

MONITORING REPORT OF THE AMAZON RIO REDD+ IFM-LTPF PROJECT



Document Prepared by Hdom Environmental Consultancy



Project Title	Amazon Rio REDD+ IFM-LtPF
Version	1.0
Report ID	Identification number of this document
Date of Issue	13-November -2017
Project ID	Amazon Rio REDD+ IFM-LtPF PD v. 3.1
Monitoring Period	05-June-2013 to 04-June-2017
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PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The Amazon Rio Project consists on the conservation of a group of private areas named “Amazon Rio I, II, III and IV”, which total 18,559 hectares (ha) of mature tropical forests, located in Manicoré city, in Amazonas State – Brazil. The target area of the project is characterized as a region of the sedimentary basin of Solimões, where Holocenics Alluvial, Içá's and the Lateritic-Detrict Formations are predominant. Topography is mainly formed by plains with mature undisturbed forests of *terra firme* (non-flooded forests) and *varzeas* (seasonally flooded forests).

The main focus of the Project are: (i) the conservation of the forest's ecosystems and it's biodiversity; (ii) social sustainable development of the region, including the promotion of ecotourism and scientific research; and (iii) emissions reductions of carbon dioxide gas (CO₂eq.) through deforestation and forest degradation restrain.

A Sustainable Forest Management Plan (SFMP) in the Project area was approved by State official agency (IPAAM¹) and was bound to operate throughout a time line of 25 years. After purchasing the property and transforming the Project area into Sustainable Development Private Reserve, EBCF implemented, in 2013, the Amazon Rio's REDD+ Improved Forest Management – Logged to Protected Forest (IFM-LtPF).

The Amazon Rio Project implementation process started on June 5th, 2013 when EBCF ceased the Sustainable Forest Management Plan (SFMP) and transformed the Project area into Private Reserves for the Sustainable Development in order to implement Amazon Rio's REDD+ Improved Forest Management – Logged to Protected Forest (IFM-LtPF).

After ceasing logging operations in 2013, EBCF promoted numerous workshops with the participation of all local communities involved in the project to promote awareness and assuring participative process to develop the Private Reserve's management Plan which contemplates a detailed diagnosis of all communities as well as social indicatives that are permanently measured throughout the years. A free, prior and informed content was also implemented by EBCF.

¹ Institute of Environmental Protection of Amazonas State, in Portuguese

Also in 2013, EBCF implemented important methodologies, following the Monitoring Plan, to monitor the Project location by satellite imagery and remote sensor as well as ground *in loco* activities directed by its forest director joined by local leadership to avoid activities such as logging, encroachment and to communicate any eventual fire caused by nature or human activities.

In 2015 a forest inventory was conducted in the area by a highly respected organization to corroborate with the local surveillance. Using consolidated by scientific studies methods of sampling design and protocols. The forest inventory installed 162, fied area, sample plots across the Project area, measuring DBH of all live trees within each plot. Sample plot's geographical coordinates were registered with a GPS device and site information estimated through collected data analysis. Results from the forest inventory corroborate with remote sensing data analysis and ground monitoring.

Social projects such as “CLEAN WATER FOR ALL” and “SAUDE NA AMAZONIA” were implemented in the communities. The project for clean water started out benefitting the children with the installation of water filters in every school in all communities. From 2014 to 2017 the project has been extended to the houses for each of the families. Nowadays, entire communities have water filters inside the houses. For the project “Saude na Amazonia” local agents are trained to monitor the health of the people in each community. A medical kit is also granted to the agents to help them with the monitoring system.

1.2 Sectoral Scope and Project Type

Sectoral Scope of the Project: Agriculture, Forestry and Other Land Use (AFOLU).

Project category: Reduction Emission from Planned Deforestation and Forest Degradation (REDD-APD)

Project type: Improved Forest Management – Logged to Protected Forest (IFM LFPP)

1.3 Project Proponent

Organization name	Empresa Brasileira de Conservação de Florestas S.A. (EBCF)
Contact person	Leonardo Barrionuevo
Title	President
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Email	leonardo@ebcf.com.br

1.4 Other Entities Involved in the Project

Organization name	Original Trade Specialized Consultancy
Role in the project	PD Update (V 2.0) and conduction of Certification process of the IFM Amazon Rio Project
Contact person	João Batista Tezza Neto
Title	Director
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Email	tezza.neto@originaltrade.net

Organization name	Hdom Environmental Consultancy
Role in the project	Sample Forest Inventory, for “existing data validation”, execution; Biomass and Carbon stock estimation; Monitoring of Deforestation and Forest Degradation report.
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1.5 Project Start Date

Project started in June 5th, 2013 (Annex 27 of the PD).

1.6 Project Crediting Period

The Crediting period is from June 5th, 2013 to June 5th, 2048, summing a total of 36 years.

1.7 Project Location

The Project Amazon Rio is in the South Region of Amazonas State, within the municipality boundaries of Manicoré (Figure 1). Located at a linear distance of, approximately, 333 km from the Manaus (Capital city of Amazonas State).

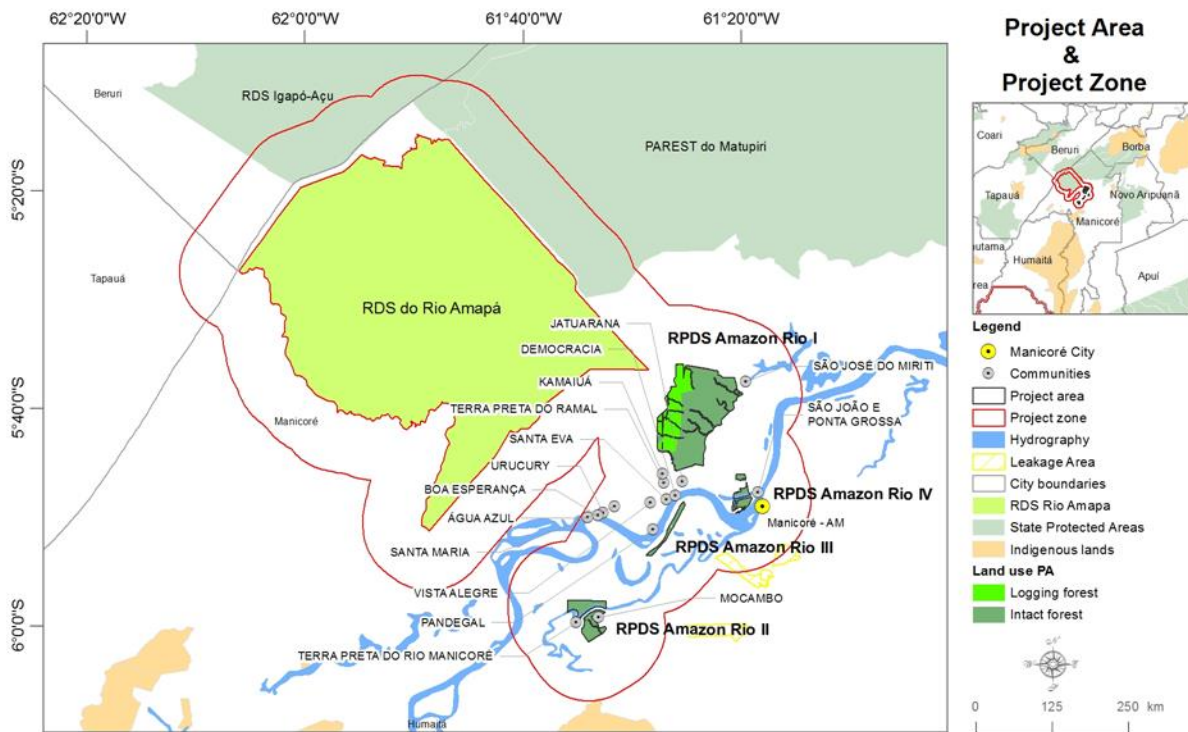


Figure 1. Localization of Manicoré, within Amazonas State and Brazil.

The Amazon Rio Project is divided in four non-contiguous areas: Amazon Rio I, II, III and IV. Amazon Rio I and IV are located at the left margin of the Madeira river (one of the main tributaries of the Amazon River). Amazon Rio II and III, on the other hand, are in the right margin of Madeira river. Central geographical coordinates are presented in Table 1 below.

Table 1- Central geographical coordinates of each Amazon Rio RPDS

RPDS	X	Y
Amazon Rio I	-61.404119	-5.672791
Amazon Rio II	-61.565014	-5.984440
Amazon Rio III	-61.440739	-5.848490
Amazon Rio IV	-61.330456	-5.798308

1.8 Title and Reference of Methodology

V-C-S VM0011: Methodology for Improved Forest Management – Logged to Protected Forest (LtPF): Calculating the GHG Benefits from Preventing Planned Degradation, version 1.0

- Emission Trading Programs and Other Binding Limits:

The proposed project is not and will not be submitted to another Emission Trading Program or other binding limits.

- Other Forms of Environmental Credit:

The proposed project is not submitted to Other Forms of Environmental Credit.

- Participation under Other GHG Programs:

The proposed project is not and will not be participating under Other GHG Programs.

1.9 Sustainable Development

The Amazon Rio REDD+ IFM-LtPF Project main contribution to sustainable development priorities (both National and Subnacional) was the introduction to a new management approach towards Amazonian tropical forests. The first action of the Project was to cease all legal logging operations, to avoid GHG emissions due to tree mortality and fossil fuel consumption, through a decision to transform the propriety into a Private Conservation Unit (RPDS – in Portuguese), based on Amazonas State Law². The main goal of the RPDS is to promote sustainable development based on minimal impact non-timber management plan, maintenance of the standing forest and social engagement by local communities.

The private property was purchase by EBCF to implement an innovative approach towards tropical forest preservation and sustainable development through value enhancement of environmental services and non-timber products. To do so, EBCF

² Amazonas State Law n° 53, of June of 2007 & State Decree n° 30,108 of June 2010.

invested in Social engagement, so local communities would become active actors on the implementation of the Project activities, decision making and benefit sharing. Which align perfectly with the Brazilian's National Environmental Policy and the Intended Nationally Determined Contributions (iNDCs) presented in the Paris Agreement, during the UNFCCC's 21st COP, in Dec. 2016.

According to the official INDC report:

The Brazilian's iNDC takes into consideration the role of the Conservation Units and Indigenous lands as managed forest areas, in accordance with the applicable guidelines from the IPCC, to estimate Greenhouse Gas removals”.

Also, iNDC reports that Brazil considers “adaptation” as a fundamental element for a global effort to mitigate climate change and its effects. The implementation of climate change adaptation policies and actions contribute for the construction of resilience of populations, ecosystems, infrastructure and production systems, reducing vulnerability and providing ecosystem services.

Regarding the Brazilian forest sector, the iNDC report states that REDD+ implementation activities and the permanence of the results achieved, demand a continuous, adequate and predictable payments, based on specific results in accordance to the relevant decisions from the DOP 21. In this case, this Project is aligned with the VCS/CCB Standard, by generating and commercialization of Verified Carbon Units (VCU).

In terms of Social benefits and sustainable income revenue, there are approximately 450 families living in 15 communities within the buffer zone of Project area, in which all have a direct relationship with the forest. The environmental benefits provided by the Project demonstrate a strong social development component and includes a number of socio-economic support programs for local communities promoting sustainable development in the region.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The first Project implementation activity was to transform the private property, with active selective logging operations in progress, into a Sustainable Development Private Reserve (RPDS, in Portuguese). The main objective of the RPDS is to promote

sustainable development without deforestation or forest degradation. Formally implementing the RPDS, all logging operations ceased (implementation activity of the Project) and all local communities that reside within the Project area and its buffer zone were formally engaged.

After ceasing logging operations, the Project area started to be monitored through remote sensing data. Official government data, from the “Deforestation Monitoring System in the Brazilian Amazon” of PRODES, a Program of the National Spatial Research Institute (INPE), was annually acquired for analysis of any spot of deforestation within the Project Area and/or the Leakage management areas. PRODES data indicates whether an area lost its forest cover from one period to the next.

The identification of lost of forest cover within the Project area (and its Leakage areas) indicates one of two possible reasons: (i) illegal deforestation from human activities, or (ii) the occurrence of a natural disturbance, such as forest fire or windstorms³. Based on satellite and PRODES data, geographical coordinates of the deforestation spot are registered, and its affected area calculated in hectares. By considering that all carbon content of all aboveground biomass (trees) is immediately⁴ emitted to the atmosphere, the carbon dioxide equivalent (CO₂e) emission from the natural disturbance event is estimated by Equation 4-16 of VM 0011, version 1.0.

Following the base of the Amazon Rio REDD+ IFM-LtPF Project, logging operations has been monitored through field surveillance. Annually, two field surveys were conducted, where the field team transited by land and river. By land, the field team road with a 4x4 vehicle in the boundaries of the RPDS Amazon Rio I, checking for any signs of evidences of logging operations or timber extraction. By river, the same method was carried out, but with a small fast boat, locally called *voadeiras*.

To corroborate with the local surveillance, a forest inventory was conducted in the Project Area. In 2015 a field team, composed by foresters, technicians, *mateiros*⁵, and local people, executed a 25-day field expedition to installed 162 (one hundred and sixty two), fixed area, sample plots across all RPDS areas (Figure 2).

³ In the Amazon region is known to occur intense convective storms, with massive wind bursts, called “Blowdowns”. These storms are considerably frequent and can affect areas from 30 to more than 3,000 hectares, causing tree mortality in rates up to 80% of aboveground biomass.

⁴ $f_{natdisturb, j, t}$ is 100%.

⁵ Professionals with great experience in dendrological (tree) identification.

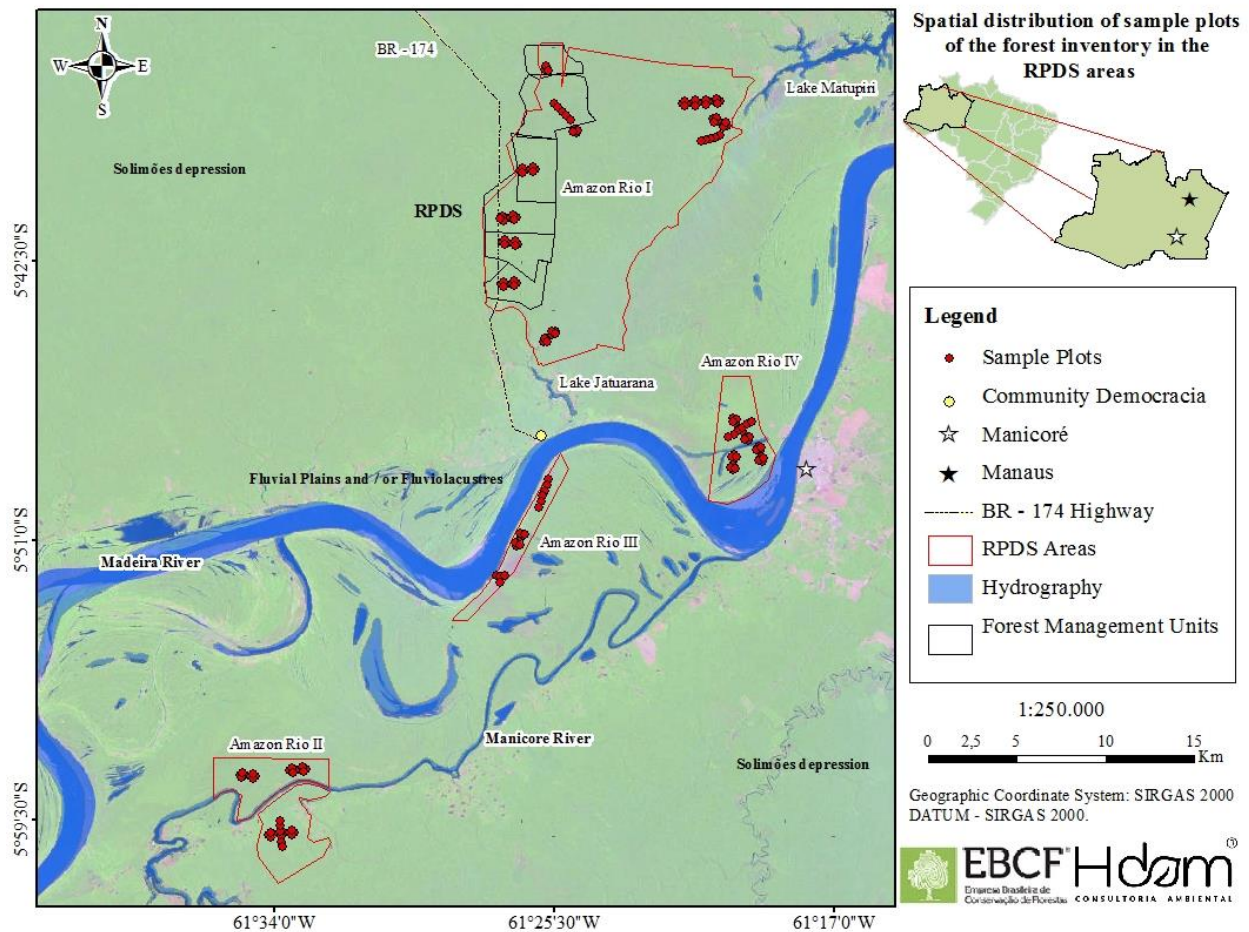


Figure 2. Geographical distribution of sample plots from the forest inventory.

Sample plots were shaped in rectangles, dimensioned in 20 meters of width and 125 meters long, totaling an area of 0.25 ha. After arriving in the forest, the starting point of the sampling arrangement was randomly selected. Based on the starting point, with a compass, the azimuth angle of the direction of the sampling design was determined. A trail, with minimal impact, was opened so that field teams could transit within the plot.

A specific team oversaw the plot's boundaries. A second team measured all live trees, with a minimal diameter at 1.3 m from the base (DBH) of 10 cm, located within the boundaries of the plot. The *mateiros* were responsible for the tree's dendrological identification and measurement of each individual DBH with a diameter tape. Base on the data collected by the forest inventory, it was possible to estimate site (per area unit –

hectare) information's, such as: tree density, basal area, bole volume, aboveground biomass and carbon stock.

All sample plots installed during the forest inventory had each respective geographical coordinate registered with a GPS device. Therefore, any plot can be remeasured at any time. With the re-measurement of these sample plots, will be possible to estimate the dynamics of any site information, changes in DBH measures overtime, tree's diversity, among others. The results from the forest inventory indicates that the forest of the Project Area has characteristics and site mean estimates similar to other mature tropical forest in the Amazon Region.

Corroborating the satellite monitoring, with field surveillance and the results of the forest inventory, it is conservative to affirm that no significant forest degradation, deforestation and/or logging (legal or not) occurred within the Project Area.

Administratively, EBCF office has being conducting social engagement activities with local communities. A group of Voluntary Environmental Agents (Agentes Ambientais Voluntários - AAVs) was formed and trained in four (4) local communities. The AAV's activities include field surveillance and transect surveys of fauna and flora. Whenever it is identified that an unplanned activity occurs within the Project Area, the AAV's reports to local authorities and informs EBCF's Office by any means of communications. Other social engagement activities implemented by the Project was the installment of water filters in all 10 (ten) local communities, promotion of gender equality programs, and training local people to become "Community Local Health Agents", to perform first aid actions and monitor health (blood pressure, glucose levels, among others).

