ARATAÚ RIVER REDD PROJECT

Document Prepared by Future Forest

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1 PROJECT DETAILS

1.1 Summary Description of the Project

In Brazil, 58.39% of its entire 851,029,591.4 ha territory[1] is covered by forests, representing almost 497 million hectares of forest area[2] and putting it in second place for nations with most forest area worldwide. Brazil has also been at times the country with the highest levels of deforestation in the world, having lost almost 15 million hectares of its forest area from 2010 to 2020[3]. The expansion of the agriculture frontier due to cattle ranching, soy farming, timber collection, infrastructure and colonization by subsistence agriculturalists has contributed to this historically high deforestation rate, which is concentrated in the northern portion of the country, where the Amazon Rainforest lies.

The primary objective of the Arataú River REDD Project is to avoid the unplanned deforestation (AUD) within the 25,417.85 ha project area, consisting of 100% Amazon rainforest. The project area is a private property, which is located in three different municipalities in the State of Pará: Tucuruí, Pacajá and Novo Repartimento This project was designed as a grouped project, as to be able to increase its contribution to the standing forest with the addition of new project activity instances in the future.

The State of Pará is one of the main meat producers in Brazil[4]. Simultaneously, Pará also registers the highest deforestation rate in Brazil, accounting for around 35% of the total cumulative deforestation in the Amazon biome until 2021, with more than 165,000 km² deforested[5].

In addition to the project's ecological and carbon benefits, a proportion of the carbon credits generated will be dedicated to improving the social and environmental conditions in the project region, specifically contributing to improving deforestation control, aiming at the propagation of environmental awareness, generation of alternative sources of income and environmental education actions.

The present REDD project is expected to avoid a predicted 11,105 ha of deforestation, equating to 5,414,313 tCO2e in emissions reductions over the 30-year project lifetime, with an annual average of 180,478 tCO2e.

[1] IBGE – Instituto Brasileiro de Geografia e Estatística. Brazil. 2019. Available at: <https://www.ibge.gov.br/cidades-e-estados>.
[2] FAO and UNEP. 2020. The State of the World's Forests 2020. Forests, biodiversity and people. Rome. Available at: <https://doi.org/10.4060/ca8642en>.
[3] FAO. 2020. Global Forest Resources Assessment 2020: Main report. Rome. Available at: < https://doi.org/10.4060/ca9825en>.
[4] Available at < https://cidades.ibge.gov.br/brasil/pa/pesquisa/24/76693?localidade1=0>
[5] Available at < http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/rates>

1.2 Sectoral Scope and Project Type

Sectoral Scope: 14 – Agriculture, Forestry, Land Use

Project Category: Avoided Unplanned Deforestation (AUD Project Activity)

This is a grouped project.

1.3 Project Eligibility

According to the VCS Methodology Requirements[6], for Reduced Emissions from Deforestation and Degradation (REDD) projects, eligible activities are those that reduce net GHG emissions by reducing deforestation. Thus, the project is eligible under the scopes of the VCS Program[7], following the VCS Standard[8]:

Eligibility Conditions	Justification of Eligibility
Projects shall meet all applicable rules and requirements set out under the VCS Program, including this document.	The project meets all applicable rules and requirements set out under the VCS Program, as detailed in this section and in Applicability of Methodology.
Projects shall apply methodologies eligible under the VCS Program. Methodologies shall be applied in full, including the full application of any tools or modules referred to by a methodology	The applied methodology is VM0015 – Methodology for Avoided Unplanned Deforestation, v1.1. Applicability conditions are detailed in section 3.2.
Projects and the implementation of project activities shall not lead to the violation of any applicable law, regardless of whether or not the law is enforced.	The project activity involves the conservation of native Tropical Rainforest, including sustainable forest management plan or not. These activities are eligible under the Brazilian law according to conditions set out in sections 1.14 and 3.5.

[6] Available at < https://verra.org/documents/vcs-methodology-requirements-v4-3/>
[7] Available at: https://verra.org/documents/vcs-program-guide-v4-3/>
[8] Available at < https://verra.org/documents/vcs-standard-v4-4/>

Eligibility Conditions	Justification of Eligibility
Where projects apply methodologies that permit the project proponent its own choice of model (see the VCS Program document Program Definitions for definition of model), such model shall meet with the requirements set out in the VCS Program document VCS Methodology Requirements and it shall be demonstrated at validation that the model is appropriate to the project circumstances (i.e., use of the model will lead to an appropriate quantification of GHG emission reductions or removals).	Not applicable. Project applies the VM0015 Methodology.
Where projects apply methodologies that permit the project proponent its own choice of third-party default factor or standard to ascertain GHG emission data and any supporting data for establishing baseline scenarios and demonstrating additionality, such default factor or standard shall meet with the requirements set out in the VCS Program document VCS Methodology Requirements.	Not applicable. Project applies the VM0015 Methodology, in addition to the VT0001 for additionality assessment.
Projects shall preferentially apply methodologies that use performance methods (see the VCS Program document VCS Methodology Requirements for further information on performance methods) where a methodology is applicable to the project that uses a performance method for determining both additionality and the crediting baseline (i.e., a project shall not apply a methodology that uses a project method where such a performance method is applicable to the project).	Not applicable. Project applies the VM0015 Methodology, in addition to the VT0001 for additionality assessment.

Eligibility Conditions	Justification of Eligibility
Where the rules and requirements under an approved GHG program conflict with the rules and requirements of the VCS Program, the rules and requirements of the VCS Program shall take precedence	The project applies approved VCS methodology and tools. The project shall take precedence to the rules and requirements of the VCS Program over other approved GHG Program.
Where projects apply methodologies from approved GHG programs, they shall comply with any specified capacity limits (see the VCS Program document Program Definitions for definition of capacity limit) and any other relevant requirements set out with respect to the application of the methodology and/or tools referenced by the methodology under those programs.	The project applies approved VCS methodology and tools. The project shall take precedence to the rules and requirements of the VCS Program over other approved GHG Program.
Where Verra issues new requirements relating to projects, registered projects do not need to adhere to the new requirements for the remainder of their project crediting periods (i.e., such projects remain eligible to issue VCUs through to the end of their project crediting period without revalidation against the new requirements). The new requirements shall be adhered to at project crediting period renewal.	Project was designed under the VCS Standard, v4 and VM0015, v1.1. Any new requirements shall be adhered to at project crediting period renewal (i.e 30 years, which may be renewed up to 100 years from Project Start Date).

Eligibility Conditions	Justification of Eligibility
There are currently six AFOLU project categories eligible under the VCS Program, as defined in Appendix 1 Eligible AFOLU Project Categories below: afforestation, reforestation and revegetation (ARR), agricultural land management (ALM), improved forest management (IFM), reduced emissions from deforestation and degradation (REDD), avoided conversion of grasslands and shrublands (ACoGS), and wetland restoration and conservation (WRC).	This is an eligible AFOLU project category under the VCS Program: Reduced Emissions from Deforestation and Degradation (REDD).
Where projects are located within a jurisdiction covered by a jurisdictional REDD+ program, project proponents shall follow the requirements in this document and the requirements related to nested projects set out in the VCS Program document Jurisdictional and Nested REDD+ Requirements.	This project is not located within a jurisdiction covered by a jurisdictional REDD+ program.
Where an implementation partner is acting in partnership with the project proponent, the implementation partner shall be identified in the project description. The implementation partner shall identify its roles and responsibilities with respect to the project, including but not limited to, implementation, management and monitoring of the project, over the project crediting period	Any implementation partners are described on the Project Description, in sections 1.5 and 1.6.

Eligibility Conditions	Justification of Eligibility
Activities that convert native ecosystems to generate GHG credits are not eligible under the VCS Program. Evidence shall be provided in the project description that any ARR, ALM, WRC or ACoGS project areas were not cleared of native ecosystems to create GHG credits (e.g., evidence indicating that clearing occurred due to natural disasters such as hurricanes or floods). Such proof is not required where such clearing or conversion took place at least 10 years prior to the proposed project start date.	This project does not convert native ecosystems to generate GHG. The project area only contains native forested land for a minimum of 10 years prior to the project start date.
Activities that drain native ecosystems or degrade hydrological functions to generate GHG credits are not eligible under the VCS Program. Evidence shall be provided in the project description that any AFOLU project area was not drained or converted to create GHG credits. Such proof is not required where such draining or conversion took place prior to 1 January 2008.	This project does not occur on wetlands and does not drain native ecosystems or degrade hydrological functions.
The project proponent shall demonstrate that project activities that lead to the intended GHG benefit have been implemented during each verification period in accordance with the project design. Where no new project activities have been implemented during a verification period, project proponents shall demonstrate that previously implemented project activities continued to be implemented during the verification period (e.g., forest patrols or improved agricultural practices of community members).	PP will demonstrate that project activities that lead to the intended GHG benefit have been implemented during each verification period in accordance with the project design.

Eligibility Conditions	Justification of Eligibility
For all IFM, APDD (except where the agent is unknown), RWE, APWD, APC, and ALM project types, the project proponent shall, for the duration of the project, reassess the baseline every ten years and have this validated at the same time as the subsequent verification. For all AUDD, APDD (where the agent is unknown), AUC and AUWD project types, the project proponent shall, for the duration of the project, reassess the baseline every six years and have this validated at the same time as the subsequent verification.	The baseline reassessment will be conducted every six years as this is an AUDD project.
Where ARR, ALM, IFM or REDD project activities occur on wetlands, the project shall adhere to both the respective project category requirements and the WRC requirements, unless the expected emissions from the soil organic carbon pool or change in the soil organic carbon pool in the project scenario is deemed below de minimis or can be conservatively excluded as set out in the VCS Program document VCS Methodology Requirements, in which case the project shall not be subject to the WRC requirements.	Not applicable. The project activity does not occur on wetlands.
Projects shall prepare a non-permanence risk report in accordance with the VCS Program document AFOLU Non-Permanence Risk Tool at both validation and verification. In the case of projects that are not validated and verified simultaneously, having their initial risk assessments validated at the time of VCS project validation will assist VCU buyers and sellers by providing a more accurate early indication of the number of VCUs projects are expected to generate. The non-permanence risk report shall be prepared using the VCS Non-Permanence Risk Report Template, which	The project has conducted a non-permanence risk analysis on validation, according to the most recent version of the VCS Program document *AFOLU Non-Permanence Risk Tool*, and shall perform the same report during subsequent verifications.

Eligibility Conditions	Justification of Eligibility
may be included as an annex to the project description or monitoring report, as applicable, or provided as a stand-alone document.	
Eligible REDD activities are those that reduce net GHG emissions by reducing deforestation and/or degradation of forests. The project area shall meet an internationally accepted definition of forest, such as those based on UNFCCC host country thresholds or FAO definitions, and shall qualify as forest for a minimum of 10 years before the project start date. The definition of forest may include mature forests, secondary forests, and degraded forests. Under the VCS Program, secondary forests are considered to be forests that have been cleared and have recovered naturally and that are at least 10-years-old and meet the lower bound of the forest threshold parameters at the start of the project. Forested wetlands, such as floodplain forests, peatland forests and mangrove forests, are also eligible provided they meet the forest definition requirements mentioned above.	The Project Area is composed of 100% native forest. The area is considered forest as per the definition of forest adopted by FAO[9]: Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ.
Activities covered under the REDD project category are those that are designed to stop planned (designated and sanctioned) deforestation or unplanned (unsanctioned) deforestation and/or degradation. Avoided planned degradation is classified as IFM.	The project activity is designed to stop unplanned (unsanctioned) deforestation as described throughout the PD.

[9] Available at <https://www.fao.org/3/y4171e/y4171e10.htm#:~:text=FAO%202000a%20(FRA%202000%20Main,of%20other%20predomina>

Eligibility Conditions	Justification of Eligibility
Activities that stop unsanctioned deforestation and/or illegal degradation (such as removal of fuelwood or timber extracted by non-concessionaires) on lands that are legally sanctioned for timber production are eligible as REDD activities. However, activities that reduce or stop logging only, followed by protection, on forest lands legally designated or sanctioned for forestry activities are included within IFM. Projects that include both avoided unplanned deforestation and/or degradation as well as stopping sanctioned logging activities, shall follow the REDD guidelines for the unplanned deforestation and/or degradation and the IFM guidelines for the sanctioned logging activities, and shall follow the requirements set out in the most recent version of the VCS Standard document.	In case future project activity instances have areas legally sanctioned for timber production, baseline and project activity shall comprehend unsanctioned deforestation and/or illegal degradation, not the reduction of logging.
Eligible REDD activities include: 1) Avoiding Planned Deforestation and/or Degradation (APDD): This category includes activities that reduce net GHG emissions by stopping or reducing deforestation or degradation on forest lands that are legally authorized and documented for conversion. 2) Avoiding Unplanned Deforestation and/or Degradation (AUDD): This category includes activities that reduce net GHG emissions by stopping deforestation and/or degradation of degraded to mature forests that would have occurred in any forest configuration.	The present Project Activity is within category AUDD: Avoided Unplanned Deforestation and/or Degradation.

1.4 Project Design

This is a grouped project and has been designed to include multiple project activity instances.

Eligibility Criteria

A set of eligibility criteria for the inclusion of any new areas as instances willing to participate within the grouped project are described below.

As Arataú River REDD Project is a grouped project, all instances implemented after validation shall meet the requirements mentioned in the most recent version of the VCS Standard.

In addition, new areas willing to become instances of the project shall comply with the applicability conditions of the selected methodology, including conditions applicable to each activity, as described in Section 3.2.

Table 1. Grouped Project eligibility criteria

VCS Standard Eligibility criteria for the inclusion of new project activity instances	Arataú River REDD Project	Instance 1
Projects shall meet the applicability conditions set out in the methodology applied to the project.	The GHG emission reductions shall be calculated according to the approved VCS Methodology VM0015 – Methodology for Avoided Unplanned Deforestation, v1.1, published on 03-December-2012.	Instance 1 complies with this requirement because it adopts the Methodology VM0015 – Methodology for Avoided Unplanned Deforestation, v1.1, published on 03-December-2012.
Projects shall use the technologies or measures specified in the project description.	All new instances shall use and apply the same technologies or measures specified in the Project description - forest conservation by avoiding unplanned deforestation, with or without forest management in project scenario.	The Instance 1 project activity complies with this criterion because it was the instance that originated the baseline scenario and the development of the grouped Project. Also, this instance is in the same reference region described on the VCS PD.
Projects shall apply the technologies or measures in the same manner as specified in the project description.		Instance 1 applies one of the technologies or measures specified on the present Project Description: forest conservation by avoiding unplanned deforestation, without forest management in project scenario.

Projects are subject to the baseline scenario determined in the project description for the specified project activity and geographic area.	The Project shall be in accordance with the same baseline scenario established in Section 3.4. of the VCS PD: "In the baseline scenario, forest is expected to be converted to non-forest by the agents of deforestation acting in the reference region, project area and leakage belt. Therefore, the project falls into the AFOLU-REDD".	The Instance 1 Project Activity complies with this criterion because it was the instance that originated the baseline scenario and the development of the grouped Project. Therefore, this instance is in accordance with the same baseline scenario determined in Section 3.4 of the VCS PD.
Projects must have characteristics with respect to additionality that are consistent with the initial instances for the specified project activity and geographic area. For example, the new project activity instances have financial, technical and/or other parameters (such as the size/scale of the instances) consistent with the initial instances, or face the same investment, technological and/or other barriers as the initial instances.	All instances must be additional to be included in the Grouped Project. The project activity must be consistent with Grouped Project Description: forest conservation by avoiding unplanned deforestation. In this case, the project activity may or may not include Sustainable Forest Management Plan. In the additionality assessment, each instance shall determine the appropriate analysis method, whether to apply simple cost, investment comparison or benchmark analysis, according to STEP 2 of VCS VT001 v 3.0 tool. 1) Instances may or may not include Sustainable Forest Management Plan. 2) In case the project activity does not involve Sustainable Forest Management Plan: - The instance should have financial, technical and scale consistent with the described in the VCS PD, facing similar investments, technological and/or other barriers as the initial instance. As the VCS AFOLU project generates no financial or economic benefits other than VCS related income, the simple cost analysis (Option I) shall be applied. 3) In case the project activity includes a Sustainable Forest Management Plan: - A new additionality analysis shall be provided. In this case, the investment comparison analysis (Option II) or the benchmark analysis (Option III) of the Tool VCS VT001 v 3.0 shall be used.	Since the PD was developed based on the characteristics, reference region and activity of the initial instance, Instance 1 complies with this additionality criterion. The additionality analysis for Instance 1 was made according to Option I of VCS VT0001 v3.0, as detailed in section 3.5.

	- In addition, a new AFOLU non-permanence risk analysis shall be performed.	
New Project Activity Instances shall occur within one of the designated geographic areas specified in the project description.	Projects must be located within the Reference Region described in Section 3.3 of the VCS PD. The areas to be included must evidence the ownership of the property in accordance with Brazilian legislation, even if overlapping public areas such as Protected Areas. - As per the VCS Standard, new *AFOLU Non-Permanence Risk* assessments shall be carried out for each geographic area specified in the project description (for requirements related to geographic areas of grouped projects, see the VCS Standard). Where risks are relevant to only a portion of each geographic area, the geographic area shall be further divided such that a single total risk rating can be determined for each geographic area. Where a project is divided into more than one geographic area for the purpose of risk analysis, the project's monitoring and verification reports shall list the total risk rating for each area and the corresponding net change in the project's carbon stocks in the same area, and the risk rating for each area applies only to the GHG emissions reductions generated by project activity instances within the area.	The project activity within the area referring to instance 1 is located within the project's reference region as described in section 3.3 of the VCS PD.
Instances shall comply with at least one complete set of eligibility criteria for the inclusion of new project activity instances. Partial compliance with multiple sets of eligibility criteria is insufficient.	All Instances must comply with the complete set of eligibility criteria for the inclusion of new project activities instances.	Instance 1 complies with all eligibility criteria for the inclusion of a new Project Activity.

Instances must be included in the monitoring report with sufficient technical, financial, geographic and other relevant information to demonstrate compliance with the applicable set of eligibility criteria and enable sampling by the validation/verification body.	The Project Activity Instances must be included in the Monitoring Report with sufficient technical, financial, geographic and other relevant information to demonstrate compliance with the applicable set of eligibility criteria and enable sampling by the validation/ verification body.	Instance 1 complies with this criterion, as it is included in this Joint PD as the first Project Activity Instance.
New Project Activity Instances must be validated at the time of verification against the applicable set of eligibility criteria	The addition of new Project Activity Instances shall be made in the monitoring report for the Grouped Project, being validated at the time of verification.	Instance 1 complies with this criterion, as it is included in this Joint PD as the first Project Activity Instance.
New Project Activity Instances must have evidence of project ownership, in respect of each project activity instance, held by the project proponent from the respective start date of each project activity instance (i.e., the date upon which the project activity instance began reducing or removing GHG emissions).	All Project Activity instances must provide evidence of Project ownership (land title and related documents) and Project start date (agreements, protection or management plan, or others in accordance with the applicable VCS Standard definitions).	Instance 1 is in accordance with this criterion. The evidence of Project ownership and Project start date were provided, as described in Sections 1.7 and 1.8 of the VCS PD.
New Project Activity Instances must have a start date that is the same as or later than the grouped project start date.	The start date of the activity of each instance shall be the same as or after the start date of the grouped project, as established in Section 1.8 of the VCS PD.	Instance 1 project activity has the same start date of the grouped Project, as described in section 1.8 of the VCS PD.
Instances shall be eligible for crediting from the start date of the instance through the end of the project crediting period	Instances shall be eligible for crediting from the start date of the instance activity until the end of the grouped project crediting period, i.e., the instance shall not generate credits after the end date of the Grouped	Instance 1 project activity's crediting period has the same start and end dates of the grouped Project, as described in section 1.9 of the VCS PD.

(only). Note that where a new project activity instance starts in a previous verification period, no credit may be claimed for GHG emission reductions or removals generated during a previous verification period and new instances are eligible for crediting from the start of the next verification period.	Project. Where a new project activity instance starts in a previous verification period, no credit may be claimed for GHG emission reductions or removals generated during a previous verification period. New instances are eligible for crediting from the start of the next verification period.	

1.5 Project Proponent

Organization name	Future Carbon Holding S.A. (Future Carbon Group)
Contact person	Marcelo Hector Sabbagh Haddad Bárbara Silva e Souza Carolina Chiarello de Andrade Carolina Pendl Abinajm Eliane Seiko Maffi Yamada Gabriel Fernandes de Toledo Piza Gabriella Hita Marangom Cesilio Guilherme Lucas Medeiros Prado Laura Pantaleão Letícia Moraes Teixeira Lyara Carolina Montone Amaral Yara Fernandes da Silva
Title	Marcelo Hector Sabbagh Haddad – Head of Future Forest Bárbara Silva e Souza – Technical Analyst Carolina Chiarello de Andrade – Technical Analyst Carolina Pendl Abinajm – Technical Coordinator Eliane Seiko Maffi Yamada – Technical Coordinator Gabriel Fernandes de Toledo Piza – Technical Coordinator Gabriella Hita Marangom Cesilio – Technical Analyst Guilherme Lucas Medeiros Prado – Technical Coordinator Laura Pantaleão – Technical Analyst Letícia Moraes Teixeira – Technical Analyst Lyara Carolina Montone Amaral – Technical Coordinator Yara Fernandes da Silva – Technical Coordinator

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1.6 Other Entities Involved in the Project

Organization name	Antônio Lucena Barros
Role in the project	Owner of Farm Arataú and Farm Arataú I
Contact person	Alan Ribeiro
Title	Director
Address	Rua Gomes de Carvalho, 1108, Sl. 81-83, Ed GC Corporate, Vila Olímpia, São Paulo-SP
Telephone	+55 62 9299-6224
Email	alan@orglucena.com

1.7 Ownership

Instance 1 is located within the municipalities of Tucuruí, Novo Repartimento and Pacajá, State of Pará, and is composed by 2 properties named Fazenda Arataú and Fazenda Arataú I.

The properties composing Instance 1 are owned by Antônio Lucena Barros. The legal documents proving the land title and ownership of the properties will be made available to the auditors during the validation process.

As per the Ownership requirements established in the VCS Standard, an enforceable and irrevocable agreement was set between Antônio Lucena Barros – the holder of the statutory, property and contractual right in the land, vegetation or conservational or management process that generates GHG emission reductions or removals –, and Future Carbon Holding S.A., which vests project ownership in the Project Proponent. Evidence of such agreement will also be made available to the audit team.

1.8 Project Start Date

According to the VCS Standard, “the project start date of an AFOLU project is the date on which activities that led to the generation of GHG emission reductions or removals are implemented (eg, preparing land for seeding, planting, changing agricultural or forestry practices, rewetting, restoring hydrological functions, or implementing management or protection plans)”.

The project start date was on 23-June-2022, and it was defined taking into consideration the date on which the project owner acquired the properties and started developing forest conservation activities. Before this date, the farms were abandoned to illegal invasions and no conservation activities were undertaken.

Due to the high deforestation pressure in the region, on the project start date the landowner initiated the installation of fences surrounding the properties, hired employees for conducting the surveillance against invasions and deforestation, and acquired equipment and vehicles for monitoring the area. It is important to note that the acquisition of the properties also took into consideration the carbon market, and carbon revenues are a very important component to implement conservation and socioenvironmental activities, as the region has one of the highest deforestation rates of the country.

The documents supporting the project start date will be made available to the auditors during the validation process.

1.9 Project Crediting Period

The project has a crediting period of 30 years, from 23-June-2022 to 22-June-2052, which may be renewed up to 100 years.

According to the VCS requirements, the baseline must be reassessed every 6 years for REDD AUDD projects because projections for deforestation are difficult to predict over the long term.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	X
Large project	

Year	Estimated GHG emission reductions or removals (tCO_2e)
2022	147,594
2023	276,612
2024	274,598
2025	272,629
2026	270,702
2027	268,817
2028	260,221
2029	258,609
2030	257,031

2031	255,486
2032	250,649
2033	244,188
2034	232,706
2035	227,728
2036	222,857
2037	218,091
2038	213,578
2039	209,103
2040	198,994
2041	194,853
2042	190,799
2043	186,830
2044	183,083
2045	179,361
2046	170,441
2047	166,998
2048	163,625
2049	160,320
2050	157,211
2051	154,116
2052	71,801
Total estimated ERs	**6,539,632**
Total number of crediting years	**30**
Average annual ERs	**217,988**

1.11 Description of the Project Activity

- The Arataú River REDD Project is a grouped project that consists in the implementation of conservation measures for avoiding unplanned deforestation within the Project Area.
- Instance 1 adopts forest conservation measures such as recruitment and management of surveillance teams to monitor suspicious and/or illegal activities and control of invasions within the project area. Other mitigation actions proposed by the Project in order to avoid unplanned deforestation will be carried out by strengthening surveillance in the area, mapping the local deforestation patterns, setting partnerships with educational and research institutions, and through providing benefits to surrounding communities, aiming to minimize invasions and illegal deforestation, offering alternative income, education and professional training.
- Therefore, besides forest conservation, the present project aims to improve and quantify its social and environmental activities that benefit the local communities, through application of the SOCIALCARBON® Methodology. This methodology measures the contribution of

carbon projects towards sustainable development. The SOCIALCARBON® Methodology is based on six main indicators: Biodiversity; Natural; Financial; Human; Social and Carbon Resources and aims to deliver high-integrity benefits in each in order to improve social and environmental conditions in the project region.

- The implementation of REDD + SOCIALCARBON mechanisms promotes sustainable development through forest conservation resulting in the permanence of carbon stocks, while reducing pressure for timber from other forest areas. In this way, biodiversity conservation and development of the local economy can be achieved simultaneously.
- All the aforementioned measures are expected to result in net GHG emission reductions by preventing illegal deforestation agents to advance with their activities, as well as by retrieving their practices and, therefore, protecting and even restoring the carbon pools.
- It is important to highlight that this project is not located within a jurisdiction covered by a jurisdictional REDD+ program.

1.12 Project Location

The first Project Activity Instance Area is located in the municipalities of Tucuruí, Novo Repartimento and Pacajá, in the State of Pará, a region known as Northeastern Amazon within the Brazilian Arc of Deforestation. The Instance 1 properties have a total area of 34,686.55 ha.

In accordance with VCS requirements, stipulated in Approved VCS Methodology VM0015, version 1.1, the project area may only include areas composed of “forest”[10] for a minimum of ten years prior to the project start date. In addition, some non-forest areas were also excluded, such as rivers, rocks, and non-forest vegetation.

The size of the areas that were considered “non-forest” (i.e. deforestation, planned roads and non-forest vegetation, hydrography or rock formations) within the project area was 9,268.71 ha. This was excluded from the initial area, resulting in 25,417.85 ha, which was then defined as project area.

Geodetic coordinates of the project location have been submitted separately as a KML file, as the Figure below presents the properties’ location.

[10] Brazil adopts FAO forest definition: “Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 meters (m) at maturity in situ.” Available at: < http://www.fao.org/3/x6896e/x6896e0e.htm >. Last visit on: August 06th, 2021.

Figure 1. Project Location

1.13 Conditions Prior to Project Initiation

The Arataú River REDD Project makes an important contribution to the conservation of Northeast Amazonia's biodiversity as well as to climate regulation in Brazil and South America.

In addition to contributing to the long-term conservation of the region, this project also functions to establish a barrier against the advancement of the Brazilian Arc of Deforestation, creating a Northeast Amazon biodiversity corridor in a vulnerable region.

The present project activity has not been implemented to generate GHG emissions for the purpose of their subsequent reduction, removal or destruction. On the other hand, the project aims to promote forest conservation combined with alternative income generation for local communities, associated with a greater surveillance against deforestation agents.

The general characteristics of the project area and reference region are described below.

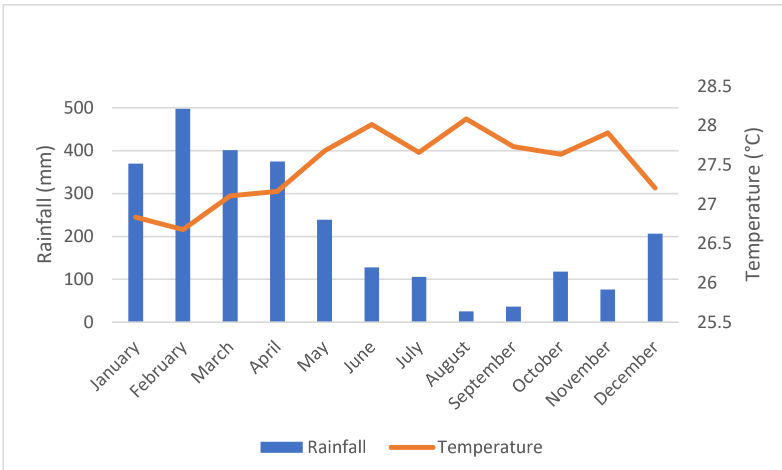
Climate

According to the Köppen classification, the project region has a dominant hot and humid climate, characteristic of Tropical Forests. Furthermore, the region maintains heavy rainfall rates (around 2,400 mm of rain), high average air temperature (26ºC) and relative humidity above 85%. The average annual temperature varies from 26º to 27ºC, highs between 31ºC and 33ºC and lows between 21ºC and 24ºC.

Regarding the pluviometry regime, the region has total annuals generally between 1800 mm and 2800 mm, but it is subject to important fluctuations during the time. The rains are not distributed equally during the year, being characterized by a sharp division in a period with heavy rains from January to July, and another with low rainfall from August to December.

The period between June and November is the driest, and with the highest temperatures. From January to March the rainfalls are up to 400 mm per month, and temperatures between 26 to 27°C. The graph below presents data from Breves as it is the climate station closest to the project area.

Figure 2. Climograph in the project region



Hydrography

The region has an hydrography rich in rivers, however, with regard to the use of regional hydrography, the most prominent rivers are the Tocantins and Pacajá Rivers, besides the Arataú River which crosses the first instance project area.

According to the description of the RADAM-BRASIL project (1974), the management area is located in the region of the Lower Plateau of the Amazon (Baixo Amazonas), in the Tucuruí hydrographic region.

Geology, Topography and Soils

The lower plateau of the Amazon is the extensive surface of the Pleistocene Pediplano that borders the riverbanks with the Amazonian plain; to the south with the peripheral depression of southern Pará and to the north with the plateau of the sedimentary basin of Amazonas. In the region in question, the pediplane is preserved despite the dense forest cover, however the region has on the left bank Tocantins River where isolated, depressed areas appear with sandy deposits, subject to floods covered by undergrowth (RADAM, 1974).

According to SUDAM (1974), the region to the north originates from the Quaternary period, with sand and clay sediments formed by rivers, or sometimes by the sea. To the south is Tertiary, with sediments mainly of clay, with sand and layers of sand stones.

According to IBGE (1990) the rocks of the mesozoic sedimentary cover constitute the formation of Cretaceous age and which represents the most widely distributed mapping unit in the plateau area of the Amazonian sedimentary basin. This formation supports the reliefs of the lowered plateau of the Amazon in which the area of the plan is inserted.

According to the Brazilian Soil Classification System (EMBRAPA, 2006), the soils in the region are composed of the following types:

- Dystrophic Yellow Latosol;
- Dystrophic Yellow Latosol Concretionary;
- Dystrophic Yellow Argisol;
- Hydromorphic Carbic Spodosol;
- Ferrocarbic Spodosol;
- Quartzarenic Neosol.

However, there is a predominance of soil classified as Yellow Latosol within the reference region and project area.

Socio-Economic Conditions

The three municipalities within the region have around 200,000 inhabitants, according to estimates of the IBGE Census (2010)[11]. Data from the Demographic Census shows that the State of Pará's MHDI was 0.359, in 2000 and 0.483, in 2010. In relative terms, the evolution of the index was 34,54% in the State.

According to estimates from 2010, the population of the three municipalities, composed, on its majority, by men. Between 2013 and 2017, Pará registered an increase of 4.98% in the population growth.

In addition, according to the Atlas of Human Development, people are considered extremely poor, poor and vulnerable to poverty when their household per capita monthly income is below R$70.00, R$140.00 and R$255.00 (values from August 2010), respectively. Thus, in 2000, 42.43% of the State population were extremely poor, 69.01% were poor and 87.21% were vulnerable to poverty; in 2010, these shares were, respectively, 39.40%, 60.55% and 80.46%[12].

According to CadÚnico, data and information collection center that aims to identify all low-income families in the country for inclusion in social assistance and income redistribution programs, from Federal Government, the share of extremely poor registered after receiving the Bolsa Família social benefit went from 75.90%, in 2014, to 61.65%, in 2017. On the other hand, the share of poor people registered in the system after receiving the Bolsa Família benefit was of 88.91%, in

[11] https://cidades.ibge.gov.br/brasil/pa/tucurui/pesquisa/10058/60027
[12] IBGE - Brazilian Institute of Geography and Statistics. Available on: <https://cidades.ibge.gov.br/brasil/pa/ >.

2014, and 92.98% in 2017. Finally, the share of people vulnerable to poverty was of 89.70%, in 2014, and 97.61%, in 2017[13].

Historically, the region's main economic activity is the extraction of forest products, mainly characterized by the development of agriculture, timber industries and trade.

Biodiversity

Brazil harbors the greatest concentration of biodiversity on the planet. It has a great abundance of life forms – which translates to over 20% of the total species on Earth – and raises Brazil to the main nation among the 17 countries with the highest biodiversity levels globally, containing over 70% of the planet's biodiversity[14].

Brazil has the greatest flora species richness in the world, with 46,392 species described. Furthermore, it contains over 8,700 known species of vertebrates consisting of 720 mammals, 986 amphibians, 759 reptiles, 1,924 birds and 4,388 fish species. It is estimated that around 93 thousand invertebrate species are known[15].

The number of known species in Brazil is estimated to range from 170 to 210 thousand, while the total number of species that the country harbors is approximately 1.8 million, putting the known proportion of biodiversity at a mere 11%. New species are described every day in Brazil[16]. It is also estimated then that approximately 10% of the entire planet's biodiversity is found in the project region, including many threatened species and those which exist only in Amazonia, or endemic species[17].

The ecosystem of Pará presents the biodiversity characteristic of the Amazon region, where more than two thousand species of fish have been catalogued, about 950 species of birds, 300 species of mammals and about 10% of all plant species on Earth.

In the territory of Pará, this variety of animal and plant species is immense, mainly due to climatic conditions (location in the equatorial zone) and the size of the area covered by forests. Among the trees considered to be noble wood, which is why they are often cut down indiscriminately, are Angelim, Cedro and Mahogany. In the extractive sector, the most sought after species are rubber and Castanheira-do Pará.

The flora also features exotic species, such as the water lily and dozens of species of bromeliads. In the last decades, the concern with the future of the Amazonian ecosystem has been manifested inside and outside Brazil, by governmental and non-governmental institutions.

[13] IBGE - Brazilian Institute of Geography and Statistics. Available on: <https://cidades.ibge.gov.br/brasil/pa>.
[14] Brazilian Government Ministry for the Environment (Ministério do Meio Ambiente – MMA). The Brazilian Biodiversity. Available at: <https://www.gov.br/mma/pt-br/assuntos/biodiversidade>. Last visit on: October 21st, 2021.
[15] Information System about the Brazilian Biodiversity (SiBBr). Available at: <https://regions.sibbr.gov.br/regions/Biomas%20Brasileiros/Amaz%25C3%25B4nia#group=ALL_SPECIES&subgroup=&guid=&from=1850&to=2021&tab=speciesTab&fq=>. Last visit on: October 21st, 2021.
[16] Information System about the Brazilian Biodiversity (SiBBr). Available at: <https://regions.sibbr.gov.br/regions/Biomas%20Brasileiros/Amaz%25C3%25B4nia#group=ALL_SPECIES&subgroup=&guid=&from=1850&to=2021&tab=speciesTab&fq=>. Last visit on: October 21st, 2021.
[17] Protected Areas Program of the Amazon - ARPA (Brasil) (Org.). Arpa Biodiversidade. Amazonas: WWF - Brasil, 2010. 34 p.

Several factors contribute to the destruction of flora and the accelerated process of extinction of animals in Pará territory. Among these factors, we highlight the selective exploitation of wood (which ends with natural reserves of hardwoods), extensive agriculture (responsible for cutting down the forest for transformation into pasture), the construction of hydroelectric plants (which alters the ecosystem of rivers and nearby areas), indiscriminate hunting aiming at the removal of leather for commercialization, overfishing and extraction of plants destined for the pharmaceutical industry.

In some areas, animals, such as the white-lipped peccary, the manatee, the pirarucu, the turtles and the curassows have already been greatly reduced.

The "Red book of Endangered Brazilian Fauna" was developed in 2008[18] and updated in 2018[19]. In 2008, the book reported that the Amazon biome presented 24 threatened species. On the 2018 update, of the total endangered species in Brazil, 15.3% are found in the Amazon, representing 180. Of this total, 124 species are endemic to this biome.

The Brazilian Government Ministry for the Environment classified the project region in its 2018 survey of Brazil's priority areas for conservation[20]. The surroundings of the project area are mainly classified within the "very high" priority category. This shows the importance of the present REDD project for the conservation of Brazilian biodiversity, creating an ecological corridor for preservation of the fauna and flora species. Thus, the conservation of these private lands contributes to the Brazilian Government's conservation proposal.

Vegetation Cover

The project area is covered by native Amazonian vegetation, as per internationally accepted definition of forest. The Region has several types of vegetation groups, which vary depending on the types of soils and water drainage.

The areas related to native vegetation are the most representative element in the region under study. They occur preferentially along the main hydrographic basins that cross the region. Thus, the region comprises two large groups of forest cover, which are:

- Group 1 - Dense Ombrophilous Lowland Forest emergent canopy: Formation typical of the Amazon region is also known as rainy tropical forest. It is characterized by its large trees, usually with one or two species that protrude from the uniform tree layer, between 30 to 50 m height. It is the predominant vegetation in the project's region, corresponding around 95% of the vegetation cover of the reference region.

[18] Available at < https://biodiversitas.org.br/wp-content/uploads/2021/06/Livro-Vermelho-BR-Vol-I.pdf> Last visit on: October 13th, 2021.
[19] Available at < https://www.icmbio.gov.br/portal/images/stories/comunicacao/publicacoes/publicacoes-diversas/livro_vermelho_2018_vol1.pdf> Last visit on: October 13th, 2021.
[20] Brazilian Government Ministry for the Environment (Ministério do Meio Ambiente – MMA). Brazilian priority areas for biodiversity conservation and sustainable use – 2nd update. Available at: <http://areasprioritarias.mma.gov.br/2-atualizacao-das-areas-prioritarias>. Last visit on: October 8th, 2021.

