Figure 8.3.

Table 8.5: The output of the project's growth model for Guarea rusby

Year	Basal Area (m^2)	Height (m)	Height Increment (m)	Form Factor	Basal Area Increment (m^2)	Basal Area Cumulative (m^2)	Thinning Percentage (% Basal Area)	Standing Volume (m^3)
1	0.1	1.1	0.5	0.7	0.1	0.1		0
2	0.4	2.3	1.2	0.7	0.3	0.4		1
3	0.9	3.6	1.3	0.7	0.5	0.9		2
4	1.7	5.0	1.4	0.7	0.8	1.7		6
5	2.8	6.3	1.4	0.7	1.1	2.8		12
6	4.2	7.8	1.4	0.7	1.4	2.9	0.30	16
7	5.9	9.2	1.4	0.7	1.7	4.6		30
8	7.9	10.7	1.5	0.7	2.0	6.6		49
9	10.2	12.1	1.5	0.7	2.3	5.8	0.35	50
10	12.9	13.6	1.5	0.7	2.7	8.5		81
11	15.9	15.2	1.5	0.7	3.0	11.5		122
12	19.3	16.7	1.5	0.7	3.4	9.7	0.35	113
13	23.0	18.2	1.5	0.7	3.7	13.4		172
14	27.1	19.8	1.6	0.7	4.1	17.5		243
15	31.6	21.4	1.6	0.7	4.5	14.3	0.35	214
16	36.5	22.9	1.6	0.7	4.9	19.2		308

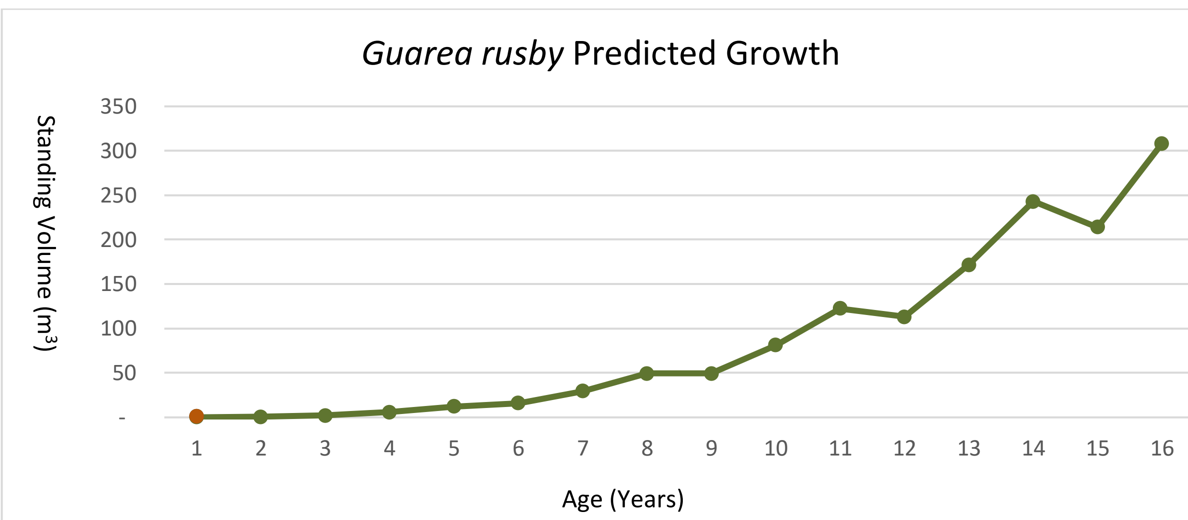


Figure 8.3: An illustration of the growth rate of Guarea rusby through predicted standing volume

8.2.2.4 Growth Model – *Schizolobium amazonicum*

The predicted growth for *Schizolobium amazonicum* is described in Table 8.6, with an illustration of this provided in Figure 8.4. This data is from Sandoval E. (2006) and was used as it provided actual data rather than extrapolated figures from teak.