2.2 Deviations

2.2.1 Methodology Deviations

Although it is a requirement of VM0011 to use forest inventory reports conducted in less than 5 years for the use of existing forest inventory data in the project area, it was used as the basis for baseline and avoided project emissions measurement the data of forest inventories for the licensing of the forest operation with information over five years. In this sense it was necessary to use a methodological deviation that refers to the

methodological criterion "3.2.1 - Pre-existing Inventory Data Path", which establishes the use of inventories more than five years.

Since the licensing documents for logging, AUTEX and POAs, issued by the competent government agency in the state of Amazonas are valid official documents capable of supporting the baseline projection of the project, and since both use the forest inventory data carried out in the form of a 100% census where all the trees that would be explored are measured, we understand that there is no way to disconnect the baseline of the project from the results of the exploration inventory, since these documents bring the exact volume of licensed wood that would be explored, estimating in this way and with greater precision the volume of emissions avoided when considering the exact volume of each tree that would be explored. Therefore, the project proponent judges to be the most adequate and faithful data to the real volume of wood, and consequently of the avoided emissions, even with data five years before the start of the project activities.

Although the proposed deviation is an integral part of the project's primary data measurement sphere, it is understood as a conservative approach, since the stock of wood today, as well as five years before the start of the project, is surely greater than that measured at the date of the inventory 100%. This is due to the fact that the trees selected for the logging, as well as the forest as a whole, suffer an annual increase of biomass.

A second methodological deviation was necessary for the adequacy of the conversion of the volume of tradable wood to carbon, since it was assumed that the commercial species are mostly "hardwood" with densities higher than the default standard adopted by VM0011. For this purpose, the specific densities for each species were adopted following the Global Wood Density Database (Appendix 23) for commercial species and applied only to the species whose density was applied to the species (considering genre and scientific name). For the species whose database presents the density for the genre, the default value reported by VM0011 was adopted, and the same default value was applied to the species whose density was not presented in the database.

Finally, a methodological deviation was applied to demonstrate that there was no market leakage after the logging stoppage in the project area, demonstrating the reduction of the licensed timber supply in the state of Amazonas in the years following the logging stoppage. Amazon Rio REDD + project area.

The data that support the argument about the absence of market leakage were directly measured and published by the government agency responsible for the licensing of logging activities in the state of Amazonas. At the time, data from the estimate of wood supply in the market were also used by the Brazilian Institute of Geography and Statistics (IBGE) for the same exploration period adopted as a basis for calculating baseline emissions, concluding that the supply of timber in the project area is insignificant given the supply of wood in the national, regional and meso-regional markets (southern region of the state of Amazonas). Details of proof of absence of leakage are described in section 5.5 of the project design, under the topic market leakage.

2.2.2 Project Description Deviations

No Project Description deviations were conducted.

2.3 Grouped Project

The proposed Project is not Grouped with any other project.

2.4 Safeguards

2.4.1 No Net Harm

The Amazon Rio REDD+ IFM Project was validated under the protocol and standards of the CCB (Climate, Community & Biodiversity) and will follow all its guidelines.

2.4.2 Local Stakeholder Consultation

The Amazon Rio REDD+ IFM Project was validated under the protocol and standards of the CCB (Climate, Community & Biodiversity) and will follow all its guidelines.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Parameters Obtained from Literature / Reports to be Reviewed / Verified (Not Monitored)

Data / Parameter	CF_{Wood}
Data unit	$tC (t d.m.)^{-1}$
Description	<i>Carbon fraction from wood to tropical forest</i>
Source of data	VCS (2011)
Value applied	0,49
Justification of choice of data or description of measurement methods and procedures applied	Conservative value indicated by VM 0011
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-3; 3-5; 3-41; 3-51 em (VCS, 2011)

Data / Parameter	CF_{AGB}
Data unit	$tC (t d.m.)^{-1}$
Description	Carbon fraction in above-ground biomass from trees to rainforest
Source of data	VCS (2011)
Value applied	0,47
Justification of choice of data or description of measurement methods and procedures applied	Conservative value indicated by VM 0011
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-8; 3-14; 3-37a; 3-37b; 3-38; 4-15; 4-17a; 4-21; 4-22; 5-8; 5-9 em (VCS, 2011)

Data / Parameter	D
Data unit	$(t d.m.) m^{-3}$
Description	<i>Wood density for tropical forest with the climate of corresponding region and ecological zone</i>
Source of data	VCS (2011)
Value applied	0,6
Justification of choice of data or description of measurement methods and procedures applied	Conservative value indicated by VM 0011

Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-3; 3-5; 3-41; 3-51; 4-21; 5-8; 5-9 em (VCS, 2011)

Data / Parameter	$fV(DBH_{n,i,s}, j, t=0, H_{n,i,s}, j, t=0)$
Data unit	<i>Dimensionless</i>
Description	<i>Allometric equation of volume as a function of DBH and height; $t = 0$ years</i>
Source of data	<i>Adjusted based on regression analysis with data from the site sampled.</i>
Value applied	Not applicable
Justification of choice of data or description of measurement methods and procedures applied	Sampled trees had their bole volume determined, based on the combination of two traditional forestry methods: Smalian and Hohenadl. This site equation was developed by the HDOM during the conduction of the forest inventory.
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-10; 3-11 em (VCS, 2011)

Data / Parameter	$fB(DBH_{n,i,s}, j, t=0, H_{n,s,i}, j, t=0, D_i)$
Data unit	<i>Dimensionless</i>
Description	<i>Allometric equation of biomass as a function of DBH and height; $t = 0$ years</i>
Source of data	Allometric equation developed by Silva (2007) applicable in dense ombrophilous forests in Central Amazonia
Value applied	Provided by HDOM in annex 23: "Anexo 23 - Inventário_Florestal_Vs_Final"
Justification of choice of data or description of measurement methods and procedures applied	Allometric equation developed in the central Amazon in dense ombrophilous forests, similar to the forest structure of the project area.
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-12 em (VCS, 2011)

Data / Parameter	k_{decay}
Data unit	yr^{-1}
Description	<i>Rate of decomposition of the dead wood tank per year</i>
Source of data	Chamberset al. (2000)
Value applied	0,167
Justification of choice of data or description of measurement methods and procedures applied	Parameter found in the central Amazon in dense ombrophilous forests, similar to the forest structure of the project area.
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-17; 3-21 em (VCS, 2011)

Data / Parameter	f_{RSD}
Data unit	<i>Dimensionless</i>
Description	<i>Factor of damage to the remaining forest, based on the fraction of carbon from the remaining forest damage by the amount of carbon in the total tradable logs extracted.</i>
Source of data	Feldpauschet al. (2005)
Value applied	2,4
Justification of choice of data or description of measurement methods and procedures applied	Parameter found in the central Amazon in dense ombrophilous forests, similar to the forest structure of the project area.
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-19; 4-21; 5-8, 5-9 em (VCS, 2011)

Data / Parameter	$f_{\text{branch_trim}}$
Data unit	<i>Dimensionless</i>
Description	<i>The fraction of remaining branches and shavings in the biomass above the ground after cutting the tradable logs and transferred to the dead wood reservoir.</i>
Source of data	Silva (2007)
Value applied	0,67

Justification of choice of data or description of measurement methods and procedures applied	Parameter found in the central Amazon in dense ombrophilous forests, similar to the forest structure of the project area.
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equations 3-20 em (VCS, 2011)

Data / Parameter	$f_{\text{lumber_recovery}}$
Data unit	<i>Dimensionless</i>
Description	<i>Recovery factor of Sawn timber for proportion of tradable log converted into lumber product.</i>
Source of data	Veríssimo (1992) apud VCS (2011)
Value applied	0,47
Justification of choice of data or description of measurement methods and procedures applied	Conservative value found in works developed in the Amazon with notorious scientific knowledge.
Purpose of the data	Calculate of baseline emissions
Comments	Application of the parameter in equations 3-26; 3-27 em (VCS, 2011)

Data / Parameter	klHWP_ox
Data unit	yr-1
Description	Oxidation rate per year for long-term felled wood products.
Source of data	<i>IPCC (2006) apud VCS (2011)</i>
Value applied	0,023
Justification of choice of data or description of measurement methods and procedures applied	Default value suggested by VM0011
Purpose of the data	Calculate of baseline emissions
Comments	Application of the parameter in equations 3-28 em (VCS, 2011)

Data / Parameter	Gregrowth, t
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Data unit	<i>(t d.m.) ha-1 yr-1</i>
Description	<i>Average regeneration per hectare per year of above-ground biomass after selective cutting in year t, in t.d.m./ha/ano.</i>
Source of data	<i>Mazzeiet al. (2010)</i>
Value applied	2,6
Justification of choice of data or description of measurement methods and procedures applied	Parameter found in the Amazon in dense ombrophilous forests, similar to the forest structure of the project with notorious scientific knowledge.
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equations 3-38 <i>em (VCS, 2011)</i>

Data / Parameter	EF _{fuel} – Gasolina
Data unit	<i>tCO₂-e kL-1</i>
Description	<i>Fuel emission factor.</i>
Source of data	<i>IPCC (2006)</i>
Value applied	3,013
Justification of choice of data or description of measurement methods and procedures applied	Default value suggested by IPCC.
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equations 3-40; 3-42; 3-43; 3-46; 3-50; 3-54; 4-8; 4-11; 4-14 <i>em (VCS, 2011)</i>

Data / Parameter	FC _{harvest} – Gasolina
Data unit	<i>kL m-3</i>
Description	<i>Fuel consumption of equipment used for cutting and hauling by m³ harvested wood</i>
Source of data	<i>Floresta Viva Amazonas</i>
Value applied	0,01
Justification of choice of data or description of measurement methods	Value of the fuel consumption factor found in areas of forest management with the same characteristics of forest management practiced in the project area.

and procedures applied	
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equation 3-40 em (VCS, 2011)

Data / Parameter	FC_{harvest – Diesel}
Data unit	kL m ⁻³
Description	<i>Fuel consumption of equipment used for cutting and hauling by m3 harvested harvested wood</i>
Source of data	Floresta Viva Amazonas
Value applied	0.05
Justification of choice of data or description of measurement methods and procedures applied	Value of the fuel consumption factor found in areas of forest management with the same characteristics of forest management practiced in the project area.
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equation 3-40 em (VCS, 2011)

Data / Parameter	CAP_{truck Carreta}
Data unit	m ³ truck ⁻¹
Description	<i>Truck load capacity</i>
Source of data	EBCF (2013)
Value applied	30
Justification of choice of data or description of measurement methods and procedures applied	Value measured by the proponent himself during the conduct of the wood exploitation activities in the field
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equation 3-44; 3-52 em (VCS, 2011)

Data / Parameter	CAP_{truck Balsa}
Data unit	m ³ truck ⁻¹
Description	<i>Loading capacity of the wooden transport “balsa”</i>

Source of data	EBCF (2013)
Value applied	500
Justification of choice of data or description of measurement methods and procedures applied	Value measured by the proponent himself during the conduct of the wood exploitation activities in the field
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equation 3-44; 3-52 em (VCS, 2011)

Data / Parameter	Eff_{vehicle Balsa}
Data unit	km kL ⁻¹
Description	<i>Fuel efficiency by type of vehicle</i>
Source of data	Barros &Uhl (1997)
Value applied	3770
Justification of choice of data or description of measurement methods and procedures applied	Value of the fuel efficiency found in areas of forest management with the same characteristics of forest management practiced in the project area.
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equation 3-46; 3-52; 3-54; 4-7; 4-11; 4-14 em (VCS, 2011)

Data / Parameter	Eff_{vehicle Carreta}
Data unit	km kL ⁻¹
Description	<i>Fuel efficiency by type of vehicle</i>
Source of data	Barros &Uhl (1997)
Value applied	2000
Justification of choice of data or description of measurement methods and procedures applied	Value of the fuel efficiency found in areas of forest management with the same characteristics of forest management practiced in the project area.
Purpose of the data	Calculate of baseline emissions
Comments	Aplication of the parameter in equation 3-46; 3-52; 3-54; 4-7; 4-11; 4-14 em (VCS, 2011)

Data / Parameter	e_{demand}
Data unit	kWh m ⁻³
Description	<i>Electrical energy demand for processed volume processing</i>
Source of data	VCS (2011)
Value applied	20
Justification of choice of data or description of measurement methods and procedures applied	Default value suggested by VM 0011
Purpose of the data	Calculate of baseline emissions
Comments	Application of the parameter in equation 3-47 em (VCS, 2011)

Data / Parameter	E_{Electricity}
Data unit	tCO ₂ -e kWh ⁻¹
Description	<i>Factor of electric energy emission in the country of origin</i>
Source of data	IEA (2011) e MCT (2013)
Value applied	0,000088 (2000), 0,000079 (2003), 0,00003223 (2006), 0,0000293 (2008)
Justification of choice of data or description of measurement methods and procedures applied	Estimated value by the ministry of science and technology of Brazil (MCT)
Purpose of the data	Calculation of project emissions
Comments	Application of the parameter in equation 3-48; 4-4 em (VCS, 2011)

Data / Parameter	E_{flight,y}
Data unit	tCO ₂ -e (passenger.km) ⁻¹
Description	<i>Flight emission factor for travel and</i>
Source of data	<i>Reported by literature</i>
Value applied	0,00026 - Domestic

	0,00036 – Short 0,0002 – Medium 0,00023 –Long
Justification of choice of data or description of measurement methods and procedures applied	Conservative values found in specific literature
Purpose of the data	Calculation of project emissions
Comments	Application of the parameter in equation 4-6, 4-10; 4-13 em (VCS, 2011)

Parameters to be Measured Once (Not Monitored)

Data / Parameter	$A_{project, t=0}$
Data unit	<i>ha</i>
Description	Project area at time, t = 0
Source of data	<i>GPS data, GIS maps and satellite data</i>
Value applied	18,598 hectares
Justification of choice of data or description of measurement methods and procedures applied	Method of measurement and procedures to be applied: Analysis in GIS platform with complement of official thematic databases Frequency: Validated / Verified before project start date IFM-LtPF Equipment: Computer resources and appropriate software Quality control applicable procedures: Georeferencing following national land regulations Calculation method: Computational resources and appropriate software using DATUM SAD 1969 and metric projection.
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equation 2-1; 3-4; 3-6; 3-9; 3-13; 3-36b em VCS (2011)

Data / Parameter	$A_{project, j, t=0}$					
Data unit	<i>Area in hectares</i>					
Description	Project Area in each stratum (j) at time t = 0					
Source of data	<i>IBGE 2004</i>					
Value applied	Phytophysiology	Project Area		Leakage Area		
		ha	%	ha	%	
	FDA	2.626,84	14,2	205,8	4,3	
	FDTB	15.911,20	85,8	4.540,0	95,7	
	Total	18.538,03	100,0	4.745,8	100,0	
Justification of choice of data or description of measurement methods and procedures applied	<p>Method of measurement and procedures to be applied: Analysis in GIS platform with complement of official thematic databases Validated / Verified before the start date of the IFM-LtPF Project</p> <p>Frequency: Validated / Verified before project start date IFM-LtPFNA</p> <p>Equipment: Computer resources and appropriate software</p> <p>Quality control applicable procedures: A responsible team will be formed and trained for activities of both RPDS surveillance as well as remote monitoring with expertise in geoprocessing technologies</p> <p>Method of calculation: For the stratification of the AP, the thematic map of phytophysiognomies of the IBGE / DGC, 2004, was used, where a cut was made for AP. Procedure in GIS environment</p>					
Purpose of the data	Calculation of baseline emissions					
Comments	Aplication of the parameter in equation 2-1; 3-4; 3-6; 3-9; 3-13em VCS (2011)					

Data / Parameter	$A_{s, j, t=0}$
Data unit	<i>Area in hectares</i>
Description	Total area of plots sampled in stratum (j) at time t = 0
Source of data	<i>Forest management plan and operating authorizations</i>
Value applied	At least 30 (thirty) sample plots

Justification of choice of data or description of measurement methods and procedures applied	<p>Method of measurement and procedures to be applied: The area of the parcels sampled is the same area licensed for the exploration, as the licensing process requires the forest inventory using the 100% sampling method where all individuals are sampled to be explored within the area known as "Talhões" and "UPAs - Annual Production Units" within the scope of the legal framework that underpins the licensing process of the wood exploitation activity.</p> <p>Frequency: Before the start date of the project.</p> <p>Equipment: GPS and Track</p> <p>Quality control applicable procedures: The IFC will be implemented by a technical team with extensive knowledge in IFC practice activities following the standard procedures below:</p> <ul style="list-style-type: none"> - ensure a measurement and allocation of the PSPs is standardized and without deviations from procedures and mainly oriented the reliability to verify the field activities, - use of appropriate measurement equipment and utilities (eg, trena, GPS navigation, compass, red paint, pipes and others); - georeferencing of vertices of PSPs; - demarcation and cleaning of access trails and their georeferencing;
Purpose of the data	Calculation of baseline emissions
Comments	Application of the parameter in equation 3-10; 3-11; 3-12 em VCS 2011

Data / Parameter	$DBH_{n,i,s,j,t=0}$
Data unit	cm
Description	Diameter at chest height t = 0 year
Source of data	<i>Ex ante field measurement in sample plots</i>
Value applied	Value to be applied: DBH > 10 cm for adult trees and DBH > 2,5 cm for young trees in natural regeneration
Justification of choice of data or description of measurement methods and procedures applied	<p>Method of measurement and procedures to be applied: Field measurement procedures as described in Annex 46.</p> <p>Frequency: Validated / Verified before project start date IFM-LtPF</p> <p>Equipment: Diameter tape and trenas</p> <p>Quality control applicable procedures: Annex 46</p> <p>Calculation method: On-site measurement in PSPs</p>
Purpose of the data	Calculation of baseline emissions
Comments	<i>Application of the parameter in equations 3-10; 3-11; 3-12 in</i>

	VCS 2011
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Data / Parameter	$H_{n,i,s,j,t=0}$
Data unit	m
Description	Description Height for individual tree, t = 0 year
Source of data	<i>Ex ante field measurement in the sample plots.</i>
Value applied	█
Justification of choice of data or description of measurement methods and procedures applied	Method of measurement and procedures to be applied: Field measurement procedures as described in Annex 46. Frequency: Validated / Verified before project start date IFM-LtPF Equipment: Diameter tape and trenas Quality control applicable procedures: Annex 46 Calculation method: On-site measurement in PSPs
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$A_{NHA_annual,t}$
Data unit	ha
Description	Net harvest area for the Project area in year t
Source of data	<i>Obtained from the Sustainable Business Management Plan. Spatial delimitation of the Annual Production Units (PAU)</i>
Value applied	According to the Environmental Licensing of the Annual Operational Plan
Justification of choice of data or description of measurement methods and procedures applied	Method of measurement and procedures to be applied: Documentary analysis of forest management operation licenses Frequency: Validated / Verified before project start date IFM-LtPF Method of calculation: Obtained from the Sustainable Business Management Plan. Spatial delimitation of the Annual Production Units (PAU)
Purpose of the data	Calculation of baseline emissions
Comments	<i>Application of the parameter in equations 3-15a; 3-16a; 3-26; 3-27; 3-33; 3-35; 3-37a; 3-38 in VCS (2011)</i>