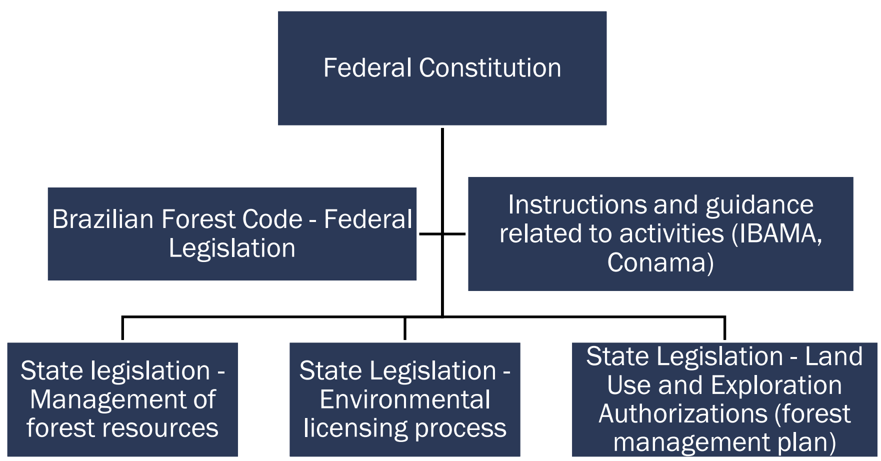
- Group 2 - Alluvial Dense Ombrophilous Forest: The high floodplains have a greater diversity of species than the low floodplain and igapó. It has a low density of large trees. Most species have rapid growth. It has a low occurrence in the area covered by the Project, bordering rivers and streams.

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

In a brief context of Brazilian legislation, the Federal Constitution determines that it is concurrent between the Union, Member States and the Federal District the competence to legislate on matters related to the protection of the environment, conservation of nature, defense of the soil, protection of landscape heritage and responsibility for damages to the environment. The same document establishes that municipalities are responsible for legislation at the local level[21].

However, in the absence of a qualified environmental agency or environmental council in the municipality, the state must carry out municipal administrative actions until its creation. In turn, in the absence of a qualified environmental agency or environmental council in the state and municipality, the Union will have to carry out administrative actions until its creation in one of those federative entities[22]. It is also necessary to observe that a municipal law cannot contradict a state law, which in turn cannot contradict a federal law, under penalty of unconstitutionality.

Figure 3. Structure of the Brazilian legislation



Thus, in the state of Pará, the Secretariat of the Environment (Sema/PA) is the body responsible for environmental licensing, including authorizations for forestry intervention.

21 Available at http://www.mpsp.mp.br/portal/page/portal/documentacao_e_divulgacao/doc_biblioteca/bibli_servicos_produtos/bibli_boletim/bibli_bol_2006/RDC_07_23.pdf

22 Available at http://pnla.mma.gov.br/competencias-para-o-licenciamento-ambiental

- National legislation

According to the current Brazilian Forest Code (Law Nº 12.651, 25/05/2012[23]), all rural estates located in forest zones shall have:

I. Permanent Preservation Area (APP): protected areas covered or not by native vegetation, with the environmental function of preserving water resources, landscape, geological stability, biodiversity, gene flow of plants and animals, protecting the soil and ensuring the well-being of human population.

II. Legal Reserve: an area located within a rural property or possession which is required to be segregated, as well as the permanent preservation area, for the sustainable use of natural resources, conservation and rehabilitation of ecological processes, biodiversity conservation and shelter, and protection of native flora and fauna. In the Brazilian Legal Amazon[24], eighty percent (80%) of a rural property should be preserved.

The 1934 version of the Brazilian Forestry Code demanded the conservation of only 25% of the vegetation coverage; the 1965 version, increased the conservation area to 50% in the Amazon; and finally, in the 2012 version, the conservation requirements increased even more, reaching 80% of areas located in the Amazon biome[25].

However, there is a clear disregard for legal conservation requirements in the region. Much of the deforestation occurs in areas that should be preserved. Lack of law enforcement by local authorities along with public policies seeking to increase commodities production and encourage land use for agricultural, bio energy and cattle breeding purposes created a scenario of almost complete disregard of the mandatory provisions of the Forest Code. High rates of criminality associated with land disputes usually jeopardize efforts concerning law enforcement improvement. In addition to that, to cover vast distances of areas with low demographic density makes tracking of illegal activities and land surveillance very difficult for the authorities[26]. Accordingly, policies implemented to address illegal deforestation only by means of command-and-control approaches have proven to be ineffective so far.

Given the permanent attempts against the Project Area, the project proponent uses their best efforts to prevent property invasion and to remain in compliance with Brazilian Forest Code.

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[23] BRASIL. Law nº. 12.651, of 25 May 2012. Forest Code. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, 25 May 2012. < http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm>

[24] The concept of Legal Amazonia was originated in 1953 and its boundaries arise from the necessity of planning the economic development of the region. For this reason, Legal Amazonia's boundaries do not correspond to those of the Amazon biome. The former has an area of approximately 5 million km², distributed through the entirety or a proportion of 9 Brazilian states.

[25] Available at https://oeco.org.br/dicionario-ambiental/28574-o-que-e-o-codigo-florestal/

[26] MOUTINHO, P. *et al*. REDD no Brasil: um enfoque amazônico: fundamentos, critérios e estruturas institucionais para um regime nacional de Redução de Emissões por Desmatamento e Degradação Florestal – REDD. Brasília, DF: Instituto de Pesquisa Ambiental da Amazônia, 2011. < https://ipam.org.br/wp-content/uploads/2015/12/redd_no_brasil_um_enfoque_amaz%C3%B4nico.pdf>

- State legislation

Instance 1 does not have Sustainable Forest Management Plan activities. In the state of Pará, the Secretariat for the Environment (Sema/PA) is the body responsible for environmental licensing and monitoring.

- Climate change legislation

Regarding other regulatory frameworks that exist in Brazil, on November 28th, 2019, occurred the approval of the Federal Decree 10,144/2019, which establishes the National Commission for Reducing Emissions of Greenhouse Gases from Deforestation and Forest Degradation, Conservation of Forest Carbon Stocks, Sustainable Management of Forests and Increase of Forest Carbon Stocks - REDD+[27].

The development of this Project is not in conflict with such Decree. In terms of the object, jurisdictionally and scope of the Decree 10,144/2019, it is understood that its application is merely administrative, that is, it merely organizes the functioning of the Federal Government about the REDD+ agenda. Its application is restricted to the federal entities of the Public Administration, and, because it is a decree, a normative type that only grants regulation to the matter of law, does not establish duties or obligations to the society.

Thus, Decree 10,144/2019 only limits the Federal Government's understanding of what shall be accounted for in order to comply with mitigation commitments of other countries to the United Nations Framework Convention on Climate Change. It does not impose a barrier or obstacles to the implementation of REDD projects and the commercialization of carbon assets generated from these projects. This consideration in the Decree does not affect or interfere with the voluntary or regulated carbon market, domestic or international.

There is no law in Brazil that does not allow or restrict the execution of REDD projects or that does not allow or restrict any commercial transaction of assets resulting from REDD projects. On the contrary, such transactions are valid and legally permitted. Thus, there is no contradiction or irregularity between the Project Activity and such Decree.

The Table below presents the compliance of the Project with aforementioned laws:

Law	Content	Compliance
Federal Legislation		
Law Nº 12.651	This Law establishes general rules on the protection of vegetation, Permanent Preservation areas and Legal Reserve areas; forest exploitation, the supply of forest raw materials, the control of the origin of forest products and the control and prevention of	Instance 1 complies with the current Federal legislation, as evidenced by the regularity in the CAR and the absence of legal pending issues on environmental matters.

[27] The Decree is available in Portuguese at: < http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2019/Decreto/D10144.htm>

	forest fires and provides economic and financial instruments to achieve its objectives.	
Decree 5975	Provides information for the exploitation of forests and successor formations, comprising the regime of sustainable forest management and the regime of suppression of forests and successor formations for alternative land use.	Instance 1 does not perform sustainable forest management within its forest area; therefore, this Decree does not apply.
Standards and guidelines from national agencies		
Administrative Rule 1 IBAMA	It institutes, within the scope of this autarchy, the technical guidelines for the elaboration of sustainable forest management plans – SFMP mentioned in art. 19 of Law 4,771, of September 15, 1965	Instance 1 does not perform sustainable forest management within its forest area; therefore, this Administrative Rule does not apply.
Administrative Rule 5 IBAMA	Provides for technical procedures for the preparation, presentation, execution and technical evaluation of sustainable forest management plans - SFMP in primitive forests and their forms of succession in the legal Amazon, and other measures	Instance 1 does not perform sustainable forest management within its forest area; therefore, this Administrative Rule does not apply.
Normative Instruction 2 MMA	Amends provisions of normative instruction no. 5, of December 11, 2006, and makes other provisions	Instance 1 does not perform sustainable forest management within its forest area; therefore, this Normative Instruction does not apply.
Resolution 406 CONAMA	Establishes technical parameters to be adopted in the preparation, presentation, technical evaluation and execution of a sustainable forest management plan - SFMP for timber purposes, for native forests and their forms of succession in the Amazon biome	Instance 1 does not perform sustainable forest management within its forest area; therefore, this Resolution does not apply.
Legislation on climate change and carbon market		
Decree 10144	Establishes the National Commission for the Reduction of Greenhouse Gas Emissions from Deforestation and Forest Degradation, Conservation of Forest Carbon Stocks, Sustainable Management of Forests and Increase of Forest Carbon Stocks - REDD+.	The development of this Project is not in conflict with such Decree. In terms of the object, jurisdictionally and scope of the Decree 10,144/2019, it is understood that its application is merely administrative, that is, it merely organizes the functioning of the Federal Government about the REDD+ agenda. Its application is restricted to the federal entities of the Public Administration, and, because it is a decree, a normative type that only grants regulation to the matter of law, it does not establish duties or obligations to the society.

Decree 11075[28]	Establishes the procedures for the elaboration of Sectoral Plans for Mitigation of Climate Changes, institutes the National System for the Reduction of Greenhouse Gas Emissions	The decree defines the carbon credit as a financial asset, the institution of the National System for the Reduction of Greenhouse Gas Emissions and organizes the functioning of the Government about the carbon agenda. Its application is restricted to the federal entities of the Public Administration, and, because it is a decree, a normative type that only grants regulation to the matter of law, it does not establish duties or obligations to the society.

1.15 Participation under Other GHG Programs

1.15.1 Projects Registered (or seeking registration) under Other GHG Program(s)

This project has not been registered and is not seeking registration under any other GHG Programs.

1.15.2 Projects Rejected by Other GHG Programs

Not applicable. This project is not requesting registration in any other GHG Programs nor has the project been rejected by any other GHG programs.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The project activity is not included in an emission trading program or any other mechanism that includes GHG allowance trading.

1.16.2 Other Forms of Environmental Credit

The project area has not sought or received any other form of GHG-related environmental credit, including renewable energy certificates.

Supply Chain (Scope 3) Emissions

The present REDD project's GHG emission reductions are not in a supply chain, i.e., there is no network of organizations (e.g., manufacturers, wholesalers, distributors, and retailers) involved in the production, delivery, and sale of a product or service to the consumer. Therefore, there are

[28] Available at https://presrepublica.jusbrasil.com.br/legislacao/1505298704/decreto-11075-22

no organizations upstream and downstream of the goods and services whose GHGs are impacted by the present REDD project activity.

1.17 Sustainable Development Contributions

The primary objective of the present Project Activity is to avoid the unplanned deforestation (AUD) of its instances, consisting of 100% Amazon rainforest. The Project also has the function of establishing a barrier against the advancement of deforestation, making an important contribution to the conservation of Amazon biodiversity and also to climate regulation in Brazil and South America.

These measures contribute to several nationally stated sustainable development priorities, such as the objectives from the Brazilian Government related to the UN Sustainable Development Goals (SDGs)[29] and the Nationally Determined Contribution (NDC).

In Brazil, the National Commission for Sustainable Development Objectives (CNODS) is responsible for internalizing, disseminating and providing transparency to the process of implementing the 2030 Agenda for Sustainable Development in Brazil[30]. The monitoring of the country's advances in relation to the SDGs established as priorities is carried out by the Institute of Applied Economic Research (IPEA) and the Brazilian Institute of Geography and Statistics (IBGE), which are also permanent technical advisory bodies.

There is no monitoring at the specific level of projects, and progress at the national level can be accompanied by the synthesis report carried out by IBGE[31] and by the IPEA reports[32].

The Arataú River REDD Project main planned contributions to the Brazilian Priority Goals are listed below[33]. These contributions are monitored by the parameters defined by the REDD project, in addition to additional standards, such as SOCIALCARBON. For more information, please consult the applicable social benefit report.

- SDG 3: Good health and well-being

Via carbon credits income, the project promotes the community's well-being and helps to solve local common issues. This SDG is monitored in the Social resource (2. Expansion of community activities) and Human (5. Public health) in the SOCIALCARBON Report. Therefore, the project may contribute to the following targets:

  - 3.3 "By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases".

29 UN's Sustainable Development Goals and targets available at: https://sdgs.un.org/goals
30 More information on the CNODS available at < http://www4.planalto.gov.br/ods/noticias/governanca-nacional-para-os-ods>
31 Available at < https://odsbrasil.gov.br/relatorio/sintese>
32 Available at < https://www.ipea.gov.br/ods/publicacoes.html>
33 Available at < https://odsbrasil.gov.br>

- SDG 4: Quality education

The carbon project encourages the local community to participate in courses regarding technical skills and educational basis. Moreover, the carbon project encourages the development of partnerships with educational entities striving for socioenvironmental scholarly initiatives. This SDG is monitored in the Social resource (2. Expansion of community activities), Human (6. Community education and training), Financial (11. Social and environmental investments), and Carbon (17. Stakeholder consultation) in the SOCIALCARBON Report. The targets determined by the UN that will act as a guideline for monitoring actions are:

    - 4.1 “By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes”;

    - 4.4 “By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship”;

    - 4.5 “By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations”;

    - 4.6 “By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy”;

    - 4.7 “By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture’s contribution to sustainable development”.

- SDG 8: Decent work and economic growth

The REDD project aims to offer training and income generation in the project region as a measure to conserve native forest standing and promote economic viability and growth in the local community. This SDG is monitored in the Social resource (3. Associations and Cooperatives), Human (6. Community education and training), Financial (7. Alternative income sources), Natural (11. Social and environmental investments), Biodiversity (Non-timber forest products (NTFPs)) in the SOCIALCARBON Report. Guideline targets are:

    - 8.3 “Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small-and medium-sized enterprises, including through access to financial services”;

- 8.6 "By 2020, substantially reduce the proportion of youth not in employment, education or training".

- SDG 13: Take urgent action to combat climate change and its impacts

Another of the main objectives of the REDD project is to reduce greenhouse gas emissions through the conservation of standing forest. Thus, its activity is already an action to combat climate change and its effects. In addition, the project stimulates biodiversity monitoring initiatives in a measure to combat climate changes. This SDG is monitored in the Biodiversity (14. Biodiversity monitoring, 15. Impact on remaining flora) and Carbon (16. Buffer reduction, 18. Project performance) resources in the SOCIALCARBON Report. The targets and guidelines for this objective are:

- 13.2 "Integrate climate change measures into national policies, strategies and planning";

- 13.3 "Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

- SDG 15: To protect, restore and promote the sustainable use of terrestrial ecosystems, to manage forests sustainably, to combat desertification, to halt and reverse land degradation, and to halt the loss of biodiversity

The project is based on the conservation and restoration of forests in the Amazon biome, ensuring forest services, preservation of natural resources, and biodiversity. This SDG is monitored in the Natural (11. Social and environmental investments) and Biodiversity (14. Biodiversity monitoring, 15. Impact on remaining flora, 15. Impact on remaining flora) resources in the SOCIALCARBON Report. The targets and guidelines related to this objective are:

- 15.1 "By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements";

- 15.5 "Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species";

- 15.9 "By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts";

- 15.a "Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems";

- 15.c "Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities".

Reducing deforestation and promoting sustainable development in the Amazon is also a key component to Brazil's Nationally Determined Contribution (NDC) under the Paris Agreement. According to the Brazilian Government Ministry for the Environment (in Portuguese, Ministério do Meio Ambiente), the implementation of REDD+ activities are an important component to meet the Country's contribution under the United Nations Framework Convention on Climate Change while preserving natural forest resources[34].

1.18 Additional Information Relevant to the Project

Leakage Management

Two areas were included in the Leakage Management Area, as they are the nearest communities to the Project Area. Further information about boundaries of the leakage management area is located at section 3.3, Project Boundaries, of the present VCS PD.

- Maracajá Settlement
- Novo Repartimento Municipality

More information on the relationship between the LMA and the Project, as well as the prospects for socio-environmental activities will be further discussed on the Social Carbon Report, which will be performed along with the 1st monitoring period.

The main objective of the project is to avoid unplanned deforestation. This goal will be achieved through the expansion of monitoring of the area, along with the inclusion of the local community in the project activities, with environmental education and alternative sources of income to minimize risks of invasion and deforestation within the project area and the reference region.

As aforementioned throughout this project description document, the present REDD Project plans to implement a program regarding the extraction of NTFPs as a way of providing an alternative income source for the local communities that surround the project area.

Brazilian law such as Decree No. 6,040 ensures the rights of traditional people and communities of attaining sustainable development, and by this, activities such as collection of forest products are permitted as long as they do not cause any damage to the area in question[35]. Hereupon, the project proponents neither can (by law) or want to prohibit the local communities from collecting NTFP in the project area.

Moreover, the project activities will enable the creation of jobs to monitor the area, prioritizing the hiring of local residents for monitoring of the area, with professional training. Income from the sale of credits will make it possible to invest in the educational and professional training of children and adults in the community.

[34] Commitments available in Brazil's iNDC, from 2016, and reinforced in its update in 2020/2021. Available at <https://www4.unfccc.int/sites/NDCStaging/Pages/Party.aspx?party=BRA>
[35] Further detailed information about legal guarantees is discussed on sections 1.14 and 2.5 of this document.

Beyond the project's ecological and carbon benefits, the implementation of REDD and SOCIALCARBON mechanisms promotes benefit sharing of carbon credits revenues.

The SOCIALCARBON methodology will serve as a plan and guideline for carrying out activities and achieving goals, in addition to assessing progress in each monitoring period. In this way, the owners are committed and add value to the carbon project with each action taken, encouraging long-term sustainable development and driving continuous improvement in the local community through prospects (at least one per Resource, totaling 6 improvement actions), on which the project proponent undertakes to implement them until the next monitoring period.

To guarantee the progression of the socioenvironmental scenario in the region, the SOCIALCARBON Standard requires that at least 50% of the actions suggested on the previous Point assessed are implemented, under the risk of losing the Standard. The monitoring period for SOCIALCARBON should be the same as the monitoring period for the Carbon Accounting Standard.

Commercially Sensitive Information

No commercially sensitive information has been excluded from the public version of the project description.

Further Information

No further information to disclose.

2 SAFEGUARDS

2.1 No Net Harm

The project is designed to not result in any negative impacts. On the other hand, it is expected that the forest conservation project will result in several positive impacts for the environment, biodiversity, and improvements on the socioeconomic conditions of local communities arising from carbon revenues.

Environmental and social performance will also be assessed using the SOCIALCARBON Standard, with the "Indicators for REDD Projects, Version 1[36]". The Table below provides details on the identified potential risks:

[36] Available at <https://static1.squarespace.com/static/6161c89d030b89374bec0b70/t/61d60484ef15e80fd266d975/1641415815983/Indicators_for_REDD_Projects_v.01.pdf>

Table 2. Main social, economic and environmental impacts of the Project Activity

Activity	Aspect	Impact	Effect		Comments/ Observation
			Beneficial	Adverse	
REDD carbon project	Empowerment	Increase independence of communities in the Project Area	X		Monitored by: • Social Resource: Women's inclusion • Human Resource: Community education and formation programs • Financial Resource: Alternative income sources; Employment creation • Biodiversity Resource: Non-timber forest products (NTFPs)
REDD carbon project	Conservation of Amazon Rainforest	Avoided deforestation	X		Monitored by: • Carbon Resource: Project Performance; Buffer reduction
REDD carbon project	Surveillance	Increased deforestation outside the Project Area		X	Monitored by: • Human Resource: Workers' safety • Natural Resource: Monitoring methods; Project efficiency in agents that fight deforestation/degrad ation • Biodiversity Resource: Biodiversity monitoring; Biodiversity Conservation • Carbon Resource: Project Performance
REDD carbon project	Conservation of Amazon Rainforest	Greenhouse Gas Emissions Reductions	X		Monitored by: • Carbon Resource: Project Performance

					• Natural Resource: Project efficiency in agents that fight deforestation/degradation
REDD carbon project	Conservation of Amazon Rainforest	Monitoring and supervision to avoid deforestation of forest within the Project Area	X		Monitored by: • Biodiversity Resource: Biodiversity monitoring • Natural Resource: Monitoring methods
REDD carbon project	Conservation of Amazon Rainforest	Conservation of the standing forest	X		Monitored by: • Carbon Resource: Project Performance • Natural Resource: Project efficiency in agents that fight deforestation/degradation
REDD carbon project	Conservation of Amazon Rainforest	Conflict management with communities in the Project Area, due to banning of timber product extraction		X	Monitored by: • Carbon Resource: Stakeholder consultation
REDD carbon project	Expansion of knowledge and investment in the area	Encouragement and investment in research on social, economic and environmental aspects in the project region	X		Monitored by: • Human Resource: Research incentive; Community education and formation programs • Financial Resource: Alternative income sources; Carbon credit benefits

The identified impacts will be monitored through the indicators described on the last column of the Table above.

In addition to the risks described above, Future Carbon has identified other risks that could affect the Project Activity. These risks are described on the Table below:

Table 3. Significant risks to the Project Activity

Activity	Aspect	Risk	Indicators that will monitor the identified potential risks
REDD carbon project	Uncertainties related to the standing forest in the future	Non-permanence of the carbon stocks: period on which carbon will remain stocked in biomass, without being emitted into the atmosphere. Due to the uncertainties related to what will happen to the forest in the future, there is a risk of non-permanence of forest carbon	Monitored by: • Carbon Resource: Buffer reduction
REDD carbon project	Land demarcation process	Risk of encroachment by deforestation agents	Monitored by: • Natural Resource: Monitoring methods; Project efficiency in agents that fight deforestation/degradation

2.2 Local Stakeholder Consultation

As preconized by the VCS Standard, the project proponent has conducted an assessment of the local stakeholders that are potentially impacted by the project. Information on the local stakeholders identified are discussed throughout this Section.

Local entities having some influence and activities developed in the Reference Region were chosen through a process to identify them and their possible impact on the Project Activity. Stakeholders chosen for local consultation also include communities and neighbors that might be impacted as well as set potential partnerships in the future.

Thus, the output list of stakeholders from this analysis is described below.

- Communities living within the Reference Region
- ITERPA
- Municipalities of Tucuruí, Novo Repartimento and Pacajá

- Secretaria Estadual de Meio ambiente e Sustentabilidade
- Secretarias Municipais de Meio Ambiente
- Secretaria de Educação
- Instituto Nacional de Colonização e Reforma Agrária (INCRA)
- WWF – Brazil;
- Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais (IBAMA).
- Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio);
- Serviço Florestal Brasileiro
- Programa Municípios Verdes
- CEPAM
- UFRA
- IFT Pará
- Maracajá Settlement

The justification for including the stakeholders list above is described below.

- Public entities: The carbon project is believed to be in the public sector's interest as it can help the state and municipalities achieve their goals of mitigating greenhouse gas emissions and illegal deforestation. In addition, partnerships with the public sector are very important for the development of activities throughout the project.
- Unions: The participation of unions is important to spread knowledge of the carbon market and include the vision of local employees and workers in the development of the project.
- Universities: It is believed that the participation of education and research institutions throughout the project is important to develop partnerships and help in the search for sustainable technological innovations, as well as the development of monitoring of fauna and flora, employees and communities training, carbon stock research, etc.
- NGOs: NGOs are entities focused on the population's objectives, whether social, environmental or economic, without ties to public governmental entities. Thus, they bring a different point of view to the activities, and communication with these entities brings transparency to the project. In addition, they are key agents for the development of partnerships to strengthen the project activity and enhance socio-environmental co-benefits.
- Communities: The employees on the Instance 1 properties were included as stakeholders as it is considered that they are directly affected by the Project, since their work influence the Project development and activities. Therefore, their participation in the planning of activities, in addition to comments and suggestions, is essential.

- Settlements: Some communities near the Instance 1 are located in settlements. Thus, in addition to communicating with the resident families, it is also important to communicate with associations, cooperatives and public health programs that deal directly with the people of the region and can bring insight on the needs of these communities, generating opportunities for improvement with the income from the carbon project.

As required by the VCS Standard, “the management teams involved in the project have expertise and prior experience implementing land management and carbon projects with community engagement at the project scale”. Information on the Project Management Team is further detailed as part of the Non-Permanence Risk analysis.

As also required by the VCS Standard, item Communication and Consultation for the Local Stakeholder Consultation, a comprehensive project summary will be actively presented to the communities and other stakeholders in Portuguese. The Project Proponent will objectively communicate in a culturally appropriate manner, including language and gender sensitivity, directly with local stakeholders or their legitimate representatives when appropriate:

i) The project design and implementation, including the results of monitoring;

ii) The risks, costs and benefits the project may bring to local stakeholders;

iii) All relevant laws and regulations covering workers’ rights in the host country;

iv) The process of VCS Program validation and verification and the validation/verification body’s site visit.

The project proponent understands that stakeholders want and need to be involved in the Project design, implementation, monitoring and evaluation throughout the Project’s lifetime. Therefore, complying with the VCS Standard, a communication channel was established for stakeholders to continually express their concerns and to solve eventual conflicts and grievances that arise during project planning, implementation, and monitoring. The main communication channel is the project's own email.

It is expected that this communication channel will be a mechanism to ensure that the project proponent and all other entities involved in project design and implementation are not involved in or complicit in any form of discrimination or harassment with respect to the project. All complaints will be available to stakeholders and auditors.

The process for receiving, hearing, responding to and attempting to resolve grievances will be performed within a reasonable time period. This Grievance Redress Procedure has three stages:

1) The project proponent shall attempt to amicably resolve all grievances and provide a written response to the grievances in a manner that is culturally appropriate;

2) Any grievances that are not resolved by amicable negotiations shall be referred to mediation by a neutral third party;

3) Any grievances that are not resolved through mediation shall be referred either to a) arbitration, to the extent allowed by the laws of the relevant jurisdiction or b) competent courts in the relevant jurisdiction, without prejudice to a party's ability to submit the grievance to a competent supranational adjudicatory body, if any (the time to accomplish this stage depends on local jurisdiction delays).

Thus, the Stakeholder Consultation will be divided into two events: a remote meeting with entities that have access to internet; and an on-site consultation with local entities in the municipalities and the local community that resides near the project area, where the Leakage Management Area was defined.

Regarding the stakeholders located in urban areas, which are mostly government agencies, a letter will be sent, briefly presenting the project and inviting them to the remote consultation. This presentation is a detailed summary of the proposed activities regarding project implementation and monitoring.

In addition to the introduction of the forest conservation measures, the carbon project development process, deforestation monitoring and projection methods, as well as the delimitation of the Project Area, Reference Region, Leakage Belt, among other information that are also displayed. The presentation also described about the SOCIALCARBON Standard, its co-benefits, monitoring methods and methodology, besides how it relates to UN's Sustainable Development Goals.

Contact information of the Future Forest[37] team will be made available at the end of the meeting. Communication can be carried out via letter, email, or telephone. The presentation will be recorded, and a PDF version might be made available through e-mail should it be requested by any stakeholder. The participants will be informed that the period for requesting information and comments about the REDD Project will be open for 30 days starting from the presentation date.

The meetings will provide a simplified presentation about the Project, guided by a folder with the main project information. Maps will also be used to explain about the dynamics of historical deforestation and its projection into the future and where the project activities and its repercussions are and/or will be located, exposing the risks and benefits resulting from the project activities for the population, which will also be assessed using the SOCIALCARBON Standard, contributing with the SDGs targets.

A permanent communication channel with the local stakeholders was created in order to receive any comments or suggestions regarding the present REDD Project. Emails, phone numbers and addresses were made available through the folder aforementioned should they want to contact the Project Proponent. It is important to note that the same contact information made available is also part of the grievance mechanism, where all comments can be received, and outcomes will be documented and stored in digital format.

[37] Future Forest is the technical team dedicated towards forestry carbon projects at Future Carbon Holding S.A. Therefore, it is Future Carbon's team responsible for developing and monitoring such projects.

The SOCIALCARBON methodology will also analyze the frequency and methods used for addressing the outcomes of each local stakeholder consultation, which will be analyzed at each verification event.

2.3 Environmental Impact

Deforestation and the associated GHG emissions are a global environmental issue but its effects, locally and regionally, are particularly concerning in developing countries, where economies and livelihoods are more closely linked to farming and use of natural resources. This REDD project will result in positive environmental benefits by conserving forest land leading to less deforestation than would have occurred in the baseline deforestation dynamics.

The Amazon Biome, the location of a hugely diverse fauna and flora, spreads over almost 50% of the Brazilian territory[38]. However, the uncontrolled deforestation is breaking up the forest in this habitat and, without necessary care, entire regions with local fauna and ancient habitats of unique species are at risk of complete destruction[39]. To further quantify, this biome holds the biggest variety of species in the world, and deforestation and degradation of tropical forests are the main cause of global biodiversity loss[40].

Another benefit, as mentioned on previous Sections of this VCS PD, is that this REDD Project also has the function of establishing a barrier against the advancement of the Brazilian Arc of Deforestation, in addition to protecting the standing forest in a high-pressure cattle ranching region. This creates an urgent situation on which levels of pressure and priority for conservation are high.

2.4 Public Comments

Until the present moment, no negative input or comment for the present REDD project activity was received. The project will undergo a public comment period. Furthermore, the Local Stakeholder Consultations will collect comments and/or suggestions regarding the project design.

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[38] BRASIL. Ministério do Meio Ambiente (MMA). Projeto de monitoramento do desmatamento nos biomas brasileiros por satélite (PMDBBS). Brasília, 2012. Available at: <http://siscom.ibama.gov.br/monitora_biomas/>.
[39] Margulis S. Causas do Desmatamento da Amazônia Brasileira. BANCO MUNDIAL. Brasil. July, 2003. Available at: <http://www.terrabrasilis.org.br/ecotecadigital/pdf/causas-do-desmatamento-da-amazonia-brasileira.pdf>.
[40] BRASIL. Ministério do Meio Ambiente (MMA). Inter-relações entre biodiversidade e mudanças climáticas: Recomendações para a integração das considerações sobre biodiversidade na implementação da Convenção-Quadro das Nações-Unidas sobre Mudança do Clima e seu Protocolo de Kyoto. Brasília, 2007. 220 p. (Biodiversidade, v.28). Available at: <http://www.terrabrasilis.org.br/ecotecadigital/index.php/estantes/diversos/2115-serie-biodiversidade-28-inter-relacoes-entre-biodiversidade-e-mudancas-climaticas>.

2.5 AFOLU-Specific Safeguards

Local Stakeholder Identification and Background

According to the VCS Standard, the project proponent shall conduct a thorough assessment of the local stakeholders that will be impacted by the project, including:

1. The process(es) used to identify the local stakeholders likely impacted by the project and a list of such stakeholders:

   Stakeholders were identified through research, visits to the project region, as well as local knowledge from the Instance 1 landowners and management team. As detailed in Section 2.2, stakeholders were identified considering the communities, government agencies, educational and research entities, taking into consideration relevant Amazon biome institutions, in addition to NGOs within the Reference Region. Sustainable development and rural development agencies were also contacted. The list is available at section Local Stakeholders Consultation, above.

   The Project and actions involving local communities will be monitored by SOCIALCARBON indicators or any other applicable social-environmental standard at each verification event, in order to analyze the extent of alternative income generation sources and further programs, besides the applied methods for local stakeholders' consultation.

2. Identification of any legal or customary tenure/access rights to the territories and resources, including collective and/or conflicting rights, held by local stakeholders:

   There are no communities living within the Project Area. Instance 1 landowners recognize the presence of the communities near the Project Area and take efforts to maintain a healthy relationship with them. These communities have no rights over the Project Area nor conflicts over land tenure or use rights with the owners.

   On July 13, 2006, the Commission for the Sustainable Development of Traditional Communities was instituted in Brazil by decree[41] and updated in 2016[42], with the objective of implementing a national policy especially directed at such communities.

   The Decree No. 6,040 of February 7, 2007[43], called National Policy for the Sustainable Development of Traditional People and Communities, has the specific objective of promoting the aforementioned "sustainable development" with an emphasis on the recognition, strengthening and guarantee of their territory, social rights, environment, economic and culture. It also advocates the respect and appreciation of the identity of traditional people and communities, as well as their forms of organization and their different institutions[44].

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[41] Available at <http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/dnn/dnn10884.htm> Last visit 20/07/2022

[42] Available at <http://www.planalto.gov.br/ccivil_03/_Ato2015-2018/2016/Decreto/D8750.htm#art20> Last visit 20/07/2022

[43] Available at <http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/decreto/d6040.htm> Last visited on 05/01/2021.

[44] Available at <https://direito.mppr.mp.br/arquivos/File/DireitodospovosedascomunidadesradicionaisnoBrasil.pdf> Last visit 05/01/2021

The Policy is structured around four strategic axes:

1. Access to Traditional Territories and Natural Resources
2. Infrastructure
3. Social Inclusion and
4. Promotion and Sustainable Production

As previously described in section 1.17, these are the same goals and guidelines of this REDD Project.

Article 215 of the Brazilian Constitution determines that the State will guarantee the full exercise of cultural rights. And as distinctive signs of the identity of the different groups that form Brazilian society, it includes, among others, their forms of expression and their ways of creating, making and living (art. 216, i and ii)[45].

The REDD methodology and the application of additional standards such as the SOCIALCARBON methodology guarantee and are guidelines for the execution of a forest conservation project that ensures not only the avoidance of unplanned deforestation, but also the integration and benefits of the traditional communities surrounding the project area.

Thus, the project is neither based on or plans the removal or alteration of this people's way of life, guaranteeing land use and subsistence production, in addition to traditional customs and methods.

3. A description of the social, economic and cultural diversity within local stakeholder groups and the differences and interactions between the stakeholder groups:

   As stated in Item 1, project stakeholders might involve from government agencies to the resident community inside and outside the Project Area. Thus, by applying different forms of consultation, it is considered that the Project covers the social, economic, and cultural diversity of the different stakeholders.

   For government agencies, private companies and NGOs, communication was carried out remotely, through writing and speaking, with the presentation of the Project, its impacts and monitoring methodologies, accounting for credits and actions in the region. In a different way, for communicating the Project to local communities within the Reference Region, a presentation was performed considering their particularities, as well as a socioeconomic diagnosis aiming the development of an action plan to be put into practice along the project lifetime.

   These communities have their rights guaranteed by federal, state, and municipal legislation, in addition to assistance from NGOs and various agencies, characterizing the interaction between the groups of stakeholders.

[45] Available at <https://direito.mppr.mp.br/arquivos/File/DireitodospovosedascomunidadesradicionaisnoBrasil.pdf> Last visited on 05/01/2021.

4. Any significant changes in the makeup of local stakeholders over time:

   No changes were identified among the stakeholders involved with the Project. Any future significant changes will be informed in this Section.

5. The expected changes in well-being and other stakeholder characteristics under the baseline scenario, including changes to ecosystem services identified as important to local stakeholders:

   The risks and impacts of the Project are analyzed at Section "No Net Harm", designing mitigation strategies for each impact observed. No alteration of communities' area, methodology or way of life in general is predicted. It is planned that the project's revenue will be invested on more socio-environmental programs to involve the local community in the Project and, therefore, minimize the damage to the environment and illegal deforestation.

6. The location of communities, local stakeholders and areas outside the project area that are predicted to be impacted by the project:

   - Maracajá Settlement: 4° 8'46.31" S; 50°13'31.22" W;
   - Novo Repartimento Municipality: 4°14'55.92" S; 49°57'8.56" W;
   - Employees village within the property.

7. The location of territories and resources which local stakeholders own or to which they have customary access.

   Territories and resources used or accessed by the communities are included on the Leakage Management Area and are, therefore, within the Reference Region.

Risks to Local Stakeholders

The Project Proponent understands that some risks are inherent to the Project Activity, and that others may arise from the stakeholder's point of view. Considering this, the Table below presents potential risks and impacts to local stakeholders and measures taken to mitigate those:

Table 4. Risks to Local Stakeholders

Aspect	Impact	Effect		Comments / Observation
		Beneficial	Adverse	
Land use	Reduced access to land and traditional areas due to the project activity		X	The baseline scenario activity of the project area will be maintained, i.e, no activity will be conducted in the Project Area. One of the objectives of the project is to benefit the local community with resources from the carbon credit sales, providing quality of life, sustainable development, and alternative income sources. Monitored by the Biodiversity Resource: • Non-timber forest products (NTFPs) Monitored by the Social resource:

				• Local traditional people assistance[46]
Resources	Withdrawal of natural, economic and cultural resources (water, food, alternative income, cultural events, etc.) from families		X	The Project's objective is to guarantee financial resources to expand the socio-environmental benefits for the communities around the Project Area. Monitored by the Biodiversity Resource: • Non-timber forest products (NTFPs) Monitored by the Financial Resource: • Alternative income sources Monitored by the Social Resource: • Additional Social Programs
Land use	Displacement of families due to Project Activity		X	Families will not be removed from any areas currently used, as they do not reside within the Project Area. Instance 1 landowners maintain a friendly relationship with the neighbors, and one of the objectives of the carbon project is to expand social and environmental benefits to local communities. The Project Activity understands the permanence and land use of the families in the surrounding areas. Monitored by the Carbon Resource: • Stakeholder Consultation Monitored by the Natural Resource: • Project efficiency in agents that fight deforestation/degradation
Food Security	Withdrawal of land used for food production or income generation		X	Communities access regions are not included within the Project Area and, therefore, they will not be affected by the maintenance of activities. The areas for planting/ranching for subsistence or for selling for income generation will not be included in the Project Activity nor the removal of these lands are planned. Monitored by the Biodiversity resource: • Non-timber forest products (NTFPs) Monitored by the Financial resource: • Alternative income sources

[46] As there are no traditional communities surrounding the Project Area, this indicator will be adapted to comply with local communities

Climate change adaptation	Adaptations and impacts related to the climate crisis	X		The main objective of the project is forest conservation through the avoidance of unplanned deforestation. The maintenance of the standing forest is essential to mitigate the effects of the climate crisis and the maintenance of natural resources for the people. The Project also contributes to achieving climate justice, since the groups that suffer most from climate change are the vulnerable communities. Monitored by the Financial Resource: • Carbon Credit Benefits Monitored by the Social Resource: • Additional Social Programs Monitored by the Carbon Resource: • Project Performance

Respect for Local Stakeholder Resources

The Project recognizes, respects, and supports local stakeholders' customary tenure/access rights to territories and resources. The Project will never encroach on private properties or relocate people off their lands without consent. At present there are not any ongoing or unresolved conflicts over property ownership, usage or resources rights, the Project shall not undertake activities that could exacerbate the conflict or influence the outcome of unresolved disputes.