Table 8.6: Predicted growth for Schizolobium amazonicum. Data from FOMABO (2006)

Year	Standing Volume (m^3)	Volume thinning (m^3)	Volume (m^3/Ha)	Average volume (m^3/ha)
1	2		2	133
2	15		15	133
3	41		41	133
4	41	28	69	133
5	69		69	133
6	105		105	133
7	147		147	133
8	197		197	133
9	126	83	209	133
10	157		157	133
11	191		191	133
12	227		227	133
13	266		266	133
14				133

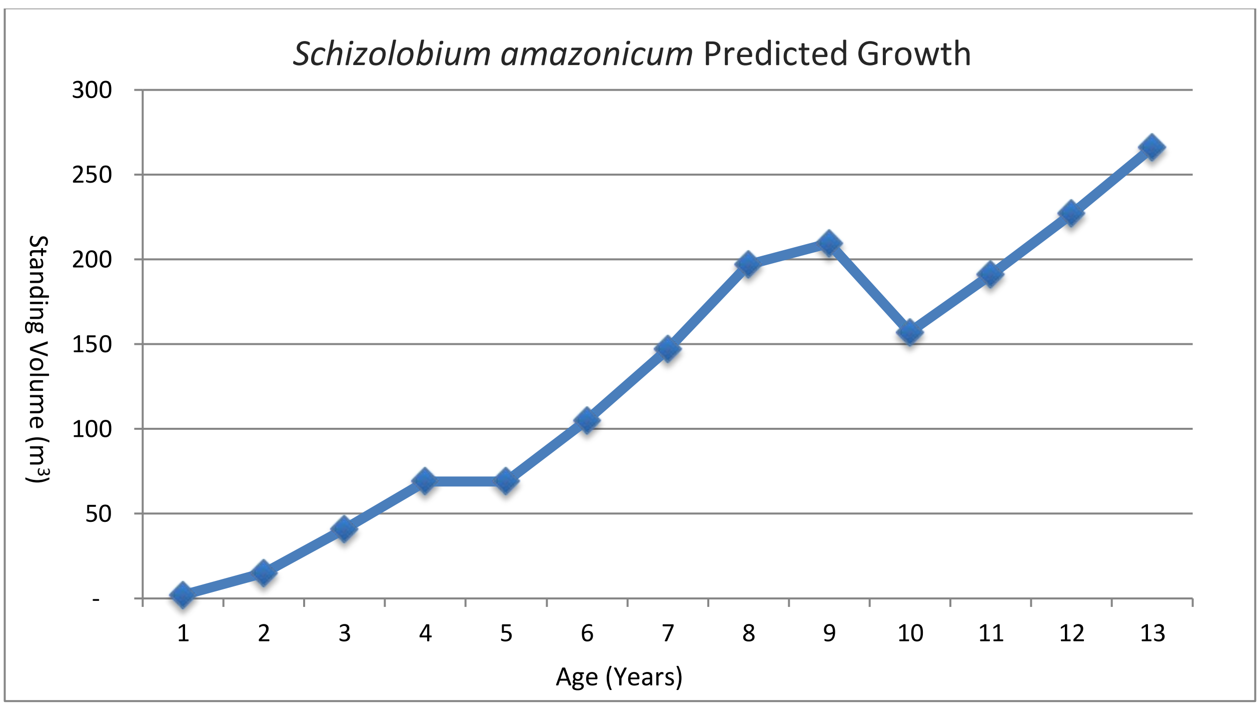


Figure 8.4: An illustration of the growth rate of Schizolobium amazonicum through predicted standing volume

8.2.2.5 Growth Model – *Stryphnodendrum purpureum*

The output of the growth models for *Stryphnodendrum purpureum* are described in Table 8.7, with an illustration of this growth provided in Figure 8.5.