Data / Parameter	$KM_{transport,t}$
Data unit	Km
Description	Annual distance from log shipping from the collection depot to the processing plant
Source of data	<i>Digital maps</i>
Value applied	The values used as input for the calculation of emission parameters due to the distribution of the logs is shown in Annex 18, in the "Calculations_baseline" tab. -
Justification of choice of data or description of measurement methods and procedures applied	<p>Method of measurement and procedures to be applied: Analysis of digital maps and cartographic bases in GIS environment with the aid of logistical information made available on the WEB.</p> <p>Frequency: Validated / Verified before project start date IFM-LtPF</p> <p>Analysis in GIS platform with the aid of official cartographic databases</p> <p>Quality control applicable procedures: Validation and Verification before the start date of the project. -</p> <p>Calculation method: Estimates in GIS environment with the aid of operational operational data complemented by survey of secondary data for the estimation of the consumption of logistic inputs. -</p>
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$KM_{distrib,t}$
Data unit	Km
Description	Annual distance of transport from the processing point to the point of distribution / export
Source of data	<i>Digital maps</i>
Value applied	All values used as inputs for the calculation of emission parameters due to the distribution of the logs are shown in Annex 18, in the "Calculations_baseline" tab.
Justification of choice of data or description of measurement methods and procedures applied	<p>Method of measurement and procedures to be applied: Analysis of digital maps and cartographic bases in GIS environment with the aid of logistical information made available on the WEB.</p> <p>Frequency: Validated / Verified before project start date IFM-LtPF</p> <p>Equipment: Analysis in GIS platform with the aid of official</p>

	cartographic databases Quality control applicable procedures: Validation and Verification before the project start date.
Purpose of the data	Calculation of baseline emissions
Comments	-

Data / Parameter	$V'_{historical_harvest,l,k}$
Data unit	m ³
Description	Total harvest volume for land I that is owned and / or operated by the Project Proponent during the historical reference period
Source of data	<i>Project Proponent Registry</i>
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	Method of measurement and procedures to be applied: Project proponent records through Annual Operational Planning (POA) licensing. Ex ante information only Frequency: Validated / Verified before project start date IFM-LtPF Value to be applied: NA (not applicable)
Purpose of the data	
Comments	

Data / Parameter	$V_{historical_harvest,l,k}$
Data unit	m ³
Description	<i>Total harvest volume for land (I) that is owned and / or operated by the Project proponent during the historical reference period</i>
Source of data	<i>Project proponent registrations and licensing documents, Operation License (LO) and Exploration Authorizations (AUTEFs).</i>
Value applied	-
Justification of choice of data or description of measurement methods	Sum of all annual AUTEFs

and procedures applied	
Purpose of the data	Determination of baseline scenario
Comments	Application of the parameter in equation 5-3 em VCS (2011)

3.2 Data and Parameters Monitored

Data / Parameter	$DBH_{n, i, s, j, t}$
Data unit	cm
Description	Diameter at breast height for individual tree n , of species i , in sample plot s , of stratum j , in year t .
Source of data	Measured using DBH tape
Description of measurement methods and procedures to be applied	Measurement, with a diameter tape, of diameter at 1.3 m from the ground of all live trees located within sample plots.
Frequency of monitoring/recording	At intervals not exceeding five years
Value monitored	Varies according to tree's size
Monitoring equipment	DBH tape.
QA/QC procedures to be applied	Use of certified diameter tape, correct point of measurement (at 1.3 m) supervised by the field's team leader.
Purpose of the data	Calculation of project emissions
Calculation method	Parameter measured, not calculated.
Comments	No additional comments

Data / Parameter	$DBH_{tree_nd, n, i, snd, j, t}$
Data unit	Cm
Description	Diameter at breast height for individual tree n , of species i , in sample plot in the naturally disturbed area s_{nd} , of stratum j , in year t .
Source of data	Measured using DBH tape
Description of measurement methods and procedures to be applied	Measurement, with a diameter tape, of diameter at 1.3 m from the ground of all live trees located within sample plots.

Frequency of monitoring/recording	At intervals not exceeding five years
Value monitored	Varies according to tree's size.
Monitoring equipment	DBH tape.
QA/QC procedures to be applied	Use of certified diameter tape, correct point of measurement (at 1.3 m) supervised by the field's team leader.
Purpose of the data	Calculation of project emissions
Calculation method	Parameter measured, not calculated.
Comments	No additional comments

Data / Parameter	$KM_{plan_flight, y, t}$
Data unit	Km
Description	Distance travelled per trip y , for a total of Y trips in year t .
Source of data	Flight travel log
Description of measurement methods and procedures to be applied	Recording all flights, their distance and date.
Frequency of monitoring/recording	Annual
Value monitored	0 – zero
Monitoring equipment	Flight log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-6 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$N_{plan_flight, y, t}$
Data unit	Number
Description	Number of passengers per trip y , in year t .
Source of data	Flight travel log
Description of measurement methods and procedures to be applied	Recording the number of passengers per trip.
Frequency of monitoring/recording	Annual
Value monitored	0 – zero
Monitoring equipment	Flight log.

QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-6 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$KM_{plan_ground, y, t}$
Data unit	Km
Description	Distance travelled per trip y , in year t .
Source of data	Vehicle travel log
Description of measurement methods and procedures to be applied	Recording the distance travelled per trip.
Frequency of monitoring/recording	Annual
Value monitored	0 – zero
Monitoring equipment	Vehicle log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-7 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$V_{fuel_plan_ground, y, t}$
Data unit	kL
Description	Annual volume of fuel consumed per trip y , in year t .
Source of data	Vehicle travel log
Description of measurement methods and procedures to be applied	Recording the fuel consumed per trip.
Frequency of monitoring/recording	Annual
Value monitored	0 - zero.
Monitoring equipment	Vehicle log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-8 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$KM_{design_flight, y, t}$
Data unit	Km
Description	Distance travelled per trip y , for a total of Y trips in year t .
Source of data	Flight travel log
Description of measurement methods and procedures to be applied	Recording all flights, their distance and date.
Frequency of monitoring/recording	Annual
Value monitored	0 - zero.
Monitoring equipment	Flight log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-10 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$N_{design_flight, y, t}$
Data unit	Number
Description	Number of passengers per trip y , in year t .
Source of data	Flight travel log
Description of measurement methods and procedures to be applied	Recording the number of passengers per trip.
Frequency of monitoring/recording	Annual
Value monitored	0 - zero.
Monitoring equipment	Flight log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-10 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$KM_{design_ground, y, t}$
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Data unit	Km
Description	Distance travelled per trip y , in year t .
Source of data	Vehicle travel log
Description of measurement methods and procedures to be applied	Recording the distance travelled per trip.
Frequency of monitoring/recording	Annual
Value monitored	0 – zero
Monitoring equipment	Vehicle log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-11 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$KM_{monitoring_flight, y, t}$
Data unit	Km
Description	Distance travelled per trip y , for a total of Y trips in year t .
Source of data	Flight travel log
Description of measurement methods and procedures to be applied	Recording all flights, their distance and date.
Frequency of monitoring/recording	Annual
Value monitored	416,860 km
Monitoring equipment	Flight log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-13 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$N_{monitoring_flight, y, t}$
Data unit	Number
Description	Number of passengers per trip y , in year t .
Source of data	Flight travel log

Description of measurement methods and procedures to be applied	Recording the number of passengers per trip.
Frequency of monitoring/recording	Annual
Value monitored	224
Monitoring equipment	Flight log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-13 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$KM_{monitoring_ground, y, t}$
Data unit	Km
Description	Distance travelled per trip y , in year t .
Source of data	Vehicle travel log
Description of measurement methods and procedures to be applied	Recording the distance travelled per trip.
Frequency of monitoring/recording	Annual
Value monitored	1,600 km
Monitoring equipment	Vehicle log.
QA/QC procedures to be applied	Double check.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-14 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$A_{nd, j, t}$
Data unit	Ha
Description	Area of natural disturbance nd , in stratum j , in year t .
Source of data	Satellite imagery and field measurement
Description of measurement methods and procedures to be applied	Acquisition of official deforestation satellite data, imagery analysis, determination of area deforested. According to our findings, all natural disturbance were classified as <i>blowdowns</i> . No fire, resulting in loss of forest cover was

	observed during monitoring period.
Frequency of monitoring/recording	Annual
Value monitored	6.69 ha.
Monitoring equipment	GIS softwares.
QA/QC procedures to be applied	Satellite images processing.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-15 and 4-17a of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$f_{natdisturb, j, t}$
Data unit	Percentage (%)
Description	Fraction of the forest naturally damaged in stratum j , in year t .
Source of data	Field survey
Description of measurement methods and procedures to be applied	Determination of the % of the forest damaged by the natural disturbance.
Frequency of monitoring/recording	Annual
Value monitored	100%
Monitoring equipment	Sample plots.
QA/QC procedures to be applied	Conservatively established
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-16 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$V_{illegal_harvest, t}$
Data unit	m^3
Description	Volume of wood sold as determined from field surveys, in year t .
Source of data	Field survey
Description of measurement methods and procedures to be applied	Determination of the volume of wood sold.
Frequency of monitoring/recording	Annual

Value monitored	0 – zero
Monitoring equipment	Surveillance.
QA/QC procedures to be applied	Visual media registration.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-21 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$A_{illegal_harvest, j, t}$
Data unit	Ha
Description	Area of illegal harvest in stratum j , in year t .
Source of data	Satellite data
Description of measurement methods and procedures to be applied	Determination of the area size of illegal harvest of timber.
Frequency of monitoring/recording	Annual
Value monitored	0 – zero
Monitoring equipment	GIS softwares.
QA/QC procedures to be applied	Field validation.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 4-22 of V-C-S's VM 0011.
Comments	No additional comments

Data / Parameter	$V_{actual_harvest, l, t}$
Data unit	$m^3 \cdot yr^{-1}$
Description	Annual actual volume of harvest for land/ that is owned and/or operated by the Project Proponent or the forest with comparable situations and condition in local or regional or nation level, in year t .
Source of data	Project Proponent records
Description of measurement methods and procedures to be applied	Determination of the annual actual volume of harvest for land.
Frequency of monitoring/recording	Annual
Value monitored	0 – zero
Monitoring equipment	Records analysis.

QA/QC procedures to be applied	Satellite imagery.
Purpose of the data	Calculation of project emissions
Calculation method	Application in equation 5-4 to 5-7 of V-C-S's VM 0011.
Comments	No additional comments

3.3 Monitoring Plan

Monitoring plan consisted in five main activities:

- Remote sensing data analysis – satellite imagery, PRODES/INPE official data and heat spot provided by INPE's Forest Fire (Queimadas, in Portuguese);
- Field surveillance – field incursions conducted by the Voluntary Environmental Agents (AAV's)
- Administrative records – purchase of flight tickets, energy consumption, etc.
- Forest inventory – sample plots instalment and DBH measurement.
- Monitoring of emissions due to the baseline activity shifting to other lands managed or operated by the project proponent and due market leakage.

Annually, the technical team from the EBCF downloads raw data from INPE's PRODES website. By clipping and overlapping PRODES data with the Project's area shapefile, it is calculated the portion of the area that had forest in the previous period and lost it in the present date. A polygon is established on the deforested area, its central geographical coordinate is registered and reported to EBCF. Based on the drawn polygon the deforested area is calculated by the GIS software, such as QGis (free software).

The same process is conducted with data from INPE's "Queimadas" Program (forest fire). Annually, INPE's data is downloaded and clipped with the Project's area. But, as for forest fire data, INPE provides information of "heat spots", which are classified based on heat signatures. If the ground temperature raises and exceeds 60 °C, this heat spot is registered in INPE's *Queimadas* Program's database. After identifying every heat spot located within the monitored area, the next step is to correlate this information with PRODES. This is necessary to determine whether the heat spot resulted in forest cover loss. During the monitoring period, only three heat spots were identified within the

Project's Area, but none of them resulted in loss of aboveground biomass, according to PRODES data.

The remote sensing data is corroborated by field incursions, two times per year, to inspect the Project Area. The AAV's transit within each RPDS, either by 4x4 vehicle or by *voadeiras*, checking for signs and evidence of logging, forest degradation, deforestation, land encroachment, forest fires and/or any other unplanned activities. The field surveillance is coordinated by Mr. Valdenor da Costa Junior, accompanied by three AAV's: Mr. João Wilson Ferreira da Silva, Mr. Marcioleno Souza da Costa and Mr. Rivelino Claro de Carvalho. Their protocol is, should any unplanned activity be detected, EBCF's headquarter must be informed immediately. Other actions are taken depending on each situation.

In 2014 it was identified a loss of 6.69 ha of forest area within RPDS Amazon Rio I. According to local surveillance team, none unplanned activity was observed or identified in that period. Also, no activity, that could result in deforestation, was authorized by EBCF (landowner and Project Manager). The next step was to correlate heat spots with the deforested area and no correlation was found, that is, the loss of forest cover could not be caused by forest fire, either natural or human induced. Considering all evidence, it was assumed that the deforestation identified was caused by natural disturbance classified as windstorms, or locally known as *blowdowns*. Then, by multiplying the $C_{AGB_gstock, t=0}$ by the CF_{AGB} , considering the $f_{natdisturb, j, t}$ as 100%, and the $A_{nd, j, t}$ it was estimated the total emission of $C_{natdisturb, t}$. Important to point out that, since the deforestation wasn't caused by fire, emission of other GHG's (CH_4 and N_2O) were not estimated.

Considering the Administrative monitoring, all travels (by any means of transportation) and energy consumption were recorded by EBCF administrative body. Every trip, motivated by the Amazon Rio REDD+ IFM-LtPF Project, was registered according to its transportation method (flight, vehicle or boat), the distance traveled (in km) and the number of passengers that travelled. According to EBCF's records, within the monitoring period approximately 415,540 km were flighted, transporting 220 passengers, summing a total of 94.98 tCO₂e of emissions; ground monitoring summed 800 km and fluvial 3,200 km, together they were responsible for, approximately, 15,57 tCO₂e during the monitoring period. As for energy consumption, EBCF's registered over 10,000 kWh consumed for the Project's purpose, accounting for an emission of, approximately, 1.01 tCO₂e.

The forest inventory was conducted in 2015 by Hdom's field team. Lead by HDOM, the forest inventory surveyed 162 sample plots, summing an area of 40.5 ha. Each sample plot had its geographical coordinate registered by a GPS device, all trees located within the plot's area were identified (according to its common name) and all DBH was measured with a diameter tape. Sampling design (plot distribution across the Project's area) was based on a random-systematic approach, where the plots were grouped in conglomerates, and the first plot of each conglomerate was randomly installed and the following plots systematically after.

All sampling was previous stratified based on remote sensing data and official information from EBCF (type of vegetation, logged and unlogged forest). After the field survey, all data was digitalized and double check by independent office teams. Statistical analysis was conducted to evaluate the degree of stratification and sampling size sufficiency. According to Hdom's findings the number of stratum were defined in two: RPDS I and the others (RPDS II, III and IV). Also, Analysis of Variance (ANOVA) showed robust evidence that sampling size (number of plots) were sufficient for statistical inference, that is, to estimate mean values and their uncertainty levels (interval of confidence in a 95% probability). Based on the collected data, site information was estimated considering the available variables: tree density, tree diversity, basal area per hectare, bole volume per area per diameter per species group (commercial species or not), biomass/carbon stock per area unit.

Parallel to the forest inventory, a survey of naturally fallen trees were also conducted, where all fallen trees, in the ground, found during the field survey were sampled. Every sampled tree had an analysis of decomposition: only whole, in perfect conditions, recent fallen, trees were sampled. Sampling included measurement of DBH (1.3 m from the tree's base), with a caliper and/or diameter tape and measurement of total and stem height, with a metric tape. All sampled trees had their bole volume determined, based on the combination of two traditional forestry methods: Smalian and Hohenadl. Where the tree's stem was divided in ten sections based on its length, and diameter of each extremity measured. Bole volume was calculated considering the cylinder formula. With the determined bole volume, through a Regression Analysis, a volumetric site-specific equation was adjusted. The adjusted equation was applied in the forest inventory data, of which resulted in the mean bole volume per area unit.

In order to monitor the market leakage, the supply of wood was analyzed in the years following the interruption of the logging activity in the project area. For that, data were consulted from the government institution responsible for regulating the activity in the state of Amazonas. Organizational structure, responsibilities and competencies of the personnel that carried out the monitoring activities are presented below.

Organization	Representative	Responsibility
EBCF Curitiba	Edmilson Castilla	Registering and recording all administrative activities, travels and energy consumption
EBCF Manaus	Valdenor da Costa Junior	Coordinator of Implementation of the Climate, Community and Biodiversity Monitoring Plan and organization of the AAV's and their activities.
EBCF Manaus	Heberton H. D. Barros	Project Description and Monitoring Report Review. Technical leader of Amazon Rio REDD+ Project. Carried out social engagement workshops with local communities and their leaders.
Hdom Environmental Consultancy®	Francisco Higuchi	Forest Inventory, Remote Sensing Data Analysis and Technical support
Local communities (AAVs)	Mr. João Wilson Ferreira da Silva; Mr. Marcioleno Souza da Costa Mr. Rivelino Claro de Carvalho	Field incursions for detection of unplanned/illegal activities

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions (CL 1, indicator 1)

For the project baseline calculation, guidelines, criteria and assumptions contained in Section 3 – Baseline Accounting - from the VCS VM0011 methodology were used. The following are the equations contained in this section that were used in the calculation of emissions in this study with their respective purposes and justifications.

All calculations presented in this section were made whereas annually harvested area from the beginning of the logging project. The Amazon Rio Reserves I, II, III and IV areas, formerly belonging to the Valdenor II farm, contained 6 plots where forest management occurred. The calculations and the results of the steps presented in this section are more fully described in the emissions spreadsheet (Annex 18) and annex documents, which will served as inputs for data calculation and referenced in each parties definition that follow.

The emissions estimates of the Amazon River REDD + Project are based on the volume of wood licensed for exploration, since this evidences basic elements for the baseline projection as the company's operational capacity for future exploration, yield and productivity of the area's forests of management.

Primary parameters such as area managed and volume exploited are backed up in the original documents that are part of the legal process of licensing the forest management activity and operating authorization documents certified by the competent governmental body. Digital copies of the documents are presented in Annexes 4 and 6.

4.1.1 Estimated Emissions from Degradations

For the purposes of calculating baseline emissions, it was considered the date when the Amazon River I Reserve was approved by the Department of Development, June 2013. This is justified by the fact that the methodology VM0011 assumes that selective logging ceases only when the project activities begins. This is not the case of this project in which the last date of the logging operations was 2010⁶.

To calculate the total carbon emitted associated with the baseline scenario equation 8 was used, considering emissions from the degradation of the project area plus emissions from selective exploration operations. The top level primary equation for calculating carbon emissions at baseline

⁶ License issued in 2008, but valid for 2 years (Annex 5, document entitled: *ACOF e LO PMFS Valdenor II 2008*).

is given by equation 1 as follows:

$$C'_{baseline,t} = C'_{degradation,t} + C'_{emissions,t}$$

Equation 1– Calculation of carbon emitted related to the baseline activities.

In which:

$C'_{baseline,t}$ – Annual total carbon emissions associated with the baseline scenario in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$C'_{degradation,t}$ – Annual total carbon emissions associated with the degradation due to the baseline activity in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$C'_{emissions,t}$ - Annual total carbon emissions associated with baseline activity operations of selective logging in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

Therefore, it was necessary to calculate the emissions generated by the degradation caused by the baseline activity, as well as the carbon emitted by the selective exploration operations separately.