The Project intends to offer benefits and training for the local community, including health related benefits, in addition to providing education for children and women, as stablished and monitored by the SOCIALCARBON methodology.

No community member has been or will be removed from their land, on the contrary, communities will be supported through programs and incentives the stimulated by the Project. In addition, the Project did not introduce any invasive species or allow an invasive species to thrive through its implementation.

Communication and Consultation

The project will take all appropriate measures to communicate and consult with local stakeholders in an ongoing process for the life of the project. As described above, the project intends to carry out local stakeholder consultations, which will be monitored by the additional standard SOCIALCARBON. Every consultation shall communicate:

- The project implementation, including the project results and the importance of forest conservation activities.

- The risks, costs and benefits the project brings to local stakeholders.
- The benefit sharing mechanism.
- Procedures related to resolving eventual conflicts with stakeholders.
- The process of VCS Program validation and verification and the validation/verification body's site visit.

Grievance redress and conflict management procedures, as well as benefit sharing mechanisms, will be discussed with communities through the stakeholder consultations.

For validation and verification, two consultations will be held, one remotely and the other one on-site, as per described at Section 2.2 – Local Stakeholder Consultation.

Furthermore, a permanent communication channel with local stakeholders was created in order to receive any comments or suggestions regarding the present REDD project. All stakeholders will received Future Carbon's contact addresses during the Local Stakeholder Consultation. All comments received will be responded, and grievances will be resolved in a suitable time frame whenever possible, taking into account culturally appropriate conflict resolution methods.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

This project uses the approved VCS Methodology VM0015 – Methodology for Avoided Unplanned Deforestation, v1.1, published on 03-December-2012[47].

Furthermore, the following tools were used:

- VT0001 - Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3, published on 01-February-2012[48];
- AFOLU Non-Permanence Risk Tool v4, published on 19-September-2019[49].

[47] Available athttps://verra.org/methodology/vm0015-methodology-for-avoided-unplanned-deforestation-v1-1/
[48]Available at https://verra.org/methodology/vt0001-tool-for-the-demonstration-and-assessment-of-additionality-in-vcs-agriculture-forestry-and-other-land-use-afolu-project-activities-v3-0/
[49] Available at https://verra.org/wp-content/uploads/2019/09/AFOLU_Non-Permanence_Risk-Tool_v4.0.pdf

3.2 Applicability of Methodology

VM0015 – Methodology for Avoided Unplanned Deforestation, v1.1	
Applicability Conditions	**Justification of Applicability**
a) Baseline activities may include planned or unplanned logging for timber, fuelwood collection, charcoal production, agricultural and grazing activities as long as the category is unplanned deforestation according to the most recent VCS AFOLU requirements.	None of the baseline land-use conversion activities are legally designated or sanctioned for forestry or deforestation, and hence the project activity qualifies as avoided unplanned deforestation. This is in accordance with the definition of unplanned deforestation under the VCS Standard. The primary land uses in the baseline scenario are: cattle ranching, mainly for producing beef cattle; and timber harvest, acting both legally and illegally. These unplanned deforestation and degradation agents have been attracted due to infrastructure expansion, such as waterways and roads. Therefore, in the baseline scenario, the Project Area would continue to be illegally deforested by the deforestation agents described above. With that said, the present criteria are fulfilled.
b) Project activities may include one or a combination of the eligible categories defined in the description of the scope of the methodology (table 1 and figure 2).	Within the categories of Table 1 and Figure 2 of the applied Methodology, the present Project Activity falls within category A, “Avoided Deforestation without Logging”. The reason is that the project area contains 100% native vegetation and has never been deforested in the past. In addition, it is important to note that degradation is not included neither in the baseline nor in the project scenario.
c) The project area can include different types of forest, such as, but not limited to, old growth forest, degraded forest, secondary	The forest classes composing the Project Area are named as per the Technical Manual for

forests, planted forests and agroforestry systems meeting the definition of “forest”.	Brazilian Vegetation[50]. The area is considered forest as per the definition of adopted by FAO[51]: Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. No deforested, degraded or areas otherwise modified by humans were included in the Project Area at the Project Start Date.
d) At project commencement, the project area shall include only land qualifying as “forest” for a minimum of 10 years prior to the project start date.	The Project Area consisted of 100% tropical rainforest over 10 years prior to the project start date – all of which according to the Brazilian definition of forest[52]. This was ascertained using satellite images, as described in the section Baseline Scenario of the present VCS PD.
e) The project area can include forested wetlands (such as bottomland forests, floodplain forests, mangrove forests) as long as they do not grow on peat. Peat shall be defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm. If the project area includes forested wetlands growing on peat (e.g. peat swamp forests), this methodology is not applicable.	As described at Section 1.13 of the present VCS PD, the main soil type within the Project Area is the Yellow Latosol. Therefore, no peat or peat swamp forests were found within the Project Area and Reference Region, satisfying this applicability criterion.

VT001	
a) AFOLU activities the same or similar to the proposed project activity on the land within	The present AFOLU project activity does not involve any economic activity apart from forest conservation, i.e., there are no financial

[50] Avaliable at https://www.terrabrasilis.org.br/ecotecadigital/pdf/manual-tecnico-da-vegetacao-brasileira.pdf
[51] Available at < https://www.fao.org/3/y4171e/y4171e10.htm#:~:text=FAO%202000a%20(FRA%202000%20Main,of%20other%20predominant%20land%20uses>
[52] Brazil adopts the FAO forest definition: “Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 meters (m) at maturity in situ.” Available at: <http://www.fao.org/docrep/006/ad665e/ad665e06.htm>.

the proposed project boundary performed with or without being registered as the VCS AFOLU project shall not lead to violation of any applicable law even if the law is not enforced;	or economic benefits other than VCUs related income. Therefore, it does not lead to violation of any applicable law even if the law is not enforced. Sustainable Forest Management Plan is an authorized and endorsed activity in Brazil, and Instances must have all environmental and legal authorizations necessary to conduct the activity, should it be the case for new Instances joining the Project, as Instance 1 does not perform sustainable forest management activities.
b) The use of this tool to determine additionality requires the baseline methodology to provide for a stepwise approach justifying the determination of the most plausible baseline scenario. Project proponent(s) proposing new baseline methodologies shall ensure consistency between the determination of a baseline scenario and the determination of additionality of a project activity.	The Methodology provides a stepwise approach to justify the determination of the most plausible baseline scenario, which is detailed at Section 3.4 – Baseline Scenario, below.

3.3 Project Boundary

<u>**Spatial Boundaries**</u>

The Table below presents the Project Area, Reference Region, Leakage Belt and Leakage Management Areas:

Table 5. Project Area, Reference Region, Leakage Belt and Leakage Management Area

Name	Area (ha)
Reference Region	718,603.27
Project Area	25,417.85
Leakage Belt	60,275.57
Leakage Management Area	312,41

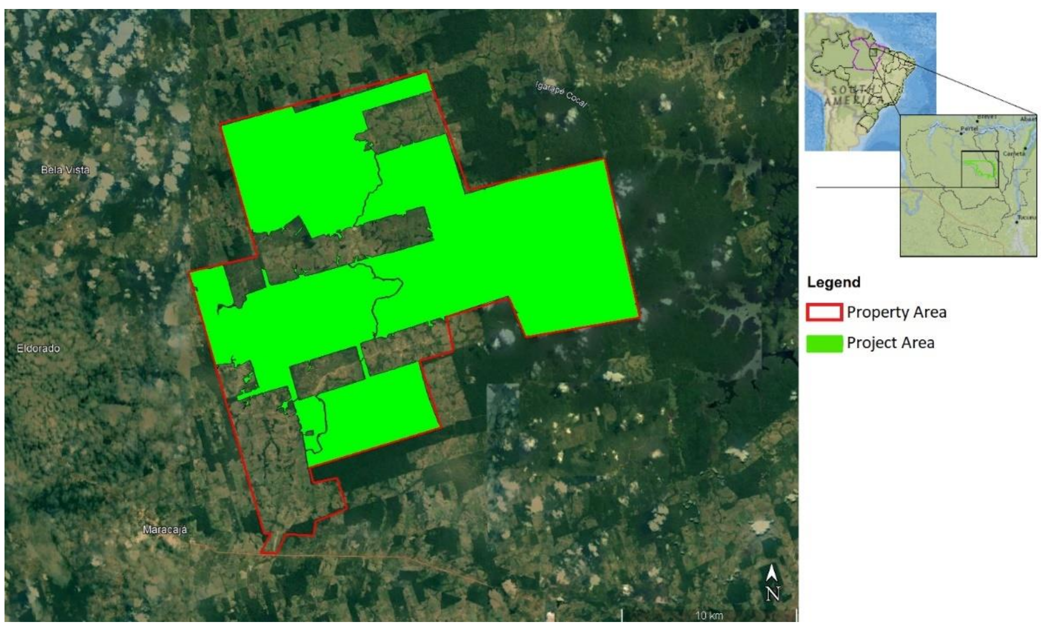
- Project Area

 The Project Area comprises Instance 1.

 Instance 1 is composed by 2 properties, which have a total area of 34,686.55 ha. According to the VM0015 methodology, the Project Area “shall include only land qualifying as ‘forest’ for a minimum of 10 years prior to the project start date”: the date when activities are initiated to protect against the risk of future deforestation. Thus, some adjustments and discounts are made to comply with the Methodology.

 In order to define the Project Area, areas deforested up to the Project Start Date, non-forest vegetation areas and areas containing water bodies were excluded from the properties’ area. As a result, the Project Area was defined as 25,417.85 ha. Further characteristics of the Project Area until the Project Start Date are described in Section 1.13.

Figure 4. Project Area of the Arataú River REDD Project



- <u>Reference Region</u>

 The Reference Region (RR) is an analytical domain through which information on rates, agents, drivers and underlying causes of land-use and land-cover (LU/LC) change are obtained, and subsequently used for future projection and monitoring.

 According to the applied Methodology, as no applicable sub-national or national baseline is available, and the country or subnational region has not been divided into spatial units for which deforestation baselines will be developed, a baseline must be developed for the Reference Region.

The Reference Region must encompass the Project Area, the Leakage Belt and any other geographic area that is relevant to determine the baseline of the Project Area.

A geographic area with agents, drivers and overall deforestation patterns observed during the minimum 10-year period preceding the start date was determined, representing a credible proxy for possible future deforestation patterns in the project area.

The RR was defined in accordance with the Methodology, following two criteria:

1. For projects below 100,000 ha, the Reference Region should be 20-40 times the size of the Project Area.
2. The conditions determining the likelihood of deforestation within the Project Area being similar or expected to become similar to those found within the Reference Region, depending on: the landscape configuration and ecological conditions (elevation, slope, vegetation, and rainfall), socio-economic and cultural conditions, and agents and drivers of deforestation (agent groups, infrastructure or other drivers). The latter condition was the most important for adjusting the RR for it to represent the land-use dynamics more accurately. Specifically, this was based on the geomorphology, waterways (watersheds) and infrastructure (roads), which are the principal means of human and product transportation in the region. As such, from the areas directly surrounding the project, the RR was expanded to meet the nearest main waterways and roads.

In addition, according to the Methodology, three main criteria are relevant to demonstrate that the conditions determining the likelihood of deforestation within the Project Area are similar or expected to become like those found within the Reference Region:

- **Agents and drivers of deforestation:** Timber logging (both legal and illegal) and cattle ranching are important economic activities within the Reference Region. As detailed in Section 3.4, the main agents of deforestation, timber harvesting and cattle ranching, are considered threats throughout the southern Amazon region. Thus, the analysis of the Reference Region definition includes these factors.
- **Socio-economic and cultural conditions:** The Methodology implies that "the legal status of the land (private, forest concession, conservation concession, etc.) in the baseline case within the project area must exist elsewhere in the reference region. If the legal status of the project area is a unique case, demonstrate that legal status is not biasing the baseline of the project area". This is complied with the areas surrounding the properties that are not public or part of any protected

area, such as the Project Area. These conditions also comply with Land Use and Land Tenure items once the conditions of the Project Area are found elsewhere in the Reference Region. The Project Area is governed by the same policies, legislation and regulations that apply elsewhere in the Reference Region. These policies are detailed in Section 1.14. Data presented of the private areas is available at Brazil's Environmental Rural Registration[53], National Protected Areas[54]. It is important to note that there are two Protected Areas (Reserva de Desenvolvimento Sustentável Alcobaça and Área de Proteção Ambiental do Lago de Tucuruí) close to the 1st Instance project area, which were then partially included within the Reference Region. No Indigenous Land was included in the Reference Region.

- **Landscape configuration and ecological conditions:** To define the Reference Region, the watersheds located around the Project Area were used as units. For each of these watersheds, the average values of elevation, slope and precipitation were determined, as well as the percentages of the different types of vegetation. Based on these values, it was possible to visualize areas that presented similar values to the Project Area's parameters. The area units were then used to achieve an extent of approximately 20-40 times the size of the Project Area as the Reference Region.

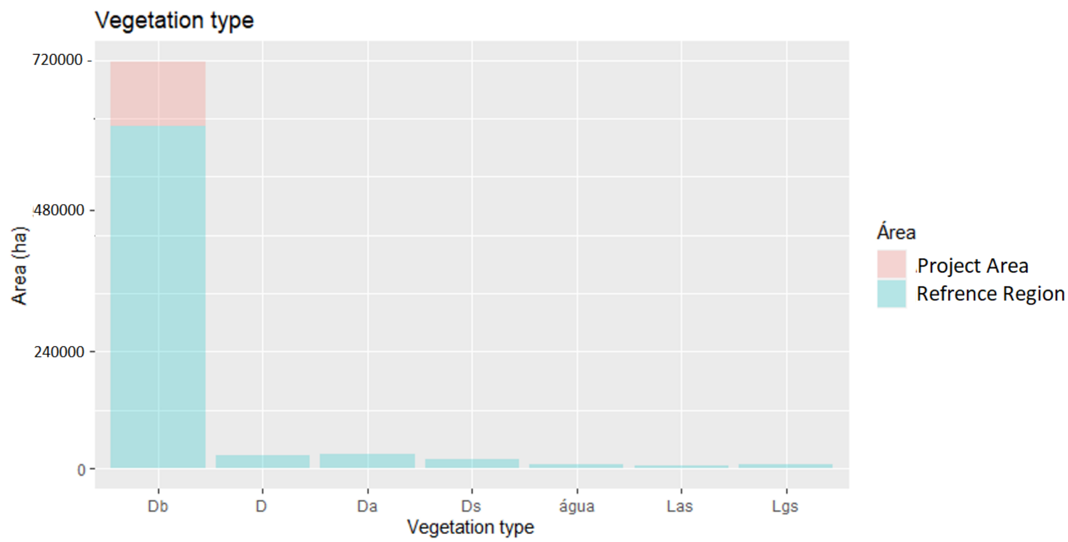
From the definition of this area, the criteria related to the type of vegetation, elevation, slope and precipitation were tested to verify the similarity in relation to the Project Area and the rest of the Reference Region. For all four variables, the values met the criteria, which indicates an adequacy of the Reference Region. The results are presented below:

Vegetation cover

The main Project Area's vegetation type, Dense Lowland Tropical Rainforest (Db), occupies more around 95% of the Reference Region, according to the graph below.

[53] Available at <https://www.car.gov.br/publico/municipios/downloads>
[54] Available at <https://metadados.snirh.gov.br/geonetwork/srv/api/records/9407d38f-84d2-48ea-97dd-ee152c493043>

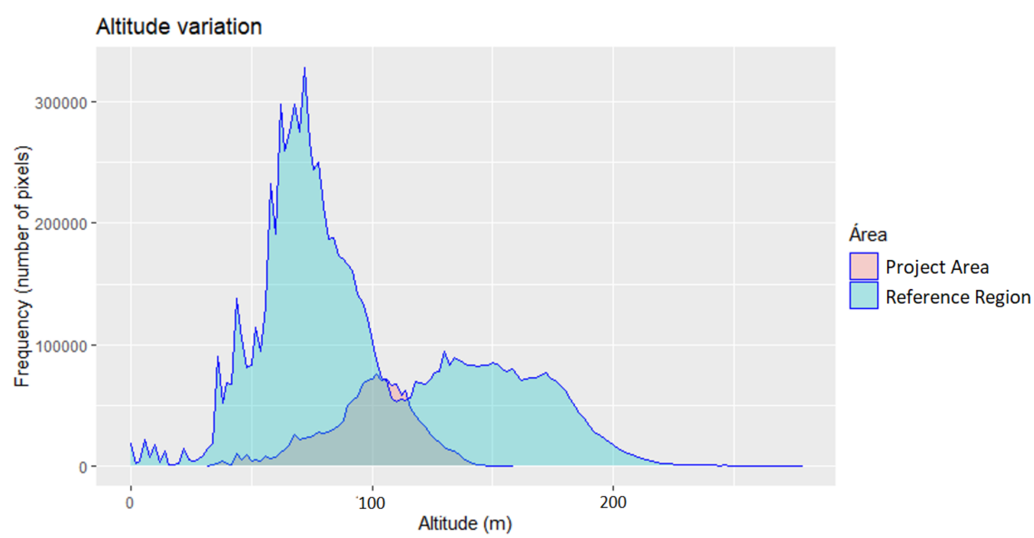
Figure 5. Distribution of phytophysiognomies, in area (ha), in the Reference Region and in the Project Area



<u>Altitude</u>

The altitude in the Project Area ranges from 96 to 178 m, these values are within 100% of the range for the rest of the Reference Region, as shown below:

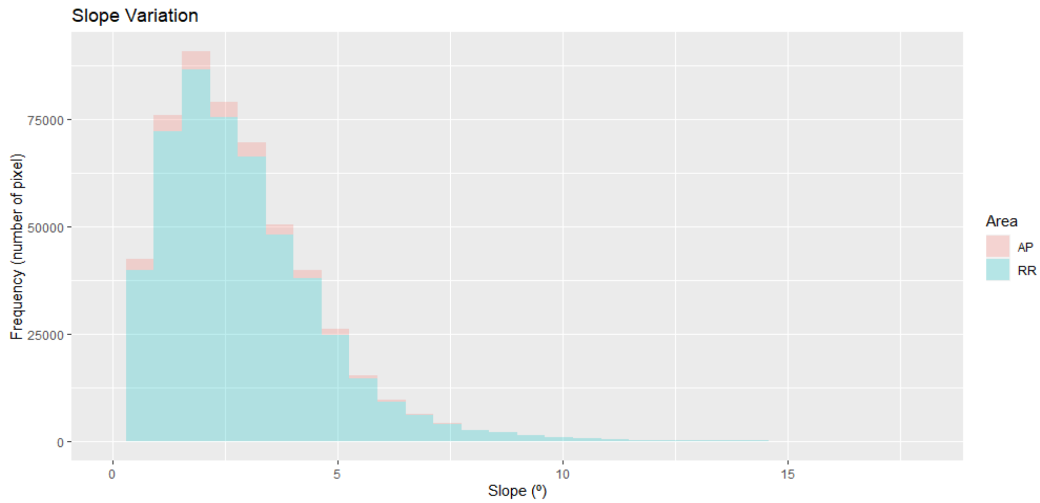
Figure 6. Altitude distribution (m), in number of pixels, in the Reference Region (RR) and in the Project Area



<u>Slope</u>

The average slope in the Project Area is 2.66 degrees, while in the rest of the Reference Region it is 2.72. Therefore, the average value of 100% of the Project Area is within the range of ± 10% of the average in this region, which is between 2.45 and 2.99 degrees.

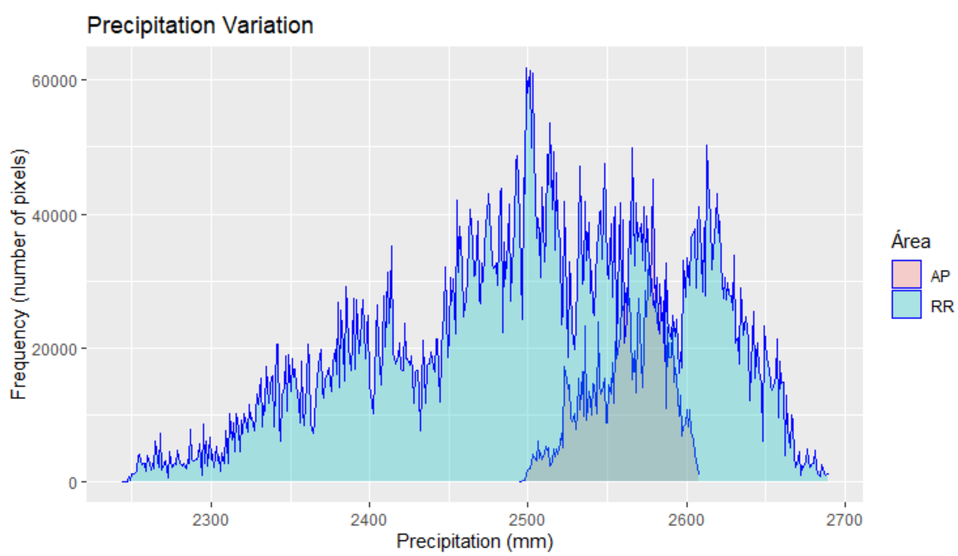
Figure 7. Slope distribution (degrees), in number of pixels, in the Reference Region and Project Area



<u>Rainfall</u>

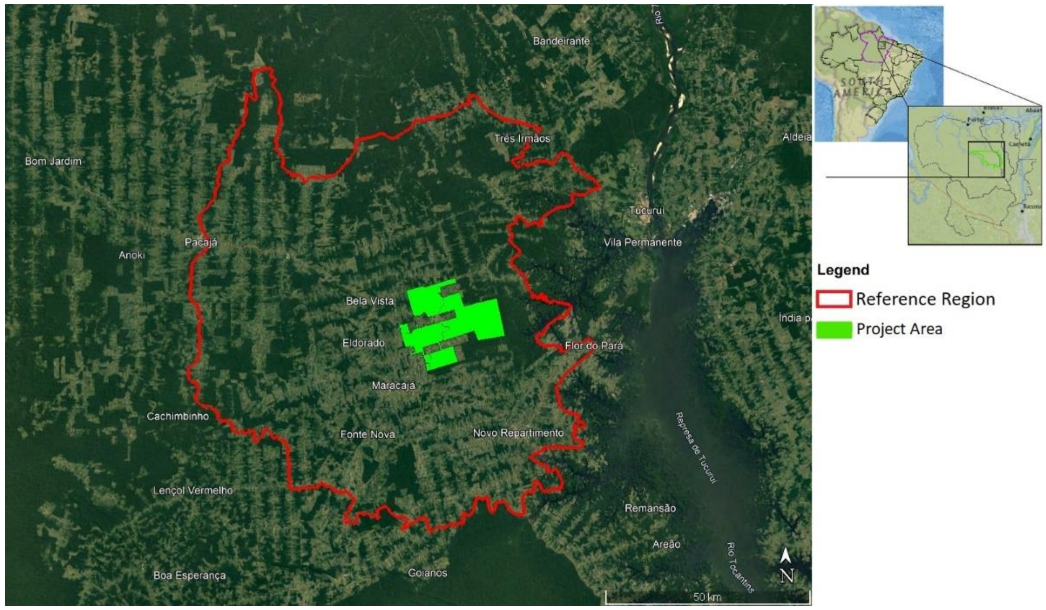
Annual rainfall in the Project Area is, on average, 2,560 mm, while in the rest of the Reference Region it is 2,500 mm. Thus, it was verified that the amount of rain in the Project Area remains within the variation of ± 10% of 100% of the average in the rest of the Reference Region, which varies between 2,250 and 2,750 mm.

Figure 8. Distribution of annual precipitation (mm), in number of pixels, in the Reference Region (RR) and Project Area (PA)



Based on the criteria related to the type of vegetation, elevation, slope and precipitation above, the reference region was defined, which has 718,603.27 ha (28.3 times the Project Area). The map showing the RR and PA is presented below:

Figure 9. Location of the Reference Region



- Leakage Belt

  The Leakage Belt is defined by the Methodology as “the land area or land areas surrounding or adjacent to the project area in which baseline activities could be displaced due to the project activities implemented in the project area”, in other words, an area where emissions may occur due to the change in behaviour of external agents in response to conservation actions carried out within the Project Area. These areas also include previously deforested areas given the region's economic patterns, but the focus is mainly on areas with potential for forest conversion for other uses.

  In order to define the Leakage Belt area, the Opportunity Cost analysis (Option I) was performed. Therefore, the economic viability of livestock production was spatialized in the project's Reference Region. Cattle is one of the main drivers of deforestation in the region, since in addition to being very profitable, it is strongly associated with land grabbing, one of the greatest threats in the region. The analysis consisted of the difference between the selling price of the cattle (per ton) and the average production cost (per ton) plus the cost of transportation to take the product to the nearest consumer center.

  The methodology for calculating road transportation costs regarding livestock in the region considered the sum of the distance that would be travelled in a straight line, between the pasture areas and the already open accesses (local highways and roads), with the distance travelled until the nearest commercial centers.

  For monetary costs, the freight table of Ordinance No. 034/2017 (SEFAZ, 2017) for minimum prices for the provision of transportation services. The table in Annex II of the aforementioned Ordinance details the value of freight for transporting live cargo, in which the scenario of a D. Deck 45/48 trailer transporting a load of 14,000 kg was considered.

The average costs per animal considering an extensive breeding system are approximately R$906.00 (CARRERO et al., 2015). The average price per arroba varies between R$80 and R$92 (CARRERO et al., 2015). In the analysis, the minimum value of R$80 was used. For an average of 13 arrobas per animal, the revenue would be around R$ 1040.00. All values were corrected by the Broad National Consumer Price Index (IPCA) considering the Project Start Date.

Thus, the calculation of the potential profitability was carried out for each territorial unit in the Reference Region, which can be summarized using the following formula:

$$PPx_l = S\$x - PCx_i - \sum_{v=1}^{V}(TDv * TCv)$$

Where:

PPx$_l$: Potential profitability of product Px at location l (pixel or polygon); R$/t

S$x: Product Px sale price; R$/t

PCx$_i$: Average in situ production cost per tonne of product Px; R$/t

TDv: Transportation distance travelled; km

TCv: Average transportation cost per tonne of product Px; R$/t/km

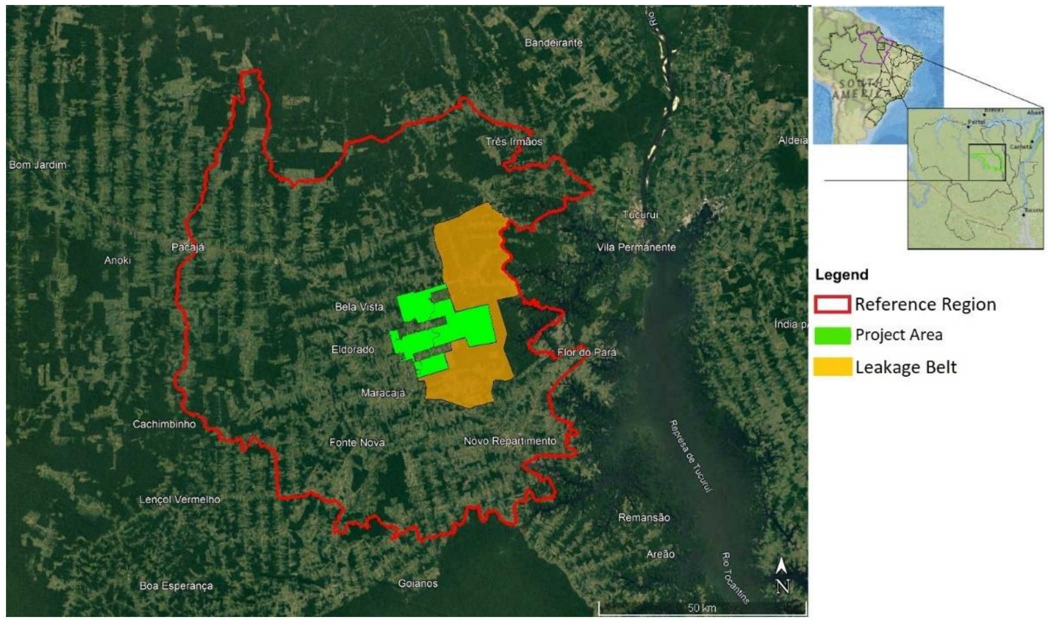
V: 1, 2, 3...V, surface type on which transportation occurs; dimensionless

From this data, it is possible to conclude that the entire Reference Region is in an economically viable area for livestock production, where the sum of revenues minus total costs is positive.

From the aforementioned considerations, it is possible to conclude that the areas with the highest profitability value would be more attractive for the activity. Thus, the areas with the highest profitability rating and adjacent to the Project Area, within a radius from 2.5 km to 20 km, would be where deforestation is most likely to occur due to the Project Activity, towards the direction of the municipality of Tucuruí (the largest municipality within the reference region). In more distant areas, the increase in deforestation, as it is already in course, is probably associated to their proximity to rivers and roads. The minimum range of 2.5 km was identified due to the proximity to Protected Areas, where it is assumed that no leakage would occur within those areas.

Finally, by overlapping the Project Area buffer with the areas with the highest profitability potential, an area of 60,275.57 ha was defined as the Leakage Belt. The Figure below illustrates its location. In summary, the Leakage Belt was composed by areas within a 2.5 – 20 km radius from the Project Area boundaries, which present forestlands areas and higher economic viability for cattle ranching, i.e., where deforestation could be displaced from the project area.

Figure 10. Location of the Leakage Belt



- Leakage Management Area

The Leakage Management Area (LMA) combines non-forest areas located outside the project boundary in which the Project intends to implement activities that will reduce the risk of leakage in the Project Scenario. These activities must include the agents of deforestation and seeks to implement alternative income sources in order to contribute to forest conservation. Leakage management could involve agricultural, agroforestry, reforestation, education, among other activities.

The Leakage Management Area was defined considering the nearest communities to Instance 1, with a total area of 312.41 ha, and their locations are represented in the Figures below:

Figure 11. Leakage Management Areas

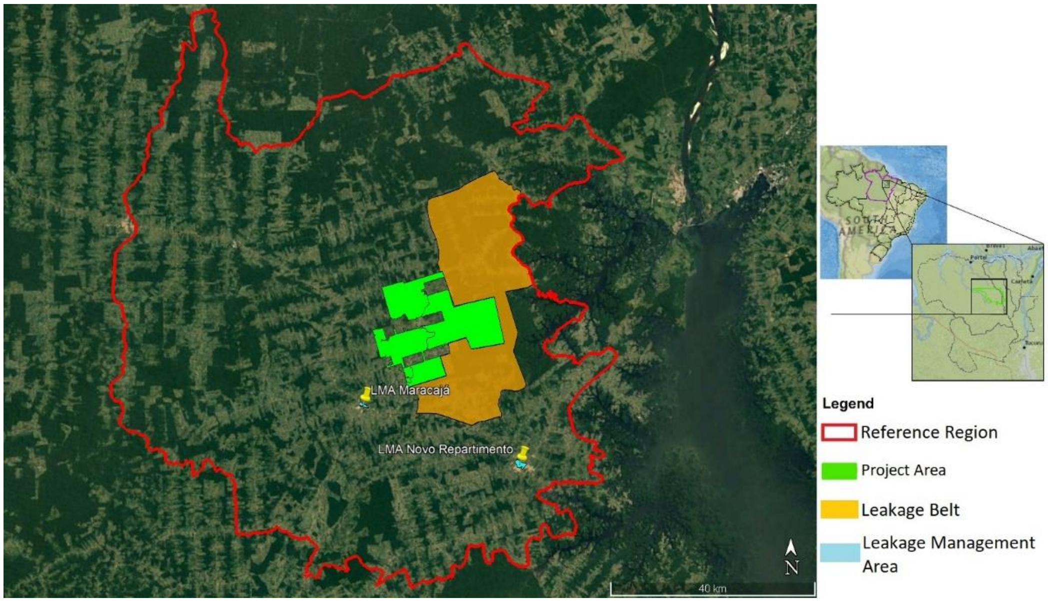
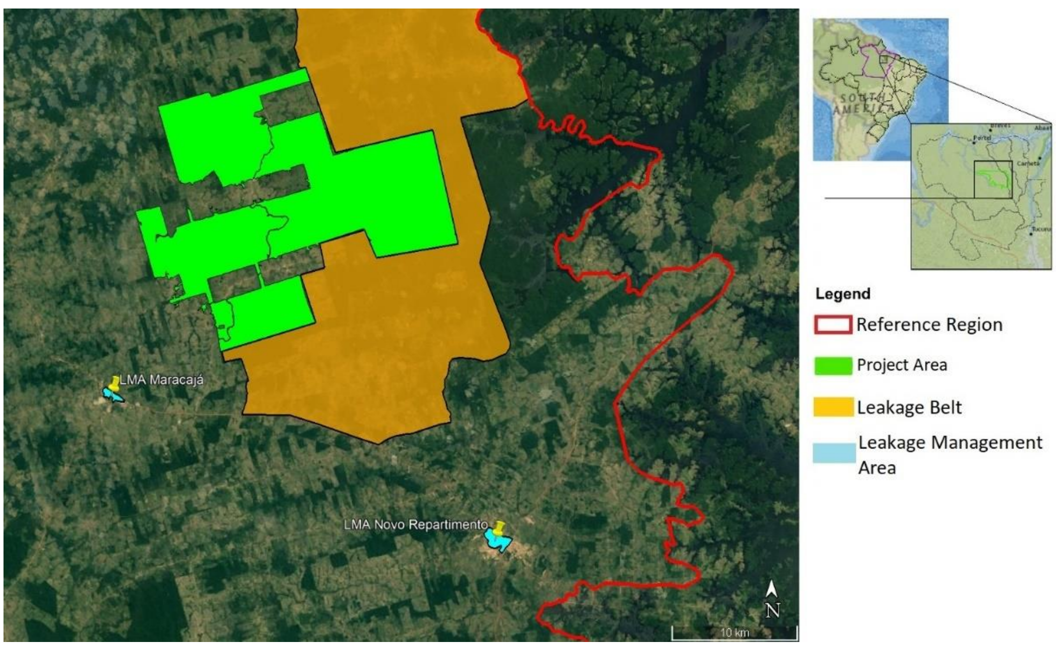


Figure 12. Details of the Leakage Management Areas



- Forest

The Brazilian Forest Service's definition of forests is lands that correspond to the vegetation typologies according to the Classification System of the Brazilian Institute of

Geography and Statistics (IBGE)[55], updated by the SIVAM project[56]. Brazil endorses the definition of forest adopted by FAO: “Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 %, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use”.

In order to define the Project Area, as previously described in this Section, only areas that comply with the definition of forest were considered. From this, the Project Area was submitted to an analysis using MapBiomas mapping and classification. MapBiomas applies a hierarchical system with a combination of LULC classes in accordance with national definition[57]. Thus, this assessment guarantees that the Project Area meets a definition of forest that has international recognition.

In addition to this, as per the VM0015 Methodology, “the Minimum Mapping Unit (MMU) size of the LULC maps created using RS imagery shall not be more than one hectare irrespective of forest definition”. Thus, the 30m pixel resolution through LANDSAT images used for mapping have the minimum mapping unit defined at 30x30m (0.09ha), easily fitting into the Methodology requirements. Details on data and image processing can be verified at Section 3.4.

Temporal Boundaries

- Starting date and end date of the historical reference period

  The adopted historical reference period was from 2011 to 2021.

- Starting date of the project crediting period of the AUD project activity

  The project has a crediting period of 30 years, from 23-June-2022 to 22-June-2052, which may be renewed up to 100 years.

- Starting date and end date of the first fixed baseline period

  The first baseline period is from 23-June-2022 to 22-June-2028.

[55] Available at <https://snif.florestal.gov.br/pt-br/conhecendo-sobre-florestas/168-tipologias-florestais?modal=1&tipo=tableau>

[56] As of 1996, through a contract signed between the Implementation Commission of the Airspace Control System - Ciscea, its Amazon’s Surveillance System Project - SIVAM, and IBGE, updated the information that make up the Legal Amazon, attending, at the same time, the Systematization of Information on Natural Resources project. Information available at <https://www.terrabrasilis.org.br/ecotecadigital/pdf/manual-tecnico-da-vegetacao-brasileira.pdf>; SIVAM Project: <https://www.camara.leg.br/noticias/55929-o-que-e-o-sivam/>

[57] A cross-reference of the MapBiomas LCLU classes with classes from other classification systems such as FAO, IBGE and National Inventory is available at Annex III of MapBiomas general handbook. Available at <https://mapbiomas-br-site.s3.amazonaws.com/Metodologia/Amazon_-_Appendix_-_ATBD_Collection_6.docx.pdf>

<u>Carbon Pools</u>

The applied Methodology considers six carbon pools. Their inclusion or exclusion within the boundary of the proposed AUD Project Activity, as well as the respective justification/explanation, are described in the Table below:

Table 6. Carbon pools included or excluded within the boundary of the proposed AUD Project Activity

Carbon pools	Included / Excluded	Justification / Explanation of choice
Above-ground	Tree: Included	Carbon stock change in this pool is always significant
	Non-Tree: Included	Included in carbon stocks estimates
Below-ground	Included	Stock change in this pool is significant
Dead wood	Exluded	Excluded for simplification. In the baseline scenario, dead wood is not removed and/or used before the deforestation, as it is often in the process of decomposition in the forest, being left to burn in the baseline case. Therefore, not accounting for this carbon pool is conservative, as it does not consider GHG emissions from deforestation and burning in the baseline.
Harvested wood products	Excluded	Stock change in this pool is not considered in baseline and project scenarios. Not a significant carbon pool.
Litter	Excluded	Excluded as it does not lead to a significant over-estimation of the net anthropogenic GHG emission reductions of the AUD project activity. This exclusion is conservative.
Soil organic carbon	Excluded	Recommended when forests are converted to cropland. Not to be measured in conversions to pasture grasses and perennial crop according to VCS Methodology Requirements.

According to the applied methodology, harvested wood products must be included if removal of timber is associated with significantly more carbon stored in long-term wood products in the baseline case compared to the project scenario. The significance criterion shall apply.

According to the most common species harvested by illegal agents in the project region[58], relating the species with the highest commercial value and their presence in the region (according to a forest inventory conducted close to the project region in the State of Pará), it can be concluded

[58] Term of apprehension of illegal wood from SEMA-PA. The document gathers information on wood species seized without documentation during the surveillance operation in the project area and its surroundings, originated from reports of illegal deforestation. From this, it is possible to evaluate the most sought-after species, usually for having greater commercial value.

that the potential volume of wood harvested by illegal loggers during the baseline would be of 17 m^3/ha.