Table 8.7: The output of the project's growth model for Stryphnodendrum purpureum

Year	Basal Area (m^2)	Height (m)	Height Increment (m)	Form Factor	Basal Area Increment (m^2)	Basal Area Cumulative (m^2)	Thinning Percentage (% Basal Area)	Standing Volume (m^3)
1	1.55	3.21	3.21	0.75	1.55	1.55		4
2	3.37	5.31	2.10	0.75	1.82	3.37		13
3	5.32	7.12	1.82	0.75	1.94	5.32		28
4	7.34	8.78	1.65	0.75	2.03	7.34		48
5	9.43	10.32	1.54	0.75	2.09	9.43		73
6	11.58	11.78	1.46	0.75	2.14	11.58		102
7	13.76	13.18	1.40	0.75	2.19	9.63	0.30	95
8	15.99	14.52	1.34	0.75	2.23	11.86		129
9	18.25	15.82	1.30	0.75	2.26	14.12		168
10	20.54	17.07	1.26	0.75	2.29	16.41		210
11	22.86	18.30	1.22	0.75	2.32	13.11	0.30	180
12	25.21	19.49	1.19	0.75	2.35	15.46		226
13	27.58	20.66	1.17	0.75	2.37	17.83		276

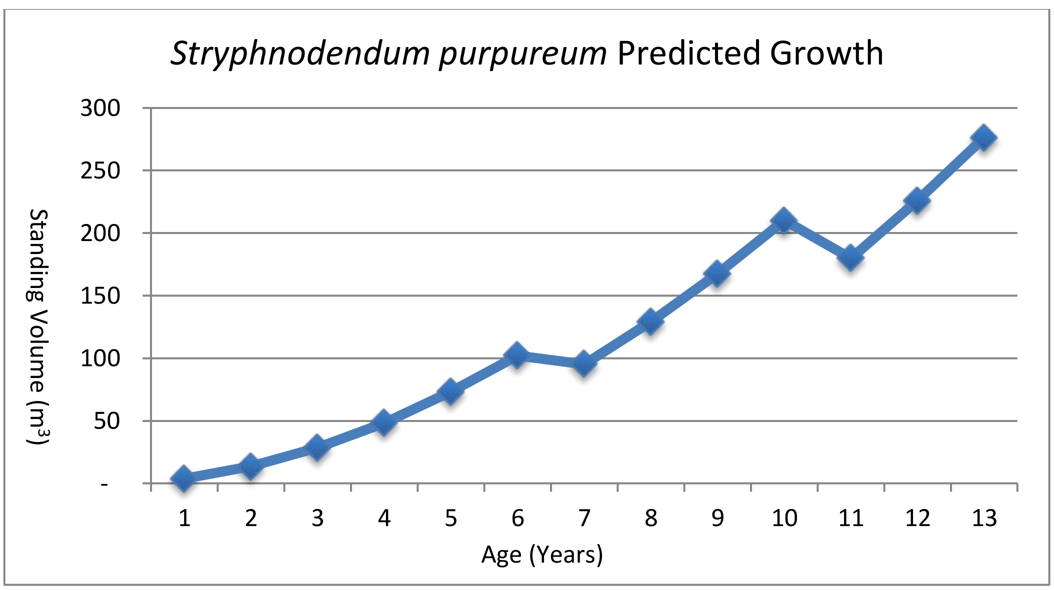


Figure 8.5: An illustration of the growth rate of Stryphnodendum purpureum through predicted standing volume

8.2.2.6 Growth Model – *Tapirira guianensis*

The output of the growth models for *Tapirira guianensis* are described in Table 8.8, with an illustration of this growth provided in Figure 8.6.

Table 8.8: The output of the project's growth model for Tapirira guianensis

Year	Basal Area (m^2)	Height (m)	Height Increment (m)	Form Factor	Basal Area Increment (m^2)	Basal Area Cumulative (m^2)	Thinning Percentage (% Basal Area)	Standing Volume (m^3)
1	0.2	1.8	1.8	0.70	0.2	0.2		0
2	0.8	3.4	1.6	0.70	0.55	0.76		2
3	1.6	4.9	1.5	0.70	0.84	1.59		5
4	2.7	6.3	1.5	0.70	1.11	2.70		12
5	4.1	7.8	1.4	0.70	1.36	4.06		22
6	5.7	9.2	1.4	0.70	1.61	3.97	0.3	26
7	7.5	10.6	1.4	0.70	1.85	5.82		43
8	9.6	11.9	1.4	0.70	2.08	7.90		66
9	11.9	13.3	1.4	0.70	2.31	10.21		95
10	14.5	14.7	1.3	0.70	2.54	8.92	0.3	92
11	17.2	16.0	1.3	0.70	2.75	11.68		131
12	20.2	17.3	1.3	0.70	2.97	14.65		178
13	23.4	18.6	1.3	0.70	3.18	10.70	0.4	140
14	26.8	19.9	1.3	0.70	3.39	14.10		197
15	30.4	21.2	1.3	0.70	3.60	17.70		263
16	34.2	22.5	1.3	0.70	3.81	12.90	0.4	204
17	38.2	23.8	1.3	0.70	4.01	16.91		282