To calculate the emissions from the degradation of the project area, equations 2 to 29, presented in section 5.3.3, were applied. For the calculation of emissions from selective exploration activity, equations 30 to 42 presented in section 5.3.4 were applied. Being calculated by applying the equations, the degradation emissions due to the extraction activities and the emissions caused by the operations related to these activities, obtained the total value of the baseline emissions, presented in table 2.

Table 2- Values found for baseline emissions

Sub areas	C'baseline	C'degradation	C'emissions,t
-----------	------------	---------------	---------------

UPA1	112,628	112,195	434
TALHÃO 2	73,156	72,706	450
TALHÃO 3	144,573	143,698	875
TALHÃO 4	52,850	52,449	401
TALHÃO 5	89,625	88,474	1,150
UPAs 5 e 6	93,913	92,527	1,386
Total	566,745	562,049	4,697

To calculate the carbon generated by the degradation caused annually by baseline activity for selective extraction, equation 2 was used:

$$C'_{degradation,t} = [(C_{DWdecay,t} + C_{ltHWPoxidation,t} + C_{stHWPoxidation,t} + C_{growth_foregone,t} - C_{regrowth,t}) * \frac{44}{12}]$$

Equation 2 – calculation of annual total carbon emissions associated with degradation as a result of the baseline activity.

In which:

$C'_{degradation,t}$ – Annual total carbon emissions associated with degradation as a result of the baseline activity in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$C_{DWdecay,t}$ - Annual carbon leaving the deadwood pool due to the decay of deadwood in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{ltHWPoxidation,t}$ Annual carbon due to the combined delayed oxidation of long-term harvested wood products and immediate oxidation of long-term harvested wood products residues in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{growth_foregone,t}$ Annual carbon lost due to growth foregone in the aboveground biomass in the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{regrowth,t}$ Annual carbon increase in the biomass due to regrowth following logging in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

44/12 = Ratio of the molecular weight of carbon dioxide to carbon.

Carbon emissions associated with degradation resulting from baseline activity are dependent and directly proportional to the commercial volume to be explored, among other primary parameters required for estimating emissions. Following the logic and script of the applied IFM methodology, the primary parameters were calculated and are presented in section 5.3.2, which follows. The

result and details of the application of sub-equations leading to the estimation of emissions associated with degradation resulting from baseline activity are presented in section 5.3.3.

4.1.2 Calculation of the Main Parameters in the Project Area

According to VM 0011, section 3, there are two ways to obtain data from the estimators that serve as inputs for the calculation of the primary parameters of the project.

- 1) the method that uses data from an existing inventory and;
- 2) the method of measuring the data in the field.

The proponent has chosen the field data measurement method, where a Forest Inventory Report is available and where the forest inventory does not distinguish between different types of forest products. The licensed volume of wood was used to calculate the commercial volume (V_{merch}), since it is calculated using the 100% forest inventory method or census, which measures and identifies all tree individuals that have been exploited, giving the exact size of the volume of wood exploited in the project area, being more conservative than estimates of commercial volume for the effect of the calculation of avoided future emissions, since the measurement of all the exploited individuals is surely more accurate than sampling methods with small and extrapolated areas to the project area.

In order to calculate the carbon stock in the commercial volume, the wood density method was applied by applying a mean wood density of all exploited species. For that, the wood density data provided by the Global Wood Density Database (Chave, 2009 and Zane, 2009), made available on a web platform, were used.

For the calculation of the above-ground biomass carbon in the growth stock, the data from the forest inventory report was used to validate the pre-existing forest inventory data using the allometric equations method. The detailed forest inventory report is available in Annex 23.

The data for the determination of the annual volume exploited and the net area exploited are backed by the licensing documents of the logging activity certified by the competent environmental agency, represented by the Environmental Protection Institute of Amazonas IPAAM. The digital copies of the Forest Management Plan and authorization documents for exploitation (AUTEX) are available in annex 4.

Existing forest inventory data validation

Operating licenses were used as input for calculating the baseline for existing forest inventory data

(Annex 4). In order to validate the data, data from the 2015 sample forest inventory were used, where permanent plots were installed to monitor carbon inventory in the project area (Annex 23). The estimated commercial volume, with DBH greater than or equal to 50 cm (minimum cutting diameter, established by current legislation) was used, considering:

1- A combined list of commercial species exploited by the company and the market value recognized by other companies in the regional sector;

2 - The volume of individual trees found in the plots of the sample forest inventory was calculated based on the volumetric equation adjusted from data collected "in situ". The equation and its regression analysis statistics are available in the technical report - Annex 23;

3- Finally, the mean volume of the forest inventory, estimated at a 95% probability level, per identified stratum (96.5 ± 12.1 m³/ha & 85.5 ± 12.5 m³/ha, strata 1 and 2, respectively) and stratified mode (93.6 ± 12.1 m³/ha). Considering the lower limits of these estimated mean values, they were higher than the mean value in the pre-existing data (33.7 m³/ha). Therefore, based on item 3.2, step 7: for the present project, the mean value of the existing data for the project parameter estimates will be used conservatively. The table of mean values with their respective confidence intervals is available in the technical reports of the sample forest inventory - Annex 23.

Carbon from merchantable logs using wood density method in which inventory data do not distinguish between different types of forest products

POAs were used to obtain the volume of potentially merchantable trees. For planning purposes appropriate forest surveys were conducted to estimate the diversity and measurements of the trees in the area (Annexes 1 and 4). The commercial timber volume was taken to mean all the extracted volume allowed by the AUTEXs (Logging Permits), presented in Annexes 4 and 6.

It is worth mentioning that the area of the sampled plots is the same area licensed for the exploration, since the licensing process requires the forest inventory using the 100% sampling method where all the individuals that are to be explored within the exploration area, known as "Talhões" and "UPAs - Annual Production Units" within the scope of the legal framework that underpins the process of licensing the timber exploitation activity. This point deserves attention because for the V_{merch} obtained in volume per hectare was considered the ratio between the volume and the area authorized for exploitation.

To calculate the carbon contained in the commercial timber per hectare in the project area, the wood density method was used, a formula was applied that makes no distinction between timber

products since all the extracted timber had the same purpose: construction. This equation uses the wood density and the fraction of carbon contained in it, as well as the volume of merchantable wood to obtain carbon in the logs:

$$\bar{C}_{merch,j,t=0} = D * CF_{wood} * \bar{V}_{merch,j,t=0}$$

Equation 3– calculation of the average carbon level per hectare in merchantable logs.

In which:

$\bar{C}_{merch,j,t=0}$ – Average carbon per hectare in merchantable logs in stratum j (where $j=1,2,3... j$ strata), determined ex ante - before the start of the IFM-LtPF project activities, hence $t=0$ years, in tC/ha.

D – Density of wood for a tropical forest with corresponding climate region and ecological zone in (t d.m)/m³.

CF_{wood} – Carbon fraction of wood for the tropical forest in tC/(t d.m).

$\bar{V}_{merch,j,t=0}$ – Average merchantable logs' volume per hectare in stratum j (where $j=1,2,3... j$ strata), determined ex ante - before the start of the IFM-LtPF project activities, hence $t=0$ years, in m³/ha.

The value of the parameter CF_{wood} were taken from Annex B of the methodology (REYES et al., 1992 and HUGHES et al., In IPCC, 2006 apud VCS, 2011) and correspond to 0.49 tC / (t.d.m), respectively. The value of parameter D was obtained from the average of the densities of the commercial species listed in the forest census inventory carried out during the licensing process, which lists the commercial species suitable for exploitation in the project area and corresponds to 0.67 tC / (t.d.m.). The value of $\bar{V}_{merch, j, t = 0}$ was obtained from the division of commercial volume exploited by the area explored to obtain the commercial volume per hectare exploited at the project baseline (Table 3).

The average carbon per hectare in the project area is then calculated by the following equation:

$$\bar{C}_{merch,t=0} = \frac{\sum_j^i (\bar{C}_{merch,j,t=0} * A_{project,j,t=0})}{A_{project,t=0}}$$

Equation 4 – Average carbon per hectare calculation in merchantable trees throughout the project area.

In which:

$\bar{C}_{merch,t=0}$ – Average carbon per hectare in merchantable logs in stratum j (where $j=1,2,3... j$ strata), determined ex ante - before the start of the IFM-LtPF project activities, hence $t=0$ years, in tC/ha.

$\bar{C}_{merch,j,t=0}$ – Average carbon per hectare in merchantable logs in stratum j (where $j=1,2,3... j$ strata), determined ex ante - before the start of the IFM-LtPF project activities, hence $t=0$ years, in tC/ha.

$A_{project,j,t=0}$ – Project Area within each stratum j (where $j=1,2,3... j$ strata) where the IFM-LtPF project activities will be implemented; determined ex ante - before the start of the IFM-LtPF project activities, hence $t=0$ year, in ha.

$A_{project,t=0}$ – Project Area where the IFM-LtPF project activities will be implemented; determined ex ante - before the start of the IFM-LtPF project activities, hence $t = 0$ years, in ha.

As a result the carbon contained in the marketable wood was obtained, as shown in table 3.

Table 3 Annual volume exploited, net area exploited, commercial timber volume and carbon from merchantable logs

Sub-areas	$A_{NHA_annual,t}$	$V_{merch,t}$	$V_{merch,j,t=0}$	$C_{merch,j,t=0}$
UPA1	587	30,970	53	17
TALHÃO 2	688	21,094	31	10
TALHÃO 3	832	41,390	50	16
TALHÃO 4	750	18,794	25	8
TALHÃO 5	1,082	32,230	30	10
UPAs 5 e 6	1,492	38,895	26	9
Total	5,430	183,373	214	71

Equations 3-5, 3-6 and 3-7 from the methodology were not used because the inventory data does not distinguish between different forest product types.

Each extraction subarea provided for in the Annual Operational Plans (POAs – Planos de Operação Anual) was considered separately. The carbon value in the tradable logs of each subarea was then multiplied by their respective extraction areas, and this value was divided by the sum of all areas of extraction. All these values, with the exception of $C_{merch, j, t = 0}$, already calculated, were acquired from POAs and operating licenses (Annexes 4 and 6).

Carbon in the biomass of growing stock using the biomass allometric method

For the average carbon per hectare in the growing stock aboveground biomass, the equation for allometric method was used, where biomass is calculated from field data from which to obtain the carbon value. As explained in the previous section, biomass value was calculated using forest inventory data (Annex 23).

To obtain the carbon per hectare contained in the above-ground biomass of the growing stock, the steps proposed by the applied methodology were followed⁷, as follows:

Step 1: The allometric biomass equation selected was the proposed by Silva (2007), developed in Central Amazonia in Ombrophilous Forests, similar to the phytophysiognomies found in the project area, widely disseminated and replicated in the scientific community . It is a simple input allometric equation, whose estimate of the biomass of the individual trees is given as a function of DAP only, applying a height correction factor (fc) which is estimated considering the dominant height (Hd) of the project area in relation to the dominant height of the forest canopy where the equation was developed. Finally discounted fresh biomass water for conversion to dry biomass considering the water content contained in the biomass of the trunks, branches, branches, leaves and roots (wf).The allometric equation was developed from the data analysis of the INPA Forest Management Laboratory, where samples were collected using destructive methods with the direct measurement of the fresh weight of 494 tree individuals and the fresh weight of thick roots by 131 arboreal individuals. All data were obtained from the experimental sustainable forest management area ZF-2. Regression models were tested to verify what best fit the estimate of fresh biomass, and as a result, the equation in form was proposed (SILVA, 2007), plus the correction factor proposed by Lima et al. (2012):

$$\bar{B}_{AGB} = a * DBH^b * fc * wf$$

Equation 5 - Allometric equation used for the above-ground living biomass calculation

In which:

\bar{B}_{AGB} – Above-ground dry biomass of tree individuals

a and b = coefficients of the exponential regression model found by Silva (2007)

DBH = Diameter at breast height

fc = Tree height correction factor at different sites

⁷ To this end, the forest inventory was conducted to obtain the primary field data required to estimate biomass in the project area. The methodological details and the results with the applied values are presented in Annex 23, which contains the final report, parameter calculation spreadsheets and field-measured data and spreadsheet containing the applied wood density information.

wf = Fraction corresponding to the water content contained in the trunks, branches, branches and roots of individual trees

For this work, the dominant height was estimated based on Higuchi (2015), where H_d is an average height of 10% of the thickest trees sampled. This variable is then used to determine a correction factor (fc) to compensate for the structural difference between the sampled site and the site from which the biomass equation was adjusted (Lima et al., 2012). Dominant Height (H_d) is calculated based on the formula below:

$$\bar{X} = \frac{\sum_{i=1}^n X_{10\%i}}{n_{10\%}}$$

Equation 6 - Calculation of dominant height based on average height of tallest trees

In which:

\bar{X} = arithmetic mean

$\bar{X}_{10\%i}$ = height of 10% of the grossest individuals sampled

$n_{10\%}$ = number of individuals representing 10% of the sample

The Tree Height Correction Factor (fc) is calculated based on the Dominant Height (H_d) of the sampled site in relation to the H_d of the site where the biomass equation was adjusted (INPA Tropical Forestry Experimental Station - ZF-2). According to Higuchi (2015), the H_d of the ZF-2 is 30.2 m. The calculated fc is then incorporated into the equation to compensate for the difference between the sites. The calculation form of the correction factor is presented below:

$$fc = \frac{H_{dSA}}{H_{dZF-2}}$$

Equation 7 – Correction factor applied to estimate tree height

In which:

fc = Tree height correction factor at different sites

H_{dSA} = Dominant height of sampled site (Project Area)

H_{dZF-2} = Dominant height of ZF-2 (Site where the equation was developed)

The dominant height found in the Project Area (Amazon Rio) was estimated at 32.9 m. The correction tree height factor of the biomass equation was estimated at 1,089.

Given the above, the equation adopted for the estimation of fresh biomass (B_{AGB}) of individual trees, or growing stock biomass is given by:

$$\bar{B}_{AGB} = 2.7179 * DBH^{1.8774} * 1.089$$

Equation 8 - General equation for above-ground biomass estimation

To obtain dry biomass for subsequent carbon conversion, the value of fresh biomass found for individual trees is multiplied by the water content found in the trunks, branches and roots and for this work the water content of 0.584 was adopted.

$$\bar{B}_{AGB} = 2.7179 * DBH^{1.8774} * 1.089 * 0.584$$

Equation 9 - Equation applied to convert above ground dry biomass to carbon

The methodological detail of the forest inventory used for the estimation of living biomass used for the estimation of biomass in the growing stock is given in Annex 23 (HDOM#P023_Relatorio-Tecnico_v1.pdf, págs 26, 27 e 28).

Step 2: No wood density value was applied to estimate the biomass in the growth stock because the adopted allometric equation was developed from a direct field biomass measurement method from the weighing of individual trees and directly correlated with DBH of weighed individuals, that is, wood density is already considered in the relationship between DBH and weight (biomass) found for individual trees.

Steps 3 and 4: As shown in Step 1, the DBH-dependent simple input allometric equation developed by Silva (2007) was adopted for the estimation of fresh biomass of the growing stock, applying the site correction factor for height trees and discounted the water content to obtain the dry biomass of the individual trees. Applying the allometric equation adopted in this work in equation 3-12 of VM-0011, the estimate of above ground biomass in the growing stock is given by:

$$\bar{B}_{AGB_{gstock,j,t=0}} = \frac{1}{A_{s,j,t=0}} * \sum_{s=1}^S \left\{ \sum_{i=1}^I \left[\sum_{n=1}^{N_i} f(2.7179 * DBH^{1.8774} * f_c * wf) \right] \right\}$$

Equation 10 - Equation for calculating biomass in growing stock

In which:

$\bar{B}_{AGB_{gstock,j,t=0}}$ = Average above-ground fresh biomass in the growing stock in stratum j, determined after the start of project activities IFM-LtPF (t.d.m) ha⁻¹

$f(2.7179 * DBH^{1.8774} * fc) =$ Allometric equation for biomass estimation as a function of diameter

at breast height (DBH) determined after IFM-LtPF project activities

DBH = diameter at breast height of individual trees *n*, in sample plots *s*, for each sampled stratum *j*, determined after the start of the project

fc = Tree height correction factor for the sampled site. Applied Value: 1,089

$A_{s,j,t=0}$ = Total area of the plots shown, in stratum *j*, determined after the start of the IFM-LtPF project activities

wf = Fraction corresponding to the water content contained in the trunks, branches, branches and roots of individual trees

During the forest inventory the influence of phytophysiognomy factors and properties was tested to verify if there was any difference between phytophysiognomies or Amazon Rio I, II III and IV properties. As a result no statistically significant difference was found between phytophysiognomies, but it was found between the Amazon Rio I Property area and the Amazon Rio II, III and IV property areas. During the forest inventory for above-ground live biomass, the area was stratified considering the difference found only between the properties. Details can be found in Annex 23 - HDOM # P023_Relatorio-Tecnico_v1.pdf, pages 36 and 37. The sampled area was 40.5 ha, distributed in 162 sample units with a size of 0.25 ha each in the EBCF properties for forest management. The above-ground living biomass values found were 271.4 ± 11.3 in stratum 1 and 290.7 ± 17.8 in stratum 2. Table 4 shows the distribution of plots in the properties and the phytophysiognomy sampled in each of them, the sampled area and the dry living biomass found.

Table 4. Properties, strata adopted, number of plots and area sampled in the forest inventory to estimate above-ground living biomass

EBCF Properties	Stratum	$\bar{B}_{AGB_{stock},j,t=0}$	forest type	n sample plots	Area (ha)
Amazon Rio I	1	271.4 ± 11.3	Alluvial Dense forest ombrophile	37	9.25
			Rain Forest land low	4	1
				40	10
Amazon Rio II	2	290.7 ± 17.8	Alluvial Dense forest ombrophile	16	4
Rain Forest Lowlands			16	4	
Amazon Rio III			Alluvial Dense forest ombrophile	17	4.25
Amazon Rio IV			32	8	
Total				162	40.5

Applying equation 11 then converts the average biomass for each stratum to the average biomass

over the entire project area.

$$\bar{B}_{AGB_{gstock,t=0}} = \frac{\sum_{j=1}^J (\bar{B}_{AGB_{gstock,j,t=0}} * A_{project,j,t=0})}{A_{project,t=0}}$$

Equation 11 - Converts the average biomass for each stratum to the average biomass over the entire project area

In which:

$\bar{B}_{AGB_{gstock,t=0}}$ = Average above-ground live biomass in the growing stock per hectare in project area

$\bar{B}_{AGB_{gstock,j,t=0}}$ = Average above-ground live biomass in the growing stock per hectare in each stratum

$A_{project,j,t=0}$ = Area of each stratum

$A_{project,t=0}$ = Project Area

The values found for the above ground dry biomass of the growing stock in each stratum proposed in the forest inventory, as well as the area of each stratum are presented in table 5.

Table 5. Above-ground dry living biomass values in the growing stock, strata and area of each stratum and for the total area

Strata	Area (ha)	$\bar{B}_{AGB_{gstock,j,t=0}}$
1	15,065.0	271.4 ± 11.3
2	5,322.0	290.7 ± 17.8
Total area	20,387.0	276.4 ± 11.9

The total area presented for each stratum differs from the project area because the sanctioned forest management area is considered as the project area as per the logging documentation of the logging activity, while the inventory area considered is the area of all properties contained in land documents (Land Ownership Documents).