In addition, logging in the baseline case occurred through planned and unplanned activities. In both cases, harvesting targeted the most commercially valuable species[59], without the use of proper machinery and planning, i.e., the same species were harvested using low efficiency methods without any criteria regarding the number of remaining trees per species. In addition, in both scenarios, after harvesting the most valuable species, the area was abandoned for illegal deforestation.

Thus, it can be concluded that logging in the baseline scenario, both by planned and unplanned activities, harvested the same species and volumes per hectare[60].

After the conclusions reported above, a significance test was performed following the "Tool for testing significance of GHG emissions in A/R CDM project activities", according to the applied methodology. According to the Tool, the sum of decreases in carbon pools and increases in emissions that may be neglected shall be less than 5% of the total decreases in carbon pools and increases in emissions, or less than 5% of net anthropogenic removals by sinks, whichever is lower.

This analysis was conducted for baseline logging activities (both planned and unplanned), and it was found that the sum of decreases in carbon pools and increases in emissions represents less than 5% of the total decrease in carbon pools and increase in emissions and less than 5% of net anthropogenic removals by sinks (i.e., 1.03%).

As per VM0015: If logging activities are present in the baseline, the harvested wood product carbon pool must be estimated and, if significantly higher in the baseline compared to the project scenario, it will have to be accounted. As harvested wood product carbon pool is not significant, harvested wood products was excluded in the baseline scenario, according to the methodology requirements.

Furthermore, in accordance with the applied Methodology, approximately 1/10 of the carbon stock in the below-ground pool of the initial "forest" class will be released in a ten-year interval. This is further discussed at Section 4.1 – Baseline Emissions.

Furthermore, the Methodology considers the two sources of GHG emissions listed in the Table below. Their inclusion or exclusion within the boundary of the proposed AUD Project Activity, as well as the respective justification/explanation, were also discussed:

[59] The comparison of the SEMA-PA apprehension term, literature and the post-exploratory report of the management plan executed before the project start date allowed to conclude that around 90% of the harvested volume carried out by baseline planned activities are composed by the same species illegally logged in the baseline.
[60] Information available at Apprehension Report by SEMA-PA – 2019 and EXPLORAÇÃO E VALORAÇÃO EM TORA DE 10 ESPÉCIES FLORESTAIS NO BAIXO AMAZONAS, ESTADO DO PARÁ, ENTRE 2006 – 2016 <https://periodicoscientificos.ufmt.br/ojs/index.php/biodiversidade/article/view/9999 >

Table 7. Sources of GHG included or excluded within the boundary of the proposed AUD Project Activity

Source		Gas	Included / Excluded	Justification / Explanation of choice
Baseline scenario	Biomass burning	CO_2	Excluded	Excluded as recommended by the applied methodology. Counted as carbon stock change.
		CH_4	Included	Included as non-CO2 emissions from biomass burning in the baseline scenario, according to the methodology.
		N_2O	Included	Included as non-CO2 emissions from biomass burning in the baseline scenario, according to the methodology.
		Other	Excluded	No other GHG gases were considered in this project activity.
	Livestock emissions	CO_2	Excluded	Not a significant source
		CH_4	Excluded	Excluded for simplification. This is conservative.
		N_2O	Excluded	Excluded for simplification. This is conservative.
		Other	Excluded	No other GHG gases were considered in this project activity.
Project scenario	Biomass burning	CO_2	Excluded	No biomass burning increase is predicted to occur in the project scenario compared to the baseline case. Therefore considered insignificant.
		CH_4	Included	Included as non-CO2 emissions from biomass burning in the project scenario, according to the methodology.
		N_2O	Included	Included as non-CO2 emissions from biomass burning in the project scenario, according to the methodology.
		Other	Excluded	No other GHG gases were considered in this project activity.
	Livestock emissions	CO_2	Excluded	Not a significant source
		CH_4	Excluded	No livestock agriculture increase is predicted to occur in the project scenario compared to the baseline case. Therefore considered insignificant.
		N_2O	Excluded	No livestock agriculture increase is predicted to occur in the project scenario compared to the baseline case. Therefore considered insignificant.
		Other	Excluded	No other GHG gases were considered in this project activity.

3.4 Baseline Scenario

In the baseline scenario, forest is expected to be converted to non-forest by the agents of deforestation acting in the Reference Region, Project Area and Leakage Belt, as described below. Therefore, the project falls into the AFOLU-REDD category, specifically: Avoided Unplanned Deforestation (AUD). The revenue from the present REDD project is essential to maintain this area as standing forest, as described under the Additionality of the Project (Section 3.5), and also to carry out the present Project's Leakage Management Activities.

Degradation was not considered in the present REDD Project, in accordance with Methodology requirements, which define "forest" and "non-forest" as the minimum land-use and land-cover classes.

Analysis of historical land-use and land-cover change

- Collection of appropriate data sources

  GIS MAPPING, REMOTE SENSING TECHNIQUES

  The assessment of land use and land cover (LU/LC) for the baseline period shall be made using the data obtained from monitoring LU/LC changes in the Reference Region during the historical reference period. The historical reference period for the present Project comprised image analysis from 2011 to 2021.

  In order to map land use dynamics within the Reference Region, remote sensing satellite analysis was carried out with MapBiomas[61] (collection 6.0) from 2011 to 2021, using images that are available in raster format on the program's website. Supervised classifications from Google Earth Engine were also used. This classifier is the same used in MapBiomas, allowing a closer adequacy to the Methodology.

  One Landsat scene per year from the reference period was required to compose the entire Reference Region. The final mapping resolution was 30 m pixel.

  MapBiomas is a multi-institutional initiative of the Greenhouse Gases Emissions Estimation System[62] promoted by the Climate Observatory. Its creation involves NGOs, universities, and technology companies. In MapBiomas, the image classification methodology uses, for each year, all Landsat images available in each period (Landsat 5 [L5], Landsat [L7] and Landsat [L8]), with a cloud cover less than or equal to 50%. Thus, a representative mosaic of each year is generated by selecting cloudless pixels from the available images. For each pixel, metrics that describe its behaviour during the year are extracted and can contain up to 105 layers of information with an artificial intelligence classifier, Random Forest. The acquisition of Landsat images is done via Google Earth Engine, with sources from NASA (American Space Agency) and USGS (US Geological Survey).

[61] Available at <http://mapbiomas.org/>
[62] Available at <SEEG - http://seeg.eco.br/en/>

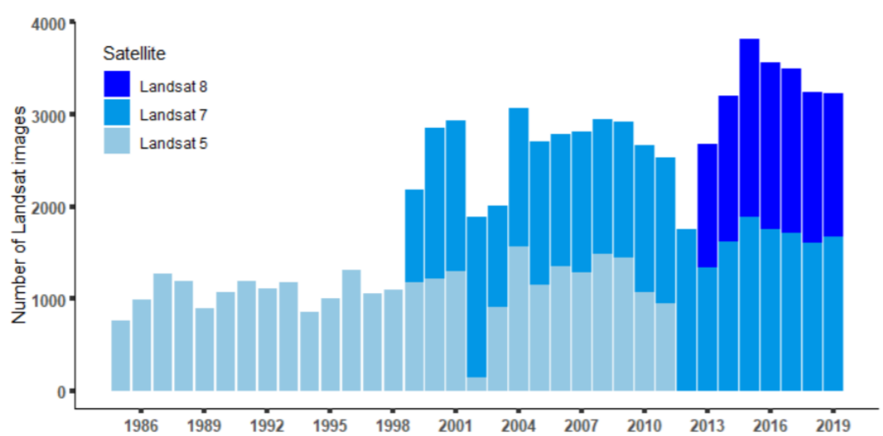
The algorithm uses samples obtained by reference maps, generation of stable collections from previous MapBiomas series and direct collection by visual interpretation of Landsat images to classify as a single map per class. This classification then goes through the stages of the spatial filter, applying neighbourhood rules and temporal filters, in particular land cover change and other impossible or prohibited kinds of use, in order to reduce spatial and temporal inconsistencies.

For the supervised classification, this same algorithm was used, but without the use of metrics, temporal filters and neighborhood rules applied in the MapBiomas methodology. In order to obtain an image suitable for direct sample classification, images from the USGS Landsat 8 Collection 1 Tier 1 TOA Reflectance collection with a 15% cloud cover limit were collected within the Reference Region, and an average of these images was generated. Training samples were generated for each land use class (forest, water and deforestation) and the Random Forest automatic classifier was applied via Google Earth Engine. The spatial filter was then applied with the Majority Filter tool from ArcGIS, using 8-pixel neighborhood. This filter is used in MapBiomas in order to avoid unwanted modifications on the edges of pixel groups (blobs).

Table 8. Satellite images used on the historical LU/LC change analysis

Vector	Sensor	Resolution		Coverage	Acquisition date	Scene	
		Spatial (m)	Spectral (µm)	(Km²)	DD/MM/YY	Path/ Latitude	Row/ Longitude
Satellite	Landsat TM	30	0.45 - 2.35	34,225	2011 – 2021	224	63
Satellite	Landsat TM	30	0.45 - 2.35	34,225	2011 - 2021	224	62

Figure 13. Number of Landsat images to map the Amazon. Source: MapBiomas

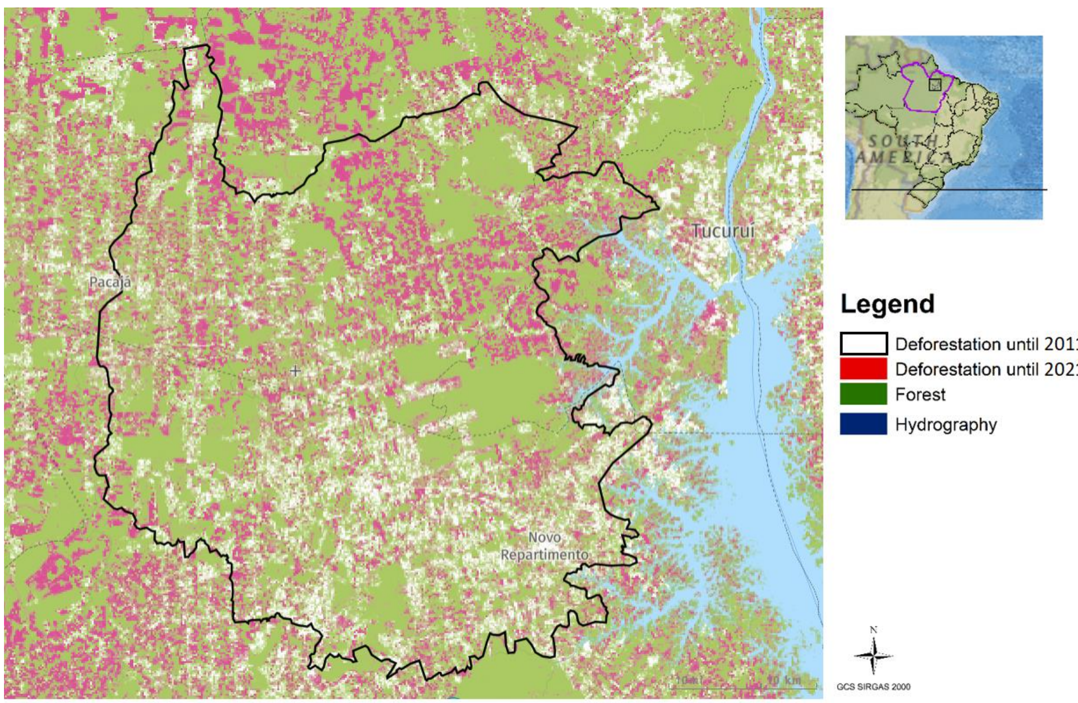


- Definition of classes of land-use and land-cover (LU/LC)

  The classes of LU/LC were defined as "forest" and "non-forest", in accordance with the procedures described above. These classes are the minimum classes to be considered in the present REDD Project, as stipulated by the Methodology. As such, degradation was not a factor.

  Stratification was not carried out in either class, and therefore the categories "forest" and "non-forest" have homogenous carbon stocks. Satellite images were used to generate the land-use and land-cover map in 2022, shown on the Figure below:

Figure 14. Land use and land cover dynamics between 2011 and 2021 within the Reference Region



Following the VM00015 Methodology requirements, the LU/LC maps have been conducted using satellite images. There are two surveys available in Brazil for deforestation and forest mapping: INPE (PRODES) and Mapbiomas. However, none of them separates deforestation by forest classes.

As aforementioned, land-use change analyses have been conducted through MapBiomas images, which is a new platform that produces maps through a pixel-by-pixel classification from Landsat satellite images. The entire process is done with extensive machine learning algorithms through the Google Earth Engine system that offers more detailed, precise and available information. MapBiomas presents a higher temporal frequency than the official data from Prodes, and thus it is recommended as image reference for regions with high cloud cover throughout the whole year.

Thus, definition of classes of land-use and land-cover was performed through MapBiomas' classification, which identifies forest, non-forest vegetation, anthropic uses (categorized as deforestation) and hydrography (lakes and rivers). For this map, the accuracy assessment has been conducted, which meets the methodology requirements.

Furthermore, the official map for all vegetation types of the country, which was elaborated by IBGE (Brazilian Institute of Geography and Statistics), was used to check the vegetation types present within the RR, PA and LK. The vegetation type map was created by IBGE considering several aspects that are able to differentiate one type of vegetation to the other, such as species composition, elevation and climate variation, soil type, among others. The accuracy assessment of this mapping would be unfeasible, since the IBGE map was generated considering characteristics such as soil type, elevation, species composition, etc.

Six vegetation types were found, and, according to this analysis, the Dense Lowland Tropical Rainforest is the main forest type present within the project area, with around 95% of the total forest cover. Thus, after verifying that most of the project boundaries were composed of only one phytophysiognomy, the mapping and modeling of the project proceeded without stratification.

The LU/LC classes present in the project area, reference region and leakage belt at the project start date are listed in Table below, which specifies whether logging, fuel wood collection or charcoal production are occurring in the baseline case.

Table 9. List of land use and land cover change categories

Class identifier		Trend in carbon stock[1]	Presence in[2]	Baseline activity[3]			Description (including criteria for unambiguous boundary definition)
IDcl	Name			LG	FW	CP	
1	Forest	constant	RR, PA, LK	yes	no	no	According to official classification of the types of vegetation of Brazil (SIVAM) and the high representativeness of the main forest type within the project area, no stratification in different forest classes was conducted. In addition, carbon density is not expected to undergo significant changes due to degradation in the baseline case. According to the significance test, carbon stock change due to logging activities in the baseline case is considered insignificant and therefore, trend in carbon stock could be deemed as constant.
2	No forest	constant	RR, PA, LK	no	no	no	Mosaic of anthropic areas: pasture, annual, perennial crops and roads according to the satellite image classification.
3	Hydrography	constant	RR, PA, LK	no	no	no	Presence of rivers and water bodies in the satellite image classification and information from the National Water Agency - ANA.

An analysis in the Amazon region[63] between 2009-2016 shows that there is no trend in degradation, although it affects an area larger than deforestation. It was concluded that degradation can serve as a warning that the region will soon be the target of deforestation practices. As the degradation has low local recurrence over the years, i.e., on average the same area is classified as degraded only once during the analyzed period, it is very unusual that the same area will suffer another degradation, since the valuable woods have already been harvested. Thus, it is very likely that carbon stocks after degradation might increase. Therefore, it is conservatively assumed that the trend in carbon stocks in the baseline case is constant.

The main forest type present in around 95% of the RR, PA and LB is described below, according to the Technical Manual of the Brazilian Vegetation[64]:

- **Dense Lowland Tropical Rainforest** – This type of vegetation is characterized by woody plants, in addition to woody lianas and epiphytes in abundance, which differentiate it from other classes of formations. However, its main ecological characteristic resides in the ombrophilous environments that mark the "floristic forest region". Thus, the thermal characteristic of the Dense Ombrophylous Forest is linked to tropical climatic factors of high temperatures (averages of 25ºC) and high precipitation, well distributed throughout the year (from 0 to 60 dry days), which determines a bioecological situation with virtually no biologically dry period. The lowland rainforest is a formation that generally occupies the coastal plains. It occurs in the Amazon, extending throughout the Brazilian Northeast region to the vicinity of the São João River, in the State of Rio de Janeiro. Towards the south, this formation occurs in the Quaternary terrains located generally just above sea level, in the plains formed by silting due to erosion in the coastal mountains, and in the maritime inlets.

Figure 15. Dense Tropical Rainforest profile

- Definition of categories of land-use and land-cover change (LU/LC-change)

The LU/LC-change categories that could occur within the project area and leakage belt during the first baseline period, in both the baseline and project case, are identified in the potential

[63] Available at https://www.climatepolicyinitiative.org/wp-content/uploads/2021/03/DQ-Degradacao-Florestal-Amazonia.pdf
[64] Available at https://www.terrabrasilis.org.br/ecotecadigital/pdf/manual-tecnico-da-vegetacao-brasileira.pdf

LU/LC-change matrix and the list of LU/LC-change categories during the project crediting period are shown in the Tables below.

It is shown that deforestation could occur in the baseline and project scenarios within both the PA and LK areas; the hectares show the quantities of deforestation during the crediting period associated with each identifier. The deforestation presented within the PA and LK are shown in the LU/LC-change map.

As shown in tables below, degradation was not considered in any of the LU/LC classes.

Table 10. Land use change matrix in the reference region

		Initial LU/LC class	
	IDcl	Forest	No forest
Final Class	Forest	I1/F1	0
	No forest	I1/F2	I2/F2

BASELINE SCENARIO

	PA	Initial LU/LC class	
	IDcl	Forest	Non Forest in the PA
Final Class	Forest	13,669.36	0.00
	Non Forest in the PA	11,748.49	0.00

	LB	Initial LU/LC class	
	IDcl	Forest	Non Forest in the LK
Final Class	Forest	18,359.88	0.00
	Non Forest in the LK	17,044.43	24,365.69

PROJECT SCENARIO

	PA	Initial LU/LC class	
	IDcl	Forest	Non Forest in the PA
Final Class	Forest	24,775.08	0.00
	Non Forest in the PA	642.77	0.00

	LB	Initial LU/LC class	
	IDcl	Forest	Non Forest in the LK
Final Class	Forest	16,597.61	0.00
	Non Forest in the LK	18,806.71	24,365.69

The Table below also shows that no classes were predicted to have growth in carbon stocks, this is because secondary forest was not considered as a category.

Table 11. List of land use and land cover change categories

IDct	Name - Initial	Trend in carbon stock[1]	Presence in	Activity in the baseline case			Name - Final	Trend in carbon stock	Presence in	Activity in the project case		
				LG	FW	CP				LG	FW	CP
I1/F1	Forest	constant	RR, PA, LK	yes	no	no	Forest	constant	RR, PA, LK	yes	no	no
I1/F2	Forest	constant	RR, PA, LK	yes	no	no	Non Forest	constant	RR, PA, LK	yes	no	no
I2/F2	Non Forest	constant	RR, LK	no	no	no	Non Forest	constant	RR, PA, LK	no	no	no

- Analysis of historical land-use and land-cover change

  According to the GIS analysis, between 2011 and 2021, there was a deforestation of 141,950ha within the Reference Region, with an average oscillation of approximately 12,904ha/year. The location where the deforestation occurred may be observed in the Figure below:

Figure 16. Deforestation dynamics between 2011 and 2021 in the Reference Region

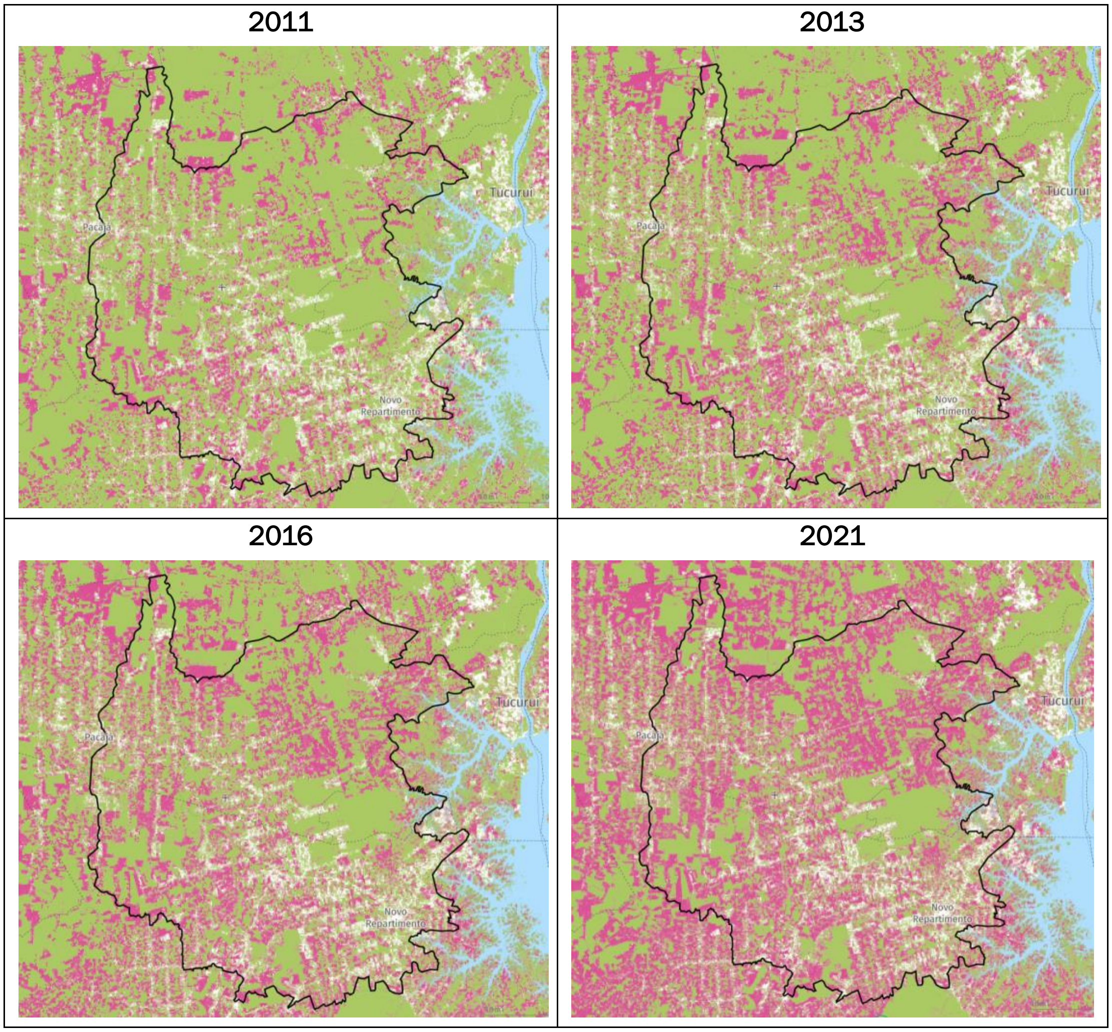


Figure 17. Variation in the deforestation rate within the reference region between 2011 and 2021

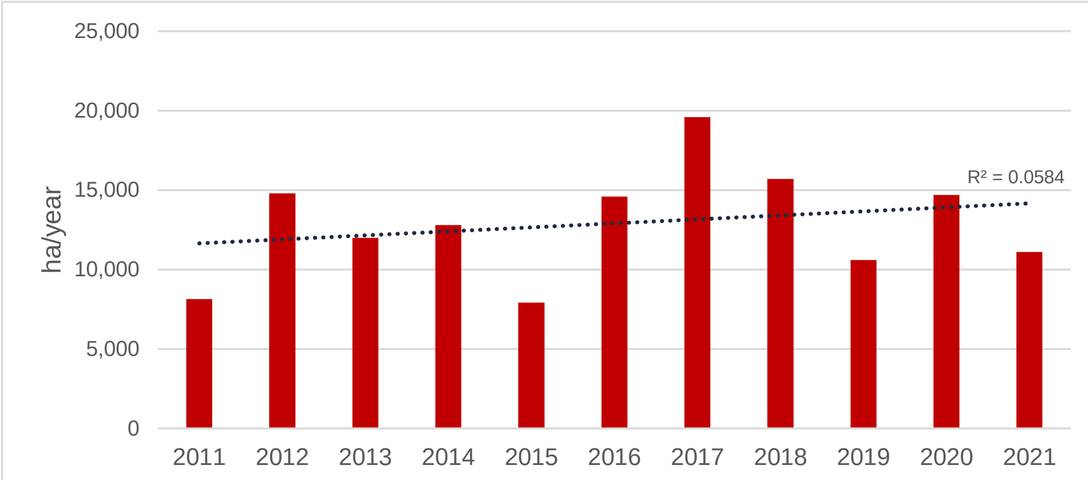


Table 12. Annual deforestation in the Reference Region between 2011 and 2021

Year	Forest	Annual deforestation (ha)	Cumulative deforestation (ha)
2011	536,860	8,140	142,140
2012	522,060	14,800	156,940
2013	510,060	12,000	168,940
2014	497,260	12,800	181,740
2015	489,350	7,910	189,650
2016	474,750	14,600	204,250
2017	455,150	19,600	223,850
2018	439,450	15,700	239,550
2019	428,850	10,600	250,150
2020	414,150	14,700	264,850
2021	403,050	11,100	275,950

- Map accuracy assessment

The results of MapBiomas undergo an accuracy assessment, which for the entire Amazon Biome is on average 95%. However, to meet the particularities of the region, an independent evaluation was carried out for the reference region from the years 2011 to 2021.

To assess the accuracy of the maps produced by the MapBiomas methodology, a confusion matrix was generated by calculating the user's and producer's percentage of correct answers, errors of omission and commission. For that, 200 sample points were randomly drawn on the reference region, 50 in each class (forest, hydrography and deforestation), and the degree of correctness classification was verified. As a reference, high resolution Landsat images were used, where it was possible to visually determine the land use of the sample points drawn.

For the supervised classification, 300 random points were drawn over the RR, 100 in each of the classes (forest, hydrography and deforestation). The table below shows the accuracy analysis carried out for each year and each land use class.

Table 13. Summary of confusion matrices from the evaluation of MapBiomas from 2011 to 2021

	Producer accuracy				User accuracy			
Year	Forest	Hydrography	Pioneer vegetation	Deforestation	Forest	Hydrography	Pioneer vegetation	Deforestation
2011	97.96%	97.96%	94.00%	92.31%	96.00%	96.00%	94.00%	96.00%
2012	97.78%	100.00%	94.23%	88.68%	88.00%	100.00%	98.00%	94.00%
2013	95.74%	98.04%	88.89%	89.58%	90.00%	100.00%	96.00%	86.00%
2014	97.62%	96.15%	90.38%	87.04%	82.00%	100.00%	94.00%	94.00%
2015	97.83%	98.04%	95.74%	85.71%	90.00%	100.00%	90.00%	96.00%
2016	91.67%	92.31%	85.45%	88.89%	88.00%	96.00%	94.00%	80.00%
2017	95.24%	96.15%	88.68%	81.13%	80.00%	100.00%	94.00%	86.00%
2018	93.88%	96.00%	96.08%	92.00%	92.00%	96.00%	98.00%	92.00%
2019	88.00%	92.45%	95.65%	86.27%	88.00%	98.00%	88.00%	88.00%
2020	97.62%	98.00%	85.71%	80.77%	82.00%	98.00%	96.00%	84.00%
2021	98.77%	95.15%		86.21%	80.00%	98.00%		100.00%

<u>Analysis of agents, drivers, and underlying causes of deforestation</u>

As specified in the Methodology, it is necessary to understand "who" the deforesting agent is and what drives land-use decisions ("drivers" and "underlying causes"). This analysis is important for two main reasons: (i) Estimating the quantity and location of future deforestation; and (ii)

Designing effective measures to address deforestation, including leakage prevention measures[65].

- **Database organization and pre-processing**

  The forest dynamics data, deforestation vectors and other base information from the region under analysis, which were used to build the Project Baseline, were organized in a spatialized database, in the File Geodatabase format of ArcGIS 10.8. The data come from different sources and have different cartographic scales (Table below). The files are stored in vector and matrix (raster) format. In order to standardize the spatial references, all data were reprojected to the WGS 1984 UTM Zone 21S projection.

  At first, several layers were pre-selected, which may be related to the greater chance of deforestation in the Reference Region and Project Area. For example, rivers and roads are usually vectors of deforestation because they are the access routes to forest areas, where deforestation agents can encroach the territory to extract timber and other deforestation byproducts.

Table 14. Spatialized data for the determination of the deforestation dynamics in the Reference Region and baseline structure

Data	Scale/Resolution	Year	Source
Watershed database	1:1.000.000	2012	ANA
Water bodies database	1:100.000	2020	ANA
Municipalities database	1:250.000	2019	IBGE
Rivers database	1:1.000.000	2013	ANA
FUNAI Indigenous Lands database	1:500.000	2020	FUNAI
CNUC Protected Areas database	Varia de 1:5.000 a 1:100.000	2019	MMA
Federated Units Database	1:250.000	2019	IBGE
Rainfall database	1 km	2020	Fick, S.E. and R.J. Hijmans, 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37 (12): 4302-4315.
Forest Class database	1:250.000	2019	IBGE

[65] VM0015: STEP 3: Analysis of agents, drivers and underlying causes of deforestation and their likely future development, page 37. Available at: <https://verra.org/wp-content/uploads/2018/03/VM0015-Methodology-for-Avoided-Unplanned-Deforestation-v1.1.pdf>.

Road transport infrastructure database	1:250.000	2019	IBGE
Road transport infrastructure database		2012	Imazon
Cities Points database	1:250.000	2019	IBGE
Settlement Projects database		2020	INCRA
Elevation digital model	30m		SRTM

- **Identification of agents of deforestation**

In the past few years, the project region has been the subject of news and studies, mainly due to the advancement of the arc of deforestation in the Amazon biome. This pressure is expected to continue, given the globalization of markets in the amazon region and international development policies planned for the region[66].

Of the ten cities that most deforested in Brazil, five are located in Pará. The municipalities in the reference region remain in the ranking of the municipalities that have lead deforestation in the Brazilian Amazon at least for five years[67,68].

The main deforestation agents identified in the region are timber harvesting, acting both legally and illegally;

a) Timber harvesting

As aforementioned in section 1 above, timber logging (both legal and illegal) is an important economic activity within the reference region. Economic data sources show that timber is the largest contributor to the value of annual production when compared to all extractivism products in the project area and reference region municipalities.

However, beyond the high production level shown in official data, the production of timber continues to be conducted illegally: studies, estimate that 36% of Brazil's timber production is legal[69]. Illegal wood harvesting is known to take place within the reference region and project area, being transported to the sawmills by riverboat. Usually, timber logging is the first deforestation agent that reaches previously inaccessible forest lands, using existing roads or creating illegal ones, followed by land speculators or farmers in search of cheap land.

It can be concluded that timber, whether firewood or roundwood, represents a product of much more attractive value compared to other types, being even more advantageous

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[66] Nepstad, D. C.; C. M. Stickler e O. T. Almeida. 2006. Globalization of the Amazon Soy and Beef Industries: Opportunities for Conservation. Conservation Biology 20(6):1595-1603

[67] Available in: <https://agenciabrasil.ebc.com.br/geral/noticia/2017-01/amazonia-perde-7989-km2-de-floresta-maior-desmatamento-desde-2008>. Last visited on 14/05/2021.

[68] IPAM. Overview Of Amazon Deforestation 2016. Available at: <http://aliancaamazonia.org.br/wp-content/uploads/2017/05/Overview-of-Amazon-deforestation-2016_IPAM.pdf> . Last visited: 14/05/2021.

[69] Serviço Florestal Brasileiro (SFB), Instituto de Pesquisa Ambiental da Amazônia (2011), "Florestas Nativas de Produção Brasileiras".

when combined with animal production afterwards, where there is no need for forest management.

b) Cattle ranching

According to Razera (2005)[70], the lack of economic alternatives has created the conditions for livestock farming to establish itself as the main economic activity causing settlement of deforested areas in Amazonia.

Cattle farming in the Amazon region is primarily due to low land prices combined with adequate rainfall levels[71]. The Amazon region attends to national and regional demand. Analysis of supply and demand show that livestock farming could expand even more to attend to the majority of global demand. This scenario is extremely worrying in relation to Amazon deforestation levels.

Livestock farmers do not pay for the public lands which they acquire legally or illegally, and furthermore they harvest timber without paying the government and, in this way, they accumulate capital freely to reinvest into their operations. Thus, land speculation and cattle farming contribute to the advancement of deforestation in more isolated regions[72]. In this way, the predominance of the free market (with no legal restrictions) will lead to the expansion of cattle farming, especially of the type based upon indiscriminate deforestation.

The State of Pará has the 4th largest cattle herd in Brazil - and the largest in the northern region-, with more than 20 million heads and constantly growing, has a beef cattle industry based on cultivated pastures with good productivity[73,74]. The evolution of livestock shows that the cattle herd in Pará grew above the Brazilian average. While the national herd obtained a variation of 9.25%, Pará's had a growth of 33.36% (superior result even when compared to the states with the largest effective cattle herd: Mato Grosso, Minas Gerais and Goiás)[75].

[70] RAZERA, A. Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí. 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.
[71] BRANDÃO, F. Tendências para o consumo de carne bovina no Brasil. 2013. 102 f. Thesis (Doctor grade) - Curso de Agronegócio, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2013
[72] RAZERA, A. Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí. 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005
[73] NETO, J. F. T; COSTA, N. A. Criação de Bovinos de Corte no Estado do Pará. EMBRAPA. Available at:
[74] Available at: https://cidades.ibge.gov.br/brasil/pa/pesquisa/18/16459. Last visited on August 6th, 2021.
[75] FAPESPA. Boletim Agropecuário do Estado do Pará (2017). Available At: http://www.fapespa.pa.gov.br/upload/Arquivo/anexo/1383.pdf?id=1533567716. Last visited on August 6th, 2021.

Figure 18. Evolution of the cattle herd in the state of Pará and Brazil[76]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Brasil	199,752	202,307	205,308	209,541	212,815	211,279	211,764	212,366	215,221	218,225
Pará	15,354	16,241	16,857	17,633	18,263	18,605	19,165	19,911	20,272	20,477

In Pará State, livestock represents 51% of the land use, equivalent to 14,523,938 ha. Until 2018, there were 281,699 agricultural establishments in the State[77].

In addition, the competitive evolution of livestock in Pará is linked to natural, economic and technological variables, such as governance structure that establishes conditions for the applicability of the bovine activity; the availability of land at lower prices compared to others regions in Brazil; the favorable weather for pastures, ideal for the development of grass and forage; the quality of the meat produced - due to feeding exclusively on pasture (green cattle); and the Aftosa Free Area International Certification. These characteristics favour the cattle raising in the State and allows producers from Pará access national and international markets[78].

Pastureland (either planted, natural or degraded) represents the main land use after forest (natural and protected areas) in the main municipalities of the reference region, which also shows that this is the main economic activity in the region[79,80].

In addition, the price per unit (specifically, the "*arroba*") of beef increased considerably in mid-2010. This fact seems to stimulate rural producers to deforest new areas and expand their herds, attracting migration to forest borders distant from the municipality's main city.

[76] FAPESPA. Boletim Agropecuário do Estado do Pará (2017). Available At: http://www.fapespa.pa.gov.br/upload/Arquivo/anexo/1383.pdf?id=1533567716.
[76] Available at: Available in <https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/estabelecimentos.html?localidade=15>.
[77] Available at: Available in <https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/estabelecimentos.html?localidade=15>.
[78] FAPESPA. Boletim Agropecuário do Estado do Pará (2017). Available At: http://www.fapespa.pa.gov.br/upload/Arquivo/anexo/1383.pdf?id=1533567716.
[79] Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.
[80] Available at: <https://cidades.ibge.gov.br/brasil/pa/>.

- **Identification of drivers of deforestation**

Furthermore, according to the methodology, after analyzing the main deforestation agents acting within the reference region during the historical reference period, it is necessary to identify the main drivers affecting the amount of deforestation in the reference region.

Some of the factors that characterize, and drive deforestation and subsequent cattle ranching are the low cost of the forested area; soil fertility and favorable weather; well-structured soil and mainly flat conditions of the area; tradition of farming existing in the municipalities and the meat market of the region[81]. Key driver variables are detailed in the section below.

a) **Driver variables explaining the quantity (hectares) of deforestation:**

1) **Population growth:**

Several studies for the Amazon biome[82,83,84] mention that deforestation rates may increase because of population growth and the need for more land for food, fuelwood, timber, or other forest products. The number of people and their socio-economic conditions both have a significant impact on deforestation. As agriculturally based population density increases in and near forested areas, the strongest relationship between population growth and deforestation occurs, as local people and young migrant families arrive at the forest frontier and clear land to provide more area for subsistence farming. Therefore, besides addressing the population numbers, policies that impact the socio-economic conditions of the people are needed if deforestation is to be delayed or forests are to be sustained.

From the 2010 census and the 2021 estimate provided by IBGE[85], it is possible to note that the population has grown in the three municipalities of the reference region at a very similar rate and trend.

2) **Prices of timber logs and livestock per *arroba*:**

As previously described above, the prices of timber logs and *arroba* (livestock) are the main reason why the cattle herd increased in the period, reaching more than 500 thousand animals in the three main municipalities composing the reference region. In

[81] FAPESPA. Boletim Agropecuário do Estado do Pará (2017). Available At: http://www.fapespa.pa.gov.br/upload/Arquivo/anexo/1383.pdf?id=1533567716.
[82] ANGELSEN; KAIMOWITZ. Rethinking the Causes of Deforestation: Lessons from Economic Models. The World Bank Research Observer, vol. 14, no. 1 (February 1999), pp. 73–98.
[83] ASHOK K.; JAGDISH C.; DAVID K. Understanding the Role of Population in Deforestation. Journal of Sustainable Forestry Vol. 7, Iss. 1-2, 1997
[84] MEYERSON, F. A. B. Population Growth and Deforestation: A Critical and Complex Relationship. Population Bulletin 58, no. 3. 2003
[85] Available at <https://cidades.ibge.gov.br/brasil>

addition, during the same period, the timber logging also increased, being one of the main produced products in the two municipalities.

It is important to note that timber stands out as having the highest values among the total annual production in the project area municipalities[86]. In addition, according to Razera (2005), given the large increase in pastureland property values, creation of new areas for livestock raising has been stimulated and intensified, raising cattle numbers and, consequently, increasing deforestation. Research accounted for approximately R$1040,00 per animal in the region, on an average of R$80,00 per *arroba*.

As detailed in previous sections and in the description of deforestation agents above, timber prices have much higher value than other products exploited in the region. Roundwood production in the region represented a higher value when compared to other PFNM produced in the municipalities. Prices vary between 560,000 and 1,100,000 reais per m^3. In 2016, non-timber forest products were responsible for moving around 2.8 billion reais, while the forestry industry generated more than 13.7 billion reais[87].