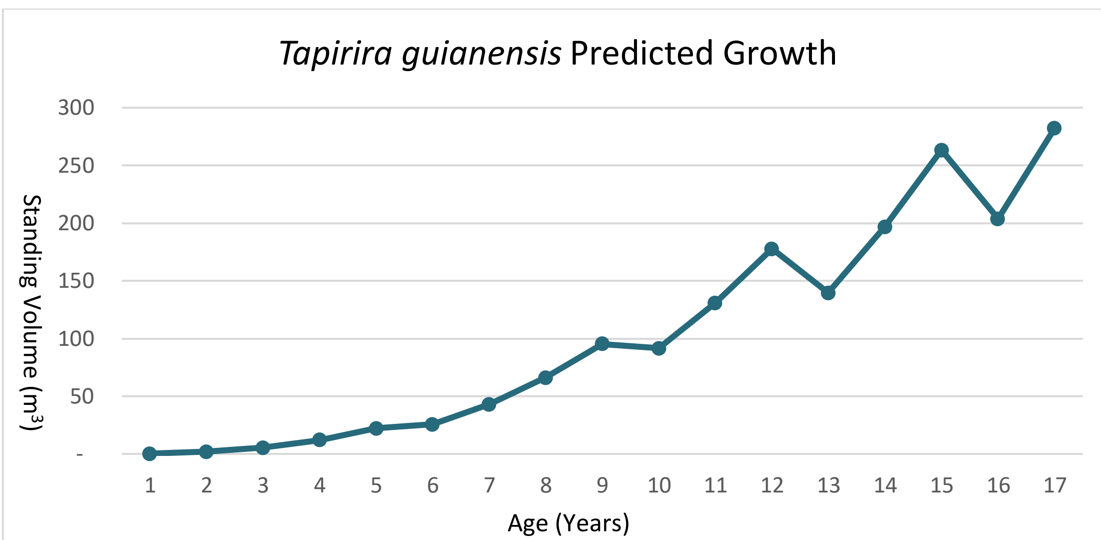


Figure 8.6: An illustration of the growth rate of Tapirira guianensis through predicted standing volume

8.2.2.7 Growth Model – *Tectona grandis*

The output of the growth models for *Tectona grandis* are described in Table 8.9, with an illustration of this growth provided in Figure 8.7.

Table 8.9: The output of the project's growth model for Tectona grandis.