All descriptive details of the statistical analysis and formulas used for parameter calculations and estimates by stratified sampling to arrive at the mean above ground live biomass stock are detailed in Annex 23 - HDOM # P023_Relatorio-Tecnico_v1.pdf. The details of the calculations, and results found by sample units and strata are presented in Annex 23 - "Hdom#P023_CÁLCULOS-ESTIMATIVAS-Inventário-Florestal_EBCF_201601.xlsx", tab "Strats-Est.-TOTAL".

Thus, the value applied for the above-ground dry biomass average stock in the growing stock is 276.4 t.d.m. ha⁻¹:

$$\bar{B}_{AGB_{gstock},t=0} = 276.4 \text{ t.d.m. ha}^{-1}$$

The estimate of the biomass of the individual trees is presented in Annex 23 - "Hdom#P023_CÁLCULOS-ESTIMATIVAS-Inventário-Florestal_EBCF_201601".xlsx in the tab "Cálculos-Estra".

Step 5: The carbon fraction (CF_{AGB}) value applied is 0.47 (tdm) ⁻¹ for trees with DBH ≥ 10 cm, as suggested by the applied methodology, Appendix B, Item B.2, Table B-2, as inventory The minimum inclusion DBH = 10 cm was adopted as criterion, and tree individuals with DBH ≥ 10 cm were measured.

Step 6: Finally, the above-ground live biomass in the growing stock was multiplied by the carbon fraction adopted in step 5 for the conversion of biomass to average carbon stock per hectare contained in the growing stock live biomass, as described in equation 12.

$$\bar{C}_{AGB_{gstock},t=0} = \bar{B}_{AGB_{gstock},t=0} * CF_{AGB}$$

Equation 12 - Average carbon per hectare in above-ground biomass in the growing stock

In which:

$\bar{C}_{AGB_{gstock},t=0}$ – Average carbon per hectare in above-ground biomass of the growing stock in the Project area, determined ex ante - before the start of the IFM-LtPF Project activities, therefore t = 0 years, in tC / ha.

$\bar{B}_{AGB_{gstock},t=0}$ - Above-ground biomass per hectare in the growing stock of the Project area, determined ex ante - before the start of the IFM-LtPF Project activities, therefore t = 0 years at t.d.m. / ha.

CF_{AGB} - fraction of carbon present in tree above-ground biomass for tropical forests. In tC by t.d.m

Thus, the value found for the average carbon stock contained in the above-ground living biomass in the Growing Stock is 129.91 tC ha⁻¹.

$$\bar{C}_{AGB_{gstock,t=0}} = 129.91 \text{ tC ha}^{-1}$$

Equations 3-8, 3-9, 3-10 and 3-11 from the methodology were not used because detailed FIR is available, and the biomass allometric method (for B_{AGB} and C_{AGB} calculations) was chosen. The inventory data does not distinguish between different forest product types.

TOTAL ANNUAL CARBON IN MERCHANTABLE LOGS

As well as the value of the volume of wood harvested per hectare used to calculate the $C_{merch, t=0}$, the annual harvest area ($ANHA_{annual, t}$) was also obtained from each of the harvesting licenses, as described above, total managed area calculated by the sum of the areas licensed for exploitation. It was considered that the whole extraction area authorized by the competent agencies was managed (Annexes 1 and 6).

These parameters were used to calculate the total annual carbon in the $C_{merch,t}$ trading volume, calculated by multiplying the Average Carbon per hectare in the trading volume by the net annual area exploited, applying equation 3-15b of the applied methodology, as Follow:

$$C_{merch,t} = \sum_{j=1}^J (\bar{C}_{merch,j,t=0} * ANHA_{annual,j,t})$$

Equation 13 - Calculation of total annual carbon in merchantable logs

In which:

$C_{merch,t}$ = Total annual carbon in tradable logs harvested from the Project Area in year t, (where t = 1,2,3 ... t * years have elapsed since the start of the IFM-LtPF project activity) in tC.

$\bar{C}_{merch,j,t=0}$ Average carbon per hectare in the tradable logs in stratum j (where j = 1,2,3 ... strata j) determined ex ante from the start of the IFM- project activity. LtPF, therefore t = 0 year, in tC ha¹.

$ANHA_{annual,j,t}$ = Annual net harvest area for Project Area in stratum j, (where j = 1,2,3 ... j strata) in year t, (where t = 1,2, 3 ... t * years since the start of the IFM-LtPF project activity), in ha

The values applied for the parameters and the total annual carbon in the tradable logs harvested in the project area at the beginning of the project are presented in table 6.

Table 6. Year of extraction, area explored, carbon contained in merchantable logs, in all sub-areas and total for Project area

Sub-area	$A_{NHA\ annual,t}$	$C_{merch.i,t=0}$	$C_{merch,t}$
UPA1	587	17	10,262
TALHÃO 2	688	10	6,990
TALHÃO 3	832	16	13,715
TALHÃO 4	750	8	6,228
TALHÃO 5	1,082	10	10,680
UPAs 5 e 6	1,492	9	12,888
Total	5,430	71	60,763

ANNUAL TOTAL CARBON IN ABOVE-GROUND BIOMASS IN THE GROWING STOCK

In order to calculate the total annual carbon contained in the above-ground biomass of the growing stock ($C_{AGB_gstock,t}$), it is necessary to multiply the average carbon per hectare in the above-ground living biomass by the net annual harvest area by applying equation 3-16b of applied methodology according to equation 14.

$$C_{AGB_gstock,t} = \sum_{j=1}^J (\bar{C}_{AGB_gstock,j,t=0} * A_{NHA_annual,j,t})$$

Equation 14 - Calculation of total annual carbon in above-ground biomass from growing stock

In which:

$C_{AGB_gstock,t}$ - Annual total carbon in above-ground biomass from growing stock harvested annually in the Project Area in year t, (where t = 1,2,3 ... t * years have elapsed since the start of IFM-LtPF project activity), tC

$\bar{C}_{AGB_gstock,j,t=0}$ - Average carbon per hectare in above-ground biomass of growing stock in stratum j, (where j = 1,2,3 ... strata J) determined ex ante - before start of the IFM-LtPF project activity, therefore t - year 0, in tC ha⁻¹

$A_{NHA_annual,j,t}$ - Annual net harvest area for Project Area in stratum j, (where j = 1,2,3 ... J strata) in year t, (where t = 1,2, 3 ... t * years elapsed since the start of the IFM-LtPF project activity), in ha

The values applied to the parameters and the annual total carbon in the above ground biomass of the growing stock found for the project area are presented in table 7.

Table 7. Parameters used to calculate annual total carbon in above-ground biomass of growing stock

<i>Sub-area</i>	$A_{NHA_annual,t}$	$C_{AGB_gstock,j,t=0}$	$C_{AGB_gstock,t}$
UPA1	587	130	76.216
TALHÃO 2	688	130	89.377
TALHÃO 3	832	130	108.019
TALHÃO 4	750	130	97.431
TALHÃO 5	1.082	130	140.560
UPAs 5 e 6	1.492	130	193.758
Total	5.430	-	705.360

4.1.3 Changes in Carbon Due to the Degradation Caused by the Baseline Scenario

The primary parameters calculated above are used to calculate the other parameters of equation 1 and get the value of carbon emitted due to degradation.

Net carbon from the deadwood pool

The deadwood pool of a particular area refers all the carbon in coarse woody debris, standing dead trees and other dead material not included in the litter or soil carbon pools. The methodology assumes that the proportion of deadwood accumulation to the deadwood pool and rate of decay from the pool due to natural mortality and disturbance will be the same for both the baseline and scenarios including project activities, and is therefore not included.

The difference between the selective logging baseline scenarios is the addition of branches and cuttings taken from uprooted trees and the ones that were left standing, but damaged due to forest management. In both cases there is an increase in the deadwood pool. Therefore, the biomass resulting from such damage is considered as input to the deadwood pool baseline selective logging scenario. The calculation of the carbon in this case is a function of that input of wood due to harvest damage and the respective decomposition rate as the equation 3-17 of the referenced methodology (VM 0011). The first step is therefore to calculate the carbon entering the deadwood pool using the following equation:

$$C_{Dwin,t} = C_{RSD,t} + C_{branch_trim,t}$$

Equation 15– Calculation of the carbon input from the deadwood pool.

In which:

$C_{Dwin,t}$ = Annual total carbon input to the deadwood pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM-LtPF activities), in tC.

$C_{RSD,t}$ = Annual carbon in the residual stand damage in year t (where $t=1,2,3... t^*$ years passed from the start of the project IFM-LtPF activities), in tC.

$C_{branch_trim,t}$ = Annual carbon in branches and trimmings left over from harvesting in year t (where $t=1,2,3... t^*$ years passed from the start of the IFM-LtPF project activities), in tC.

The values found for the total carbon input in the deadwood pool are presented in table 8.

Table 8. Total annual carbon input into the deadwood pool in year t , Annual carbon from remaining forest damage and Annual carbon on branches and cuttings from selective logging in the project area.

<i>Sub-area</i>	C_{RSD}	C_{branch_trim}	$C_{DWin,t}$
UPA1	24,630	3,171	27,801
TALHÃO 2	16,776	2,160	18,935
TALHÃO 3	32,916	4,238	37,154
TALHÃO 4	14,947	1,924	16,871
TALHÃO 5	25,632	3,300	28,932
UPAs 5 e 6	30,932	3,983	34,915
Total	145,832	18,776	164,608

To solve equation 15, a separate calculation of the carbon values resulting from damage to the standing forest by felling of trees and the carbon emitted from trimmings cut from felled logs is made, and presented in the following equations.

Carbon from residual stand damage

The remaining forest damage accounts for a ratio of 2.4 times the damage caused in the forest, ie for each ton of carbon contained in the commercial wood, 2.4 tons of carbon comes from the damage caused to the forest. The factor was obtained by Feldpausch et al. (2005). The authors of this study made several carbon analyses in low impact selective areas in southern Amazonia, the same biome and the same method used in the Amazon Rio Reserve I, II, III and IV areas. Therefore, it is reasonable to assume that the factor calculated by Feldpausch and his collaborators is applicable to the project areas.

$$C_{RSD,t} = F_{RSD,t} * C_{merch,t}$$

Equation 16 – Calculation of carbon resulting from forest damage residuals left in the forest after trimming the extracted logs.

In which:

$C_{RSD,t}$ – Annual carbon in the residual stand damage in year t , t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM-LtPF activities), in tC.

f_{RSD} – Factor for residual stand damage, based on the fraction of quantity of carbon damaged in the residual stand to the quantity of carbon in total merchantable logs harvested, Dimensionless.

$C_{merch,t}$ – Annual total carbon in merchantable logs harvested in the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

The values found for the carbon resulting from residues left in the forest after logging and the applied parameter values are presented in table 9.

Table 9. Total carbon contained in merchantable logs, remaining forest damage factor and annual carbon from remaining forest damage in year t

Sub-area	$C_{merch,t}$	f_{RSD}	C_{RSD}
UPA1	10,262	2.4	24,630
TALHÃO 2	6,990	2.4	16,776
TALHÃO 3	13,715	2.4	32,916
TALHÃO 4	6,228	2.4	14,947
TALHÃO 5	10,680	2.4	25,632
UPAs 5 e 6	12,888	2.4	30,932
Total	60,763	2.4	145,832

Carbon in branches and trimmings left in the forest after timber extraction

The crooked branches, canopies, and trunks cut of harvested trees are also removed in log preparation at the extraction site itself. The material removed and left in the forest is accounted for in the following equation:

$$C_{branch_trim,t} = f_{branch_trim} * C_{merch,t}$$

Equation 17– Calculation of carbon present in the branches and trimmings removed from extracted merchantable logs.

In which:

$C_{branch_trim,t}$ = Annual carbon in branches and trimmings left in the forest after harvesting in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{merch,t}$ = Total annual carbon in the merchantable logs harvested in the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

f_{branch_trim} = The fraction of branches and trimmings in the aboveground biomass remaining after trimming of the merchantable logs transferred to the deadwood pool. Dimensionless.

The branch and trimmings factor – f_{branch_trim} – must be derived from the ratio between the trimmed branches biomass to the total tree biomass. For this factor was adopted a ratio between canopy and aerial biomass of 30.9%, as reported by Silva (2007). At the time the author considered the average values of the biomass found and the biomass found in the crowns of all the trees sampled.

The values found for the annual carbon in branches and cuttings left in the forest after extraction in year t and the values applied for the carbon contained in merchantable logs are presented in table 10.

Table 10. Parameters used and values found for annual carbon contained in branches and cuttings left in the forest after logging.

<i>Sub-area</i>	$C_{merch,t}$	f_{branch_trim}	C_{branch_trim}
UPA1	10,262	0.3	3,171
TALHÃO 2	6,990	0.3	2,160
TALHÃO 3	13,715	0.3	4,238
TALHÃO 4	6,228	0.3	1,924
TALHÃO 5	10,680	0.3	3,300
UPAs 5 e 6	12,888	0.3	3,983
Total	60,763		18,776

Carbon emissions due to the decay of the deadwood pool

For the calculation of carbon in the deadwood pool, the following equations 18 to 21 were used. According to the decay rate, we calculated the remaining carbon fraction in the deadwood pool:

$$F_{DW_remain,t} = e^{-k_{decay} \cdot t}$$

Equation 18 – Carbon contained in the deadwood pool.

In which:

$F_{DW_remain,t}$ - Annual fraction of carbon in the deadwood pool that would remain in the deadwood pool in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities) after applying the decomposition rate. Dimensionless.

k_{decay} - Rate of decay of the deadwood pool, per year.

$t - 1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities.

The deadwood decomposition rate, k_{decay} was extracted from research performed in the Central Amazon rainforest (CHAMBERS et al., 2000) and corresponds to 0.167 per year.

Equation 3.22 in VM0011 (Equation 28 of this report) was used to calculate the carbon *input* in the deadwood pool. This equation should be used for a variable annual harvest volume as set out in the harvesting plan or equivalent document, implying a variable input into the deadwood pool (Annex 18).

$$C_{DWpool,t} = \sum_{t=1}^{t^*} (F_{DW_remain,t} * C_{DWin,t})$$

Equation 19– Carbon in the deadwood pool.

In which:

$C_{DWpool,t}$ Cumulative carbon remaining in the deadwood pool in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$F_{DW_remain,t}$ - Annual fraction of carbon in the deadwood pool that would remain in the deadwood pool in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities) after applying the decomposition rate. Dimensionless.

$C_{DWin,t}$ Annual total carbon input to the deadwood pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM-LtPF activities), in tC.

From the values of carbon entering the deadwood pool and its accumulated carbon, it is possible to calculate the amount of carbon leaving the deadwood pool and returning to the atmosphere .

$$C_{DWout,t} = \sum_{t=1}^{t^*} C_{DWin,t} - C_{DWpool,t}$$

Equation 20– Carbon emitted to the atmosphere from the deadwood pool.

In which:

$C_{DWout,t}$ Cumulative carbon leaving the deadwood pool and emitted into the atmosphere in year t ,

(where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC

$C_{DWin,t}$ Annual total carbon input to the deadwood pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM- LtPF activities), in tC

$C_{DWpool,t}$ Cumulative carbon remaining in the deadwood pool in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

To calculate the carbon that leaves the deadwood pool due to wood decay.

$$C_{DWdecay,t} = C_{DWout,t} - C_{DWout,t-1}$$

Equation 21– Annual carbon that leaves the deadwood pool due to wood decay.

In which:

$C_{DWdecay,t}$ Annual carbon leaving the deadwood pool due to the decay of the deadwood in year t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM-LtPF activities), in tC.

$C_{DWout,t}$ Cumulative carbon leaving the deadwood pool and emitted into the atmosphere in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{DWout,t-1}$ - Cumulative carbon leaving the deadwood pool and emitted into the atmosphere in year $t-1$, (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

As explained above, each area that suffered selective logging has its own Annual Operational Extraction Plan (POA), and thus operates individually. Therefore carbon which leaves the pool annually ($C_{DWdecay,t}$) is considered the same as the carbon leaving the pool in year t ($C_{DWout,t}$), since the sub-areas underwent logging only once. Therefore $t-1$ ($C_{DWout,t-1}$) does not exist.

The values of the parameters found to estimate carbon emissions due to decomposition of the deadwood reservoir are presented in table 11.

Table 11. Parameters found to estimate carbon emissions due to decomposition of deadwood pool

Sub-area	F_{DW} <i>remain,t</i>	F_{DW} <i>remain,t</i>	$C_{DWin,t}$	$C_{DWpool,t}$	$C_{DWout,t}$	$C_{DWout,t-1}$	$C_{DWdecay,t}$
UPA1	0.1	0.1	27,800.9	3,171.1	24,629.8	0.0	24,629.8
TALHÃO 2	0.1	0.1	18,935.4	5,907.3	40,829.0	24,629.8	16,199.2
TALHÃO 3	0.2	0.2	37,154.0	11,604.5	72,285.8	40,829.0	31,456.8
TALHÃO 4	0.2	0.2	16,870.9	16,934.7	83,826.4	72,285.8	11,540.7
TALHÃO 5	0.4	0.4	28,931.9	26,794.2	102,898.9	83,826.4	19,072.4
UPAs 5 e 6	0.6	0.6	34,914.9	42,236.8	122,371.2	102,898.9	19,472.3
Total	1.6	1.6	164,608.0	106,648.6	446,841.0	324,469.9	122,371.2

Net carbon from the long-term wood products pool

All wood extracted from the project area was to be used for construction, so the entire extracted amount was recorded as long-term wood products, e.g., with a half-life greater than 30 years in carbon estimates emitted by wood products. Thus, short-term wood products (with a 2-year half-life or less) were not considered as carbon sources in this PD and hence the $C_{stHWPoxidation}$ parameter is absent from Equation 22.

The carbon emitted from long-term wood products is the sum of the carbon emitted by the immediate oxidization of wood processing residues and the carbon emitted by the delayed oxidization of the products themselves.

$$C_{ItHWPoxidation,t} = C_{ItHWPresidues,t} + C_{ItHWPnet_out,t}$$

Equation 22 – Annual carbon from the oxidation of long-term wood products.

In which:

$C_{ItHWPoxidation,t}$ = Annual carbon due to the combined delayed oxidation of long-term harvested wood products and immediate oxidation of long-term harvested wood product residues in year t (where $t = 1, 2, 3 \dots t^*$ years elapsed since the start of IFM-LtPF project activities) in tC.

$C_{ItHWPresidues,t}$ = Annual carbon due to the immediate oxidation of long-term harvested wood product residues in year t (where $t=1,2,3\dots t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{ItHWPnet_out,t}$ = Annual net carbon due to the delayed oxidation of the long-term harvested wood products, leaving the long-term harvested wood products pool in year t (where $t=1,2,3 \dots t^*$ years elapsed since the start of IFM-LtPF project activities), in tC.

$C_{ItHWPresidues,t}$ and $C_{ItHWPnet_out,t}$ equations are properly described in the following sections.