Furthermore, forested property values are almost 6 times cheaper than established pasturelands. Thus, this disparity promotes the purchase of new forested areas, deforestation and further creation of new pasturelands[88]. Thus, partly due to the expansion of globalization, deforestation rates in Amazonia appear to be linked to the growth of the international market, especially of beef[89].

b) Driver variables explaining the location of deforestation:

The main drivers of deforestation related to the location of impact in the project region are:

1) Distance from deforested areas

The presence of "non-forest" is a driver variable predicting quantity and location of future deforestation. Forested areas are influenced by their proximity to areas that have already been deforested. The distance from previously deforested areas is one of the major causes of forest degradation in the Amazon biome and their spatio-temporal dynamics are highly influenced by annual deforestation patterns. In addition, forest fragmentation

[86] IBGE Cidades – Extração vegetal e silvicultura. Available at: https://cidades.ibge.gov.br/brasil/pa.
[87] SNIF. Boletim 2017 sobre Recursos Florestais no Brasil. Available at: https://www.florestal.gov.br/documentos/publicacoes/3230-boletim-snif-2017-ed1-final/file. Last visited on July 7th, 2021.
[88] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.
[89] Fearnside, P. M. 2005. Deforestation in Brazilian Amazonia: history, rates and consequences. **Conservation Biology** 19(3):680-688.

results from deforestation and disturbance, with subsequent edge effects extending deep into remaining forest areas[90,91].

2) Roads, highways, access roads and navigable rivers

Access roads are means of communication, which influence the spatial distribution of land-uses. Access roads have an influence on fragmentation, population densities, agriculture and pastureland. The possible creation of new access roads, added to the already plentiful rivers in the region, increases anthropogenic pressure and, consequently, the intensity of deforestation[92,93,94].

Waterways remain the overwhelmingly predominant means of transport and access to forest products. The reference region is located in one of Brazil's richest areas in terms of waterways, which historically determined the locations of settlements in relation to extraction of non-timber forest products (NTFPs) and timber. Waterways remain the overwhelmingly predominant means of transport and access to forest products. Furthermore, the small sawmills to which timber is taken for processing are located on riverbanks. For these reasons, the great majority of the regional population is located in small settlements on the banks of the rivers[95].

3) Extreme poverty

Poverty and government abandonment, which does not develop welfare public policies aimed at the sustainable development of the region, encourages illegal activities associated with the lack of economic options and the need to generate income. Logging in the region is marked by a strong connection between communities and companies. This connection was mainly based on the need to generate income for these families, who sell wood logs from their land at extremely low prices, clandestinely, without any planning of use or notion of the value of the forest[96].

[90] BROADBENT et al. Forest fragmentation and edge effects from deforestation and selective logging in the Brazilian Amazon. Biological Conservation. Volume 141, Issue 7, July 2008, Pages 1745–1757

[91] IMAZON. Carbon emissions from deforestation and forest fragmentation in the Brazilian Amazon. 2011. Available at: <http://imazon.org.br/publicacoes/carbon-emissions-from-deforestation-and-forest-fragmentation-in-the-brazilian-amazon/?lang=en>. Last visit on: August 6th, 2021.

[92] BROADBENT et al. Forest fragmentation and edge effects from deforestation and selective logging in the Brazilian Amazon. Biological Conservation. Volume 141, Issue 7, July 2008, Pages 1745–1757.

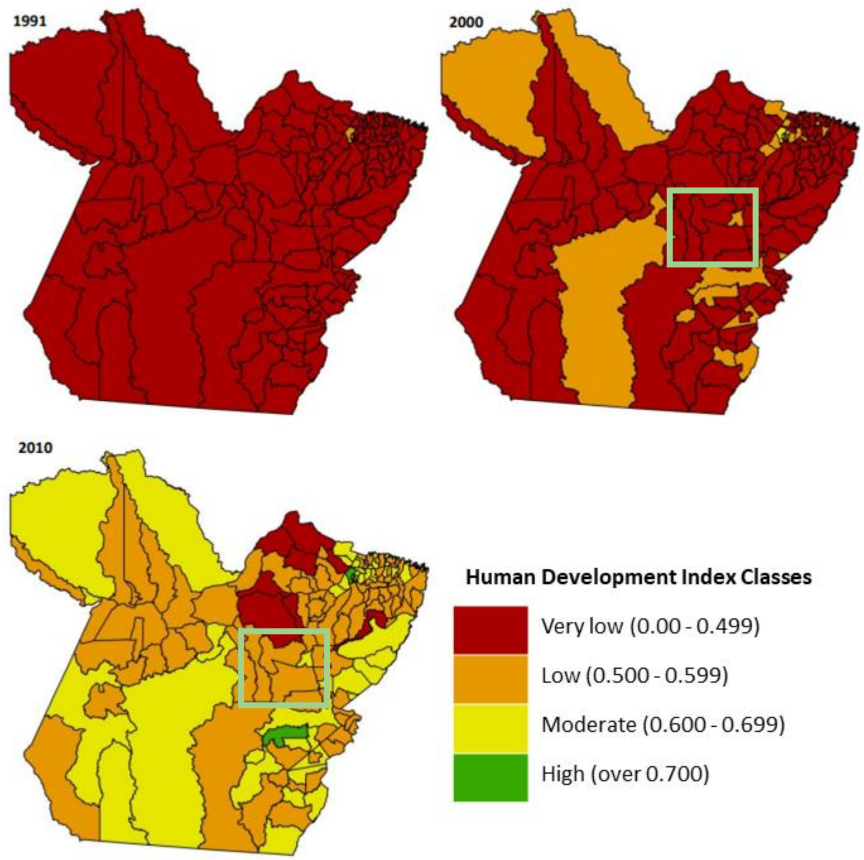
[93] GENELETTI, D. Biodiversity Impact Assessment of roads: an approach based on ecosystem rarity. Environmental Impact Assessment Review, v.23, n.3, p.343-365, 2003

[94] Fearnside, P.M. e P.M.L.A. Graça. 2006. BR-319: Brazil's Manaus-Porto Velho Highway and the Potential Impact of Linking the Arc of Deforestation to Central Amazonia. Environmental Management 38:705-716

[95] Grupo Executivo do Estado do Pará para o Plano Marajó (GEPLAM) (2007), "Plano De Desenvolvimento Territorial Sustentável Do Arquipélago Do Marajó".

[96] D'Arace, L. M. B. et al. Wood production in log and firewood in northern Brazil and the state of Pará. Brazilian Journal. of Development, Curitiba, v. 5, n. 9, p. 16885-16896, september 2019.

Figure 19. Historical analysis of the HDI in the state of Pará (project region is highlighted by the rectangle)[97]



Despite the evolution in the HDI of almost all municipalities in the State of Pará between 1991 and 2010, The figure above allows to observe that the municipalities composing the reference region have a low socioeconomic situations, with Low to Moderate HDI.

Many *ribeirinhos* that live around the project area sell timber illegally to smugglers along the Arataú and Pacajá Rivers, as a way to generate a small income for subsistence, as these families often do not have another source of income. The absence of the State, the limitations due to lack of income and distance create a favorable scenario for illegal deforestation.

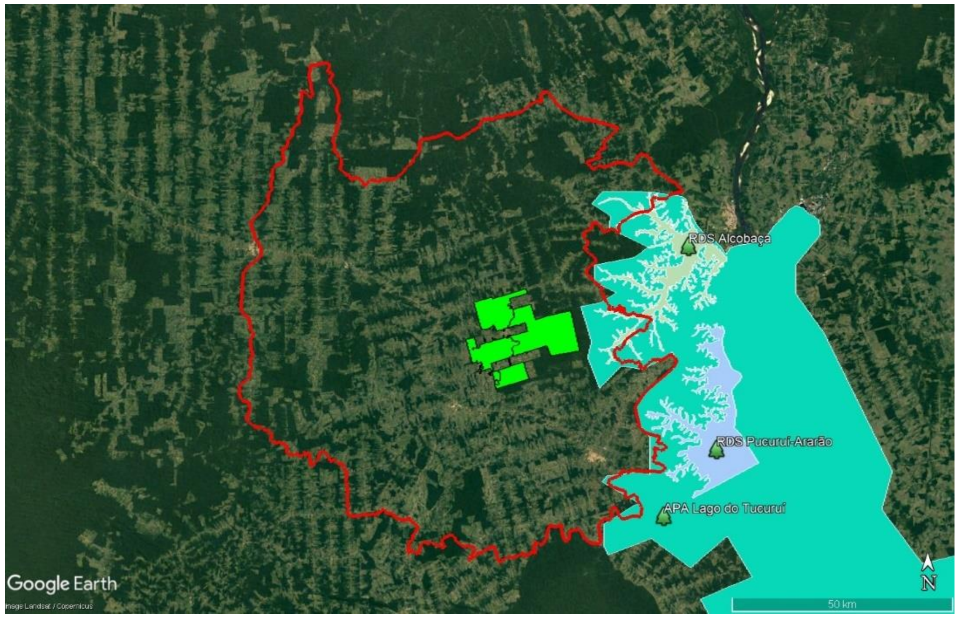
4) Presence of protected areas

The reference region is surrounded by a couple of Protected Areas, listed below:

- Reserva de Desenvolvimento Sustentável Alcobaça
- Área de Proteção Ambiental do Lago de Tucuruí

[97] IDESP. Síntese do Índice De Desenvolvimento Humano Municipal – IDHM Para o Estado do Pará. Available at: http://www.fapespa.pa.gov.br/upload/Arquivo/anexo/234.pdf?id=1479216410. Last visited on July 7th, 2021

Figure 20. Protected Areas in the Reference Region



The presence of protected areas in the surroundings of the project area would in theory decrease the likelihood of deforestation, affecting the location of future deforestation. However, between 2012 and 2015, 237.3 thousand hectares were deforested within Conservation Units (UCs) in the Amazon. In that period, the occupants may have obtained a gross income of R $ 300 million from the sale of timber illegally harvested from protected areas, which created an enormous investment potential in deforestation, with logging being the main agent of deforestation[98]. Deforestation has increased within some protected areas and the percentage share of deforestation in conservation units in the total deforested in the Legal Amazon doubled from 6% to 12% between 2008 and 2015. In 2015, deforestation within conservation units was 79% higher than in 2012. In the last 4 years (2016-2020), the area of devastated forest in conservation units in the Legal Amazon rose 80%, against 35% of deforestation in general.

The political scenario is intrinsically related to the upward trend. For more than a decade, Brazil has elected a series of governments that are little concerned or completely averse to the country's environmental agenda. After the flexibilization of the Forest Code - the central piece of legislation regulating land use and management on private properties - in 2012, the deforestation rates in the country, which had been declining since 2005, increased again in the Brazilian Amazon[99].

From 2016 onwards, Brazil has been in the midst of a severe political and ethical crisis after suffering a putsch that removed the democratically elected president from the

98 Available in <https://imazon.org.br/imprensa/novo-estudo-do-imazon-alerta-para-tendencia-de-aumento-do-desmatamento-em-unidades-de-conservacao-da-amazonia-e-identifica-as-50-mais-desmatadas-entre-2012-e-2015/>

99 ROCHEDO, P. RR; SOARES-FILHO, B; SCHAEFFER, R. VIOLA, E. SZKLO, A; LUCENA, A.F.P; KOBERLE, A; DAVIS, J.L; RAJÃO, R; RATHMANN, R. The threat of political bargaining to climate mitigation in Brazil. **Nature Climate Change,** vol 8, August 2018, pg. 695–69.

federal government. Since then, the country suffered consecutive attacks on the environmental agenda, resulting in the dismantling of the national environmental policy. The new president governed between 2016 and 2018 and during this period, Brazil was the stage for a series of acts against the environmental area, such as cutting budgets for protected areas control, reducing the protection of more than 600,000 ha of Amazon and Atlantic Forest biomes[100] and the attempt to promulgate a decree that would allow the exploration of an area of 46,450 square kilometers between Pará and Amapá States, for exploration by mining companies.

Therefore, it is concluded that, although in theory the presence of conservation units is an indication of areas extremely protected by law, it has been demonstrated that, in practice, the opposite occurs, leaving large areas of native forests exposed to invasions, exploitation and illicit sales, facilitated by lack of inspection and public policies.

- Identification of underlying causes of deforestation

Underlying causes of deforestation include the political scenario related to the environment in the baseline period. The political instability would probably reflect in the increase of deforestation. There are no applicable mitigation actions for these causes, as they are political and determined through elections every 4 years. However, it is expected that the local actions developed by the project activity will help to reduce the impacts of these facts.

Due to being located in a region of large cattle ranchers and settlements, the reference region has a considerable social conflict issue, primarily land conflict. Land is occasionally illegally occupied by squatters and illegal loggers[101],[102],[103]. Thus, the main underlying causes of deforestation within the reference region are associated with land conflicts (tenure issues), and the lack of public policies promoting sustainable alternatives to combat deforestation and degradation activities.

The continued lack of resolution of land tenure issues contributes to reducing legal production options and continues to promote the expansion of deforestation associated with cattle farming and land speculation. According to studies conducted in the region by Idesam, there is a pressing need for restructuring at a local level, which is lacking investment in infrastructure, equipment, and human resources to attend to strong land-tenure demand. The low presence of Governance and lack of land-tenure documentation, with thousands of rural producers owning non-documented properties, promotes a

[100] CROUZEILLES, R., FELTRAN-BARBIERI, R., FERREIRA, M. S. & STRASSBURG, B. B. N. Hard times for the Brazilian environment. Nat. Ecol. Evol. 1, 1213 (2017).
[101] Available at <https://g1.globo.com/natureza/noticia/2019/09/04/invasoes-grilagem-e-queimadas-ameacam-areas-protegidas-na-amazonia.ghtml>
[102] Available at <https://acervo.socioambiental.org/sites/default/files/documents/prov0227_0.pdf>
[103] Available at https://www.bbc.com/portuguese/brasil-56211156

scenario of forest destruction for exploration of natural resources and creation of pastureland, driving the tendency for the frontier to grow[104].

Environmental governance in Brazil can be divided into three major periods: pre-2005, a period with very poor governance and high rates of deforestation; 2005-2011, a period with improvements in environmental governance and effective results in reducing deforestation; and after 2012, when governance suffered a gradual erosion with the large amnesty granted to past illegal deforesters in the revision of the Forest Code and a return of deforestation rates to the peak levels of the last decade.

2012's political scenario, with the flexibilization of the forest code legislation and amnesty to deforesters, the interruption of the creation of protected areas, including the unprecedented reduction of several of these protected areas in the Amazon, among other actions, proved to be the beginning of a series of setbacks, which have continued over the past 5 years.

From 2016 onwards, the impeachment on Brazil's president Dilma Rousseff wide opened the dismantling policy of the environmental agenda created by the new government (Michel Temer, May 12, 2016 to December 31, 2018) to gain the support of the ruralist bench, constituted by a coalition of parliamentarians of the Brazilian National Congress with common interests, such as the advance of the livestock and agribusiness barrier in Brazil – and, consequently, the deforestation and the environmental policies that prevent it from occur. The Brazilian National Congress has approximately 500 parliamentarians, which means that obtaining support from the ruralist committee (which has around 350 parliamentarians) guarantees a strategic advantage for the approval of provisional measures and decrees.

The 2017's federal government is marked by a series of acts against the environmental area, and such as Cutting budget and freezing investments in Brazilian science. The main ministries linked to Higher Education Institutions (Ministry of Education and Ministry of Science and Technology) suffered billionaire budget cuts, endangering scientific research and environmental monitoring bodies, as the largest network of biodiversity research in Brazil, the PPBio. Besides the budget cut, the Ministry of Science and Technology suffered another attack when it was merged with the Ministry of Communications, devaluing science by uniting two ministries with opposing goals and threatening the future of the country's scientific research. After the measure, which froze investments in education for the next 20 years, the National Council for Scientific and Technological Development (CNPq), the responsible body for financing most undergraduate and graduate research projects in the country, had a budget in 2017 lower than the equivalent of 2004. The scrapping of Brazilian scientific research bodies directly affects the monitoring and

[104] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1). 141 Available in <
https://idesam.org/publicacao/REDD_Estudo_de_Oportunidades_Sul_Amazonas.pdf>

production of knowledge about the dynamics of deforestation and the influence of agribusiness in it.

In the Bolsonaro's pre-election period in 2018, the country was already discussing the threat of political bargaining to climate mitigation and the forest conservation in general. In exchange of political support, the government offered landholders to increase deforestation, and the signature of provisionary acts and decrees lowering environmental licensing requirements, suspending the ratification of indigenous lands, reducing the size of protected areas and facilitating land grabbers to obtain the deeds of illegally deforested areas[105].

In the beginning of 2019, the fusion of Environment and Agriculture Ministries was a clear attempt to obtain more rights for the expansion of agriculture and livestock. The decision was cancelled a few days later, after pressure from environmentalists and others in the sector; however, major changes occurred in the ministerial office, limiting the reach and autonomy of the Environmental Ministry, with the absence of resources to combat deforestation[106.]

In addition, the transference of policies and instruments of water resources, including the National Water Agency (ANA) to the Ministry of Regional Development[107] and the Brazilian Forest Service and the Rural Environmental Registry (main instrument for controlling the regularization of large and small properties in forest regions) to the Ministry of Agriculture, Livestock and Supply[108] demonstrated the dismantling of the Environment Ministry. Furthermore, the officialization of indigenous lands, in addition to other land tenure issues, such as the agrarian reform and land regularization in the legal Amazon and traditional territories have also been transferred to the Ministry of Agriculture, Livestock and Supply[109].

As a consequence, the deforestation in the Amazon Rainforest was widely reported in 2019, as it was the third largest in history, with an increase of 29.5% in comparison to 2018. In total, 9,762 km^2 were deforested during that year[110]. In August, during the peak of fire warnings in the forest, fact that caused climate effects in São Paulo, 2,790 km away from the Amazon[111], the government tried to deviate attention from the fires, claiming they were fake news[112]. The number of fires in Brazilian forests increased 70%

[105] Available in < https://epoca.oglobo.globo.com/ciencia-e-meio-ambiente/blog-do-planeta/noticia/2017/09/o-desmanche-ambiental-do-governo-temer.html>
[106] Available in <https://www.socioambiental.org/pt-br/blog/blog-do-isa/a-anatomia-do-desmonte-das-politicas-socioambientais>
[107] Available in <https://oeco.org.br/reportagens/ana-muda-de-pasta-e-atribuicao-mas-incertezas-continuam/>
[108] Available in <https://oglobo.globo.com/brasil/bolsonaro-transfere-concessao-de-florestas-publicas-para-ministerio-da-agricultura-24427684>
[109] Available in <https://politica.estadao.com.br/noticias/geral,ministerio-da-agricultura-sera-responsavel-por-reforma-agraria-terras-indigenas-e-quilombos,70002663895>
[110] Available in <http://www.inpe.br/noticias/noticia.php?Cod_Noticia=5294>
[111] Available in <https://www.economist.com/the-americas/2019/08/22/forest-fires-in-the-amazon-blacken-the-sun-in-sao-paulo>
[112] Available in <https://www.theguardian.com/environment/2019/sep/09/amazon-fires-brazil-rainforest>

in 2019, the highest rate in 7 years. According to National Spatial Research Institute (INPE), the most affected biome was the Amazon, with 51.9%[113].

Also, during August, Germany and Norway announced the suspension of transfers to Amazon Programs after affirming that the Brazilian Government was not playing its part in fighting deforestation. The contribution to protecting the rainforest amounted to more than 133 million Brazilian reais, destined to the Amazon Fund[114].

Even though fire alerts increased in the period between 2019 and 2020, the Brazilian Government reduced the budget for forest fire prevention and control personnel. A reduction of 58% reached the brigade teams, with budget ranging from 23.78 million reais in 2019 to 9.99 million in 2020[115].

In June 2020, investment funds that manage approximately 4 trillion US dollars in assets asked Brazilian government to suspend the deforestation in the Amazon Rainforest. In an open letter, they warned of the systematic, reputational, operation and regulatory risks of clients and projects in Brazil, in addition to the survival of the forest[116].

Government agencies such as INPE and IBAMA, responsible for deforestation monitoring have suffered funding cutoffs, dismissals and had their functions and increasing deforestation data publicly questioned and denied by the government[117].

The quantity of national parks protected areas and indigenous lands in the country was already questioned by Bolsonaro, that intended to extinguish those by decree[118], an unconstitutional action, after announcing the intention to review the protected areas' law (SNUC) and the existing units[119]. In addition, the Minister of the Environment speaks publicly, in a video released during investigations, of his intention to take advantage of the Covid-19 pandemic to approve several controversial changes to environmental protection and avoid critics and justice processes[120].

There are also several threats to the national environmental license process, which has existed since 1981, including from the Minister of the Economy, who wants to loosen the

[113] Available in <https://noticias.uol.com.br/meio-ambiente/ultimas-noticias/redacao/2019/08/19/numero-de-queimadas-cresce-70-e-e-o-maior-desde-2013-amazonia-lidera.htm>

[114] Available in <https://brasil.elpais.com/brasil/2019/08/15/politica/1565898219_277747.html>

[115] Available in <https://g1.globo.com/natureza/noticia/2020/09/12/em-um-ano-governo-bolsonaro-corta-verba-para-brigadistas-em-58.ghtml>

[116] Available in <https://noticias.uol.com.br/ultimas-noticias/rfi/2020/06/23/fundos-de-investimentos-estrangeiros-cobram-de-bolsonaro-fim-do-desmatamento-da-amazonia.htm?cmpid=copiaecola>

[117] Available in <https://g1.globo.com/natureza/noticia/2019/08/02/cronologia-reacao-do-governo-ao-uso-de-dados-sobre-desmatamento-leva-a-exoneracao-de-diretor-do-inpe.ghtml>

[118] Available at <http://www.ihu.unisinos.br/78-noticias/589958-em-live-bolsonaro-reclama-que-nao-consegue-extinguir-parques-por-decreto>

[119] Available at <https://oeco.org.br/noticias/ricardo-salles-quer-rever-todas-as-unidades-de-conservacao-federais-do-pais-e-mudar-snuc/#:~:text=A%20lei%20do%20SNUC%20determina,extinguir%20uma%20unidade%20de%20conserva%C3%A7%C3%A3o>

[120] Available at <https://g1.globo.com/politica/noticia/2020/05/22/ministro-do-meio-ambiente-defende-passar-a-boiada-e-mudar-regramento-e-simplificar-normas.ghtml>

process to favour mining companies, even with the several recent cases of environmental crimes of breaches of poorly executed and maintained mining dams from companies in the country[121].

Specialists affirm that, with the current pace of dismantling of the inspection structure and environmental legislation demonstrated since the first 6 months of the current government, the forest destruction can reach an irreversible limit in 4 to 8 years. Recent scientific research shows that if an area of 40% of the original forest gets deforested, the rest cannot sustain the functioning of the tropical rainforest, and in this scenario, part of the forest may not be able to sustain itself. The Amazon has so far lost approximately 20% of its original coverage[122]

The development of REDD projects and a new culture of sustainable development and production, in addition to the profit from carbon credit sales, to encourage the maintenance of standing forest, goes against the non-environmental policy currently adopted by the country. Despite the National Commission for REDD+ being since 2015 established by decree, which is responsible for coordinating and monitoring the implementation of the National REDD+ Strategy in Brazil, it is noted that the main effort comes from landowners and project developers, since there is no guideline or effective planning from the government to amplify the development of new projects.

Although the Project is not able to change political and agricultural issues in Brazil, its position as a conservation agent will be used to try to reduce the inequalities that act as drivers of deforestation and expand forest monitoring actions, actions possible through the investment of proceeds from the sale of credits. More mitigation actions are detailed in the Monitoring Plan.

This key underlying cause has a major impact on deforestation decisions, as the main agents (cattle ranchers, operationally supported by loggers and land-grabbers) can easily recruit cheap manpower, consisting of workers seeking to sustain their families by means of this profitable activity, despite it being illegal, due to the inconsistency of law enforcement.

Over the coming years, it is not expected that the poverty issue will be rapidly solved, as it is historically deeply rooted. Given this context, poverty can be assumed to be a constant underlying cause during the project lifetime.

Although the Project Activity cannot solve the poverty issue, it aims to provide new jobs for local agents, who will be able to generate alternative revenue to support their families by means of legal and sustainable initiatives.

[121] Available at <https://brasil.elpais.com/brasil/2019/01/27/opinion/1548547908_087976.html>
[122] Available at <https://www.bbc.com/portuguese/brasil-48805675>

- **Analysis of chain of events leading to deforestation**

  The analysis of chain events leading to deforestation within the reference region was based on the facts presented above, analyzing the relations between main deforestation agents, drivers and underlying causes that caused and most likely will lead to deforestation.

  Based on the historical evidence collected, the relations between main agent groups, key drivers and underlying causes of deforestation explain the sequence of events that typically has lead and most likely will lead to deforestation within the reference region.

  The project region is located in the main Brazilian biome, a region of high vulnerability, deforestation risk and rate. Furthermore, it is a region of intense and traditional livestock activity, followed by a growing market. The historical deforestation that has been occurring over the past 15 years within the reference region has followed this same pattern.

  It is possible to relate the deforestation curve to the increase in livestock and wood production in the region, all of which are growing. Those two land-use changes (timber harvesting and cattle ranching) are the main deforestation agents in the region. The profit from both products is also considerably higher than the production of other common forest products in the region, such as Brazil nuts and *açaí*. Furthermore, deforestation will probably increase due to setbacks in environmental legislation and deforestation control occurred in 2016 onwards, namely reduction in control programs to reduce deforestation in the Amazon, reduction of protected areas and the amnesty to deforesters.

  The socioeconomic conditions of the population of the region, the fact that it is predominantly dominated by large properties landowners (with political and historical contributions that made the region an important livestock center), and the demographic growth implies the need for new infrastructure projects and the arrival of new habitants coming from other regions of the country, attracted by the favorable conditions of production in low-cost forested areas. This increases the pressure on the forests in the project area.

  The historic of polemics and anti-environmentalism of the last Brazilian governments, in addition to not tackling the direct causes, minimizing monitoring and restrictions in critical environmental areas and no investments in sustainable management and farming methods end up influencing and even motivating deforestation, illegal occupation and non-compliance with environmental laws. There is no strong environmental policy, and even with good advances, Brazilian laws have gaps that allows to be taken advantage of by landowners, or the inspection mechanisms suffer dismantling by the interest parties, making the conservation of the extensive Brazilian biomes even more difficult.

- **Conclusion**

  The conduction of this analysis and available evidence allows to analyze that the most likely future deforestation trend within the reference region and project area is conclusive.

  The hypothesized relationships between agent groups, driver variables, underlying causes and historical levels of deforestation can be verified at hand of statistical tests, literature studies, or other verifiable sources of information, such as documented information provided by local experts, communities, deforestation agents and other groups with good knowledge about the project area and the reference region.

  The increasing deforestation rate, added to the region's cattle ranching advancement, population increase and lack of effective governmental control and environmental planning are clear evidence that the overall trend in future baseline deforestation rates will be increasing, and this demonstrates the need for conservation measures that encourage a change in the business and production model in the region.

3.5 Additionality

The VCS Tool for the Demonstration and Assessment of Additionality in VCS Agricultural, Forestry and Other Land Use (AFOLU) Project Activities - VT0001 version 3.0[123] must be applied for all project activities instances.

On the additionality assessment, each instance shall determine the appropriate analysis method, whether to apply simple cost, investment comparison or benchmark analysis, according to STEP 2 of VCS VT001 v. 3.0.

Project instances must not be mandated by any law, statute, or other regulatory framework, or for UNFCCC non-Annex I countries, any systematically enforced law, statute, or other regulatory framework;.

Instances may or may not include Sustainable Forest Management Plan, as described on the Grouped Project Eligibility Criteria in Section 1.4.

In case the project activity does not involve Sustainable Forest Management Plan:

- The instance shall have financial, technical and scale consistent with the described in this PD, facing similar investments, technological and/or other barriers as the initial instance. As the VCS AFOLU project generates no financial or economic benefits other than VCS related income, the simple cost analysis (Option I) shall be applied.

In case the project activity includes a Sustainable Forest Management Plan:

[123] Available in <https://verra.org/wp-content/uploads/2017/11/VT0001v3.0.pdf>

- A new additionality and AFOLU non-permanence risk analyses shall be provided. In this case, the investment comparison analysis (Option II) or the benchmark analysis (Option III) of the Tool shall be used.

This tool is applicable for this project activity because the following conditions have been met:

a) AFOLU activities the same or similar to the proposed project activity on the land within the proposed project boundary performed with or without being registered as the VCS AFOLU project shall not lead to violation of any applicable law even if the law is not enforced;

b) The applied baseline methodology provides a stepwise approach to justify determination of the most plausible baseline scenario, in accordance to VCS AFOLU Requirements.

Other instances shall perform the additionality analysis at the time of their inclusion in the monitoring report.

STEP 1. Identification of alternative land use scenarios to the AFOLU project activity.

Sub-step 1a. Identify credible land use scenarios to the proposed VCS AFOLU project activity

Credible alternative land use scenarios to the present AFOLU project activity are:

Instance 1 (Rio Arataú and Rio Arataú I farms)

I. **The continuation of the current (pre-project) land use scenario**:

As there is no activity being held on Instance 1, the pre-project land use is the maintenance of the area as it is, without any activities and conservation measures, but still being accountable for the costs of taxes required to maintain the land tenure. Although no economic activities are carried out in the pre-project scenario, the area is exposed to invasions and illegal deforestation, precedents to cattle raising, a common practice in the region, for example, as detailed in section 3.4.

II. **Project activity on the land within the project boundary performed without being registered as the VCS AFOLU project:**

The application of the Project Activity could be carried out on the land within the project boundary, nevertheless performed without being registered as the VCS REDD project. This scenario would include avoiding deforestation through security and monitoring installation. Additionally, complementary activities to improve the monitoring of deforestation caused by the agents (identified in Section 3.4, above) would have to be carried out, such as: increased surveillance, monitoring and control by satellite images, REDD+ technical studies, social and environmental activities promoted by the SOCIALCARBON Standard, among others. These investments are usually not made by the Brazilian Government, as they are not mandatory. Therefore, the economic feasibility of this scenario would be reduced without additional revenues from the sale of VCUs.

Sub-step 1b. Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations.

Scenario I - The pre-project activity consists of no activities to be developed within the area, which is in compliance with the Brazilian environmental laws.

Scenario II - The conservation of the forest, monitoring and surveillance are in compliance with the Brazilian environmental laws.

Sub-step 1c. Selection of the baseline scenario

The baseline scenario is the continuation of the pre project activity. The area holds no activity in the baseline scenario. There are no economic activities implemented in the area or other land use activities.

Therefore, the difficulty in monitoring the area makes it exposed to encroachment and illegal deforestation, and activities such as cattle raising and wood extraction, without any control of the activities carried out within the area.

STEP 2. Investment Analysis

Sub-step 2a. Determine appropriate analysis method

Instance 1 generates no financial or economic benefits other than VCS related income, then it was applied the Simple Cost Analysis (Option I).

Sub-step 2b. Simple Cost Analysis

The simple cost analysis was determined as the appropriate analysis method once the Project does not generate any financial or economic benefits other than VCUs related income. There is no for-profit sale of any products, as the NTFPs has not yet been implemented and as there is no timber production in the area as well.

Table below provides an estimate of yearly expenses for the landowner, without considering the costs of the present REDD project:

Table 15. Estimated annual costs for the REDD Project[124]

Estimated Annual Costs of Conservation (R$/year)	
Surveillance and security of the area	R$ 180,000.00
Fuel and machinery maintenance	R$ 12,500.00
Proposed socio-environmental activities	R$ 87,500.00[125]
TOTAL	**R$ 280,000.00**

[124] Costs were estimated based on the quotes provided by the respective service providers, according to the available cashflow.
[125] The cost with socio-environmental activities was calculated based on other REDD projects, which have implemented similar measures.

According to the additionality tool applied: If it is concluded that the proposed VCS AFOLU project produces no financial benefits other than VCS related income then proceed to Step 4 (Common Practice Analysis).

STEP 4. Common practice analysis

Given that no financial benefits were found in the results of the Simple Cost Analysis, the following step according to the VCS additionality tool is the Common Practice Analysis.

The practice of conservation of privately-owned forest areas in the State of Pará as a whole is extremely rare. Conservation activities in larger areas are usually made in public areas, such as Conservation Units, Federal and State protected areas.

Although most of Brazil's agricultural output is deforestation-free, it is observed that a fraction of properties in the Amazon and Cerrado are responsible for 62% of all potentially illegal deforestation and that roughly 20% of soy exports and at least 17% of beef exports from both biomes to the EU may be contaminated with illegal deforestation[126]. As previously detailed, Pará is one of the main producers of cattle in the country, and this sector represents most of the State's GDP.

In addition to REDD projects, other forms of conservation of private areas are promoted in the country:

- **Private Reserve of Natural Heritage (RPPN)[127]:** it is a category of conservation unit created voluntarily by the landowner. When the area is categorized as RPPN, the owner is committed to nature conservation, without land expropriation. The benefits of the private reserve are preference in the analysis of applications to acquire rural credit, tax benefits and the possibility of cooperation with private and public entities in the protection and management of the land, but no revenue is generated as it is on REDD+ projects due to the sale of verified carbon units. In Pará, there are 6 registered RPPNs and none of them are located in the municipalities of the reference region[128].

  RPPN management tends to be much more affordable than REDD+ projects due to its costless implementation.

- **Payment for Environmental Services (PES)[129]:** PES is a transaction of voluntary nature, through which a buyer of environmental services grants the provider of these services with financial resources or other form of payment, under the agreed conditions, in compliance with the relevant legal and regulatory provisions, so the provider can maintain, restore or improve the environmental conditions of ecosystems. Regulation regarding this type of service in Brazil is at its early stages, as it has recently been

126 Available at <https://www.gov.br/icmbio/pt-br/servicos/crie-sua-reserva/perguntas-e-respostas-sobre-rppn>.
127 Available at <https://www.icmbio.gov.br/portal/images/stories/comunicacao/downloads/perguntaserespostasrppn.pdf>
128 Available at: <https://dados.mma.gov.br/>
129 Available at <http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/L14119.htm>

approved, on January 13, 2021, when Law n° 14.119 was sanctioned. The aforementioned law establishes the National Policy on Payment for Environmental Services and amends other laws to adapt to the new policy. However, the financial incentive is usually determined by the State, and it is commonly applied in taxes discounts, not representing an income to invest in other activities or in the maintenance of the area.

It is possible to note that, for the aforementioned reasons, the project does not characterize as a common practice due to the presented barriers, such as lack of investment and opportunity cost of other land uses. During the attempt to identify similar projects, the essential distinctions between REDD+ projects compared in terms of area, challenges, monitoring costs, among other aspects, greatly diverge from the alternative initiatives identified.

The significant difference between the present REDD+ project and similar conservation practices on the region, regarding financial and opportunity obstacles, makes it possible to conclude that the project is unable to support itself and its conservation activities without the revenues from the verified carbon units, as investment and capital costs for REDD+ projects are very high, which differ from other similar practices (RPPN and PES).

Besides, due to the context of the region, and the fact that the project is located in a reference area for both logging and cattle ranching of the State offer risks to the conservation of the Project Area.

Therefore, the present Instance depends on the revenue from the VCUs to support itself and hence, it is additional.

3.6 Methodology Deviations

This project activity does not apply any methodology deviations.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

PROJECTION OF FUTURE DEFORESTATION

As the Methodology stipulates, the aim of this step is to locate in space and time the baseline deforestation in the project area, reference region and leakage belt.

- <u>Selection of Baseline Approach</u>

According to the Section 3.4 – Baseline Scenario above, between 2011 and 2021, there was a deforestation of 141,950 ha within the Reference Region, with an average oscillation of approximately 12,905 ha/year and a low increasing trend (R^2 = 0.06).

Therefore, the Historical Average (Approach A from the applied methodology) was chosen as Baseline Approach, since deforestation rates measured in different historical sub-periods in the reference region reveal a low increasing trend and therefore, in order to be conservative, a constant historical average deforestation rate trend was utilized to project future deforestation.

The analysis of presented evidence related to deforestation agents and drivers, in addition to underlying causes, allows to conclude that the deforestation rate trend is likely to continue in the future.

- <u>Quantitative projection of future deforestation</u>

For the deforestation baseline, the average deforestation rate during the 2011-2021 period (2.37%/year).

- <u>Projection of the annual areas of baseline deforestation in the reference region, leakage belt and project area:</u>

Based on the selection of baseline approach, using the historical average approach, tables below show the results of the projection of the annual areas of baseline deforestation in reference region, leakage belt and project area.