Year	Basal Area (m^2)	Height (m)	Height Increment (m)	Form Factor	Diameter at Breast Height (m)	Basal Area Increment (m^2)	Basal Area Cumulative (m^2)	Thinning Percentage (% Basal Area)	Standing Volume (m^3)
1	1.6	4.6	4.6	0.7	0.04	1.6	**1.6**	0	5
2	3.2	6.3	1.7	0.7	0.06	1.62	3.21		14
3	4.8	7.5	1.3	0.7	0.07	1.63	4.84		25
4	6.5	8.6	1.0	0.7	0.09	1.64	6.48		39
5	8.1	9.5	0.9	0.7	0.10	1.64	8.12		54
6	9.8	10.3	0.8	0.7	0.11	1.65	5.86	0.4	42
7	11.4	11.0	0.7	0.7	0.12	1.65	7.51		58
8	13.1	11.7	0.7	0.7	0.13	1.66	9.17		75
9	14.7	12.3	0.6	0.7	0.14	1.66	10.83		93
10	16.4	12.9	0.6	0.7	0.15	1.66	12.49		113
11	18.1	13.5	0.6	0.7	0.16	1.66	8.49	0.4	80
12	19.7	14.0	0.5	0.7	0.18	1.67	10.16		100
13	21.4	14.5	0.5	0.7	0.19	1.67	11.82		120
14	23.1	15.0	0.5	0.7	0.21	1.67	13.49		142
15	24.7	15.5	0.5	0.7	0.22	1.67	15.16		165
16	26.4	16.0	0.5	0.7	0.23	1.67	10.10	0.4	113
17	28.1	16.4	0.4	0.7	0.25	1.67	11.77		135
18	29.8	16.8	0.4	0.7	0.27	1.67	13.45		159
19	31.4	17.3	0.4	0.7	0.28	1.68	15.13		183
20	33.1	17.7	0.4	0.7	0.30	1.68	16.80		208
21	34.8	18.1	0.4	0.7	0.31	1.68	11.09	0.4	140
22	36.5	18.4	0.4	0.7	0.34	1.68	12.77		165
23		38.1	18.8 0.4	0.7	0.36	1.68	14.45		190
24		39.8	19.2 0.4	0.7	0.38	1.68	16.13		217
25		41.5	19.5 0.4	0.7	0.40	1.68	17.81		244

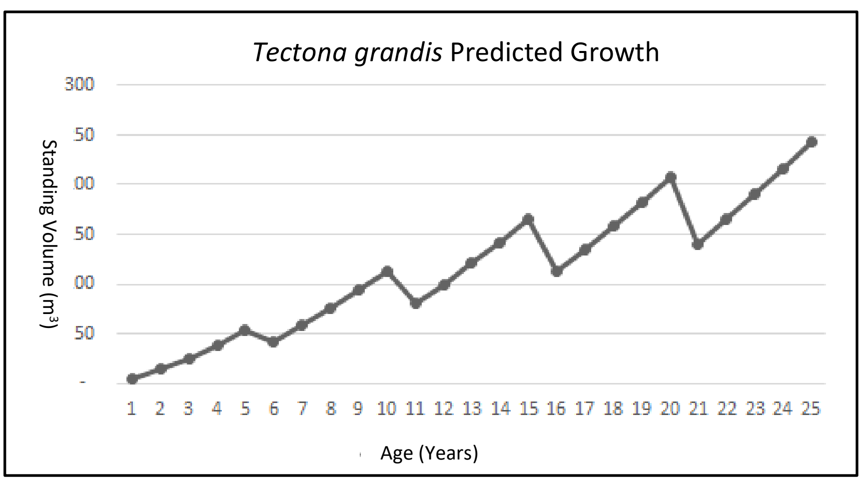


Figure 8.7: An illustration of the growth rate of Tectona grandis through predicted standing volume

8.3 Carbon stocks for above and below-ground biomass

Table 8.10 compares the revised long-term average GHG removal per hectare for each species (based on the monitoring data). This is calculated using the equations mentioned in section 5 for above and below ground carbon stocks.

Table 8.10: Long term average GHG removal per specie in tCO2e/ha

Tree species	BEF	R-t-S	Wood density [g/cm^3]	Carbon fraction	Stem volume [m^3]	Mean Stem volume [m^3]	rotation period	period mean stem volume	MAI [m^3]	Final C - according to the formula	Final CO_2 [tCO_2/ha]
Schyzolobium amazonicum	1.50	1.42	0.49	0.5	266	133	13	6	20.5	69	254
Stryphnodendron purpureum	1.50	1.42	0.52	0.5	265	133	12	7	22.1	73	269
Calophyllum brasiliense	1.50	1.42	0.55	0.5	268	134	22	13	12.2	78	288
Centrolobium tomentosum	1.50	1.42	0.58	0.5	267	134	24	11	11.1	82	302
Guarea rusby	1.50	1.42	0.52	0.5	308	154	16	11	19.3	85	313
Tapirira guianensis	1.50	1.42	0.55	0.5	282	141	18	11	15.7	83	282
Tectona grandis	1.50	1.42	0.52	0.5	244	122	25	11	9.8	68	248
Virola flexuasa	1.50	1.42	0.49	0.5	212	106	25	13	8.5	55	203
Buchenavia oxycarpa	1.50	1.42	0.77	0.5	156	78	35	18	4.4	64	234
Dipteryx odorata	1.50	1.42	0.91	0.5	156	78	35	18	4.5	76	277
Terminalia amazonica	1.50	1.42	0.66	0.5	216	108	35	15	6.2	76	278
Terminalia oblonga	1.50	1.42	0.75	0.5	156	78	30	18	5.2	62	228