Table 12. Values found for annual carbon from oxidation of long-term timber products

Sub-area	$C_{ItHWPresidues,t}$	$C_{ItHWPnet_out,t}$	$C_{ItHWPoxidation,t}$
UPA1	5,439	1,247	6,686
TALHÃO 2	3,705	766	4,470
TALHÃO 3	7,269	1,481	8,750
TALHÃO 4	3,301	379	3,680
TALHÃO 5	5,660	719	6,379
UPAs 5 e 6	6,831	754	7,585
Total	32,205	5,345	37,550

Carbon resulting from long-term wood products residues

It is assumed that the residues from sawmills undergo oxidation in the same year they are processed, therefore the carbon they release is calculated by the following equation:

$$C_{ItHWPresidues,t} = \bar{C}_{merch,p,t=0} * (1 - f_{lumber_recovery}) * A_{NHA_annual,t}$$

Equation 23– Carbon released due to immediate oxidation of long-term wood product residues.

In which:

$C_{ItHWPresidues,t}$ = Annual carbon due to the immediate oxidation of residues from long-term wood products in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{merch,p,t=0}$ = Average carbon per hectare in merchantable logs of forest product type p =sawlog, in the Project area, determined ex ante - before the start of IFM-LtPF project activities, hence $t=0$ years, in tC/ha.

$f_{lumber_recovery}$ = Lumber recovery factor for proportion of merchantable log converted to harvested wood product. Dimensionless.

$A_{NHA_annual,t}$ = Annual net harvest area for the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in ha.

The lumber recovery factor was obtained from Annex B of the methodology used (VERISSIMO et al., 1992 apud VCS, 2011) and was calculated for the Amazon and corresponds to 0.47.

Table 13. Values found for carbon calculation from long-term wood products residues

LOTE	$A_{NHA_annual,t}$	$C_{merch,t}$	$C_{ItHWPresidues,t}$
UPA1	587	10,262	5,439
TALHÃO 2	688	6,990	3,705
TALHÃO 3	832	13,715	7,269
TALHÃO 4	750	6,228	3,301
TALHÃO 5	1,082	10,680	5,660
UPAs 5 e 6	1,492	12,888	6,831
Total	5,430	60,763	32,205

Carbon due to the oxidation of long-term wood products reservoir

The average carbon input of long-term harvested wood products in the pool is calculated as follows:

$$C_{ItHWPin,t} = \bar{C}_{merch,p,t=0} * f_{lumber_recovery} * A_{NHA_annual,t}$$

Equation 24 – Annual carbon input to the long-term harvested wood products pool.

In which:

$C_{ItHWP_{in},t}$ = Annual carbon input to the long-term harvested wood products pool from sawlog in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{merch, p,t=0}$ = Average carbon per hectare in merchantable logs of forest product type $p=log$ in the project area, determined ex ante – before the start of the IFM-LtPF project activities, hence $t=0$ years, in tC/ha.

$f_{lumber_recovery}$ = Lumber recovery factor for the proportion of merchantable logs converted into harvested wood products. Dimensionless.

$A_{NHA_annual,t}$ = Net annual harvest area for the project area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in ha

The recovery factor of lumber is the same used in the previous equation, obtained from Annex B of the applied methodology (VERISSIMO et al., 1992 apud VCS, 2011), calculated for the Amazon and corresponds to 0.47. The value applied for the annual carbon input to the reservoir of long-term felled wood products from lumber is 28,558.8 tC.

According to the IPCC, the individual values for oxidation of different long-term wood products do not vary significantly. A constant product disposal rate is applied to the carbon contained in the reservoir (IPCC, 2006). Therefore it is possible to use a single oxidation factor for all long-term timber products.

$$F_{ItHWP_remain,t} = e^{-k_{ItHWP_ox} * t}$$

Equation 25 – Fraction of long-term wood products that remain in the long-term wood products pool.

In which:

$F_{ItHWP_remain,t}$ = Annual fraction of ItHWP that would remain in the ItHWP pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities) after applying the rate of oxidation. Dimensionless.

k_{ItHWP_ox} = Rate of oxidation for long-term harvested wood products
 t - 1,2,3... t^* years elapsed since the start of the IFM-LtPF project activities.

The oxidation rate of long-term wood products was obtained from the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and presented in Annex B of VM 0011 and corresponds to 0.023 per year. The value found for the fraction of long-term wood products remaining in the long-term timber pool is 4.9.

With these calculated parameters, it is possible to calculate the carbon that accumulates in the long-term harvested wood products pool with the following equation, for a variable harvest volume, as established in the harvesting plan or equivalent document, there is a variable entry in the lHWP group, VM0011, Equation 3-29b:

$$C_{lHWP_{pool,t}} = (F_{lHWP_{remain,t-(t-1)}} \times C_{lHWP_{in,t}}) + (F_{lHWP_{remain,t-(t-2)}} \times C_{lHWP_{in,t-1}}) + (F_{lHWP_{remain,t-(t-3)}} \times C_{lHWP_{in,t-2}}) + (F_{lHWP_{remain,t-(t-t^*)}} \times C_{lHWP_{in,t-(t^*-1)}})$$

Equation 26– Remaining carbon in the long-term harvested wood products pool.

In which:

$C_{lHWP_{pool,t}}$ Cumulative carbon remaining in the lHWP pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM-LtPF activities), in tC.

$F_{lHWP_{remain,t}}$ Annual fraction of lHWP that would remain in the lHWP pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities) after applying the oxidation rate. Dimensionless.

$C_{lHWP_{in,t}}$ Annual carbon input to the long-term harvested wood products pool from sawlog in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

The value found for the carbon remaining in the long-term wood pool is 75,466.8 tC

And the cumulative overall emissions leaving the long-term harvested wood products pool is calculate by equation 27:

$$C_{lHWP_{out,t}} = \sum_{t=1}^t C_{lHWP_{in,t}} - C_{lHWP_{pool,t}}$$

Equation 27– Carbon leaving the long-term harvested wood products pool.

In which:

$C_{lHWP_{out,t}}$ Cumulative carbon leaving the lHWP pool and emitted into the atmosphere from year $t=1$ to year t (where $t=1,2,3... t^*$ years elapsed since the start of the project activities IFM- LtPF), in tC.

$C_{lHWP_{in,t}}$ Annual carbon input to the long-term harvested wood products pool from sawlog in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{lHWP_{pool,t}}$ Cumulative carbon remaining in the lHWP pool in year t (where $t=1,2,3... t^*$ years elapsed since the start of the project IFM-LtPF activities), in tC.

The value found for cumulative carbon leaving the ItHWP pool and emitted into the atmosphere is 20,561.3 tC.

Finally, to calculate annual emissions leaving the long-term harvested wood products pool due to delayed oxidization, the following equation is used:

$$C_{ItHWPnet_out,t} = C_{ItHWPout,t} - C_{ItHWPout,t-1}$$

Equation 28– Annual net carbon from the delayed oxidation of long-term harvested wood products.

In which:

$C_{ItHWPnet_out,t}$ Annual net carbon due to the delayed oxidation of the long-term harvested wood products, leaving the long-term harvested wood products pool in year t (where $t = 1,2,3 \dots t^*$ years elapsed since the start of IFM-LtPF project activities), in tC.

$C_{ItHWPout,t}$ Cumulative carbon leaving the ItHWP pool and emitted into the atmosphere in year $t=1$ until the year t (where $t=1,2,3\dots t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{ItHWPout,t-1}$ Cumulative carbon leaving the ItHWP pool and emitted into the atmosphere in year $t-1$ (where $t=1,2,3\dots t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

In the same way that there is no $C_{DW_out,t-1}$, there is also no $C_{ItHWPout,t-1}$, as each sub-area suffered extraction only once over the years, as aforementioned. Thus, the net annual carbon due to delayed long-term wood product oxidation leaving the long-term wood product reservoir has a value of $C_{ItHWPout,t}$.

The synthesis of the values found for the estimation of carbon emissions due to the oxidation of the ItHWP pool and the necessary parameters for its estimation found in the project area, described throughout this topic are presented in table 14.

Table 14. Parameters calculated for the estimation of carbon emissions due to oxidation of the long term wood product pool

Sub-areas	$C_{merch,j,t=0}$	$C_{ItHWPin,t}$	$F_{ItHWP_remain,t}$	$C_{ItHWPpool,t}$	$C_{ItHWPout,t}$	$C_{ItHWPout,t-1}$	$C_{ItHWPnet_out,t}$
UPA1	17	4,823	1	3,577	1,247	0	1,247
TALHÃO 2	10	3,285	1	6,096	2,012	1,247	766
TALHÃO 3	16	6,446	1	11,061	3,493	2,012	1,481
TALHÃO 4	8	2,927	1	13,609	3,873	3,493	379
TALHÃO 5	10	5,020	1	17,910	4,591	3,873	719
UPAs 5 e 6	9	6,058	1	23,213	5,345	4,591	754
Total	71	28,559	5	75,467	20,561	15,216	5,345

Carbon in the growth foregone due to selective logging

Foregone carbon growth ($C_{growth_foregone}$) is the growth that did not occur in the trees that were extracted which consequently no longer store biomass, and is calculated after two consecutive monitoring periods. The above-ground biomass of all marketable trees within the permanent sampling plots should be measured in these two periods. Further calculations should be made using a comparison of these values to obtain the annual growth of aboveground biomass per hectare ($\bar{G}_{growth_foregone}$). Using this value it is possible to reach the carbon lost due to growth with the following equation:

$$C_{growth_foregone,t} = CF_{AGB} * \bar{G}_{growth_foregone,t} * \sum_{t=1}^{t*} A_{NHA_annual,t}$$

Equation 29—Calculation of carbon in the growth foregone due to the selective logging

In which:

$C_{growth_foregone,t}$ = Annual carbon lost due to growth foregone in the aboveground biomass in the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$\bar{G}_{growth_foregone,t}$ = Average growth per hectare per year in the aboveground biomass in the merchantable trees in the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in t d.m/ha/year.

CF_{AGB} - Carbon fraction in the aboveground biomass of trees for the tropical forest. In tC per t d.n.

$A_{NHA_annual,t}$ = Annual net harvest area for the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in ha.

As this parameter is to be estimated by two time measurements with two monitoring periods, the parameter is not applied as there were no two monitoring periods. Therefore the value applied to the parameter is equal to 0 tC, which is a conservative approach to the project emissions.

Carbon in the regrowth after selective logging

The methodology presents a conservative approach to calculate the carbon contained in regrowth, taking into account the regrowth that occurs throughout the managed area. The calculation of the carbon present in forest regrowth after selective logging is given by the following equation:

$$C_{regrowth,t} = (\bar{G}_{regrowth,t} * CF_{AGB}) * \sum_{t=1}^{t*} A_{NHA_annual,t}$$

Equation 30– Carbon due to regrowth

In which:

$C_{regrowth,t}$ Annual carbon increase in the biomass due to regrowth following logging in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$\bar{C}_{regrowth,t}$ Average regrowth per hectare per year of the aboveground biomass after logging in year t (where $t=1, 2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in t d.m./ha/year.

CF_{AGB} Carbon fraction in the aboveground biomass of trees for the tropical forest, in tC/t d.m.

$A_{NHA_annual,t}$ Annual net harvest area for the Project Area in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in ha.

The average annual above-ground biomass regeneration after extraction per hectare ($\bar{C}_{regrowth,t}$) was taken from a study done in eastern Amazonia on above-ground biomass dynamics after low impact selective extraction (MAZZEI et al., 2010), that is, the same case of this study and corresponds to 2.6 t.d.m./ha/year. The carbon fraction of above-ground biomass in tropical forest trees - CF_{AGB} – was obtained from the applied methodology and corresponds to 0.47 tC/t.d.m. The applied value for regeneration carbon after selective extraction is presented in table 15.

Table 15. Estimation of regeneration carbon after selective extraction obtained for the project area.

Sub-areas	$A_{NHA_annual,t}$	$C_{regrowth,t}$
UPA1	587	717
TALHÃO 2	688	841
TALHÃO 3	832	1.016
TALHÃO 4	750	917
TALHÃO 5	1.082	1.322
UPAs 5 e 6	1.492	1.823
Total	5.430	6.635

Finally and with all estimates made as described, it is possible to obtain the value of carbon emissions due to decay. The table below (Table 33) includes the main pools and the result from Equation 11. Notably, two pools are absent: the foregone carbon growth and carbon released by the oxidation of short-term timber products. The first one will only be calculated when monitoring activities begin. The latter is zero because there are no short-term timber products from the logging activities in the area.

Table 16. Value of carbon emissions due to decay in the Project Area (calculated from the carbon arising from the decay of dead matter, decay of long-term wood products and forest regeneration in logging areas)

Sub-areas	$C_{DWdecay,t}$	$C_{ItHWPoxidation,t}$	$C_{growth_foregone}$	$C_{regrowth,t}$	$C'_{degradation}$
UPA1	24.630	6.686	0	717	112.195
TALHÃO 2	16.199	4.470	0	841	72.706
TALHÃO 3	31.457	8.750	0	1.016	143.698
TALHÃO 4	11.541	3.680	0	917	52.449
TALHÃO 5	19.072	6.379	0	1.322	88.474
UPAs 5 e 6	19.472	7.585	0	1.823	92.527
Total	122.371	37.550	0	6.635	562.049

$C_{DWdecay,t}$ – annual carbon leaving the deadwood pool due to the decay of deadwood;
 $C_{ItHWPoxidation,t}$ – annual carbon due to the oxidation of long-term harvested wood products;
 $C_{growth_foregone}$ – annual carbon lost due to growth in the logged area; $C_{regrowth,t}$ – annual carbon increase in the biomass due to regrowth; $C'_{degradation}$ – annual total carbon emissions associated with degradation as a result of the baseline activity.

4.1.4 Baseline Activity Emissions

Besides the emissions produced by the logging itself, all emissions caused by the implementation of baseline activities must be taken into account, e.g., fuel consumption and electricity demands for the activities. The following equation includes all these additional emissions:

$$C'_{emissions,t} = E_{harvest,t} + E_{onsiteprep,t} + E_{hauling,t} + E_{transport,t} + E_{processing,t} + E_{distribution,t}$$

Equation 31– Carbon emissions due to the baseline activity.

In which:

$C'_{emissions,t}$ - Annual total carbon emissions associated with the baseline activity of selective logging operations in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{harvest,t}$ - Annual emissions due to harvesting operations such as felling and snigging in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{onsiteprep,t}$ - Annual emissions due to on-site preparation such as trimming of tree canopy, roots, branches and defective components in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{hauling,t}$ - Annual emissions due to log hauling in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{transport,t}$ Annual emissions due to log transport from collection site to processing site in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{processing,t}$ Annual emissions due to electricity consumption in sawmill in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{distribution,t}$ Annual emissions due to transport of the sawn product from the mill to the port for export or to the warehouse for local usage in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

The described parameters, equations and calculations are presented in the following sections.

Emissions due to harvesting operations

Logging is a mechanized process and therefore contributes to GHG emissions. In tropical forests, the most common logging method used including is the chainsaw. This is also true for the project area. The following formula is used to calculate the contribution of carbon released into the atmosphere due to selective logging operations:

$$E_{harvest,t} = FC_{harvest} * EF_{fuel} * V_{merch,t}$$

Equation 32– Calculation of emissions from harvesting operations.

In which:

$E_{harvest,t}$ Annual emissions due to harvesting operations such as felling and snigging in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$FC_{harvest}$ – Fuel consumption of equipment employed for felling and snigging per m³ of merchantable log harvested, in kL/m³.

EF_{fuel} – Fuel emission factor, in tCO₂-e/kL.

$V_{merch,t}$ Annual volume of merchantable logs in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m³.

Fuel consumption for chainsaws was taken from a master's thesis, written in the Amazon, which calculated the fuel and oil used in logging operations for this biome (Campos, 2012) and corresponds to 0.15 liters / m³ of gasoline and 0.031 liters / m³ of oil.

Both fuel and diesel oil emission factors were taken from the table presented by the IPCC (IPCC, 2006). All VM0011 methodology instructions contained in Annex C (C.2 and C.3) for the conversion of other emitted gases (CH₄ e N₂O) due to a CO₂ equivalent (CO₂-e). were followed.

For this conversion, a Global Warming Potential (GWP) value is required for each fuel, obtained from the United Nations Framework Convention on Climate Change website (UNFCCC, 2013). Transformation of the emission factor to the correct units also requires knowledge of each fuel's heating value and density. These values were also obtained from the IPCC (IPCC, 2006). The above explanation applies to all equations referring to the emission factor of a fuel (EF_{fuel}).

The parameters used to calculate the fuel emission factor and the values found are presented in tables 17 and 18.

Table 17. Parameters used to calculate the diesel emission factor for each gas converted to equivalent carbon dioxide.

Gas	$EF_{default}$	HV_{diesel}	P_{fuel_diesel}	GWP	EF_{diesel}
CO ₂	74,100	0.00004	844	1	2.68892
CH ₄	4	0.00004	844	21	0.00015
N ₂ O	29	0.00004	844	310	0.00104
Total	-	-	-	-	3.01381

Table 18. Parameters used for calculating the gasoline emission factor for each gas converted to equivalent carbon dioxide

Gas	$EF_{default}$	$HV_{gasoline}$	$P_{fuel_gasoline}$	GWP	$EF_{gasoline}$
CO ₂	69,300	0.00004	741	1	2.27394
CH ₄	170	0.00004	741	21	0.00558
N ₂ O	0	0.00004	741	310	0.00001
Total	-	-	-	-	2.39515

Finally, applying equation 41, the value found for emissions from harvesting operations corresponds to 67.59 tCO₂-e, which represents 1.4% of project emissions. This parameter was considered insignificant according to the tool explained in item 5.1.3.

Emissions due to on-site preparation

Preparation of logs in the extraction site consists of trimming branches, removing canopies and defective parts of the trunks. The use of chainsaws was also considered for all these procedures,. Thus, we adopted the same fuel consumption value for machinery presented earlier (CAMPOS, 2012). Equations 33 and 34 were used to calculate the carbon from these activities. The first equation calculates the volume of branches and trimmings removed from the logs to calculate the total emissions from site preparations using the second equation.

$$V_{branch_trim,t} = \frac{C_{branch_trim,t}}{CF_{wood} * D}$$

Equation 33 – calculation of the volume of branches and trimmings removed from the logs.

In which:

$V_{branch_trim,t}$ – Annual volume of the trimmings and branches produced from harvesting in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m^3 .

$C_{branch_trim,t}$ – Annual carbon in branches and trimmings left over from harvesting in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

CF_{wood} – Carbon fraction of wood for the tropical forest, in tC/(t.d.m.).

D – Wood density for the tropical forest with corresponding climate region and ecological zone, in (t d.m.)/ m^3 followed and correspond to 0.49 tC / t.d.m. and 0.676 (t d m) / m^3 .

The carbon fraction and wood density values for tropical forests were both taken from Annex B of the Methodology and correspond to 0.49 tC / t.d.m. e 0.676 (dm / m^3), respectively. For the annual carbon calculation in branches and cuttings left after extraction, the ratio of branches and cuttings to the volume of merchantable logs found by Silva (2007) was adopted and corresponds to 0.309 (dimensionless), or a ratio of 30.9% carbon on the volume of tradable logs.

$$E_{onsiteprep,t} = FC_{trim_equip} * EF_{fuel} * V_{branch_trim,t}$$

Equation 34 – Emissions from the preparation of the logs at the extraction site.

In which:

$E_{onsiteprep,t}$ – Annual emissions due to on-site preparation such as trimming of tree heads, butts, branches and defective components in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO_2-e .

FC_{trim_equip} – Fuel consumption of equipment employed for trimming per m^3 of trimmed material, in kL/m^3 .