Table 16. Annual areas of baseline deforestation in the reference region

Project year t	Stratum i in the reference region (ha)	Total (ha)	
	ABSLRR	annual $ABSLRR_t$	cumulative ABSLRR
2022	4,769.11	4,769.11	4,769.11
2023	8,862.33	8,862.33	13,631.44
2024	8,662.98	8,662.98	22,294.42
2025	8,468.12	8,468.12	30,762.54
2026	8,277.63	8,277.63	39,040.17
2027	8,091.43	8,091.43	47,131.61
2028	7,714.32	7,714.32	54,845.92
2029	7,167.82	7,167.82	62,013.74
2030	7,018.42	7,018.42	69,032.16
2031	6,872.14	6,872.14	75,904.30
2032	6,728.91	6,728.91	82,633.22
2033	6,588.66	6,588.66	89,221.88

2034	6,313.54	6,313.54	95,535.42
2035	5,875.52	5,875.52	101,410.94
2036	5,761.67	5,761.67	107,172.62
2037	5,650.03	5,650.03	112,822.65
2038	5,540.55	5,540.55	118,363.19
2039	5,433.18	5,433.18	123,796.38
2040	5,186.17	5,186.17	128,982.55
2041	4,833.94	4,833.94	133,816.49
2042	4,747.32	4,747.32	138,563.80
2043	4,662.25	4,662.25	143,226.06
2044	4,578.71	4,578.71	147,804.77
2045	4,496.67	4,496.67	152,301.43
2046	4,275.76	4,275.76	156,577.19
2047	3,991.50	3,991.50	160,568.69
2048	3,925.71	3,925.71	164,494.40
2049	3,861.01	3,861.01	168,355.41
2050	3,797.37	3,797.37	172,152.78
2051	3,734.78	3,734.78	175,887.57
2052	3,672.20	3,672.20	179,559.76

Table 17. Annual areas of baseline deforestation in the project area

Project year t	Stratum i in the project area (ha)	Total (ha)	
	ABSLPA	annual $ABSLPA_t$	cumulative ABSLPA
2022	290.27	290.27	290.27
2023	539.84	539.84	830.11
2024	528.12	528.12	1,358.22
2025	516.65	516.65	1,874.87
2026	505.43	505.43	2,380.31
2027	494.46	494.46	2,874.77
2028	470.45	470.45	3,345.21
2029	460.51	460.51	3,805.73
2030	450.79	450.79	4,256.52
2031	441.27	441.27	4,697.79
2032	431.96	431.96	5,129.75
2033	422.84	422.84	5,552.58
2034	401.67	401.67	5,954.26
2035	393.44	393.44	6,347.70
2036	385.38	385.38	6,733.08
2037	377.48	377.48	7,110.56

2038	369.75	369.75	7,480.31
2039	362.17	362.17	7,842.49
2040	343.49	343.49	8,185.97
2041	336.67	336.67	8,522.64
2042	329.99	329.99	8,852.64
2043	323.45	323.45	9,176.08
2044	317.03	317.03	9,493.11
2045	310.74	310.74	9,803.85
2046	294.20	294.20	10,098.05
2047	288.57	288.57	10,386.62
2048	283.04	283.04	10,669.66
2049	277.61	277.61	10,947.27
2050	272.29	272.29	11,219.56
2051	267.07	267.07	11,486.64
2052	261.86	261.86	11,748.49

Table 18. Annual areas of baseline deforestation in the leakage belt

Project year t	Stratum i in the leakage belt (ha)	Total (ha)	
	ABSLLK	annual $ABSLLK_t$	cumulative ABSLLK
2022	423.61	423.61	423.61
2023	787.18	787.18	1,210.78
2024	769.47	769.47	1,980.25
2025	752.16	752.16	2,732.41
2026	735.24	735.24	3,467.65
2027	718.70	718.70	4,186.36
2028	685.21	685.21	4,871.56
2029	670.17	670.17	5,541.74
2030	655.47	655.47	6,197.21
2031	641.09	641.09	6,838.30
2032	627.02	627.02	7,465.32
2033	613.27	613.27	8,078.59
2034	583.84	583.84	8,662.43
2035	571.37	571.37	9,233.79
2036	559.17	559.17	9,792.96
2037	547.23	547.23	10,340.19
2038	535.54	535.54	10,875.72
2039	524.10	524.10	11,399.83
2040	498.19	498.19	11,898.01
2041	487.85	487.85	12,385.86
2042	477.73	477.73	12,863.60
2043	467.82	467.82	13,331.42
2044	458.12	458.12	13,789.54
2045	448.62	448.62	14,238.16

2046	425.75	425.75	14,663.91
2047	417.19	417.19	15,081.10
2048	408.81	408.81	15,489.91
2049	400.59	400.59	15,890.50
2050	392.54	392.54	16,283.03
2051	384.65	384.65	16,667.68
2052	376.75	376.75	17,044.43

- Projection of the location of future deforestation

The projection of the future deforestation within the reference region followed four steps:

(i) Definition of the model assumptions, which consists of defining the modelled deforestation;

(ii) Organization of the spatial and non-spatial database that represents the selection and standardization of the variables used;

(iii) Calibration and validation of the model, which consist of the combination of variables and evaluation of the adjustments of the models; and

(iv) Development of scenarios, which is the creation of future scenarios using historical trends through the Business-as-usual scenario.

- Assigning weightings to change agents

The predictive variables considered to have the potential to influence the risk of deforestation in the region are the proximity to roads, proximity to cities, slope, altitude, proximity to settlements and proximity rivers.

Deforestation risk maps show regions with the highest (risk = 1) or lowest (risk = 0) conditions for deforestation to occur. The risk map was created using Dinamica EGO Software[130], which modeling techniques are used for calibrating, running and validating space-time models.

Dinamica EGO is an environmental platform for land use change modeling. Dinamica EGO allows the design of a model by simply dragging and connecting operators that perform calculations upon various types of data, such as constants, matrices, tables and raster maps. In this way, it is possible to set up a model by establishing a sequence of operators involving an ample range of analytical and simulation algorithms.

In addition, Dinamica EGO holds multiple transitions that can be calibrated employing the Weights of Evidence. This method calculates the influence of spatial determinants on the changes, producing as a result an integrated transition potential map, also known as the transition probability map.

[130] Dinamica Ego Software. Available at: https://csr.ufmg.br/dinamica/ .

The weights of evidence are calculated in Dinamica EGO based on the predictor variables and also on the deforestation maps. The weights of evidence are defined by a Bayesian method, which considers the joint probability of deforestation a posteriori within each class of all explanatory variables. These values represent how much each of the different ranges that compose each predictor variable is related to deforestation. Positive values indicate a correlation with deforestation and negative values indicate ranges that have suffered little deforestation in the past and, therefore, should be less likely to be deforested in the future. Higher values, whether positive or negative, indicate greater weight to positively or negatively influence the calculation of the probability of deforestation in an area.

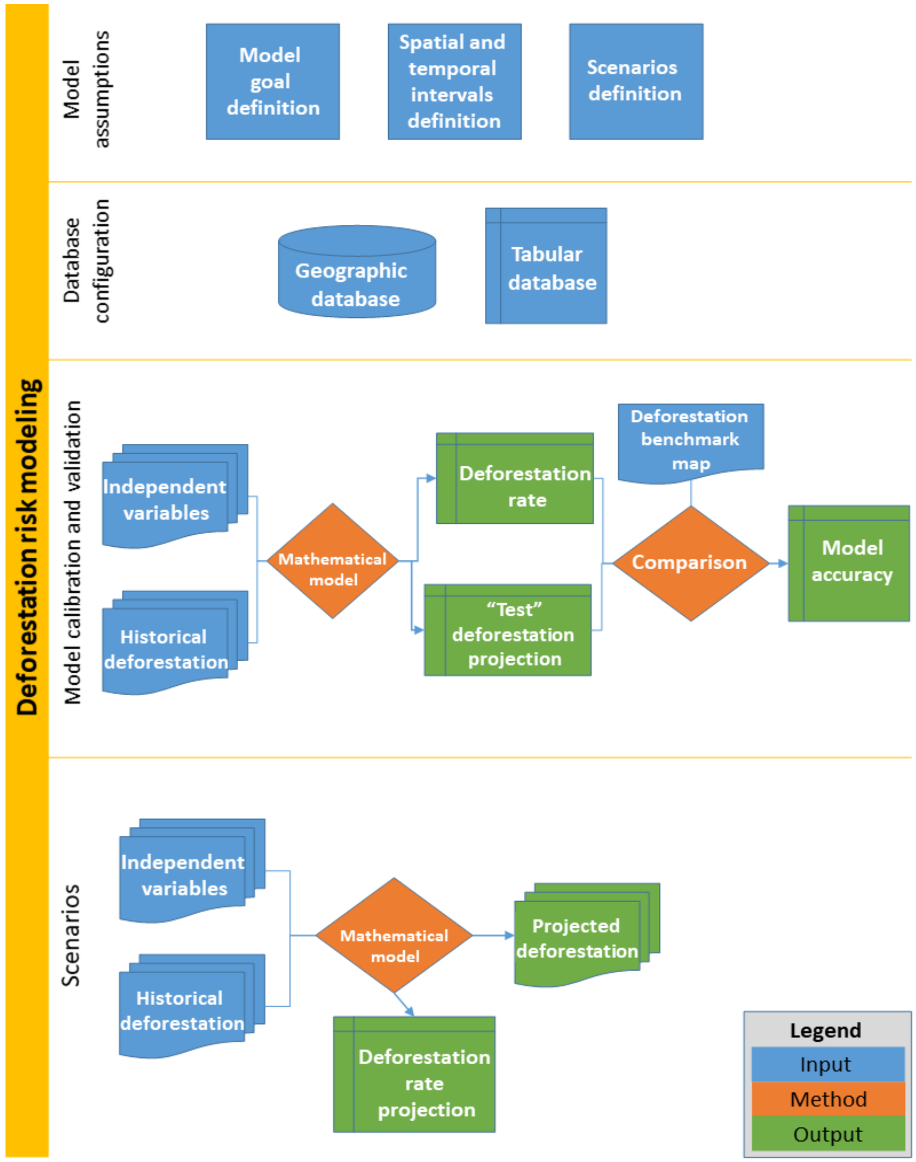
Based on the weights of the evidence, the transition probability of each forest pixel to become other types of anthropic use is calculated. This probability is calculated based on the sum of all the weights of evidence that overlap on a given pixel and are dependent on the combinations of all static and dynamic maps[131].

The result of the application of Dinamica EGO is a transition potential map that identifies areas that present favorable conditions for deforestation to occur in areas classified as forest. This map is the starting point for spatialization of future areas of deforestation, from which annual rates are allocated in conjunction with dynamic variables.

The flowchart below illustrates the modelling steps, showing how the risk map was generated and how the projection of future deforestation was carried out.

[131] Soares-Filho, B., Nepstad, D., Curran, L. et al. Modelling conservation in the Amazon basin. Nature 440, 520–523 (2006). <https://doi.org/10.1038/nature04389>

Figure 21. Modelling steps focusing on the creation of the deforestation risk map and the projection of future deforestation



The spatial variables that most likely represent the patterns of baseline deforestation in the reference region were identified, and the digital maps representing the spatial features of each variable were created. The list of variables, maps and factor maps is presented below.

Table 19. List of variables, maps and factor maps

Factor Map		Source	Variable represented		Meaning of categories or pixel value		Other maps or variables used to create the Factor Map		Algorithm or equation used	Comments
ID	File Name		Unit	Description	Range	Meaning	ID	File Name		
1	d_estradas_edited_v2.tif	IBGE/ Imazon	Meter	Distance from paved and unpaved roads	0-15,017.7	Lower values mean more proximity		Merge_IBGE_Imazon_edited_v2	Euclidean Distance (ArcGis 10.6)	Quantitative variable
2	UCs.tif	MMA		Sustainable Use Protected Areas						Categoric variable
3	Tis.tif	FUNAI		Indigenous lands						Categoric variable
4	Assentamentos.tif	INCRA		Rural Settlements						Categoric variable
5	d_rios_g.tif	ANA	Meter	Distance from water bodies	0 – 33,354	Lower values mean more proximity		RiosGrandes_ANA	Euclidean Distance (ArcGis10.6)	Quantitative variable
6	d_rios_mbiomas.tif	MapBiomas	Meter	Distance from water bodies	0-17,197.6	Lower values mean more proximity		Rios_MapBiomas	Euclidean Distance (ArcGis10.6)	Quantitative variable
7	d_rios.tif	ANA	Meter	Distance from rivers	0-11,370.4	Lower values mean more proximity		Rios_ANA	Euclidean Distance (ArcGis10.6)	Quantitative variable
8	d_urbana.tif	IBGE	Meter	Distance from urban centers	10,441.6-101,033	Lower values mean more proximity		AreasUrbanas_IBGE	Euclidean Distance (ArcGis10.6)	Quantitative variable
9	dem.tif	SRTM	Meter	Average altitude variation	0-139	Lower values mean lower altitude				Quantitative variable
10	slope_perc.tif	SRTM	Degrees	Average slope variation	0-97.1825	Lower values mean lower slope			Slope (ArcGis 10.6)	Quantitative variable

The variables and deforestation patterns presented in the Table above were analyzed together to produce the risk map. Factor maps were created using the empirical approach, in which the deforestation likelihood was estimated as the percentage of pixels that were deforested during the period of analysis. Tables below describe the rule used to build classes and the deforestation likelihood assigned to each distance class.

Table 20. Variation of the weights of evidence according to deforestation distance ranges

Deforestation distance ranges		Weight of evidence
0	100	1.97
100	200	1.05
200	300	0.63
300	400	0.32
400	500	0.08
500	600	-0.10
600	800	-0.29
800	1000	-0.41
1000	1200	-0.49
1200	1400	-0.60
1400	1600	-0.69
1600	1900	-0.77
1900	2200	-0.92
2200	2500	-1.03
2500	2900	-1.02
2900	3400	-0.91
3400	3700	-0.69
3700	3900	-0.50
3900	4100	-0.27
4100	4700	-0.08
4700	5900	-0.26
5900	6600	-0.46
6600	6700	-2.80
6700	9100	-5.26

Table 21. Variation of the weights of evidence according to the distance from roads

Distance from roads		Weight of evidence	Distance from roads		Weight of evidence
0	100	1.53	4800	5500	-0.59
100	200	1.10	5500	5600	-0.40
200	300	0.81	5600	6500	-0.37
300	500	0.59	6500	7800	-0.36
500	700	0.32	7800	7900	-0.59
700	1000	0.14	7900	8100	-0.91
1000	1300	0.00	8100	8200	-1.32
1300	1600	-0.13	8200	12300	-1.04
1600	1900	-0.18	12300	12400	0.05
1900	2200	-0.15	12400	12900	-0.14
2200	2600	-0.28	12900	13000	-0.63
2600	3000	-0.42	13000	13300	-0.91
3000	3100	-0.68	13300	13600	-1.31
3100	3600	-0.64	13600	14500	-1.75
3600	4200	-0.60	14500	14600	0.00
4200	4800	-0.76	14600	15100	0.00

Table 22. Variation of the weights of evidence according to the distance from rivers

Distance from rivers		Weight of evidence
0	100	0.25
100	300	0.47
300	600	0.58
600	900	0.36
900	1200	0.17
1200	1400	-0.01
1400	1700	-0.16
1700	2000	-0.24

2000	2300	-0.23
2300	2600	-0.23
2600	3000	-0.26
3000	3400	-0.29
3400	3800	-0.31
3800	4100	-0.13
4100	4600	0.00
4600	5200	0.09
5200	5800	-0.05
5800	5900	-0.26
5900	6400	-0.07
6400	6700	0.11
6700	7900	-0.06
7900	8000	-0.45
8000	8800	-0.23
8800	8900	0.11
8900	10300	-0.10
10300	10400	-5.29
10400	11400	-5.36

Table 23. Variation of the weights of evidence according to slope

Slope		Weight of evidence
0	2	-0.19
2	3	-0.18
3	4	-0.16
4	5	-0.13
5	6	-0.06
6	7	-0.01

7	8	0.07
8	10	0.17
10	13	0.36
13	22	0.57
22	98	0.67
12	13	-0.21
13	15	-0.22
15	18	-0.19
18	55	-0.35

Table 24. Variation of the weights of evidence according to altitude

Altitude		Weight of evidence	Altitude		Weight of evidence
0	2	0.88	40	41	-0.25
2	3	-1.76	41	43	-0.43
3	4	-1.22	43	44	-0.65
4	6	-0.95	44	45	-0.93
6	8	-0.46	45	47	-1.19
8	10	0.01	47	50	-1.50
10	11	0.20	50	54	-1.51
11	12	0.48	54	59	-1.25
12	13	0.91	59	60	-0.93
13	15	0.64	60	66	-0.81
15	16	0.95	66	68	-0.51
16	19	0.58	68	74	-0.42
19	26	0.69	74	79	-0.24
26	27	1.06	79	85	0.56
27	28	0.75	86	92	0.35
28	30	0.47	93	100	0.49
30	33	0.45	101	115	0.72

33	35	0.16	116	135	1.07
35	37	-0.05	136	155	1.47
37	38	-0.22	156	175	1.98
38	40	-0.04	176	200	1.45

Table 25. Variation of the weights of evidence according to Protected Areas categories

Protected areas	Weight of evidence
Outside protected areas	0.65
Protected Areas within the Sustainable Use Category	-0.16

Table 26. Variation of the weights of evidence according to the presence of settlements

Settlements	Weight of evidence
Outside settlements	-0.28
Within settlements	1.53

Table 27. Variation of the weights of evidence according to distance from urban areas

Distance from urban areas		Weight of evidence	Distance from urban areas		Weight of evidence
0	11000	1.00	48500	49500	-0.17
11000	13000	1.50	49500	50000	-0.42
13000	13500	2.08	50000	53000	-0.44
13500	17500	1.44	53000	54500	-0.65
17500	18000	0.89	54500	55000	-1.04
18000	18500	0.46	55000	55500	-0.74
18500	19000	0.69	55500	56500	-1.00
19000	19500	0.05	56500	57000	-1.35
19500	21000	0.18	57000	57500	-0.90

21000	21500	0.68
21500	22000	1.03
22000	22500	0.77
22500	23000	0.55
23000	23500	0.22
23500	24000	0.37
24000	26000	0.15
26000	28500	-0.03
28500	29000	-0.31
29000	29500	-0.68
29500	30000	-0.90
30000	31500	-0.74
31500	32000	-0.08
32000	32500	0.11
32500	33000	0.33
33000	33500	0.14
33500	36500	0.32
36500	41000	0.22
41000	45000	0.19
45000	48500	0.03

57500	60500	-0.82
60500	61000	-0.53
61000	63500	-0.46
63500	64000	-0.68
64000	65000	-0.94
65000	68000	-0.86
68000	68500	-0.39
68500	71500	-0.22
71500	75000	-0.11
75000	78500	-0.21
78500	79000	-0.01
79000	81500	0.23
81500	82000	0.72
82000	85000	0.48
85000	85500	-0.23
85500	86500	-0.02
86500	87500	0.27
87500	88000	0.70
88000	92500	0.83
92500	101500	0.73

- Selection of most accurate deforestation risk map

As previously noted, the historical average approach was chosen to project the quantity of future deforestation, given the tendency to increase over time. In addition, to validate which are the best models to allocate where the deforestation happens, the calibration and confirmation methodology was applied, dividing the deforestation period in two.

For that, simulations of the deforestation projection were made, taking three dates as reference: 2011, 2015 and 2021. The period of 2011-2015 was used to generate the correlations between the deforested areas and the predictor variables, calculating the adjustment parameters of the models. After that a projection from 2016 to 2021 was made, developing a reference region scenario for this date. Therefore, the deforestation map for the period of 2016 to 2021 and two 2021 scenarios, real and projected, were developed. These scenarios were compared regarding the degree of similarity considering the exponential decay. The higher the similarity, the better the prediction of the model. This index ranges from 0 (no overlapping) to 1 (completely overlapped), and the closer to 1, the more similar is the simulated scenario in relation to the real. Two values are calculated for the indices, the comparison of the simulated map in relation to the real deforestation map and, the opposite, the real map in relation to the simulated map. Thus, to define the most accurate map, the average of these two values was used.

Table 28. Best deforestation projection models from 2016 to 2021. Each line corresponds to a model and was evaluated by the degree of Similarity.

Model	Similarity 1	Similarity 2	Average	Distance from deforestation	Protected Areas	Settlement	Distance from rivers	Distance from roads	Distance from urban areas	Slope	Altitude
m00	0.154	0.203	0.179	1	1	1	1	1	1	1	1
m01	0.254	0.261	0.258	0	1	1	1	1	1	1	1
m02	0.196	0.205	0.201	1	0	1	1	1	1	1	1
m03	0.311	0.325	0.318	1	1	0	1	1	1	1	1
m04	0.485	0.501	0.493	1	1	1	0	1	1	1	1
m05	0.425	0.469	0.447	1	1	1	1	0	1	1	1
m06	0.399	0.427	0.413	1	1	1	1	1	0	1	1
m07	0.374	0.396	0.385	1	1	1	1	1	1	0	1
m08	0.288	0.317	0.303	1	1	1	1	1	1	1	0
m09	0.329	0.364	0.347	1	0	0	0	1	1	0	0
m10	0.273	0.298	0.286	1	1	1	0	1	1	0	1
m11	0.335	0.362	0.349	1	1	0	1	1	1	0	1
m12	0.319	0.344	0.331	1	0	1	1	0	0	1	1

The first tested model was the one with all the predictor variables of deforestation (m00); next, the models were tested by removing each factor separately and measuring the degree of correctness of the model (m01 to m08). Therefore, the most important variables were those in which their absence caused a greater drop in the degree of similarity between the real and projected deforestation maps.

Next, the inverse combinations were made, that is, the models were analyzed only with the deforestation proximity variable (dynamic variable) and the static variables with the greatest impact on the degree of similarity, adding one by one in order of impact. Through this procedure it is possible to guarantee that all the best models could be assessed. During this second round of analysis, only the dynamic variable “Proximity to Deforestation” was used in all models, as there is evidence that proximity to deforested areas is one of the most important variables to predict deforestation.

The best model was m04, with an average similarity of 0.493. This model applies seven variables: distance from deforestation, distance from protected areas, distance from settlements, distance from roads, distance from urban areas, slope and altitude. Thus, it was selected to project the future deforestation.

In addition, the AUC (Area Under the Curve), which is the area under the ROC curve (Receiver Operating Characteristic) was calculated. This represents the accuracy of the probability maps, that is, it shows whether the actual deforestation is indicated with the deforestation probabilities by the models (deforestation risk map). Regarding the AUC values, the best model presented a value of 0.78[132].

- <u>Definition of Land-Use and Land-Cover Change Component of the Baseline</u>

Now that the area and location of future deforestation are both known, pre-deforestation carbon stocks can be determined by matching the predicted location of deforestation with the location of forest classes with known carbon stocks. The goal of this step is to calculate activity data of the initial forest classes (icl) that will be deforested and activity data of the post-deforestation classes (fcl) that will replace them in the baseline case.

In accordance with analysis achieved through the procedure described above, the quantity of baseline LU/LC-change was projected throughout the crediting period, in the reference region, project area and leakage belt in each stratum. This is in accordance with step 5 of the methodology "Definition of the land-use and land-cover change component of the baseline".

- <u>Calculation of baseline activity data per forest class</u>

The following is in accordance with step 5.1 Calculation of baseline activity data per forest class", in which is stipulated that the previously created maps of annual baseline deforestation and LU/LC map can be combined, producing a map showing deforestation per class in the baseline case.

The LU/LC-change within the project crediting period, caused by baseline deforestation consisted of initial forest classes being converted to the final LU/LC class of 'non-forest'.

[132] According to KHATAMI, Reza; MOUNTRAKIS, Giorgos; STEHMAN, Stephen V. **Mapping per-pixel predicted accuracy of classified remote sensing images.** Remote Sensing of Environment, v. 191, p. 156-167, 2017., models that present values over 0.5 may be used.

Table 29. Annual areas deforested per forest class icl within the reference region in the baseline case (baseline activity data per forest class)

Area deforested per forest class *icl* within the reference region		Total baseline deforestation in the reference region	
IDicl	1	annual ABSLRRt (ha)	ABSLRR cumulative (ha)
Name	Forest		
Project year *t*	ha		
2022	4,769.11	4,769.11	4,769.11
2023	8,862.33	8,862.33	13,631.44
2024	8,662.98	8,662.98	22,294.42
2025	8,468.12	8,468.12	30,762.54
2026	8,277.63	8,277.63	39,040.17
2027	8,091.43	8,091.43	47,131.61
2028	7,714.32	7,714.32	54,845.92
2029	7,167.82	7,167.82	62,013.74
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2033	6,588.66	6,588.66	89,221.88
2034	6,313.54	6,313.54	95,535.42
2035	5,875.52	5,875.52	101,410.94
2036	5,761.67	5,761.67	107,172.62
2037	5,650.03	5,650.03	112,822.65
2038	5,540.55	5,540.55	118,363.19
2039	5,433.18	5,433.18	123,796.38
2040	5,186.17	5,186.17	128,982.55
2041	4,833.94	4,833.94	133,816.49
2042	4,747.32	4,747.32	138,563.80
2043	4,662.25	4,662.25	143,226.06
2044	4,578.71	4,578.71	147,804.77
2045	4,496.67	4,496.67	152,301.43
2046	4,275.76	4,275.76	156,577.19
2047	3,991.50	3,991.50	160,568.69
2048	3,925.71	3,925.71	164,494.40
2049	3,861.01	3,861.01	168,355.41
2050	3,797.37	3,797.37	172,152.78
2051	3,734.78	3,734.78	175,887.57
2052	3,672.20	3,672.20	179,559.76

Table 30. Annual areas deforested per forest class icl within the project area in the baseline case (baseline activity data per forest class)

Area deforested per forest class icl within the project area		Total baseline deforestation in the project area	
IDicl	1	annual ABSLPAt (ha)	ABSLPA cumulative (ha)
Name	Forest		
Project year *t*	ha		
2022	290.27	290.27	290.27
2023	539.84	539.84	830.11
2024	528.12	528.12	1,358.22
2025	516.65	516.65	1,874.87
2026	505.43	505.43	2,380.31
2027	494.46	494.46	2,874.77
2028	470.45	470.45	3,345.21
2029	460.51	460.51	3,805.73
2030	450.79	450.79	4,256.52
2031	441.27	441.27	4,697.79
2032	431.96	431.96	5,129.75
2033	422.84	422.84	5,552.58
2034	401.67	401.67	5,954.26
2035	393.44	393.44	6,347.70
2036	385.38	385.38	6,733.08
2037	377.48	377.48	7,110.56
2038	369.75	369.75	7,480.31
2039	362.17	362.17	7,842.49
2040	343.49	343.49	8,185.97
2041	336.67	336.67	8,522.64
2042	329.99	329.99	8,852.64
2043	323.45	323.45	9,176.08
2044	317.03	317.03	9,493.11
2045	310.74	310.74	9,803.85
2046	294.20	294.20	10,098.05
2047	288.57	288.57	10,386.62
2048	283.04	283.04	10,669.66
2049	277.61	277.61	10,947.27
2050	272.29	272.29	11,219.56
2051	267.07	267.07	11,486.64
2052	261.86	261.86	11,748.49

Table 31. Annual areas deforested per forest class icl within the leakage belt in the baseline case (baseline activity data per forest class)

Area deforested per florest class icl within the leakage belt		Total baseline deforestation in the leakage belt	
IDicl	1	annual ABSLLKt (ha)	ABSLLK cumulative (ha)
Name	Forest		
Project year *t*	ha		
2022	423.61	423.61	423.61
2023	787.18	787.18	1,210.78
2024	769.47	769.47	1,980.25
2025	752.16	752.16	2,732.41
2026	735.24	735.24	3,467.65
2027	718.70	718.70	4,186.36
2028	685.21	685.21	4,871.56
2029	670.17	670.17	5,541.74
2030	655.47	655.47	6,197.21
2031	641.09	641.09	6,838.30
2032	627.02	627.02	7,465.32
2033	613.27	613.27	8,078.59
2034	583.84	583.84	8,662.43
2035	571.37	571.37	9,233.79
2036	559.17	559.17	9,792.96
2037	547.23	547.23	10,340.19
2038	535.54	535.54	10,875.72
2039	524.10	524.10	11,399.83
2040	498.19	498.19	11,898.01
2041	487.85	487.85	12,385.86
2042	477.73	477.73	12,863.60
2043	467.82	467.82	13,331.42
2044	458.12	458.12	13,789.54
2045	448.62	448.62	14,238.16
2046	425.75	425.75	14,663.91
2047	417.19	417.19	15,081.10
2048	408.81	408.81	15,489.91
2049	400.59	400.59	15,890.50
2050	392.54	392.54	16,283.03
2051	384.65	384.65	16,667.68
2052	376.75	376.75	17,044.43

- <u>Calculation of baseline activity data per post deforestation forest class</u>

The following is in accordance with step 5.2 of the methodology: "Calculation of baseline activity data per post-deforestation forest class". As all of the initial classes represented in the tables above were transformed into non-forest (final post-deforestation class) in the considered baseline, the annual values corresponding to the final classes are the same as those of the initial classes.

According to the methodology VM0015, the Historical LU/LC-change (Method 1) was used to calculate the LU/LC class that will replace the forest cover in the baseline scenario. The table below shows the area of Zone 1 that encompasses areas of possible post-deforestation LU/LC-class within the reference region.

Table 32. Zone of the Reference Region encompassing potential post deforestation LU/LC class

Zone		Name		Total area of each zone	
		Non-forest			
		ID_{fcl}	1		
		Area	% of zone	Area	% of zone
IDz	Name	ha	%	ha	%
1	Reference region	179,559.76	26%	179,559.76	26%
Total area of each class *fcl*		179,559.76	26%	179,559.76	26%

Tables below depict the annual areas deforested in each zone in the baseline case within the reference region, project area and leakage belt, respectively.

Table 33. Annual areas deforested in each zone within the Reference Region in the baseline case (baseline activity data per zone)

Area established after deforestation per zone within the reference region		Total baseline deforestation in the reference region	
ID_{fcl}	1	$ABSLRR_t$	$ABSLRR$
Name	Non forest	annual	cumulative
Project year	ha	ha	ha
2022	4,769.11	4,769.11	4,769.11
2023	8,862.33	8,862.33	13,631.44
2024	8,662.98	8,662.98	22,294.42
2025	8,468.12	8,468.12	30,762.54
2026	8,277.63	8,277.63	39,040.17
2027	8,091.43	8,091.43	47,131.61
2028	7,714.32	7,714.32	54,845.92
2029	7,167.82	7,167.82	62,013.74
2030	7,018.42	7,018.42	69,032.16
2031	6,872.14	6,872.14	75,904.30
2032	6,728.91	6,728.91	82,633.22
2033	6,588.66	6,588.66	89,221.88
2034	6,313.54	6,313.54	95,535.42
2035	5,875.52	5,875.52	101,410.94
2036	5,761.67	5,761.67	107,172.62
2037	5,650.03	5,650.03	112,822.65
2038	5,540.55	5,540.55	118,363.19
2039	5,433.18	5,433.18	123,796.38
2040	5,186.17	5,186.17	128,982.55
2041	4,833.94	4,833.94	133,816.49
2042	4,747.32	4,747.32	138,563.80
2043	4,662.25	4,662.25	143,226.06
2044	4,578.71	4,578.71	147,804.77
2045	4,496.67	4,496.67	152,301.43
2046	4,275.76	4,275.76	156,577.19
2047	3,991.50	3,991.50	160,568.69
2048	3,925.71	3,925.71	164,494.40
2049	3,861.01	3,861.01	168,355.41
2050	3,797.37	3,797.37	172,152.78
2051	3,734.78	3,734.78	175,887.57
2052	3,672.20	3,672.20	179,559.76

Table 34. Annual areas deforested in each zone within the Project Area in the baseline case (baseline activity data per zone)

Area established after deforestation per zone within the project area		Total baseline deforestation in the project area	
ID_{fcl}	1	*$ABSLPA_t$*	*ABSLPA*
Name	Non forest	annual	cumulative
Project year	ha	ha	ha
2022	290.27	290.27	290.27
2023	539.84	539.84	830.11
2024	528.12	528.12	1,358.22
2025	516.65	516.65	1,874.87
2026	505.43	505.43	2,380.31
2027	494.46	494.46	2,874.77
2028	470.45	470.45	3,345.21
2029	460.51	460.51	3,805.73
2030	450.79	450.79	4,256.52
2031	441.27	441.27	4,697.79
2032	431.96	431.96	5,129.75
2033	422.84	422.84	5,552.58
2034	401.67	401.67	5,954.26
2035	393.44	393.44	6,347.70
2036	385.38	385.38	6,733.08
2037	377.48	377.48	7,110.56
2038	369.75	369.75	7,480.31
2039	362.17	362.17	7,842.49
2040	343.49	343.49	8,185.97
2041	336.67	336.67	8,522.64
2042	329.99	329.99	8,852.64
2043	323.45	323.45	9,176.08
2044	317.03	317.03	9,493.11
2045	310.74	310.74	9,803.85
2046	294.20	294.20	10,098.05
2047	288.57	288.57	10,386.62
2048	283.04	283.04	10,669.66
2049	277.61	277.61	10,947.27
2050	272.29	272.29	11,219.56
2051	267.07	267.07	11,486.64
2052	261.86	261.86	11,748.49

Table 35. Annual areas deforested in each zone within the Leakage Belt in the baseline case (baseline activity data per zone)

Area established after deforestation per zone within the leakage belt		Total baseline deforestation in the leakage belt	
ID_{fcl}	1	$ABSLLK_t$	$ABSLLK$
Name	Non forest	annual	cumulative
Project year	ha	ha	ha
2022	423.61	423.61	423.61
2023	787.18	787.18	1,210.78
2024	769.47	769.47	1,980.25
2025	752.16	752.16	2,732.41
2026	735.24	735.24	3,467.65
2027	718.70	718.70	4,186.36
2028	685.21	685.21	4,871.56
2029	670.17	670.17	5,541.74
2030	655.47	655.47	6,197.21
2031	641.09	641.09	6,838.30
2032	627.02	627.02	7,465.32
2033	613.27	613.27	8,078.59
2034	583.84	583.84	8,662.43
2035	571.37	571.37	9,233.79
2036	559.17	559.17	9,792.96
2037	547.23	547.23	10,340.19
2038	535.54	535.54	10,875.72
2039	524.10	524.10	11,399.83
2040	498.19	498.19	11,898.01
2041	487.85	487.85	12,385.86
2042	477.73	477.73	12,863.60
2043	467.82	467.82	13,331.42
2044	458.12	458.12	13,789.54
2045	448.62	448.62	14,238.16
2046	425.75	425.75	14,663.91
2047	417.19	417.19	15,081.10
2048	408.81	408.81	15,489.91
2049	400.59	400.59	15,890.50
2050	392.54	392.54	16,283.03
2051	384.65	384.65	16,667.68
2052	376.75	376.75	17,044.43

CALCULATION OF BASELINE EMISSIONS

The total average biomass stock per hectare (Mg ha^{-1}) was converted to tCO_2e using the following equations:

$$Cab_{icl} = ab \times CF \times 44/12$$

Where,

Cabicl	Average carbon stock per hectare in the above-ground biomass carbon pool of initial forest class icl; tCO2e ha^{-1}
ab	Average biomass stock per hectare in the above-ground biomass pool of initial forest class icl; Mg ha^{-1}
CF	Default value of carbon fraction in biomass
44/12	Ratio converting C to CO2e

$$Cbb_{icl} = bb \times CF \times 44/12$$

Where,

Cbbicl	Average carbon stock per hectare in the below-ground biomass carbon pool of initial forest class icl; tCO2e ha^{-1}
bb	Average biomass stock per hectare in the below-ground biomass pool of initial forest class icl; Mg ha^{-1}
CF	Default value of carbon fraction in biomass
44/12	Ratio converting C to CO2e

The total baseline carbon stock change in the project area at year t is calculated as follows:

$$\Delta CBSLPA_t = \Delta CabBSLPA_{icl,t} + \Delta CbbBSLPA_{icl,t}$$

Where,

ΔCBSLPAt	Total baseline carbon stock changes in the project area at year t; tCO2e
ΔCabBSLPAicl,t	Total baseline carbon stock change for the above-ground biomass pool in the project area for initial forest class at year t; tCO2e
ΔCbbBSLPAicl,t	Total baseline carbon stock change for the below-ground biomass pool in the project area for initial forest class at year t; tCO2e

$$\Delta CabBSLPA_{icl,t} = ABSLPA_{icl,t} * \Delta Cab_{icl}$$

Where,

ΔCabBSLPAicl,t	Total baseline carbon stock change for the above-ground biomass pool in the project area for initial forest class at year t; tCO2e
ABSLPAicl,t	Area of initial forest class icl deforested at time t within the project area in the baseline case; ha
ΔCabicl	Average carbon stock change factor per hectare in the above-ground biomass carbon pool of initial forest class icl; tCO2e ha^{-1}

$$\Delta CbbBSLPA_{icl,t} = ABSLPA_{icl,t} * \Delta Cbb_{icl}$$

Where,

ΔCbbBSLPAicl,t	Total baseline carbon stock change for the below-ground biomass pool in the project area for initial forest class at year t; tCO2e
ABSLPAicl,t	Area of initial forest class icl deforested at time t within the project area in the baseline case; ha
ΔCbbicl	Average carbon stock change factor per hectare in the below-ground biomass carbon pool of category icl; tCO2e ha^{-1}

Estimation of the average carbon stocks of each LU/LC class

According to the applied methodology, average carbon stocks must be estimated for the forest classes existing within the project area. This information must be collected from existing carbon stock data for these classes from local published studies and existing forest and carbon inventories, according to the following criteria:

- The data are less than 10 years old;
- The data are derived from multiple measurement plots;
- All species above a minimum diameter are included in the inventories;
- The minimum diameter for trees included is 30 cm or less at breast height (DBH);
- Data are sampled from good coverage of the classes over which they will be extrapolated.

As previously described, Dense Lowland Tropical Rainforest is the main forest type present within the project area, with around 95% of the total forest cover. Thus, due to the high representativeness of this forest type within the project area, the forest class was not stratified, i.e., the “Forest” class includes just one strata due to the low difference in average carbon stocks within the project area.

The estimation of the average carbon stocks for Dense Lowland Tropical Rainforest was based on Higuchi (2015)[133], which fulfil the criteria mentioned above.

The classification of the Brazilian vegetation is still constantly updated and studied, being evaluated and subdivided according to biological, geological or biodiversity characteristics. Pires & Prance (1985)[134] classified the forest formation of the Amazon biome into two major groups, Forest on *terra firme* (dense forest) and *Várzeas and igapós* forests, and their respective subdivisions. The authors classify that *terra firme* forests dominate the largest percentage of area in the Amazon. Most of it consist of lowland undulating terrain, rarely above 200 m, and most below 100 m.

The IBGE "Technical Manual for Brazilian Vegetation" (1992)[135] divides forestry formation into two types: Ombrophilous and Seasonal, being Ombrophilous, open and dense, predominant in the Brazilian Amazon.

As both classifications are based on characteristics of cover, soil, climate and location of the biome, the table below lists the respective definitions, comparing them:

Table 36. Comparison of forest classifications by Pires & Prance and IBGE

Pires & Prance (1985)		Technical Manual of the Brazilian vegetation (2012)
Forest on *Terra firme* (dense forest)	<u>Dense forest</u> Dense forest is the formation with the greatest biomass, with a clear litter and occurs where environmental conditions are optimal and there are no limiting factors such as scarcity or excess of water.	<u>Dense Ombrophylous rainforest (tropical rain forest)</u> The ombrothermal characteristic of the Dense Ombrophilous Forest is linked to tropical climatic factors of high temperatures and high rainfall, well distributed throughout the year, with practically no biologically dry period. It can be of uniform or emergent canopy. It is subdivided into five formations ordered according to topographic hierarchy, which reflect different physiognomies: **Alluvial, low land, submontane, montane and high montane formations.**

[133] HIGUCHI, Francisco Gasparetto. Dinâmica de volume e biomassa da floresta de terra firme do Amazonas. 2015. 201 f. Tese (Doutorado) - Curso de Engenharia Florestal, Setor de Ciências Agrárias, Universidade Federal do Paraná, Curitiba, 2015. Available at: <https://acervodigital.ufpr.br/bitstream/handle/1884/41822/R%20-%20T%20-%20FRANCISCO%20GASPARETTO%20HIGUCHI.pdf?sequence=1&isAllowed=y> Last visited on: August 2021.

[134] Pires & Prance (J.M.Pires, & Prance, G.T.. (1985). The vegetation types of the Brazilian Amazon. Available at <https://www.researchgate.net/publication/259688522_The_vegetation_types_of_the_Brazilian_Amazon> Last visited on 21/March/2021.