Table 8.11 shows the original projected CO2e/ha at the start of the project, compared with the adapted CO2e sequestration. The justification for the adjusted values is explained in the section on monitoring results.

Table 8.11: Long-term average C and CO_2e in tCO_2e/ha

Growth class	Scientific name	Common name	Rotation	Above and Below Ground GHG removal (tCO2e/ha) adjusted	Above and Below Ground GHG removal (tCO2e/ha) initial	Monitoring result
Fast	Schizolobium amazonicum	Serebo	13	254	248	Adapted
Fast	Stryphnodendron purpureum	Palo yugo	13	269	263	Confirmed
Medium	Calophyllum basiliense	Palo maría	25	288	215	Adapted
Medium	Centrolobium tomentosum	Tejeyeque	25	302	231	Adapted
Medium	Guarea rusby	Trompillo de altura	22	313	386	Adapted
Medium	Tapirira guianensis	Palo román	22	282	303	Adapted
Medium	Tectona Grandis	Teca	25	248	217	Adapted
Medium	Virola flexuasa	Gabún	25	203	203	Confirmed
Slow	Buchenavia oxycarpa	Verdolago negro de pepa	35	234	234	Confirmed
Slow	Dipteryx odorata	Almendrillo	35	277	277	Confirmed
Slow	Terminalia amazonica	Verdolago negro de ala	30	278	278	Confirmed
Slow	Terminalia oblonga	Verdolago amarillo de ala	35	228	228	Confirmed

8.4 Net GHG emission reductions

As mentioned in section 3.5, some negative removals exist due to weeding and competition during the first 4 years. Since this is a conservative approach, no further monitoring is needed. However, these removals have to be deducted from the Net Long-term Average GHG removals, which results in the Net GHG Removals per specie and per hectare as shown in Table 8.12.

Table 8.12: Net GHG removal per hectare for each specie in tons of CO2e/ha

			Net Average GHG removal (CO2e/ha) over crediting period per baseline				
Growth class	**Scientific name**	**Common name**	**Grassland**	**Grassland with trees**	**Annual crops**	**Perennial crops**	**Status**
Fast	Schizolobium amazonicum	Serebo	251	251	254	248	Adapted
Fast	Stryphnodendron purpureum	Palo yugo	267	267	269	266	Confirmed
Medium	Calophyllum basiliense	Palo maría	286	286	288	284	Confirmed
Medium	Centrolobium tomentosum	Tejeyeque	300	300	302	299	Adapted
Medium	Guarea rusby	Trompillo de altura	310	310	313	308	Adapted
Medium	Tapirira guianensis	Palo román	279	279	282	278	Adapted
Medium	Tectona Grandis	Teca	246	246	248	244	Adapted
Medium	Virola flexuasa	Gabún	202	202	203	201	Confirmed
Slow	Buchenavia oxycarpa	Verdolago negro de pepa	233	233	234	232	Confirmed
Slow	Dipteryx odorata	Almendrillo	276	276	277	275	Confirmed
Slow	Terminalia amazonica	Verdolago negro de ala	277	277	278	276	Confirmed
Slow	Terminalia oblonga	Verdolago amarillo de ala	227	227	228	226	Confirmed

9. Buffer level

Although growth projections are rather conservative, the percentage of carbon credits sold upfront is 80%. After new area validation, a maximum of 90% of the existing carbon will be sold, leaving 10% as a risk buffer for the project as insurance against unexpected losses or under-achievement later on in the project.

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