EF_{fuel} – Fuel emission factor, in tCO_2-e/kL .

$V_{branch_trim,t}$ – Annual volume of the trimmings and branches produced from harvesting in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m^3 .

Chainsaw fuel consumption was obtained from a master's dissertation made in the Amazon, which accounts for the gasoline and oil used in the extraction operations for this biome (CAMPOS, 2012) and corresponds to 0.15 liters / m^3 of gasoline and 0.031 liters / m^3 of oil. The fuel emission factor

adopted for estimating emissions due to log preparation at the extraction site is the same as that adopted for calculating emissions due to logging operations and are presented in the previous topic.

The value found for the estimated emissions due to log preparation at the extraction site was 9.55 tCO₂-e, which represents 0.2% of the total annual project emissions (Table 19). Therefore, this parameter was considered insignificant according to the tool explained in item 5.1.3 and emissions are not accounted.

Table 19. Parameters used to estimate emissions due to on-site preparation.

Sub-area	$C_{merch,t}$	C_{branch_trim}	$V_{branch_trim,t}$	$E_{onsiteprep,t}$
UPA1	10,262	3,171	4,376	2
TALHÃO 2	6,990	2,160	2,981	1
TALHÃO 3	13,715	4,238	5,849	2
TALHÃO 4	6,228	1,924	2,656	1
TALHÃO 5	10,680	3,300	4,554	2
UPAs 5 e 6	12,888	3,983	5,496	2
Total	60,763	18,776	25,913	10

Emissions due to log hauling

To calculate the emissions due to dragging logs one must know the vehicle's fuel consumption per m³ for such an operation, in this case the *skidder*. Since it was not possible to find the value for the make and model used (skidder Muller TS 22) not even from the manufacturer, the value for a Grapple Skidder was used and correspond to 2.11x10⁻⁴ kl/m³.

A conservative approach was adopted using the lowest value from a range of values provided in the study (SMIDT E GALLAGHER S/A). The fuel emission factor adopted for estimating logging drag emissions is the same as that used for calculating emissions due due to log hauling are presented in tables 17 and 18 in this topic.

$$E_{hauling,t} = FC_{hauling} * EF_{fuel} * V_{merch,t}$$

Equation 35 – Calculation of carbon emissions from dragging extracted logs.

In which:

$E_{hauling,t}$ – Annual emissions due to log hauling in year t (where $t=1,2,3... t$ *years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$FC_{hauling}$ - Fuel consumption of equipment for hauling one m3 of merchantable log, in kL/m³.

EF_{fuel} – Fuel emission factor, in tCO₂-e/kL.

$V_{merch,t}$ – Annual volume of merchantable logs in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m^3 .

The value found for the estimation of log hauling emissions at the extraction site was 116.61 tCO₂-e, representing 2.4% of the total annual project emissions (Table 20). Therefore, this parameter was considered insignificant according to the tool explained in item 5.1.3 and emissions are not accounted.

Table 20. Parameters used to estimate emissions due to log dragging at the extraction site.

Sub-area	$V_{merch,t}$	$E_{hauling,t}$
UPA1	30,970	20
TALHÃO 2	21,094	13
TALHÃO 3	41,390	26
TALHÃO 4	18,794	12
TALHÃO 5	32,230	20
UPAs 5 e 6	38,895	25
Total	183,373	117

Emissions due to log transport

Timber was shipped either on trucks or ferries, both using diesel fuel. The transportation was performed between three points until reaching the processing site. The first transport was carried by carts from the extraction site (inside the forest) to the extraction port, from where the timber was transported to the city headquarters by ferries. In this route was considered the transportation of the whole volume of wood by the two means of transportation. From the port of Manicoré municipal headquarters, part of the timber was trucked to a sawmill in Manicoré (2%), and the rest went to the Gethal processing plant in Itacoatiara (98%) by ferry.

The calculation of the number of vehicles required for log transport is given by the equation:

$$N_{trucks_transport,t} = \frac{V_{merch,t}}{Cap_{truck}}$$

Equation 36– Formula to estimate the number of trucks/ferries needed to transport the amount of wood extracted.

In which:

$N_{trucks_transport,t}$ – Number of truck trips required for log transport from collection depot to processing sites in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in number of trucks/ferries.

$V_{merch,t}$ – Annual volume of merchantable logs in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m^3 .

Cap_{truck} – Truck load capacity, in m^3 per truck/ferry.

The load capacity of each vehicle was provided by the project proponent institution and correspond to $30 m^3$ for trailers and $500 m^3$ for ferries, considering the need for two means of transport, 2% of the volume transported by truck to the sawmill and 98% by ferry to the Gethal plant. Therefore the calculations are performed separately. The number of trailers and rafts required to transport the harvested wood is shown in table 21.

Table 21. Volume of tradable logs, number of trailers and rafts required to transport all timber to municipal headquarters, volume of sawmills (2%), volume of Gethal (98%) and number of trailers needed transport to processing place

Sub-area	$V_{merch,t}$	$N_{trucks_transport,t}$	$N_{balsas_transport,t}$	$V_{merch_2\%}$	$V_{merch_98\%}$	$N_{trucks_transport,t\ 2\%}$	$N_{balsas_transport,t\ 98\%}$
UPA1	30,970	1,032	62	619	30,351	21	61
TALHÃO 2	21,094	703	42	422	20,672	14	41
TALHÃO 3	41,390	1,380	83	828	40,562	28	81
TALHÃO 4	18,794	626	38	376	18,418	13	37
TALHÃO 5	32,230	1,074	64	645	31,586	21	63
UPAs 5 e 6	38,895	1,297	78	778	38,117	26	76
Total	183,373	6,112	367	3,667	179,706	122	359

The total kilometers driven can be subsequently calculated according to the round trip distance between the sites and the number of transport vehicles needed.

$$KM_{transport_total,t} = KM_{transport,t} * N_{trucks_transport,t} * 2$$

Equation 37–Total of kilometers driven in transporting logs.

In which:

$KM_{transport_total,t}$ – Annual total log transport distance in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in km.

$KM_{transport,t}$ – Annual log transport distance from collection depot to processing location in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in km per transportation vehicle.

$N_{trucks_transport,t}$ – Number of transportation vehicle trips required for log transport from collection depot to processing plant in year

t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in number of trucks/ferries.

2 – Constant, indicating return trip. Dimensionless.

The distance between sites was also provided by the project proponent institution. The distance traveled by trucks between the extraction site and the extraction port is 30 km. The distance traveled by ferries between the port of extraction and the port of Manicoré for distribution is 20 km. The distance traveled from the port of the municipal headquarters to the sawmill by trailer (2% of the volume) is 3 km. The distance traveled by ferries between the port of Manicoré and the port of Itacoatiara, the municipality where the Gethal factory is located, is 330 km. The total km traveled to transport the logs to the processing site is shown in table 22.

Table 22. Total distance traveled for transporting logs by trucks and ferriers considering the round trip on each leg traveled from the exploration site to the processing site.

Sub-area	$Km_{transport_t_truck}$	$Km_{transport_ba_lsa}$	$Km_{transport_truck_2\%}$	$Km_{transport_balsa_98\%}$	$Km_{transport_total_truck,t}$	$Km_{transport_total_balsa,t}$
UPA1	61,940	2,478	124	40,063	62,064	42,541
TALHÃO 2	42,188	1,688	84	27,287	42,272	28,975
TALHÃO 3	82,779	3,311	166	53,542	82,945	56,853
TALHÃO 4	37,588	1,504	75	24,312	37,664	25,816
TALHÃO 5	64,460	2,578	129	41,693	64,589	44,271
UPAs 5 e 6	77,790	3,112	156	50,315	77,946	53,427
Total	366,747	14,670	733	237,212	367,480	251,882

Finally, Emissions related to the transportation of logs can be calculated in terms of mileage, efficiency of vehicles and their emission factors, as shown in the following equation:

$$E_{transport,t} = \frac{KM_{transport_total,t}}{Eff_{vehicle}} * EF_{fuel}$$

Equation 38– Calculation of carbon emissions due to extracted logs transport.

In which:

$E_{transport,t}$ – Annual emissions due to log transport haulage from felling location to the collection depot/sawmill in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$KM_{transport_total,t}$ – Annual total log transport distance in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in km.

$Eff_{vehicle}$ – Fuel efficiency for vehicle type, in km per kL.

EF_{fuel} – Fuel emission factor, in tCO₂-e/kL.

Truck consumption was obtained by querying the websites of several manufacturers, which indicate an efficiency of 2 km/l. Ferry fuel consumption was obtained from a study carried out in Amazonas river by Barros and Uhl (1997) and corresponds to an efficiency of 3.77 km/l. The total annual distance of log transport by trucks and ferry is shown in table 40. The emission factors for fuels applied are 2.40 tCO₂-e/kL for gasoline and 3.01 tCO₂-e/kL for diesel⁸.

Table 23.– Emissions due to the transport of logs by trucks and ferries

Sub-area	$KM_{transport_total_truck,t}$	$KM_{transport_total_balsa,t}$	$E_{transport_truck}$	$E_{transport_balsa}$	$E_{transport,t}$
UPA1	62,064	42,541	94	34	128
TALHÃO 2	42,272	28,975	64	23	87
TALHÃO 3	82,945	56,853	125	45	170
TALHÃO 4	37,664	25,816	57	21	77
TALHÃO 5	64,589	44,271	97	35	133
UPAs 5 e 6	77,946	53,427	117	43	160
Total	367,480	251,882	554	201	755

Emissions from processing where grid electricity is available

The energy used in processing wood comes from the power grid and steam turbines from the burning of non-usable wood. As the wood used for the generation of steam has been accounted for in the calculation of long-term wood product residues ($C_{tHWPresidues,t}$) it is not considered again in this section to avoid double counting.

Emissions from wood processing depend on the source of electricity available and it is a function related to the processed amount, the demand for electricity and the electricity emission in the country where the IFM project is performed. The steps for calculation are found in equations 39 and 40.

$$Q_{processing,t} = V_{merch,t} * e_{demand}$$

Equation 39 – Calculation of electricity consumption required for wood processing.

In which:

$Q_{processing,t}$ – Annual quantity of electricity consumption for processing in year t (where $t=1,2,3...$

... t^* years elapsed since the start of the IFM-LtPF project activities), in kWh.

⁸The description of the application of the method for calculating the fuel emission factor is presented in the topic: “Emission due to cutting operations”

$V_{merch,t}$ – Annual volume of merchantable logs in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m^3 .

e_{demand} – Electricity demand for processing per volume processed, in $kWh m^{-3}$.

The electricity demand factor (e_{demand}) was taken from Annex B of the applied methodology VCS-VM0011 (POOLE AND PINHEIRO, 2003 apud VCS, 2011) and corresponds to an energy demand of $20 kWh m^{-3}$.

$$E_{processing,t} = Q_{processing,t} * EF_{electricity}$$

Equation 40 – Calculation of emissions from the harvested wood processing.

In which:

$E_{processing,t}$ – Annual emissions due to electricity consumption in sawmill in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO_2-e .

$Q_{processing,t}$ – Annual quantity of electricity consumption for processing in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in kWh .

$EF_{electricity}$ – Electricity emission factor for the host country, in tCO_2-e in kWh .

The electricity emission factors for Brazil for each year were obtained from the Ministry of Science and Technology website (MCTIC, 2013), and a publication from the International Energy Agency (IEA, 2012). The IEA provides values for the electricity emissions factor for the years 1990, 1995, 2000 and yearly from 2002 to 2009. As often as possible we chose the value corresponding to the logging year, when not possible we used the value of the closest year. Emissions were calculated up to the year 2003. The MCTIC website is more accurate with respect to information for Brazil, but only emission factors beginning in the year 2006 are available therefore only information from the years 2006-2008 was used.

The electricity emission factors for the project were $8.8 \times 10^{-5} tCO_2e / kWh$ for the year 2000, $7.8 \times 10^{-5} tCO_2e/kWh$ for the year 2003, $3.2 \times 10^{-5} tCO_2e / kWh$ for the year 2006 and $2.9 \times 10^{-5} tCO_2e / kWh$ for the year 2008.

The estimated emissions due to wood processing where a power grid is available found for the project emissions calculation is presented in table 24.

Table 24. Electricity emission factor adopted in Brazil for the years 2000, 2003, 2006 and 2008.

Sub-area	$Q_{processing,t}$	$E_{processing,t}$
UPA1	619,404	55
TALHÃO 2	421,881	37
TALHÃO 3	827,792	65
TALHÃO 4	375,884	33
TALHÃO 5	644,603	21
UPAs 5 e 6	777,905	23
Total	3,667,469	233

Emissions Due to Log Distribution

Harvested wood was directed to two locations, as mentioned above. The 2% transported to the sawmill in Manicoré was distributed throughout the municipality. There is no information available for the distances to local wood sellers. Conservatively, the 2% was considered to be zero, as suggested by the methodology. The calculation of emissions due to wood distribution focused on the 98% of the remaining wood, which left the Gethal factory in Itacoatiara for domestic and international destinations.

Domestic destinations included the ports of Santos in São Paulo, Paranaguá in Paraná and Itajai in Santa Catarina, receiving 50% of the wood from the Gethal factory. The information on the volume of wood sent to each of these ports is unknown, so an average distance of 313 km between these ports was considered for shipping the timber, with a maximum difference in distance from the Itacoatiara port to all the others,. The remaining 50% was exported to the United States and Germany, each receiving half of total exports. The entire plywood volume, both domestic and international, was sent in cargo ships.

Estimates for port distance were taken from the National Agency for Waterway Transportation (in Portuguese *Agência Nacional de Transportes Aquaviários*) (ANTAQ, 2004), which are more accurate. International distances were estimated in a straight line using Internet tools (<http://www.cidademapa.com.br/>). The ships were able to transport between 600 and 1,000 m³ of wood each trip, however, it is not known what type of ships were used and which trips and how many trips were made. Therefore a value of 1,000 m³ was used as a conservative estimate. Ship fuel consumption was calculated based on ANTAQ data (2009). All values used as inputs for the calculation of emission parameters due to the distribution of the logs are shown in Annex 18 in the "Calculations_baseline" tab. Table 21 presents the compiled values of emissions caused by the project activities.

To calculate emissions from the distribution of the logs from sawmills to their destination, the amount of long-term wood products is first calculated by the following equation:

$$V_{itHWP,t} = \frac{C_{itHWPin,t}}{D * CF_{wood}}$$

Equation 41– Amount of long-term wood products.

In which:

$V_{itHWP,t}$ – Annual volume of long-term harvested wood products in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in m^3 .

$C_{itHWPin,t}$ – Annual carbon input to the long-term harvested wood products pool from sawlog in year t , (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

D – Wood density for the tropical forest with corresponding climate region and ecological zone, in (t d.m.)/ m^3 .

CF_{wood} – Carbon fraction of wood for the tropical forest, in tC/(t d.m.).

The wood density values (D) and the wood carbon fraction in tropical forests (CF_{wood}) were taken from Annex B of the VCS-VM0011 methodology.

The value of parameter D was obtained from the average density of commercial species listed in the forest census inventory carried out during the licensing process, which lists the commercial species suitable for exploitation in the project area and corresponds to 0.49 tC/t d.m. The carbon fraction of wood in tropical forests (CF_{wood}) was taken from appendix B of the applied methodology VM0011 and corresponds to 0.49 t d.m./ m^3 . The values found for the volume of long-term timber products are presented in table 42.

Table 25. Values found to calculate emissions due to log distribution

Sub-area	$C_{itHWPin,t}$	$V_{itHWP,t}$
UPA1	4,823	3,495
TALHÃO 2	3,285	4,534
TALHÃO 3	6,446	8,896
TALHÃO 4	2,927	4,040
TALHÃO 5	5,020	6,928
UPAs 5 e 6	6,058	8,360
Total	28,559	36,252

The number of transports (ships) required for distribution is then determined by dividing the volume of long-life products by the vehicles' carrying capacity:

$$N_{trucks_{distrib,t}} = \frac{V_{ltHWP,t}}{CAP_{truck}}$$

Equation 42 - Calculation of the number of ships required to transport logs

In which:

$N_{trucks_{distrib,t}}$ - Annual number of transport trips required to distribute logs from the processing plant to the distribution / export point in year t, (where t = 1,2,3 ... t * years elapsed since the beginning of the IFM-LtPF project activity);

$V_{ltHWP,t}$ = Annual volume of long-term harvested wood products in year t, (where t = 1,2,3 ... t * years elapsed since the start of the IFM-LtPF project activity) in m³;

CAP_{truck} - Transport load capacity in m³/transport

Then you must determine the total distance traveled using the equation

$$KM_{distribtotal,t} = KM_{distrib,t} \times N_{truck_{distrib,t}} \times 2$$

Equation 43- Calculation of the total distance traveled for log transportation

In which:

$KM_{distribtotal,t}$ - Total annual distribution distance in year t, (where t = 1,2,3 ... t * years elapsed since the start of the IFM-LtPF project activity) km

$KM_{distrib,t}$ - Annual transport distance from the processing point to the distribution / export point in year t (where t = 1,2,3 ... t * years have elapsed since the activity began. IFM-LtPF project) km/ship⁻¹

$N_{truck_{distrib,t}}$ - Annual number of transport trips required to distribute logs from the processing plant to the distribution / export point in year t (where t = 1,2,3 ... t * years have elapsed since the beginning of the IFM-LtPF project activity) in number of ships

2 - Constant, indicating return trip without dimensions

Finally, we must estimate the emissions due to the distribution of logs through the equation:

$$E_{distribution,t} = \frac{KM_{distribtotal,t}}{Eff_{vehicle}} \times EF_{fuel}$$

Equation 44 - Calculation of emissions due to log distribution

In which:

$E_{distribution,t}$ - Annual emissions due to the transportation of sawn product from the mill to the export dock or local warehouse in year t (where t = 1,2,3 ... t * years have elapsed since start of IFM Project Activity -LtPF) in tCO2-e

$KM_{distribtotal,t}$ - Total annual distribution distance in year t, (where t = 1,2,3 ... t * years elapsed since the start of the IFM-LtPF project activity) in km

$Eff_{vehicle}$ - Fuel efficiency for vehicle type in km / kL⁻¹

EF_{fuel} - Fuel emission factor at tCO2-e / kL⁻¹

The applied fuel efficiency for ships is 250 km/kl⁻¹. The emission factor for fuels applied is 3.01 tCO2-e/kL for diesel. The calculated parameters and the estimated emissions due to the distribution of logs are presented in table 26.

Table 26. Total distance traveled for log distribution and estimated emissions due to log distribution.

Sub-area	$Km_{distribtotal,t}$	$E_{distribution,t}$
UPA1	20,861	251
TALHÃO 2	27,062	326
TALHÃO 3	53,100	640
TALHÃO 4	24,112	291
TALHÃO 5	82,699	997
UPAs 5 e 6	99,801	1,203
Total	307,635	3,709

With all parameters calculated it is possible to estimate emissions due to Baseline Activities. Table 27 presents the compiled emission figures from Project activities.

Table 27. Emissions due to processes related to baseline activities.