[135] Manual Técnico da Vegetação Brasileira – IBGE, 1992. Available at <https://biblioteca.ibge.gov.br/visualizacao/monografias/GEBIS%20-%20RJ/ManuaisdeGeociencias/Manual%20Tecnico%20da%20Vegetacao%20Brasileira%20n.1.pdf> Last visited on 21/March/2021.

	<u>Open forest without palms</u> Since there is a greater penetration of light, because of its lower trees, there is a tendency for shrub and liana species to develop well, and the forest floor is much more densely covered by vegetation. In this forest, even though it is much lower, occasional scattered individuals of very large trees occur. The lower biomass can be caused by a lower water table, by the impermeability of the soil, by poor drainage or by conditions which do not permit good root penetration, or by the occurrence of relatively long dry seasons and a lower relative humidity. These forests are not notably seasonally deciduous, and they are also not affected by fire. <u>Open forest with palms</u> Similar to the preceding, with trees of about the same height in the same density and of a similar floristic composition. It occurs more frequently than the forest without palms. <u>Liana forest:</u> Generally has an abundance of lianas. Generally not continuous. Usually intermeshed with dense forests wthout lianas forming a complex mosaic. <u>Dry forest:</u> Formation of transition forest that is occasionally found in the southeastern part of Amazonia on the border between Amazonia and Central Brazil. In this region, the climate is much more seasonal and dryer with lower relative humidity, with the result that in the dry season, the trees lose some of their leaves. Dry forest occurs in small clusters that do not occupy large areas.	<u>Open</u> Ombrophylous <u>forest</u> This type of vegetation was considered for years as a type of transition between the Amazon rainforest and the extra-Amazonian areas. It presents four floristic factions that alter the ecological physiognomy of the dense rainforest, giving it a clear appearance, hence the name adopted, in addition to the climatic gradients with more than 60 dry days per year. It is divided into: <u>Lowland</u> – predominance of palm trees <u>Submontane</u> – predominance of palm trees, vines, sororoca and bamboo <u>Montane</u> – predominance of palms and vines, the latter much more common. <u>Alluvial</u> – on ancient terraces located along the river; riverside formation that always occupies alluvial lands located in the fluvia of coastal mountains or plateaus.

	<u>Montane forests:</u> Forest formations which are differentiated by their altitude and rocky soil types. It occurs only at the extremities of Amazonia.	
<u>Inundated forests (*várzeas* and *igapós*)</u> Várzeas and igapós are regional terms applied both to types of soil and vegetation, noting the excess of humidity or swampy conditions, i.e., any ground that is not terra firme. *Igapó* is located in black and clearwater areas, while *Várzea* to muddy water inundation. Várzeas are formed by sedimentar ground that during its formation were influenced by fluctuation in sea levels.		Classification of forests by location - alluvial. While Pires and Prance unified the marshy characteristic in a classification, the manual divides them according to the context of the other formations, with respective information on species, cover, etc. Thus, the term alluvial represents, as a whole, riverside formation or riparian forest that occurs along water courses, occupying the old terraces of quaternary plains. It can occur in dense, open and mixed rain forest within the classifications above.

Thus, it can be concluded that the general definition of Dense Ombrophylous rainforest is similar to the definition of *terra firme* forests, as described by Higuchi (2015).

Therefore, the Higuchi's study of volume and biomass dynamics of the Amazonian rainforest was adopted to define the carbon stock of the category of dense tropical rainforest (lowland) located in PA, RR and LK. It is important to highlight that this vegetation type is characterized as Dense Ombrophylous Forest.

This choice was motivated by the focus of the study, which covered upland forests and the same phytophysiognomy, despite focusing on the State of Amazonas, the study covered a large number of sample plots and low uncertainty, with a confidence interval of 95%.

The data will be updated and may be stratified if new and more updated references for each phytophysiognomy are published. It is also important to note that revenues from carbon credits will be an important factor in encouraging specific studies in the project area, which would produce direct data on the region's carbon dynamics.

The methodology of Higuchi (2015) is summarized below.

The research was conducted in 11 locations distributed in 12 different municipalities in the State of Amazonas. All plots were allocated in areas of mature upland forests. None of the sampled areas has shown any clear sign of human disturbance in the past 50 years.

Regarding the sampling method, permanent plots were used, in addition to the standard EMBRAPA method.

EMBRAPA Method: 18 square plots of 1 ha (100 m x 100 m) each were installed and measured, randomly distributed over an area of 4 km² (2,000 m x 2,000 m). Each plot of 1 ha was subdivided into 100 units of 100 m², dimensioned in 10 m x 10 m. In each plot, the DBHs of all trees with a diameter greater than or equal to 10 cm were identified and measured. Dead trees and palm trees were not sampled in this location. Trees with DBH between 5 and 10 cm were sampled in ten subsamples randomly distributed in the 1 ha plot.

Permanent plots method: rectangular units with 2,500 m² were installed (¼ ha), dimensioned in 20 m x 125 m, according to the work of Higuchi et al. (1982), Higuchi, 1986-87 and Oliveira et al. (2014). Each sample unit had two sub-plots of 100 m² (10 mx 10 m) at the ends, one at the beginning of the left side and another at the end of the right side of the central path, for the measurement of natural regeneration (RN) (trees with DBH greater than or equal to 5 cm and less than 10 cm). The access path of each plot was arranged in the center of it, dividing it into two sides of 10 m each.

The sampling process adopted was mixed, where the sampling point of the first parcel was randomly drawn and the following parcels were systematically allocated from the first sampling unit.

The estimates of biomass were calculated using the equations adjusted by Silva (2007), in Manaus. The transformation to dry biomass considered the values of water and carbon in the wood determined by Silva (2007). A correction factor (fc) was applied for the use of these equations in different locations according to the dominant height of the sampled site. The equations used were:

$$BStot = 2{,}7179 \times DAP^{1{,}8774} \times 0{,}584 \times fc \text{, onde } R^2 = 0{,}94 \text{ e } Syx\% = 3{,}91.$$

$$AGB = 2{,}2737 \times DAP^{1{,}9156} \times 0{,}584 \times fc \text{, onde } R^2 = 0{,}85 \text{ e } Syx\% = 4{,}20.$$

$$BGB = 0{,}0469 \times DAP^{2{,}4754} \times 0{,}533 \times fc \text{, onde } R^2 = 0{,}95 \text{ e } Syx\% = 5{,}12.$$

$$fc = \frac{Hdom_i}{Hdom_{ZF2}}$$

Considering a minimum DBH of 5 cm and the arithmetic mean of the estimated averages for each site, the aboveground dry biomass (AGB) of *terra firme* forests in the state of Amazonas is 327.4 t.ha-1 (± 24.2 at 95% CI). This value was used for phytophysiognomies of Dense Ombrophilous Forest (Dense Tropical Rainforest).

According to the applied methodology, as the uncertainty of the total average carbon stock is less than 10% of the average value, the average carbon stock value can be used.

In addition, average values for the below-ground biomass were taken from the applied methodology VM0015 v1.1, which estimates a root-to-shoot ratio of 0.24 for tropical rainforest having above ground biomass values above 125 tons/ha.

In order to convert biomass into carbon, and carbon into carbon-dioxide, the conversion factors defined in table below were used.

Table 37. Biomass to CO2 conversion factors[136]

Conversion Factors***	
Biomass to Carbon	0.5
C to CO_2	3.6667

Therefore, the carbon stocks values for above and belowground biomass for this project activity are described below.

Table 38. Biomass values used for the "forest" classes within the Project area.

Forest class	Aboveground			Belowground			TOTAL		
	Biomass (Mg ha^{-1})	Biomass to Carbon (tC/ha)	Cab_{icl} (tCO2/ha)	Biomass (Mg ha^{-1})	Biomass to Carbon (tC/ha)	Cbb_{icl} (tCO2/ha)	Total biomass (Mg ha^{-1})	Biomass to Carbon (tC/ha)	$Ctot_{icl}$ (tCO_2/ha)
Dense Lowland Tropical Rainforest	327.40	163.70	600.23	78.58	39.29	144.06	405.98	202.99	744.29

Average carbon stocks of post-deforestation classes

Fearnside (1996)[137] is one of the most recognized studies for the Brazilian Amazon about long term carbon stocks in deforested areas. This study constructed a Markov matrix of annual transition probabilities to estimate landscape composition and to project future changes in the Brazilian Amazon. The average carbon stock value of non-forest vegetation in anthropic areas in equilibrium (post deforestation class) was defined as 12.8 tC/ha, or 46.93 tCO_2e/ha. It is important to note that no sampling was applied to calculate this data.

Table 39. Long-term (20 years) average carbon stocks per hectare of post-deforestation LU/LC classes present in the reference region

Post deforestation class fcl	
Name	Non forest
ID_{fcl}	1
Average carbon stock per hectare ±90% CI	
$Ctot_{fcl}$	
tCO_2e/ha	
46.93	

136 IPCC, 2003. Good practice guidance for land use, land-use change and forestry. Kanagawa: IGES, 2003. Available at: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

137 FEARNSIDE, Philip M. Amazonian deforestation and global warming: carbon stocks in vegetation replacing Brazil's Amazon forest. Forest Ecology And Management, Manaus, v. 80, p.21-34, 1996 Available at < https://www.jstor.org/stable/3591054>

Following a literature review, the use of Fearnside (1996) value for non-forest vegetation carbon stocks in equilibrium is conservative because it is based on several land-use types in the Amazon, including agriculture, pasturelands and secondary vegetation, reaching a final value of 46.93 tCO_2/ha. Meanwhile, based on the Brazilian Government data available in the 3rd National GHG Inventory[138], the weighted average for carbon stocks in other land uses (mainly agriculture and pasturelands) was 32.99 tCO_2e. Therefore, the most conservative value between these two data was used.

<u>Uncertainty assessment</u>

According to the applied methodology, if the uncertainty of the total average carbon stock is less than 10% of the average value, the average value, the average carbon stock value can be used. Otherwise, the lower boundary of the 90% confidence interval must be considered in the calculations if the class is an initial forest class in the project area or a final non-forest class in the leakage belt, and the higher boundary of the 90% confidence interval if the class is an initial forest class in the leakage belt or a final non-forest class in the project area.

Higuchi (2015), for the Dense tropical and submontane rainforest, was conducted at a 95% confidence interval and present an uncertainty level less than 10% of the average carbon stock value.

Therefore, tables below present carbon stocks per hectare of initial forest classes icl existing in the project area and leakage belt, uncertainties at confidence interval of 90%, and final values after discounts for uncertainties, if applicable.

Table 40. Carbon stocks per hectare of initial forest classes icl existing in the project area and leakage belt

Initial forest class *icl*						
Boundaries	Average carbon stock 90% CI					
	Name	Forest - Dense Lowland Tropical Rainforest				
	ID_{icl}	1				
	Cab_{icl}		Cbb_{icl}		$Ctot_{icl}$	
	C stock	±90% CI	C stock	±90% CI	C stock	±90% CI
	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha
Project Area	600.23	37.23	144.06	8.94	744.29	46.17
Leakage Belt	600.23	37.23	144.06	8.94	744.29	46.17

[138] Available at https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/arquivos/LIVRORESULTADOINVENTARIO30062021WEB.pdf

Table 41. Carbon stocks per hectare of initial forest classes icl existing in the project area and leakage belt after discounts for uncertainties

	Initial forest class *icl*						
	Boundaries	Average carbon stock 90% CI					
		Name	Forest - Dense Lowland Tropical Rainforest				
		ID_{icl}	1				
		Cab_{icl}		Cbb_{icl}		$Ctot_{icl}$	
		C stock	C stock change	C stock	C stock change	C stock	C stock change
		tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha
Initial forest class	**Project Area**	600.23	600.23	144.06	144.06	744.29	744.29
Final forest class		600.23	600.23	144.06	144.06	744.29	744.29
Initial forest class	**Leakage Belt**	600.23	600.23	144.06	144.06	744.29	744.29
Final forest class		600.23	600.23	144.06	144.06	744.29	744.29

Carbon stock change factors

The VM0015 methodology v1.1 applies default linear functions to account for the decay of carbon stock in initial forest classes (icl) and increase of carbon stocks in post-deforestation classes. In addition, the methodology stipulates that various change factors must be applied to the baseline case initial and post-deforestation classes in above-ground and below ground biomass:

a) Above-ground biomass:

- Initial forest classes (icl): immediate release of 100% of the carbon stock is assumed to happen during year t = t* (year in which deforestation occurs).
- Post-deforestation classes (fcl): linear increase from 0 tCO_2e/ha in year t = t* to 100% of the long-term average carbon stock in year t = t*+10 is assumed to happen in the 10-years period following deforestation (i.e. $1/10^{th}$ of the final carbon stock is accumulated each year).

b) Below-ground biomass:

- Initial forest classes (icl): an annual release of $1/10^{th}$ of the initial carbon stock is assumed to happen each year between t = t* and t = t*+9.
- Post-deforestation classes (fcl): linear increase from 0 tCO_2e/ha in year t = t* to 100% of the long-term average carbon stock in year t = t*+10 is assumed to happen in the 10 years period following deforestation (i.e. $1/10^{th}$ of the final carbon stock is accumulated each year).

As such, the tables below show carbon stock change factors for initial and final forest classes in above and below-ground carbon pools, which were then applied to calculate baseline carbon stock changes.

Table 42. Carbon stock change factors for initial forest classes (icl) in the reference region (Method 1)

Forest			
Year after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$
		tCO_2/ha	tCO_2/ha
1	t*	-600.23	-14.41
2	t*+1	0	-14.41
3	t*+2	0	-14.41
4	t*+3	0	-14.41
5	t*+4	0	-14.41
6	t*+5	0	-14.41
7	t*+6	0	-14.41
8	t*+7	0	-14.41
9	t*+8	0	-14.41
10	t*+9	0	-14.41
11	t*+10	0	0
12	t*+11	0	0
13	t*+12	0	0
14	t*+13	0	0
15	t*+14	0	0
16	t*+15	0	0
17	t*+16	0	0
18	t*+17	0	0
19	t*+18	0	0
20	t*+19	0	0
21-T	t*+20…	0	0

Table 43. Carbon stock change factors for initial forest classes (icl) in the Project Area (Method1)

Forest			
Year after deforestation		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$
		tCO_2/ha	tCO_2/ha
1	t*	-600.23	-14.41
2	t*+1	0	-14.41
3	t*+2	0	-14.41
4	t*+3	0	-14.41
5	t*+4	0	-14.41
6	t*+5	0	-14.41
7	t*+6	0	-14.41
8	t*+7	0	-14.41
9	t*+8	0	-14.41

10	t*+9	0	-14.41
11	t*+10	0	0
12	t*+11	0	0
13	t*+12	0	0
14	t*+13	0	0
15	t*+14	0	0
16	t*+15	0	0
17	t*+16	0	0
18	t*+17	0	0
19	t*+18	0	0
20	t*+19	0	0
21-T	t*+20…	0	0

Table 44. Carbon stock change factors for initial forest classes (icl) in the Leakage Belt (Method 1)

Year after deforestation		Forest	
		$\Delta Cab_{icl,t}$	$\Delta Cbb_{icl,t}$
		tCO_2/ha	tCO_2/ha
1	t*	-600.23	-14.41
2	t*+1	0	-14.41
3	t*+2	0	-14.41
4	t*+3	0	-14.41
5	t*+4	0	-14.41
6	t*+5	0	-14.41
7	t*+6	0	-14.41
8	t*+7	0	-14.41
9	t*+8	0	-14.41
10	t*+9	0	-14.41
11	t*+10	0	0
12	t*+11	0	0
13	t*+12	0	0
14	t*+13	0	0
15	t*+14	0	0
16	t*+15	0	0
17	t*+16	0	0
18	t*+17	0	0
19	t*+18	0	0
20	t*+19	0	0
21-T	t*+20…	0	0

Table 45. Carbon stock change factors for final classes fcl or zones z (Method 1)

Year after deforestation		$\Delta Ctot_{fcl,t}$ (tCO_2e/ha)
1	t*	0.00
2	t*+1	5.21

3	t*+2	5.21
4	t*+3	5.21
5	t*+4	5.21
6	t*+5	5.21
7	t*+6	5.21
8	t*+7	5.21
9	t*+8	5.21
10	t*+9	5.21
11	t*+10	0
12	t*+11	0
13	t*+12	0
14	t*+13	0
15	t*+14	0
16	t*+15	0
17	t*+16	0
18	t*+17	0
19	t*+18	0
20	t*+19	0
21-T	t*+20…	0

<u>Calculation of baseline carbon stock changes</u>

The resulting changes in carbon stock for initial forest classes for the reference region, project area and leakage belt are shown in tables below.

Table 46. Baseline carbon stock change in the Reference Region

Carbon stock change in the above-ground biomass per initial forest class *icl*		Total carbon stock change in the above-ground biomass of initial forest class in the reference region		Carbon stock change in the below-ground biomass per initial forest class *icl*		Total carbon stock change in the below-ground biomass of initial forest class in the reference region		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change of post deforestation zones in the reference region		Total net carbon stock change in the reference region	
ID_{cl}	1	$\Delta CabBSLRR_{icl,t}$	$\Delta CabBSLRR_{icl}$	ID_{cl}	1	$\Delta CbbBSLRR_{icl,t}$	$\Delta CbbBSLRR_{icl}$	ID_{iz}	1	$\Delta CBSLRR_{z,t}$	$\Delta CBSLRR_{z}$	$\Delta CBSLRR_{t}$	$\Delta CBSLRR$
Name	Forest	annual	cumulative	Name	Forest	annual	cumulative	Name	Non-forest	annual	cumulative	annual	cumulative
Project year	tCO_2e	tCO_2e	tCO_2e	Project year	tCO_2e	tCO_2e	tCO_2e	Project year	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	2,862,577	2,862,577	2,862,577	2022	68,702	68,702	68,702	2022	0	0	0	2,931,279	2,931,279
2023	5,319,468	5,319,468	8,182,045	2023	196,369	196,369	265,071	2023	24,870	24,870	24,870	5,490,967	8,422,246
2024	5,199,811	5,199,811	13,381,856	2024	321,165	321,165	586,235	2024	71,085	71,085	95,955	5,449,890	13,872,137
2025	5,082,846	5,082,846	18,464,702	2025	443,153	443,153	1,029,388	2025	116,261	116,261	212,217	5,409,737	19,281,874
2026	4,968,511	4,968,511	23,433,214	2026	562,397	562,397	1,591,785	2026	160,421	160,421	372,638	5,370,488	24,652,361
2027	4,856,749	4,856,749	28,289,963	2027	678,959	678,959	2,270,745	2027	203,587	203,587	576,225	5,332,121	29,984,482
2028	4,630,390	4,630,390	32,920,352	2028	790,088	790,088	3,060,833	2028	245,783	245,783	822,008	5,174,695	35,159,178
2029	4,302,362	4,302,362	37,222,714	2029	893,345	893,345	3,954,178	2029	286,011	286,011	1,108,019	4,909,696	40,068,873
2030	4,212,691	4,212,691	41,435,405	2030	994,450	994,450	4,948,628	2030	323,390	323,390	1,431,409	4,883,750	44,952,624
2031	4,124,889	4,124,889	45,560,294	2031	1,093,447	1,093,447	6,042,075	2031	359,990	359,990	1,791,399	4,858,346	49,810,970
2032	4,038,916	4,038,916	49,599,210	2032	1,121,679	1,121,679	7,163,754	2032	395,827	395,827	2,187,226	4,764,769	54,575,738
2033	3,954,736	3,954,736	53,553,946	2033	1,088,926	1,088,926	8,252,680	2033	406,047	406,047	2,593,273	4,637,615	59,213,353
2034	3,789,598	3,789,598	57,343,544	2034	1,055,080	1,055,080	9,307,760	2034	394,190	394,190	2,987,463	4,450,488	63,663,841
2035	3,526,686	3,526,686	60,870,229	2035	1,017,733	1,017,733	10,325,493	2035	381,938	381,938	3,369,401	4,162,480	67,826,321
2036	3,458,348	3,458,348	64,328,578	2036	981,489	981,489	11,306,982	2036	368,418	368,418	3,737,820	4,071,418	71,897,740
2037	3,391,335	3,391,335	67,719,912	2037	946,319	946,319	12,253,300	2037	355,298	355,298	4,093,118	3,982,355	75,880,095
2038	3,325,620	3,325,620	71,045,532	2038	915,004	915,004	13,168,305	2038	342,567	342,567	4,435,684	3,898,058	79,778,153
2039	3,261,179	3,261,179	74,306,711	2039	890,016	890,016	14,058,321	2039	331,231	331,231	4,766,915	3,819,964	83,598,117
2040	3,112,915	3,112,915	77,419,626	2040	863,621	863,621	14,921,942	2040	322,185	322,185	5,089,100	3,654,351	87,252,468
2041	2,901,490	2,901,490	80,321,115	2041	834,260	834,260	15,756,202	2041	312,630	312,630	5,401,730	3,423,119	90,675,587
2042	2,849,499	2,849,499	83,170,614	2042	805,714	805,714	16,561,915	2042	302,001	302,001	5,703,731	3,353,211	94,028,798
2043	2,798,439	2,798,439	85,969,053	2043	777,963	777,963	17,339,878	2043	291,668	291,668	5,995,399	3,284,734	97,313,532
2044	2,748,295	2,748,295	88,717,348	2044	752,971	752,971	18,092,849	2044	281,622	281,622	6,277,021	3,219,644	100,533,176
2045	2,699,049	2,699,049	91,416,397	2045	733,108	733,108	18,825,957	2045	272,575	272,575	6,549,596	3,159,582	103,692,758
2046	2,566,453	2,566,453	93,982,849	2046	711,703	711,703	19,537,660	2046	265,384	265,384	6,814,980	3,012,771	106,705,529
2047	2,395,830	2,395,830	96,378,680	2047	687,810	687,810	20,225,470	2047	257,636	257,636	7,072,616	2,826,005	109,531,534
2048	2,356,343	2,356,343	98,735,023	2048	664,548	664,548	20,890,018	2048	248,987	248,987	7,321,603	2,771,904	112,303,438
2049	2,317,506	2,317,506	101,052,528	2049	641,900	641,900	21,531,918	2049	240,566	240,566	7,562,169	2,718,840	115,022,277
2050	2,279,309	2,279,309	103,331,838	2050	621,893	621,893	22,153,811	2050	232,367	232,367	7,794,536	2,668,835	117,691,113
2051	2,241,742	2,241,742	105,573,579	2051	606,059	606,059	22,759,870	2051	225,125	225,125	8,019,660	2,622,676	120,313,789
2052	2,204,175	2,204,175	107,777,754	2052	590,571	590,571	23,350,441	2052	219,393	219,393	8,239,053	2,575,353	122,889,142

Table 47. Baseline carbon stock change in the Project Area

Carbon stock change in the above-ground biomass per initial forest class *icl*		Total carbon stock change in the above-ground biomass of initial forest class in the project area	
ID_{cl}	1	$\Delta CabBSLPA_{icl,t}$	$\Delta CabBSLPA_{icl}$
Name	Forest	annual	cumulative
Year	tCO_2e	tCO_2e	tCO_2e
2022	174,230	174,230	174,230
2023	324,027	324,027	498,257
2024	316,993	316,993	815,250
2025	310,111	310,111	1,125,361
2026	303,378	303,378	1,428,739
2027	296,792	296,792	1,725,531
2028	282,378	282,378	2,007,909
2029	276,416	276,416	2,284,325
2030	270,580	270,580	2,554,905
2031	264,867	264,867	2,819,771
2032	259,274	259,274	3,079,046
2033	253,800	253,800	3,332,846
2034	241,097	241,097	3,573,943
2035	236,157	236,157	3,810,100
2036	231,318	231,318	4,041,419
2037	226,579	226,579	4,267,998
2038	221,936	221,936	4,489,934
2039	217,389	217,389	4,707,323
2040	206,172	206,172	4,913,494
2041	202,081	202,081	5,115,576
2042	198,072	198,072	5,313,648
2043	194,143	194,143	5,507,791
2044	190,291	190,291	5,698,082
2045	186,516	186,516	5,884,598
2046	176,591	176,591	6,061,189
2047	173,207	173,207	6,234,396
2048	169,888	169,888	6,404,284
2049	166,632	166,632	6,570,917
2050	163,439	163,439	6,734,356
2051	160,307	160,307	6,894,663
2052	157,175	157,175	7,051,838

Carbon stock change in the below-ground biomass per initial forest class *icl*		Total carbon stock change in the below-ground biomass of initial forest class in the project area	
ID_{cl}	1	$\Delta CbbBSLPA_{icl,t}$	$\Delta CbbBSLPA_{icl}$
Name	Forest	annual	cumulative
Year	tCO_2e	tCO_2e	tCO_2e
2022	4,182	4,182	4,182
2023	11,958	11,958	16,140
2024	19,566	19,566	35,706
2025	27,009	27,009	62,714
2026	34,290	34,290	97,004
2027	41,413	41,413	138,417
2028	48,190	48,190	186,607
2029	54,824	54,824	241,430
2030	61,318	61,318	302,748
2031	67,675	67,675	370,423
2032	69,716	69,716	440,138
2033	68,030	68,030	508,168
2034	66,209	66,209	574,377
2035	64,434	64,434	638,811
2036	62,704	62,704	701,515
2037	61,019	61,019	762,534
2038	59,569	59,569	822,103
2039	58,152	58,152	880,255
2040	56,606	56,606	936,861
2041	55,099	55,099	991,960
2042	53,630	53,630	1,045,591
2043	52,199	52,199	1,097,789
2044	50,979	50,979	1,148,769
2045	49,788	49,788	1,198,557
2046	48,474	48,474	1,247,031
2047	47,194	47,194	1,294,225
2048	45,944	45,944	1,340,169
2049	44,726	44,726	1,384,895
2050	43,701	43,701	1,428,596
2051	42,698	42,698	1,471,294
2052	41,717	41,717	1,513,011

Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change of post deforestation zones in the project area	
ID_{lz}	1	$\Delta CBSLPA_{z,t}$	$\Delta CBSLPA_{z}$
Name	Non-forest	annual	cumulative
Year	tCO_2e	tCO_2e	tCO_2e
2022	0	0	0
2023	1,514	1,514	1,514
2024	4,329	4,329	5,843
2025	7,083	7,083	12,925
2026	9,777	9,777	22,703
2027	12,413	12,413	35,115
2028	14,991	14,991	50,107
2029	17,445	17,445	67,551
2030	19,846	19,846	87,398
2031	22,197	22,197	109,595
2032	24,498	24,498	134,093
2033	25,237	25,237	159,330
2034	24,627	24,627	183,957
2035	23,967	23,967	207,924
2036	23,325	23,325	231,249
2037	22,699	22,699	253,948
2038	22,089	22,089	276,037
2039	21,564	21,564	297,601
2040	21,051	21,051	318,651
2041	20,491	20,491	339,143
2042	19,946	19,946	359,089
2043	19,414	19,414	378,503
2044	18,896	18,896	397,399
2045	18,454	18,454	415,853
2046	18,023	18,023	433,876
2047	17,548	17,548	451,424
2048	17,084	17,084	468,508
2049	16,632	16,632	485,140
2050	16,191	16,191	501,331
2051	15,820	15,820	517,151
2052	15,457	15,457	532,607

Total net carbon stock change in the project area	
$\Delta CBSLPA_{t}$	$\Delta CBSLPA$
annual	cumulative
tCO_2e	tCO_2e
178,411	178,411
334,472	512,883
332,230	845,113
330,037	1,175,149
327,891	1,503,041
325,792	1,828,833
315,576	2,144,409
313,795	2,458,204
312,051	2,770,255
310,344	3,080,599
304,492	3,385,091
296,593	3,681,685
282,679	3,964,364
276,623	4,240,987
270,698	4,511,685
264,899	4,776,584
259,416	5,036,000
253,977	5,289,977
241,727	5,531,704
236,689	5,768,393
231,757	6,000,150
226,927	6,227,077
222,375	6,449,452
217,850	6,667,301
207,043	6,874,344
202,853	7,077,197
198,748	7,275,945
194,727	7,470,672
190,949	7,661,621
187,186	7,848,806
183,435	8,032,241

Table 48. Baseline carbon stock change in the Leakage Belt

Carbon stock change in the above-ground biomass per initial forest class *icl*		Total carbon stock change in the above-ground biomass of initial forest class in the leakage belt	
ID_{cl}	1	$\Delta CabBSLLK_{icl,t}$	$\Delta CabBSLLK_{icl}$
Name	Forest	annual	cumulative
Project year	tCO_2e	tCO_2e	tCO_2e
2022	254,262	254,262	254,262
2023	472,490	472,490	726,752
2024	461,861	461,861	1,188,613
2025	451,472	451,472	1,640,085
2026	441,317	441,317	2,081,402
2027	431,390	431,390	2,512,792
2028	411,284	411,284	2,924,075
2029	402,261	402,261	3,326,336
2030	393,435	393,435	3,719,771
2031	384,804	384,804	4,104,575
2032	376,361	376,361	4,480,936
2033	368,104	368,104	4,849,040
2034	350,437	350,437	5,199,478
2035	342,954	342,954	5,542,431
2036	335,630	335,630	5,878,061
2037	328,463	328,463	6,206,524
2038	321,448	321,448	6,527,973
2039	314,584	314,584	6,842,556
2040	299,027	299,027	7,141,584
2041	292,825	292,825	7,434,409
2042	286,751	286,751	7,721,160
2043	280,804	280,804	8,001,964
2044	274,979	274,979	8,276,943
2045	269,276	269,276	8,546,219
2046	255,549	255,549	8,801,769
2047	250,413	250,413	9,052,181
2048	245,379	245,379	9,297,560
2049	240,446	240,446	9,538,006
2050	235,613	235,613	9,773,619
2051	230,877	230,877	10,004,496
2052	226,141	226,141	10,230,637

Carbon stock change in the below-ground biomass per initial forest class *icl*		Total carbon stock change in the below-ground biomass of initial forest class in the leakage belt	
ID_{cl}	1	$\Delta CbbBSLLK_{icl,t}$	$\Delta CbbBSLLK_{icl}$
Name	Forest	annual	cumulative
Project year	tCO_2e	tCO_2e	tCO_2e
2022	6,102	6,102	6,102
2023	17,442	17,442	23,544
2024	28,527	28,527	52,071
2025	39,362	39,362	91,433
2026	49,954	49,954	141,387
2027	60,307	60,307	201,694
2028	70,178	70,178	271,872
2029	79,832	79,832	351,704
2030	89,275	89,275	440,978
2031	98,510	98,510	539,488
2032	101,440	101,440	640,928
2033	98,935	98,935	739,863
2034	96,261	96,261	836,124
2035	93,656	93,656	929,780
2036	91,120	91,120	1,020,900
2037	88,650	88,650	1,109,549
2038	86,494	86,494	1,196,043
2039	84,389	84,389	1,280,432
2040	82,124	82,124	1,362,556
2041	79,916	79,916	1,442,472
2042	77,765	77,765	1,520,237
2043	75,670	75,670	1,595,907
2044	73,859	73,859	1,669,767
2045	72,091	72,091	1,741,857
2046	70,169	70,169	1,812,026
2047	68,296	68,296	1,880,322
2048	66,470	66,470	1,946,792
2049	64,691	64,691	2,011,483
2050	63,169	63,169	2,074,652
2051	61,682	61,682	2,136,334
2052	60,227	60,227	2,196,561

Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change of post deforestation zones in the leakage belt		Total net carbon stock change in the leakage belt	
ID_{iz}	1	$\Delta CtotBSLLK_{z,t}$	$\Delta CtotBSLLK_{z}$	$\Delta CtotBSLLK_{t}$	$\Delta CtotBSLLK$
Name	Non-forest	annual	cumulative	annual	cumulative
Project year	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	0	0	0	260,364	260,364
2023	2,209	2,209	2,209	487,723	748,087
2024	6,314	6,314	8,523	484,074	1,232,161
2025	10,327	10,327	18,850	480,508	1,712,669
2026	14,249	14,249	33,099	477,021	2,189,690
2027	18,083	18,083	51,182	473,614	2,663,303
2028	21,831	21,831	73,013	459,631	3,122,934
2029	25,404	25,404	98,417	456,688	3,579,622
2030	28,899	28,899	127,316	453,811	4,033,433
2031	32,317	32,317	159,634	450,996	4,484,429
2032	35,660	35,660	195,294	442,141	4,926,570
2033	36,721	36,721	232,015	430,318	5,356,888
2034	35,814	35,814	267,830	410,884	5,767,772
2035	34,846	34,846	302,676	401,764	6,169,535
2036	33,904	33,904	336,580	392,846	6,562,382
2037	32,985	32,985	369,565	384,127	6,946,509
2038	32,091	32,091	401,656	375,851	7,322,360
2039	31,311	31,311	432,967	367,663	7,690,022
2040	30,549	30,549	463,515	350,602	8,040,624
2041	29,729	29,729	493,244	343,012	8,383,637
2042	28,930	28,930	522,174	335,587	8,719,224
2043	28,151	28,151	550,325	328,323	9,047,547
2044	27,393	27,393	577,717	321,446	9,368,993
2045	26,737	26,737	604,454	314,630	9,683,623
2046	26,097	26,097	630,551	299,622	9,983,244
2047	25,401	25,401	655,952	293,307	10,276,551
2048	24,723	24,723	680,675	287,126	10,563,677
2049	24,062	24,062	704,737	281,075	10,844,752
2050	23,418	23,418	728,155	275,364	11,120,116
2051	22,867	22,867	751,022	269,692	11,389,808
2052	22,329	22,329	773,351	264,039	11,653,848

Baseline non-CO2 emissions from forest fires

As described in baseline scenario, slash-and-burn deforestation to clear the area is carried out for cattle ranching, which is the main cause of deforestation within the project area.

Therefore, baseline deforestation in the project area involves fire and all above ground biomass is burnt. It is worth mentioning that the effect of fire on CO2 emissions is counted in the estimation of carbon stock changes; therefore, CO2 emissions from biomass burning were ignored to avoid double counting. However, non-CO2 emissions (CH4 and N2O) from forest fires (EBBBSLPAt) were quantified and included as baseline emissions, as follows.

$$EBBtot_{icl,t} = EBBN_2O_{icl,t} + EBBCH_{4icl,t}$$

Where,

$EBBtot_{icl,t}$	Total GHG emission from biomass burning in forest class icl at year t; tCO_2e/ha
$EBBN_2O_{icl,t}$	N_2O emission from biomass burning in forest class icl at year t; tCO_2e/ha
$EBBCH_{4icl,t}$	CH_4 emission from biomass burning in forest class icl at year t; tCO_2e/ha

$$EBBN_2O_{icl,t} = EBBCO_{2icl,t} * 12/44 * NCR * ER_{N2O} * 44/28 * GWP_{N2O}$$

Where,

$EBBCO_{2icl,t}$	Per hectare CO_2 emission from biomass burning in slash and burn in forest class icl at year t; tCO_2e/ha
NCR	Nitrogen to Carbon Ratio (IPCC default value = 0.01); dimensionless
ER_{N2O}	Emission ratio for N_2O (IPCC default value = 0.007)
GWP_{N2O}	Global Warming Potential for N_2O (IPCC default value)[139]

$$EBBCH_{4icl,t} = EBBCO_{2icl,t} * 12/44 * ER_{CH4} * 16/12 * GWP_{CH4}$$

Where,

$EBBCO_{2icl,t}$	Per hectare CO_2 emission from biomass burning in slash and burn in forest class icl at year t; tCO_2e/ha
ER_{CH4}	Emission ratio for CH_4 (IPCC default value = 0.012)

[139] According to the VCS Standard, the six Kyoto Protocol greenhouse gases and ozone-depleting substances shall be converted using 100 year global warming potentials derived from the IPCC's Fifth Assessment Report (GWP for N2O = 265).

GWP_{CH4} Global Warming Potential for CH_4 (IPCC default value) [140]

$$EBBCO_{2icl,t} = Fburnt_{icl} * \sum_{p=1}^{P} (C_{picl,t} * Pburnt_{p,icl} * CE_{p,icl})$$

Where,

$EBBCO_{2icl,t}$ Per hectare CO_2 emission from biomass burning in the forest class icl at year t; tCO_2e/ha

$Fburnt_{icl}$ Proportion of forest area burned during the historical reference period in the forest class icl; %

$C_{picl,t}$ Average carbon stock per hectare in the carbon pool p burnt in the forest class icl at year t; tCO_2e/ha

$Pburnt_{p,icl}$ Average proportion of mass burnt in the carbon pool p in the forest class icl; %

$CE_{p,icl}$ Average combustion efficiency of the carbon pool p in the forest class icl; dimensionless (IPCC default of 0.5)

p Carbon pool that could burn, above-ground biomass

The Fburnt analysis was carried out on the municipalities of the reference region, as it is where the Project Area is fully inserted in. Hot spots were considered during the period from historical reference period (prior to 2014, the data has no fire risk classification, and therefore, was not taken into account). For the assessed years, the fire risk predicted for the day of detection of the outbreak was considered, contemplating only outbreaks with a fire risk of >= 0.5 as, according to INPE's methodology, fire risk higher than 0.4 is considered as medium to critical (=1). By overlapping these fire outbreaks with the deforestation mapping of the same time period, it was possible to verify the tendency of fire outbreaks being directly related to areas with recent and/or consolidated deforestation. This can also be verified by the proximity of deforestation detection dates by satellite and the close or overlapping heat spots. Thus, it is possible to assume that these outbreaks are related to anthropic actions to open pastures/crops. Thereby, there was an overlap of 89.44% of the pixels analysed during the reference period where the project is located.

The Pburnt estimated using the average biomass per hectare that has commercial value and could be removed prior to clear cutting and burning. Based on literature, an average value of 61.6 m^3/ha was obtained, which would correspond to approximately 11% of the total biomass in 1 ha. In this way, the remaining is burned to clear the area, therefore, its new value is 88.6%.

However, due to the lack of literature estimates, a study from the Brazilian Amazon in the Cerrado vegetation was used for the comparison. This study reported that the total biomass consumed by

[140] According to the VCS Standard, the six Kyoto Protocol greenhouse gases and ozone-depleting substances shall be converted using 100 year global warming potentials derived from the IPCC's Fifth Assessment Report (GWP for CH_4 = 28).

fires varies from 72% to 84% (average 78%) in denser Cerrado types, which is a forest vegetation. The most conservative value between these two estimates were used, i.e., Pburnt was estimated as 78%.

It is important to note that slash and burn practices are commonly used in the Amazon region to clear the area for other land uses thus, when burning an area, the main objective is to completely remove all the remaining biomass. Therefore, assuming that 78% of the biomass is combusted, there would still be a 22% remaining biomass that shall be left to decompose, which also emits GHG to the atmosphere in this process.