Sub-areas	$E_{harvest,t}$	$E_{onsiteprep,t}$	$E_{hauling,t}$	$E_{transport,t}$	$E_{processing,t}$	$E_{distribution,t}$	$C'_{emissions,t}$
UPA1	11	2	20	128	55	251	434
TALHÃO 2	8	1	13	87	37	326	450
TALHÃO 3	15	2	26	170	65	640	875

TALHÃO 4	7	1	12	77	33	291	401
TALHÃO 5	12	2	20	133	21	997	1.150
UPAs 5 e 6	14	2	25	160	23	1,203	1.386
Total	68	10	117	755	233	3,709	4.697

$E_{harvest,t}$ – annual emissions due to harvesting operations; $E_{onsiteprep,t}$ – annual emissions due to on-site preparation; $E_{hauling,t}$ – annual emissions due to log hauling; $E_{transport,t}$ – Annual emissions due to log transport; $E_{processing,t}$ – annual emissions due to electricity consumption for processing wood; $E_{distribution,t}$ – annual emissions due to transport of wood; $C'_{emissions,t}$ – annual total carbon emissions associated with baseline activity operations of selective logging

4.2 Project Emissions (CL2.1)

The project activities effectively begin when the logging activities end and forest carbon stocks are stored by suspending emissions from forest management. In the case of the Amazon Rio areas I, II, III and IV, the official start of the project is 2013, though logging activities were suspended in 2010.

At the start of the project, carbon emissions related to planning and implementation are generated. There are also emissions caused by natural disturbances and the illegal deforestation that may occur in the area. These emissions must also be accounted for and are considered in this section. The general equation for emissions generated by the project is as follows:

$$C'_{actual,t} = E_{projplan,t} + E_{design,t} + E_{monitoring,t} + [(C_{natdisturb,t} + C_{illegalharvest,t}) * \frac{44}{12}]$$

Equation 45 - Total annual emissions related to project activities.

In which:

$C'_{actual,t}$ – Annual total carbon emissions associated with the project activity in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{projplan,t}$ – Annual emissions due to administration and project planning in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{design,t}$ – Annual emissions from travel for design and set up in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{monitoring,t}$ Annual emissions due to monitoring for field work in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$C_{natdisturb,t}$ Annual carbon losses due to natural disturbances in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

$C_{illegal_harvest,t}$ Annual carbon losses due to illegal harvesting in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tC.

44/12 – The ratio of molecular weight of carbon dioxide to carbon, in tCO₂-e tC.

The primary and secondary effects of the project activities were determined using the protocol given by the World Business Council for Sustainable Development in conjunction with the World Resources Institute (WBCSD and WRI, 2005).

The main activity of the project is to transform areas previously used for selective extraction in protected areas, i.e., a change in forest management. The primary purpose of the project is to increase the forest carbon stock, since this project activity increases the storage and reduces CO₂ emissions to the atmosphere by biological processes from the regeneration resulting from suspending extraction activities. The secondary effects of the IFM project are only *upstream*, i.e., they are related to inputs used in the activities that generate emissions. These effects include the fuel spent on transportation for the administration, planning, design and monitoring of project activities. The table 28 summarizes the annual emissions from project activities since 2011 to calculate an annual average for the three years and to project as the basis for the estimation of emissions from project activities.

Table 28. Annual carbon emissions from the project activities, since the year 2011.

Ano	$E_{projplan}$	E_{design}	$E_{monitoring,t}$	$n_{atdisturb,t}$	$C_{illegal_harvest,t}$	$C_{actual,t}$
2011	11.27	12.18	16.33	0.00	0.00	39.77
2012	10.25	8.04	16.33	0.00	0.00	34.62
2013	50.58	8.96	16.33	0.00	0.00	75.87
Total	72.09	29.18	48.99	0.00	0.00	150.26

4.2.1 Emissions Due to Project Planning

The emissions from project planning come from administrative activities and associated travel:

$$E_{projplan,t} = E_{admin,t} + E_{plan_travel,t}$$

Equation 46 - Emissions associated with project planning

In which:

$E_{projplan,t}$ – Annual emissions due to administration and project planning in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{admin,t}$ – Annual emissions due to electricity consumption required for administration of the project activity in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{plan_travel,t}$ – Annual emissions due to travel for project planning in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

Emissions due to Administration

The calculation of emissions generated by administrative activities are related to the consumption of electricity and are shown in the following equation:

$$E_{admin,t} = Q_{admin,t} * EF_{electricity}$$

Equation 47 - Calculation of emissions generated by the management of project activities.

In which:

$E_{admin,t}$ – Annual emissions due to electricity consumption required for administration of the project activity in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$Q_{admin,t}$ – Annual electricity consumption due to administration of the project activity in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in kWh.

$EF_{electricity}$ – Electricity emission factor for the host country, in tCO₂-e in kWh.

Emissions related to the administration of the project related to electricity consumption ($Q_{admin,t}$), can be accounted for by summing the energy bills of the office that manages the project.

EBCF supplied the values in kWh for its office in Manaus for the monthly bills from June 2012 to July 2013, and for the office in Curitiba from December 2012 to September 2013 (Annex 21, "Admin emissions" tab). Before this period the EBCF had no office, which complicates the

measurement of energy spent in planning the project previously. The values for the year 2012 and 2013 are 1,296 kWh and 2,962 kWh respectively, totaling 4,376 kWh.

The emission factor for electricity was obtained from the Ministry of Science and Technology (MCTIC 2013) website. The corresponding annual values were used. The factor for the year 2013 was calculated as the average of the values for January and September, corresponding to the months in which EBCF provided energy bills for that year (Annex 21, "Admin emissions" tab).

Emissions due to Travel

Emissions from travel for project planning are divided into aircraft and ground transportation:

$$E_{plan_travel,t} = E_{plan_flight,t} + E_{plan_ground,t}$$

Equation 48 – Emissions related to trips made for project planning.

In which:

$E_{plan_travel,t}$ – Annual emissions related to travel for the planning of the project in the year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{plan_flight,t}$ – Annual emissions due to flights in the year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{plan_ground,t}$ – Annual emissions related to ground transportation in the year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

Emissions due to Flights

Emissions due to flights are calculated using the distance and the CO₂ emission factor per passenger, per km (Annex 21).

$$E_{plan_flight,t} = \sum_{y=1}^Y (KM_{plan_flight,y,t} * N_{plan_flight,y,t} * EF_{flight,y})$$

Equation 49 – Calculation of emissions related to flights made for project planning.

In which:

$E_{plan_flight,t}$ – Annual emissions due to flights in the year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$KM_{plan_flight,y,t}$ – Annual distance traveled per trip y (where $y=1,2,3... Y$ trips), in the year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in km.

$N_{plan_flight,y,t}$ – Annual number of passengers per trip y (where $y=1,2,3... Y$ trips), in the year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities).

$EF_{flight,y}$ – Flight emission factor for trip, y (where $y=1,2,3... Y$ trips), in tCO₂-e per person per km.

Distances were calculated using Google Maps, with a straight line between the departure and arrival points providing the distance. EBCF specified the number of passengers on each flight segment, for each year (Annex 21, tabs "Voos_2011", "Voss_2012" and Voos_"2013"). In cases where planes were chartered for the Manaus – Manicoré segment, maximum occupancy on the flights was assumed for both outbound and inbound flights. The emission factors for flights were obtained from Ross (2009).

Emissions due to Ground Transport

Land transportation related to Project activities was calculated by car and boat, both using gasoline. The emissions were calculated with the following equation:

$$E_{plan_ground,t} = \sum_{y=1}^Y (V_{fuel_plan_ground,y,t} * EF_{fuel})$$

Equation 50– Calculation of the project related ground transportation.

In which:

$E_{plan_ground,t}$ – Annual emissions due to ground transportation in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$V_{fuel_plan_ground,y,t}$ – Annual volume of fuel consumed per trip y (where $y=1,2,3... Y$ trips), in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in kL.

EF_{fuel} – Fuel emission factor, in tCO₂-e kL.

The volume of fuel consumed in trips per year was provided by the proponent institution (Annex 21). The values for emission factors were obtained from the IPCC (2006).

4.2.2 Emissions due to Design

The volume of fuel consumed in the trips per year was provided by the proposing institution and the calculations are presented in Annex 18, tab "transporte_terrestre_sec4". The emission factor values were obtained from the IPCC (2006).

$$E_{design,t} = E_{design_ground,t} + E_{design_flight,t}$$

Equation 51 – Emissions related to project design.

In which:

$E_{design,t}$ – Annual emissions from travel for design and set up in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{design_ground,t}$ – Annual emissions due to ground travel for the design stage in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$E_{design_flight,t}$ – Annual emissions due to air travel for the design stage in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

Emissions due to Flights

Emissions of flights related to the design of the project are calculated in the same way as emissions of flights related to planning:

$$E_{design_flight,t} = \sum_{y=1}^Y (KM_{design_flight,y,t} * N_{design_flight,y,t} * EF_{flight,y})$$

Equation 52–Calculation of emissions from flights related to the project design

In which:

$E_{design_flight,t}$ – Annual emissions due to air travel for the design stage in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in tCO₂-e.

$KM_{design_flight,y,t}$ – Annual distance travelled per trip y (where $y=1,2,3... Y$ trips), in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities), in km.

$N_{design_flight,y,t}$ – Annual number of passengers per trip y (where $y=1,2,3... Y$ trips), in year t (where $t=1,2,3... t^*$ years elapsed since the start of the IFM-LtPF project activities).

$EF_{flight,y}$ – Flight emission factor for trip, y (where $y=1,2,3... Y$ trips), in tCO₂-e per person per km.

Emissions from ground transportation related to project design are calculated in the same way as emissions from ground transportation related to project planning. It was not possible to separate the ground transportation activity that corresponds to each project phase. Thus, both were calculated together in planning emissions. This does not affect the final result since all the carbon emissions related to project activities result from the sum of the emissions for each component. Thus, equation 4.11 of VM0011 was not applied.

4.2.3 Emissions due to Monitoring

Monitoring activities in the Project area have not yet begun, however the parameter $E_{monitoring,t}$ for the general project emissions equation was estimated for the reference years to calculate the emissions from project activities (2011, 2012, 2013) according to the planned number of trips, distance traveled, movement of the team in the field and air travel for the coordinators responsible for developing the activities. The calculation of emissions derived from monitoring activities will be recalculated at each verification period, based on the activities carried out in each monitoring and verification period during the project and will be quantified according to section 4.3 of the VM0011 v.1 methodology, to be subsequently subtracted from the reduced ex-post emissions. The values used as inputs are evidenced in the tabs "transport_terrestre_sec4" and "Emissions project activities".

4.2.4 Emissions due to Natural Disturbances

Volcanoes, landslides, tornadoes and wildfires are the natural disturbances foreseen by the VM0011 methodology include. Among these, the only one that applies to the project areas are forest fires.

Considering that the project areas are composed exclusively of dense ombrophilous forest and that they are located in a region that experiences substantial rainfall, the probability of occurrence of forest fires is quite low, even in drier periods.

Although they are relatively frequent, the fires observed in the region rarely reach forest phytophysognomies. This is because these fires are mainly associated with the use of fire as a means to manage pastures and clear capoeira and newly deforested areas, in order to plant new crops and sustain pasture areas. Even in cases where fires become out of control due to inefficiency or absence of firefighters, they are rarely able to overtake forest areas, mainly due to the high humidity of the forest material that could catch fire, even during the dry season.

On the other hand, the edges of forests that are systematically exposed to fire present gradual losses of biomass and a marked increase in the risk of fires of higher proportion due to the greater presence of burnable material (dead trees) left by previous fires. Thus, even if forest biomass stock losses are not expected within the project area, the boundaries of the project zones that border with areas of capoeira and pasture should receive more intense monitoring and prevention work.

Even if ex ante estimates are not considered due to low probability, emissions from forest fires will

be monitored, measured and taken into account in the ex post calculations of net GHG emission reductions. Monitoring will be done remotely based on INPE's fire management system (*Programa Queimadas do INPE*)⁹, followed by field verification to measure the intensity of the damage caused and GIS analysis to calculate the area damaged.

The ex-post quantification of emissions from fires, as well as the removal of GHG from natural regeneration, will follow the methodological roadmap contained in steps 1 to 8 of section 4.4 of the methodology VM0011 v.1.

4.2.5 Emissions due to Illegal Logging

Emissions due to illegal deforestation after the beginning of the project (2013) are equal to zero. Consolidated data from the 2012 Monitoring Program of Deforestation in the Legal Amazon (INPE/Prodes) were analyzed and 10 deforestation alerts within the IFM project area were found prior to 2013: 2010, 2004, 2000 and 1997.

4.3 Project Emissions

After implementation of the Project, there were two main sources of emission: administrative, travels motivated by the monitoring plan and from natural disturbance, from windstorms. Details on methods of determining Project emissions were presented in section 3.3 above.

Emissions from “administrative” are related to energy consumption. EBCF registered the amount of energy consumed in their offices due to administrative activities, related to the Project. The correspondent value was obtained through the energy bill, where it contains the amount of energy, in kWh, consumed within a given period. EBCF administrative body was able to distinguish the number of hours per period was dedicated to this Project. By doing so, it was possible to estimate the emission from energy consumptions. According to EBCF’s records, over 10,000 kWh was consumed within the monitoring period, summing, approximately 1.11 tCO₂e.

Travels motivated by the monitoring plan considered flights, vehicles and *voadeiras*. According to EBCF records, within the monitoring period it was travelled by airplane over 415.5 thousand km, summing, approximately, 94.98 tCO₂e. Emissions from ground and

⁹ <https://prodwww-queimadas.dgi.inpe.br/bdqueimadas/>

fluvial monitoring during the analyzed period total 800 km by vehicle and 3,200 km by *voadeiras*, resulting in an emission of, approximately, 15.57 tCO₂e.

From natural disturbance, based on the evidence at hand: no unplanned or planned activity, that could result in deforestation, was registered during the monitoring period; no heat spot identified within the Project area resulted in loss of forest cover, corroborated by PRODES data; windstorms caused a loss of aboveground biomass in an area of, approximately, 6.69 ha. Which, considering the carbon stock of the forest, estimated by the results of the forest inventory conducted at the Project area; and the $f_{natdisturb\ j,t}$ as 100%, resulted in an emission of, approximately, 3,186.64 tCO₂e. Table 29, below, summarizes the Project's emissions.

Table 29. Project emissions, due to Project activities and natural disturbance within the Project area and its buffer zones, from June 5th, 2013, to June 4th, 2017.

Year	Energy (KWh)*	Energy (tCO ₂ e)	Travels (Km)*	Travels (tCO ₂ e)	Deforestation by Natural Disturbance (ha)	Deforestation by Natural Disturbance (tCO ₂ e)**	Total (tCO ₂ e)
2013	4,079	0.45	231,749	58.18	0	0	58.63
2014	2,722	0.3	16,789	8.48	6.69	3,186.64	3,195.42
2015	2,231	0.25	28,340	9.87	0	0	10.12
2016	1,015	0.11	136,662	34.03	0	0	34.14
Total	10,047	1.11	413,540	110.56	6.69	3,186.64	3,298.31

* Means of transportation considered are: flights, vehicles and *voadeiras*. Sources of calculation available on the Appendix 1.

** Mean estimate, based on the aboveground biomass CO₂e content, calculated in Annex 23 of the PD, and the remote sensing monitoring of the Project area (Annex 24 of the PD).

4.4 Leakage

Monitoring activities showed that no logging operations were conducted within the Project area or the Leakage management belt. Likewise, the project proponent (EBCF) does not own or operate any other forest areas with plans for logging management, nor is this activity featured among activities that company has proposed¹⁰. As such, there is no possibility of:

- Intensified logging in other areas to compensate for the activities suspended in the project area;

¹⁰ <http://www.ebcf.com.br/ebcf/quem-somos/>

- Transfer of logging operations from the project area to any other forest concession in the country.

It is worth reiterating that EBCF acquired the areas for conservation purposes, with the intent to develop a strategy for generating revenue through conservation and total suspension of logging activities. In this context, EBCF's focus on the project area will be dedicated exclusively to emissions reduction activities and trading of VCUs and CRAs, while allowing the surrounding communities to extract non-timber forest products (NTFPs) and conduct community-based ecotourism.

Since there is no possibility of leakages due to shifting of baseline activities (logging management) to other areas, it is zero.

It can be credibly stated that no market leakage has occurred due to project activities. According to data presented by the official environmental agency responsible for the licensing of Amazonian timber exploration activity (IPAAM - Instituto de Proteção Ambiental do Amazonas), the volume of timber harvested in the municipality of Manicoré in which the project is located, and in the Amazonas state as a whole has declined since logging operations were disrupted in the project area, particularly in the first two years (Table 30).

Table 30. Volume of tropical wood in logs offered in the state of Amazonas and in the municipality of Manicoré, showing the reduction in wood supply in the years following the interruption of logging in the project area.

Year	State of Amazonas (m ³ /ano)	Municipality of Manicoré (m ³ /ano)	Project proponent (m ³ /ano)
2009	358,709.5	98,643.3	38,895.24
2010	189,063.8	40,330.7	
2011	209,043.9	45,511.5	
2012	320,193.7	71,352.6	
2013	557,721.2	76,070.5	

It is possible to observe that the fluctuation in the supply of licensed wood is attributed to other factors that go beyond the question of the interruption of timber exploitation in the project area, which led the project proponent to assume the market leakage resulting from

the project activities as null.

The original documents containing the data presented here can be independently evaluated through the links on this site: <http://www.ipaam.am.gov.br/estatisticas-ipaam/>

Base year 2009: <http://www.ipaam.am.gov.br/wp-content/uploads/2018/04/6-Volume-de-Madeira-Autorizada-para-Manejo-2009.pdf>

Base year 2010: <http://www.ipaam.am.gov.br/wp-content/uploads/2018/04/5-Volume-de-Madeira-Autorizada-para-Manejo-2010.pdf>

Base year 2011: <http://www.ipaam.am.gov.br/wp-content/uploads/2018/04/5-Volume-de-Madeira-Autorizada-para-Manejo-2011.pdf>

Base year 2012: <http://www.ipaam.am.gov.br/wp-content/uploads/2018/04/5-Volume-de-Madeira-Autorizada-para-manejo-2012.pdf>

Base year 2013: <http://www.ipaam.am.gov.br/wp-content/uploads/2018/04/5-Volume-de-Madeira-Autorizada-para-Manejo-2013.pdf>

4.5 Net GHG Emission Reductions and Removals

Based on the results from the Monitoring activities, along the first crediting period (4 years), it is estimated that the net GHG emission reductions, due to the Project, is **202,787tCO₂e**.

Table 31. Net GHG emission reductions of the Project, in metric tons of carbon dioxide equivalent (tCO₂e).

Year	Baseline emissions (tCO ₂ e)	Project emissions (tCO ₂ e)	Leakage emissions (tCO ₂ e)	Net GHG emission reductions (tCO ₂ e)	Buffer pool allocation	VCUs eligible for issuance
05 June 2013 to 04 June 2014	51.522	59	-	51.463	5.110	46.353
05 June 2014 to 04 June 2015	51.522	3.196	-	48.326	5.110	43.216
05 June 2015 to 04 June 2016	51.522	11	-	51.511	5.110	46.401
05 June 2016 to 04 June 2017	51.522	35	-	51.487	5.110	46.377
Total	206.088	3.301	-	202.787	20.440	182.347

Considering the buffer determinate by the non permanence risk report calculation tool (10%), the number of buffer credits to be deposited in the AFOLU pooled buffer account, considering the monitoring period 2013 - 2016 is 20,440 VCU's, or 5,110 VCU's per year.

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