Thus, the total actual non-CO_2 emissions from forest fire at year t in the project area at the baseline scenario ($EBBBSLPA_t$) were calculated as follows.

$$EBBBSLPA_t = ABSLPA_{icl,t} * EBBtot_{icl,t}$$

Where,

$EBBBSLPA_t$	Total actual non-CO_2 emissions from forest fire at year t in the project area in the baseline scenario; tCO_2e/ha
$ABSLPA_{icl,t}$	Annual area of deforestation of initial forest classes icl in the project area at year t; ha
$EBBtot_{icl,t}$	Total GHG emission from biomass burning in forest class icl at year t; tCO_2e/ha

Values of all estimated parameters are reported in the following table.

Table 49. Parameters used to calculate non-CO2 emissions from forest fires

Initial Forest Class		Parameters								
		$Fburnt_{icl}$	Cab	$Pburnt_{ab,icl}$	$CE_{ab,icl}$	ECO2-ab	EBBCO2-tot	$EBBN2O_{icl}$	$EBBCH4_{icl}$	$EBBtot_{icl}$
IDcl	Name	%	tCO2e/ha	%	%	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha	tCO2e/ha
1	Forest	89%	600.23	78%	50%	209.38	209.38	1.87	22.84	24.71

Table 50. Baseline non-CO2 emissions from forest fires in the project area

Project year *t*	Emissions of non-CO_2 gasses from baseline forest fires		Total baseline non-CO_2 emissions from forest fires in the project area	
	ID_{cl} = 1 Forest		annual	cumulative
	$ABSLPA_{icl,t}$	$EBBBSLtot_{icl}$	$EBBBSLPA_t$	EBBBSLPA
	ha	tCO_2e/ha	tCO_2e	tCO_2e
2022	290.27	24.71	7,173.58	7,173.58
2023	539.84	24.71	13,341.22	20,514.80
2024	528.12	24.71	13,051.59	33,566.39
2025	516.65	24.71	12,768.24	46,334.63
2026	505.43	24.71	12,491.04	58,825.67
2027	494.46	24.71	12,219.87	71,045.54
2028	470.45	24.71	11,626.39	82,671.92
2029	460.51	24.71	11,380.91	94,052.83
2030	450.79	24.71	11,140.61	105,193.45
2031	441.27	24.71	10,905.39	116,098.84
2032	431.96	24.71	10,675.14	126,773.98
2033	422.84	24.71	10,449.75	137,223.73
2034	401.67	24.71	9,926.73	147,150.46
2035	393.44	24.71	9,723.33	156,873.79
2036	385.38	24.71	9,524.11	166,397.90
2037	377.48	24.71	9,328.96	175,726.86
2038	369.75	24.71	9,137.81	184,864.68
2039	362.17	24.71	8,950.58	193,815.26
2040	343.49	24.71	8,488.73	202,303.99
2041	336.67	24.71	8,320.32	210,624.32
2042	329.99	24.71	8,155.26	218,779.57
2043	323.45	24.71	7,993.47	226,773.04
2044	317.03	24.71	7,834.89	234,607.93
2045	310.74	24.71	7,679.45	242,287.38
2046	294.20	24.71	7,270.82	249,558.20
2047	288.57	24.71	7,131.48	256,689.68
2048	283.04	24.71	6,994.82	263,684.50
2049	277.61	24.71	6,860.78	270,545.28
2050	272.29	24.71	6,729.30	277,274.58
2051	267.07	24.71	6,600.35	283,874.92
2052	261.86	24.71	6,471.39	290,346.31

4.2 Project Emissions

The present activity instance does not include planned deforestation and planned logging activities within the project area. In case future instances include Sustainable Forest Management Plan, the respective parameters and calculation must be included in this section.

Nevertheless, some unplanned deforestation may happen in the project area despite the implemented REDD project activity. The level at which deforestation will actually be reduced in the project case depends on the effectiveness of the proposed activities, which cannot be measured *ex ante*. *Ex post* measurements of the project results will be important to determine actual emission reductions.

To allow ex ante projections to be made, a conservative assumption was made about the effectiveness of the proposed project activities in order to define the Effectiveness Index (EI). The estimated value of EI is used to multiply the baseline projections by the factor (1 - EI) and the result was considered to be the *ex ante* estimated emissions from unplanned deforestation in the project case. This is calculated as follows:

$$\Delta CUDdPA_t = \Delta CBSLPA_t * (1 - EI)$$

Where,

$\Delta CUDdPA_t$	Total ex ante actual carbon stock change due to unavoided unplanned deforestation at year t in the project area; tCO_2e
$\Delta CBSLPA_t$	Total baseline carbon stock change in the project area at year t; tCO_2e
EI	*Ex ante* estimated Effectiveness Index; %
t	1, 2, 3 … T, a year of the proposed project crediting period; dimensionless

$$\Delta CPSPA_t = \Delta CPAdPA_t + \Delta CUDdPA_t - \Delta CPAiPA_t$$

Where,

$\Delta CPSPA_t$	Sum of ex ante estimated actual carbon stock changes in the project area at year t; tCO_2e
$\Delta CPAdPA_t$	Total decrease in carbon stock due to all planned activities at year t in the project area; tCO_2e
$\Delta CUDdPA_t$	Total ex ante actual carbon stock change due to unavoided unplanned deforestation at year t in the project area; tCO_2e
$\Delta CPAiPA_t$	Total increase in carbon stock due to all planned activities at year t in the project area; tCO_2e

Due to the importance of project activities, which is expected to generate improvements in the local economy and employment generation, the Effectiveness Index (EI) was conservatively assumed as 94.53%. This percentage was calculated based on the effectiveness of other VM0015 REDD projects located in Brazil in containing deforestation, comparing the project versus the baseline scenarios in verified monitoring reports.

It was then applied to the ex-ante estimate of net carbon stock change in the project area under the project scenario, shown in Table below.

Table 51. Ex ante estimated net carbon stock change in the project area under the project scenario

Project year t	Total carbon stock decrease due to planned activities		Total carbon stock increase due to planned activities		Total carbon stock decrease due to unavoided unplanned deforestation		Total carbon stock change in the project case	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CPAdPA_t$	$\Delta CPAdPA$	$\Delta CPAiPA_t$	$\Delta CPAiPA$	$\Delta CUDdPA_t$	$\Delta CUDdPA$	$\Delta CPSPA_t$	$\Delta CPSPA$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	0.00	0.00	0.00	0.00	9,761.09	9,761.09	9,761.09	9,761.09
2023	0.00	0.00	0.00	0.00	18,299.35	28,060.45	18,299.35	28,060.45
2024	0.00	0.00	0.00	0.00	18,176.70	46,237.14	18,176.70	46,237.14
2025	0.00	0.00	0.00	0.00	18,056.70	64,293.85	18,056.70	64,293.85
2026	0.00	0.00	0.00	0.00	17,939.32	82,233.17	17,939.32	82,233.17
2027	0.00	0.00	0.00	0.00	17,824.48	100,057.64	17,824.48	100,057.64
2028	0.00	0.00	0.00	0.00	17,265.56	117,323.21	17,265.56	117,323.21
2029	0.00	0.00	0.00	0.00	17,168.10	134,491.31	17,168.10	134,491.31
2030	0.00	0.00	0.00	0.00	17,072.70	151,564.01	17,072.70	151,564.01
2031	0.00	0.00	0.00	0.00	16,979.31	168,543.32	16,979.31	168,543.32
2032	0.00	0.00	0.00	0.00	16,659.12	185,202.44	16,659.12	185,202.44
2033	0.00	0.00	0.00	0.00	16,226.98	201,429.42	16,226.98	201,429.42
2034	0.00	0.00	0.00	0.00	15,465.71	216,895.13	15,465.71	216,895.13
2035	0.00	0.00	0.00	0.00	15,134.41	232,029.53	15,134.41	232,029.53
2036	0.00	0.00	0.00	0.00	14,810.20	246,839.74	14,810.20	246,839.74
2037	0.00	0.00	0.00	0.00	14,492.95	261,332.69	14,492.95	261,332.69
2038	0.00	0.00	0.00	0.00	14,192.96	275,525.65	14,192.96	275,525.65
2039	0.00	0.00	0.00	0.00	13,895.39	289,421.05	13,895.39	289,421.05
2040	0.00	0.00	0.00	0.00	13,225.16	302,646.21	13,225.16	302,646.21
2041	0.00	0.00	0.00	0.00	12,949.56	315,595.76	12,949.56	315,595.76
2042	0.00	0.00	0.00	0.00	12,679.70	328,275.46	12,679.70	328,275.46
2043	0.00	0.00	0.00	0.00	12,415.46	340,690.93	12,415.46	340,690.93
2044	0.00	0.00	0.00	0.00	12,166.39	352,857.31	12,166.39	352,857.31
2045	0.00	0.00	0.00	0.00	11,918.81	364,776.12	11,918.81	364,776.12
2046	0.00	0.00	0.00	0.00	11,327.55	376,103.67	11,327.55	376,103.67
2047	0.00	0.00	0.00	0.00	11,098.34	387,202.01	11,098.34	387,202.01
2048	0.00	0.00	0.00	0.00	10,873.76	398,075.77	10,873.76	398,075.77
2049	0.00	0.00	0.00	0.00	10,653.74	408,729.51	10,653.74	408,729.51
2050	0.00	0.00	0.00	0.00	10,447.05	419,176.55	10,447.05	419,176.55
2051	0.00	0.00	0.00	0.00	10,241.15	429,417.70	10,241.15	429,417.70
2052	0.00	0.00	0.00	0.00	10,035.95	439,453.65	10,035.95	439,453.65

As forest fires were included in the baseline scenario, non-CO_2 emissions from biomass burning should also be included in the project scenario. This is done by multiplying the baseline emissions by the factor (1 – EI), as follows.

$$EBBPSPA_t = EBBBSPA_t * (1 - EI)$$

Where,

$EBBPSPA_t$	Total *ex ante* actual non-CO_2 emissions from forest fire due to unavoided unplanned deforestationat at year t in the project area; tCO_2e/ha
$EBBBSPA_t$	Total non-CO_2 emissions from forest fire at year t in the project area; tCO_2e
EI	*Ex ante* estimated Effectiveness Index; %
t	1, 2, 3 … t, a year of the proposed project crediting period; dimensionless

Furthermore, it is conservatively assumed that all unplanned deforestation within the project area will involve fire and all above ground biomass will be burnt. It is worth mentioning that the effect of fire on CO_2 emissions is counted in the estimation of carbon stock changes in the parameter ΔCUDdPAt; therefore, CO_2 emissions from forest fires should be ignored to avoid double counting.

Table 52. Total ex ante estimated actual emissions of non-CO2 gases due to forest fires in the project area

Project year *t*	Total ex ante estimated actual non-CO_2 emissions from forest fires in the Project area	
	$EBBPSPA_t$	EBBPSPA
	annual	cumulative
	tCO_2e	tCO_2e
2022	392.48	392.48
2023	729.91	1,122.39
2024	714.07	1,836.46
2025	698.57	2,535.02
2026	683.40	3,218.42
2027	668.56	3,886.99
2028	636.09	4,523.08
2029	622.66	5,145.74
2030	609.52	5,755.26
2031	596.65	6,351.91
2032	584.05	6,935.96
2033	571.72	7,507.68
2034	543.10	8,050.78
2035	531.98	8,582.76
2036	521.08	9,103.83
2037	510.40	9,614.23
2038	499.94	10,114.17
2039	489.70	10,603.87
2040	464.43	11,068.30
2041	455.21	11,523.51
2042	446.18	11,969.70
2043	437.33	12,407.03
2044	428.66	12,835.68
2045	420.15	13,255.84
2046	397.80	13,653.63
2047	390.17	14,043.80
2048	382.70	14,426.50
2049	375.36	14,801.86
2050	368.17	15,170.03
2051	361.11	15,531.14
2052	354.06	15,885.20

<u>Total *ex ante* estimations for the project area</u>

The expected *ex ante* net carbon stock changes and non-CO_2 emissions in the Project area is summarized in the table below.

Table 53. Total ex ante estimated actual net carbon stock changes and emissions of non-CO2 gases in the project area

Project year *t*	Total *ex ante* carbon stock decrease due to planned activities		Total *ex ante* carbon stock increase due to planned activities		Total *ex ante* carbon stock decrease due to unavoided unplanned deforestation		Total *ex ante* carbon stock change		Total *ex ante* estimated actual non-CO_2 emissions from forest fires in the project area	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CPAdPA_t$	$\Delta CPAdPA$	$\Delta CPAiPA_t$	$\Delta CPAiPA$	$\Delta CUDdPA_t$	$\Delta CUDdPA$	$\Delta CPSPA_t$	$\Delta CPSPA$	$EBBPSPA_t$	$EBBPSPA$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	0	0	0	0	9,761	9,761	9,761	9,761	392	392
2023	0	0	0	0	18,299	28,060	18,299	28,060	730	1,122
2024	0	0	0	0	18,177	46,237	18,177	46,237	714	1,836
2025	0	0	0	0	18,057	64,294	18,057	64,294	699	2,535
2026	0	0	0	0	17,939	82,233	17,939	82,233	683	3,218
2027	0	0	0	0	17,824	100,058	17,824	100,058	669	3,887
2028	0	0	0	0	17,266	117,323	17,266	117,323	636	4,523
2029	0	0	0	0	17,168	134,491	17,168	134,491	623	5,146
2030	0	0	0	0	17,073	151,564	17,073	151,564	610	5,755
2031	0	0	0	0	16,979	168,543	16,979	168,543	597	6,352
2032	0	0	0	0	16,659	185,202	16,659	185,202	584	6,936
2033	0	0	0	0	16,227	201,429	16,227	201,429	572	7,508
2034	0	0	0	0	15,466	216,895	15,466	216,895	543	8,051
2035	0	0	0	0	15,134	232,030	15,134	232,030	532	8,583
2036	0	0	0	0	14,810	246,840	14,810	246,840	521	9,104
2037	0	0	0	0	14,493	261,333	14,493	261,333	510	9,614
2038	0	0	0	0	14,193	275,526	14,193	275,526	500	10,114
2039	0	0	0	0	13,895	289,421	13,895	289,421	490	10,604
2040	0	0	0	0	13,225	302,646	13,225	302,646	464	11,068
2041	0	0	0	0	12,950	315,596	12,950	315,596	455	11,524
2042	0	0	0	0	12,680	328,275	12,680	328,275	446	11,970
2043	0	0	0	0	12,415	340,691	12,415	340,691	437	12,407
2044	0	0	0	0	12,166	352,857	12,166	352,857	429	12,836
2045	0	0	0	0	11,919	364,776	11,919	364,776	420	13,256
2046	0	0	0	0	11,328	376,104	11,328	376,104	398	13,654
2047	0	0	0	0	11,098	387,202	11,098	387,202	390	14,044
2048	0	0	0	0	10,874	398,076	10,874	398,076	383	14,426
2049	0	0	0	0	10,654	408,730	10,654	408,730	375	14,802
2050	0	0	0	0	10,447	419,177	10,447	419,177	368	15,170
2051	0	0	0	0	10,241	429,418	10,241	429,418	361	15,531
2052	0	0	0	0	10,036	439,454	10,036	439,454	354	15,885

4.3 Leakage

This step provides an *ex ante* estimate of the possible decrease in carbon stock and increase in GHG emissions (other than carbon stock change) due to leakage. According to the applied methodology, two sources of leakage are considered: a) decrease in carbon stocks and increase in GHG emissions associated with leakage prevention measures; and b) decrease in carbon stocks and increase in GHG emissions associated with activity displacement leakage.

Ex ante **estimation of decrease in carbon stocks and increase in GHG emissions due to leakage prevention measures**

To reduce the risk of activity displacement leakage, baseline deforestation agents could participate in activities within the project area and leakage management area that together will replace baseline income, product generation and livelihood of the agents as much as possible, so that deforestation will be reduced, and the risk of displacement minimized. As such, a reduction in carbon stocks and/or an increase in GHG emissions may occur compared to the baseline case. If this decrease in carbon stock or increase in GHG emission is significant, it must be accounted, and ex post monitoring will be required.

Leakage prevention activities generating a decrease in carbon stocks should be estimated *ex ante* and accounted. In order to calculate the net carbon stock changes that the planned leakage prevention measures are expected to occasion during the project crediting period, the projected carbon stocks shall be estimated in the leakage management area under the baseline case and project scenario.

The following activities in leakage management areas could occasion a decrease in carbon stocks or an increase in GHG emissions:

- Carbon stock changes due to activities implemented in leakage management areas;
- Methane (CH_4) and nitrous oxide (N_2O) emissions from livestock intensification (involving a change in the animal diet and/or animal numbers).

$$\Delta CLPMLKt = \Delta CBSLLKt - \Delta CPSLKt$$

Where,

ΔCLPMLKt	Carbon stock decrease due to leakage prevention measures at year t; tCO_2e
ΔCBSLLKt	Annual carbon stock changes in leakage management areas in the baseline case at year t; tCO_2e
ΔCPSLKt	Annual carbon stock change in leakage management areas in the project case; tCO_2e

If the net sum of carbon stock changes within a monitoring period is more than zero, leakage prevention measures are not causing any carbon stock decrease. The net increase shall conservatively be ignored in the calculation of net GHG emission reductions of the project activity. Nevertheless, if the net sum is negative, it must be accounted if significant.

According to the planned interventions proposed by present project activity, no decrease in carbon stocks and/or increase in GHG emissions due to activities implemented in the leakage management area were identified. The leakage prevention measures proposed by the present project do not include agricultural intensification, fertilization, fodder production and/or other measures to enhance cropland and grazing land areas. However, if such activities are implemented in the future, changes in carbon stock will be monitored, and if significant, will be accounted. In addition, it is important to note that consumption of fossil fuels is considered insignificant in avoided unplanned deforestation project activities and shall not be considered

Therefore, the total *ex ante* estimated carbon stock changes and increases in GHG emissions due to leakage prevention measures are shown in the table below.

Table 54. Ex ante estimated net carbon stock change in leakage management areas

Project year	Total carbon stock change in the baseline case		Total carbon stock change in the project case		Net carbon stock change due to leakage prevention measures	
	annual	cumulatve	annual	cumulatve	annual	cumulatve
	$\Delta CBSLLK_t$	$\Delta CBSLLK$	$\Delta CPSLK_t$	$\Delta CPSLK$	$\Delta CLPMLK_t$	$\Delta CLPMLK$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	0.00	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00	0.00
2024	0.00	0.00	0.00	0.00	0.00	0.00
2025	0.00	0.00	0.00	0.00	0.00	0.00
2026	0.00	0.00	0.00	0.00	0.00	0.00
2027	0.00	0.00	0.00	0.00	0.00	0.00
2028	0.00	0.00	0.00	0.00	0.00	0.00
2029	0.00	0.00	0.00	0.00	0.00	0.00
2030	0.00	0.00	0.00	0.00	0.00	0.00
2031	0.00	0.00	0.00	0.00	0.00	0.00
2032	0.00	0.00	0.00	0.00	0.00	0.00
2033	0.00	0.00	0.00	0.00	0.00	0.00
2034	0.00	0.00	0.00	0.00	0.00	0.00
2035	0.00	0.00	0.00	0.00	0.00	0.00
2036	0.00	0.00	0.00	0.00	0.00	0.00
2037	0.00	0.00	0.00	0.00	0.00	0.00
2038	0.00	0.00	0.00	0.00	0.00	0.00
2039	0.00	0.00	0.00	0.00	0.00	0.00
2040	0.00	0.00	0.00	0.00	0.00	0.00
2041	0.00	0.00	0.00	0.00	0.00	0.00
2042	0.00	0.00	0.00	0.00	0.00	0.00
2043	0.00	0.00	0.00	0.00	0.00	0.00
2044	0.00	0.00	0.00	0.00	0.00	0.00
2045	0.00	0.00	0.00	0.00	0.00	0.00
2046	0.00	0.00	0.00	0.00	0.00	0.00
2047	0.00	0.00	0.00	0.00	0.00	0.00
2048	0.00	0.00	0.00	0.00	0.00	0.00
2049	0.00	0.00	0.00	0.00	0.00	0.00
2050	0.00	0.00	0.00	0.00	0.00	0.00
2051	0.00	0.00	0.00	0.00	0.00	0.00
2052	0.00	0.00	0.00	0.00	0.00	0.00

No livestock agriculture increase resulting from activities developed by the 1st Instance is predicted to occur in the project scenario compared to the baseline case. However, in case any future instance includes any activity that might result in such increase, in order to estimate the increase in emissions of methane and nitrous oxide from grazing animals in leakage management areas, the GHG emissions are estimated as follows, according to Appendix 4 of the applied Methodology and default values from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 – AFOLU, Chapter 10[141]:

$$EgLK_t = ECH_4ferm_t + ECH_4man_t + EN_2Oman_t$$

Where,

$EgLK_t$	Emissions from grazing animals in leakage management areas at year t; tCO_2e/year
ECH_4ferm_t	CH_4 emissions from enteric fermentation in leakage management areas at year t; tCO_2e/year
ECH_4man_t	CH_4 emissions from manure management in leakage management areas year t; tCO_2e/year
EN_2Oman_t	N_2O emissions from manure management in leakage management areas at year t; tCO_2e/year
t	1, 2, 3, … T years of the project crediting period; dimensionless

$$ELPMLK_t = EgLK_t + \Delta CLPMLK_t$$

Where,

$ELPMLK_t$	Annual total increase in GHG emissions due to leakage prevention measures at year t; tCO_2e

The leakage prevention measures proposed by the 1st instance project activity does not include agricultural intensification, fertilization, fodder production and/or other measures to enhance cropland and grazing land areas.

[141] Available at https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf

Table 55. Ex ante estimated total emissions above the baseline from leakage prevention activities

Project year	Carbon stock decrease due to leakage prevention measures		Total *ex ante* GHG emissions from increased grazing activities		Total *ex ante* increase in GHG emissions due to leakage prevention measures	
	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CLPMLK_t$	$\Delta CLPMLK$	$EgLK_t$	$EgLK$	$ELPMLK_t$	$ELPMLK$
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	0.00	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00	0.00
2024	0.00	0.00	0.00	0.00	0.00	0.00
2025	0.00	0.00	0.00	0.00	0.00	0.00
2026	0.00	0.00	0.00	0.00	0.00	0.00
2027	0.00	0.00	0.00	0.00	0.00	0.00
2028	0.00	0.00	0.00	0.00	0.00	0.00
2029	0.00	0.00	0.00	0.00	0.00	0.00
2030	0.00	0.00	0.00	0.00	0.00	0.00
2031	0.00	0.00	0.00	0.00	0.00	0.00
2032	0.00	0.00	0.00	0.00	0.00	0.00
2033	0.00	0.00	0.00	0.00	0.00	0.00
2034	0.00	0.00	0.00	0.00	0.00	0.00
2035	0.00	0.00	0.00	0.00	0.00	0.00
2036	0.00	0.00	0.00	0.00	0.00	0.00
2037	0.00	0.00	0.00	0.00	0.00	0.00
2038	0.00	0.00	0.00	0.00	0.00	0.00
2039	0.00	0.00	0.00	0.00	0.00	0.00
2040	0.00	0.00	0.00	0.00	0.00	0.00
2041	0.00	0.00	0.00	0.00	0.00	0.00
2042	0.00	0.00	0.00	0.00	0.00	0.00
2043	0.00	0.00	0.00	0.00	0.00	0.00
2044	0.00	0.00	0.00	0.00	0.00	0.00
2045	0.00	0.00	0.00	0.00	0.00	0.00
2046	0.00	0.00	0.00	0.00	0.00	0.00
2047	0.00	0.00	0.00	0.00	0.00	0.00
2048	0.00	0.00	0.00	0.00	0.00	0.00
2049	0.00	0.00	0.00	0.00	0.00	0.00
2050	0.00	0.00	0.00	0.00	0.00	0.00
2051	0.00	0.00	0.00	0.00	0.00	0.00
2052	0.00	0.00	0.00	0.00	0.00	0.00

<u>*Ex ante* estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage</u>

Activities that will cause deforestation within the project area in the baseline case could be displaced outside the project boundary due to the implementation of the AUD project activity. A greater decrease in carbon stocks within the leakage belt during the project scenario than those predicted ex-ante would indicate displacement of deforestation activities due to the project.

The baseline rate of deforestation within the leakage belt is shown in the variable ABSLLK. The ex ante activity displacement leakage is calculated based on the anticipated combined effectiveness of the proposed leakage prevention measures and project activities. This is done by multiplying the estimated baseline carbon stock changes for the project area by a "Displacement Leakage Factor" (DLF) representing the percent of deforestation expected to be displaced outside the project boundary. It is calculated as follows:

$$\Delta CADLKt = \Delta CBSLPAt * DLF$$

Where,

ΔCADLKt	Total decrease in carbon stocks due to displaced deforestation at year t; tCO_2e
DLF	Displacement leakage factor; %

As per the methodology, where leakage prevention activities are implemented, the factor shall be equal to the proportion of the baseline agents estimated to be given the opportunity to participate in leakage prevention activities and project activities.

To reduce the risk of activity displacement leakage, baseline deforestation agents mapped may participate in activities within the project area and leakage management area, so that deforestation will be reduced, and the risk of displacement minimized. This is monitored by social reports such as SOCIALCARBON report, which analyzes education and training programs, alternative income sources and the extent of social activities to local communities.

For this project, the default activity-shifting leakage deduction of 15 percent to the gross GHG emission reductions and/or removals was considered, as per VCS Standard.

Furthermore, the *ex ante* emissions from forest fires due to activity displacement leakage was calculated by multiplying baseline forest fire emissions in the project area by the same DLF[142] used to estimate the decrease in carbon stocks, as follows.

$$EADLKt_t = EBBBSPA_t * DLF$$

Where,

[142] If deforestation agents do not participate in leakage prevention activities and project activities, the Displacement Factor shall be 100%. Where leakage prevention activities are implemented, the factor shall be equal to the proportion of the baseline agents estimated to be given the opportunity to participate in leakage prevention activities and project activities.

$EADLKt_t$	Total *ex ante* estimated increase in GHG emissions due to displaced forest fires; tCO_2e
$EBBBSPA_t$	Total non-CO_2 emissions from forest fire at year t in the project area; tCO_2e
DLF	Displacement leakage factor; %
t	1, 2, 3 … t, a year of the proposed project crediting period; dimensionless

The actual calculated values for ex ante estimated leakage due to activity displacement, annually and cumulatively, are shown in the table below

Table 56. Ex ante estimated leakage due to activity displacement

Project year	Total ex ante estimated decrease in carbon stocks due to displaced deforestation		Total ex ante estimated increase in GHG emissions due to displaced forest fires	
	annual	cumulative	annual	cumulative
	$\Delta CADLK_t$	$\Delta CADLK$	$EADLK_t$	EADLK
	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	26,761.68	26,761.68	1,076.04	1,076.04
2023	50,170.76	76,932.44	2,001.18	3,077.22
2024	49,834.48	126,766.92	1,957.74	5,034.96
2025	49,505.50	176,272.42	1,915.24	6,950.19
2026	49,183.66	225,456.08	1,873.66	8,823.85
2027	48,868.81	274,324.89	1,832.98	10,656.83
2028	47,336.45	321,661.34	1,743.96	12,400.79
2029	47,069.25	368,730.59	1,707.14	14,107.92
2030	46,807.68	415,538.27	1,671.09	15,779.02
2031	46,551.64	462,089.91	1,635.81	17,414.83
2032	45,673.78	507,763.69	1,601.27	19,016.10
2033	44,488.99	552,252.68	1,567.46	20,583.56
2034	42,401.85	594,654.53	1,489.01	22,072.57
2035	41,493.52	636,148.05	1,458.50	23,531.07
2036	40,604.67	676,752.72	1,428.62	24,959.69
2037	39,734.87	716,487.59	1,399.34	26,359.03
2038	38,912.40	755,399.99	1,370.67	27,729.70
2039	38,096.56	793,496.55	1,342.59	29,072.29
2040	36,259.01	829,755.56	1,273.31	30,345.60
2041	35,503.39	865,258.95	1,248.05	31,593.65
2042	34,763.52	900,022.48	1,223.29	32,816.94
2043	34,039.09	934,061.56	1,199.02	34,015.96
2044	33,356.20	967,417.76	1,175.23	35,191.19
2045	32,677.43	1,000,095.19	1,151.92	36,343.11
2046	31,056.39	1,031,151.57	1,090.62	37,433.73
2047	30,427.96	1,061,579.53	1,069.72	38,503.45
2048	29,812.25	1,091,391.78	1,049.22	39,552.68
2049	29,209.01	1,120,600.79	1,029.12	40,581.79
2050	28,642.34	1,149,243.13	1,009.40	41,591.19
2051	28,077.83	1,177,320.96	990.05	42,581.24
2052	27,515.24	1,204,836.20	970.71	43,551.95

Ex ante estimation of total leakage

The result of all sources of leakage is calculated as follows:

$$\Delta CLKt = \Delta CADLKt + \Delta CLPMLKt$$

Where,

ΔCLKt	Total decrease in carbon stocks within the leakage belt at year t; tCO_2e
ΔCADLKt	Total decrease in carbon stocks due to displaced deforestation at year t; tCO_2e
ΔCLPMLKt	Carbon stock decrease due to leakage prevention measures at year t; tCO_2e

To reduce the risk of activity displacement leakage, baseline deforestation agents shall participate in activities within the project area and leakage management area, so that deforestation will be reduced, and the risk of displacement minimized.

If leakage prevention activities include measures to enhance cropland and grazing land areas, a reduction in carbon stocks and/or an increase in GHG emissions may occur compared to the baseline case. The reduction in carbon stocks (ΔCLPMLKt) shall be calculated as explained above. However, leakage emissions due to leakage prevention measures implemented by the project activity shall be calculated as follows:

$$ELK_t = EgLK_t + EADLK_t$$

Where,

ELK_t	Annual total increase in GHG emissions due to leakage prevention measures at year t; tCO_2e
$EgLK_t$	Emissions from grazing animals in leakage management areas at year t; tCO_2e
$EADLK_t$	Total *ex ante* increase in GHG emissions due to displaced forest fires at year t; tCO_2e

No displaced forest fires nor increase in GHG emissions due to activities implemented in the leakage management area are expected to occur, such as emissions from fertilizer or fuel use.

Table 57. Ex ante estimated total leakage

Project year	Total ex ante GHG emissions from increased grazing activities		Total ex ante increase in GHG emissions due to displaced forest fires		Total ex ante decrease in carbon stocks due to displaced deforestation		Carbon stock decrease due to leakage prevention measures		Total net carbon stock change due to leakage		Total net increase in emissions due to leakage	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$EgLK_t$	$EgLK$	$EADLK_t$	$EADLK$	$\Delta CADLK_t$	$\Delta CADLK$	$\Delta CLPMLK_t$	$\Delta CLPMLK$	ΔCLK_t	ΔCLK	ELK_t	ELK
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	0	0	1,076	1,076	26,762	26,762	0	0	26,762	26,762	1,076	1,076
2023	0	0	2,001	3,077	50,171	76,932	0	0	50,171	76,932	2,001	3,077
2024	0	0	1,958	5,035	49,834	126,767	0	0	49,834	126,767	1,958	5,035
2025	0	0	1,915	6,950	49,505	176,272	0	0	49,505	176,272	1,915	6,950
2026	0	0	1,874	8,824	49,184	225,456	0	0	49,184	225,456	1,874	8,824
2027	0	0	1,833	10,657	48,869	274,325	0	0	48,869	274,325	1,833	10,657
2028	0	0	1,744	12,401	47,336	321,661	0	0	47,336	321,661	1,744	12,401
2029	0	0	1,707	14,108	47,069	368,731	0	0	47,069	368,731	1,707	14,108
2030	0	0	1,671	15,779	46,808	415,538	0	0	46,808	415,538	1,671	15,779
2031	0	0	1,636	17,415	46,552	462,090	0	0	46,552	462,090	1,636	17,415
2032	0	0	1,601	19,016	45,674	507,764	0	0	45,674	507,764	1,601	19,016
2033	0	0	1,567	20,584	44,489	552,253	0	0	44,489	552,253	1,567	20,584
2034	0	0	1,489	22,073	42,402	594,655	0	0	42,402	594,655	1,489	22,073
2035	0	0	1,459	23,531	41,494	636,148	0	0	41,494	636,148	1,459	23,531
2036	0	0	1,429	24,960	40,605	676,753	0	0	40,605	676,753	1,429	24,960
2037	0	0	1,399	26,359	39,735	716,488	0	0	39,735	716,488	1,399	26,359
2038	0	0	1,371	27,730	38,912	755,400	0	0	38,912	755,400	1,371	27,730
2039	0	0	1,343	29,072	38,097	793,497	0	0	38,097	793,497	1,343	29,072
2040	0	0	1,273	30,346	36,259	829,756	0	0	36,259	829,756	1,273	30,346
2041	0	0	1,248	31,594	35,503	865,259	0	0	35,503	865,259	1,248	31,594
2042	0	0	1,223	32,817	34,764	900,022	0	0	34,764	900,022	1,223	32,817
2043	0	0	1,199	34,016	34,039	934,062	0	0	34,039	934,062	1,199	34,016
2044	0	0	1,175	35,191	33,356	967,418	0	0	33,356	967,418	1,175	35,191
2045	0	0	1,152	36,343	32,677	1,000,095	0	0	32,677	1,000,095	1,152	36,343
2046	0	0	1,091	37,434	31,056	1,031,152	0	0	31,056	1,031,152	1,091	37,434
2047	0	0	1,070	38,503	30,428	1,061,580	0	0	30,428	1,061,580	1,070	38,503
2048	0	0	1,049	39,553	29,812	1,091,392	0	0	29,812	1,091,392	1,049	39,553
2049	0	0	1,029	40,582	29,209	1,120,601	0	0	29,209	1,120,601	1,029	40,582
2050	0	0	1,009	41,591	28,642	1,149,243	0	0	28,642	1,149,243	1,009	41,591
2051	0	0	990	42,581	28,078	1,177,321	0	0	28,078	1,177,321	990	42,581
2052	0	0	971	43,552	27,515	1,204,836	0	0	27,515	1,204,836	971	43,552

4.4 Net GHG Emission Reductions and Removals

The net anthropogenic GHG emission reduction of the proposed AUD project activity is calculated as follows:

$$\Delta REDDt = (\Delta CBSLPAt + EBBBSLPAt) - (\Delta CPSPAt + EBBPSPAt) - (\Delta CLKt + ELKt)$$

Where:

ΔREDDt	Ex ante estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year t; tCO2e
ΔCBSLPAt	Sum of baseline carbon stock changes in the project area at year t; tCO2e
EBBBSLPAt	Sum of baseline emissions from biomass burning in the project area at year t; tCO2e
ΔCPSPAt	Sum of ex ante estimated actual carbon stock changes in the project area at year t; tCO2e Note: If ΔCPSPAt represents a net increase in carbon stocks, a negative sign before the absolute value of ΔCPSPAt shall be used. If ΔCPSPAt represents a net decrease, the positive sign shall be used.
EBBPSPAt	Sum of (ex ante estimated) actual emissions from biomass burning in the project area at year t; tCO2e
ΔCLKt	Sum of ex ante estimated leakage net carbon stock changes at year t; tCO2e Note: If the cumulative sum of ΔCLKt within a fixed baseline period is > 0, ΔCLKt shall be set to zero.
ELKt	Sum of ex ante estimated leakage emissions at year t; tCO2e
t	1, 2, 3 … t, a year of the proposed project crediting period; dimensionless.

The number of Verified Carbon Units (VCUs) to be generated through the proposed AUD project activity at each year is calculated as follows:

$$VCUt = \Delta REDDt - VBCt$$

$$VBCt = (\Delta CBSLPAt - \Delta CPSPAt) * RFt$$

Where:

VCUt	Number of Verified Carbon Units that can be traded at time t; t CO2e
ΔREDDt	Ex ante estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year t; tCO2e

VBCt	Number of Buffer Credits deposited in the VCS Buffer at time t; t CO2e
ΔCBSLPAt	Sum of baseline carbon stock changes in the project area at year t; tCO2e
ΔCPSPAt	Sum of ex ante estimated actual carbon stock changes in the project area at year t; tCO2e ha-1
RFt	Risk factor used to calculate VCS buffer credits; %
t	1, 2, 3 ... T, a year of the proposed project crediting period; dimensionless.

The RFt was estimated using the most recent version of the VCS-approved AFOLU Non-Permanence Risk Tool and the resulting value was 15%.

The specific summary of GHG reductions and removals by this project activity is included in the table below, which includes estimates of GHG emissions reduction (REDDt), calculations of buffer and leakage, and the calculation of tradable Verified Carbon Units (VCUt).

The present REDD project is expected to avoid a predicted 11,105 ha of deforestation, equating to 5,414,343 tCO_2e in emissions reductions over the 30-year project lifetime, with an annual average of 180,478 tCO_2e.

Table 58. Ex ante estimated net anthropogenic GHG emission reductions (REDDt) and verified carbon units (VCUt)

Project year	Baseline carbon stock changes		Baseline GHG emissions from biomass burning		Ex ante project carbon stock changes		Ex ante project GHG emissions from biomass burning		Ex ante leakage carbon stock changes		Ex ante leakage GHG emissions		Ex ante net anthropogenic GHG emission reductions		Ex ante VCUs tradable		Ex ante buffer credits	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulat.	annual	cumulative	annual	cumulat	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CBSLPA_t$	$\Delta CBSLPA$	$EBBBSLPA_t$	EBBBSLPA	$\Delta CPSPA_t$	$\Delta CPSPA$	$EBBPSPA_t$	EBBPSPA	ΔCLK_t	ΔCLK	ELK_t	ELK	$\Delta REDD_t$	$\Delta REDD$	VCU_t	VCU	VBC_t	VBC
	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e	tCO_2e
2022	178,411	178,411	7,174	7,174	9,761	9,761	392	392	26,762	26,762	1,076	1,076	147,594	147,594	122,295	122,295	25,298	25,298
2023	334,472	512,883	13,341	20,515	18,299	28,060	730	1,122	50,171	76,932	2,001	3,077	276,612	424,205	229,185	351,480	47,426	72,723
2024	332,230	845,113	13,052	33,566	18,177	46,237	714	1,836	49,834	126,767	1,958	5,035	274,598	698,804	227,490	578,970	47,108	119,831
2025	330,037	1,175,149	12,768	46,335	18,057	64,294	699	2,535	49,505	176,272	1,915	6,950	272,629	971,433	225,831	804,801	46,797	166,628
2026	327,891	1,503,041	12,491	58,826	17,939	82,233	683	3,218	49,184	225,456	1,874	8,824	270,702	1,242,135	224,209	1,029,010	46,493	213,121
2027	325,792	1,828,833	12,220	71,046	17,824	100,058	669	3,887	48,869	274,325	1,833	10,657	268,817	1,510,952	222,621	1,251,631	46,195	259,316
2028	315,576	2,144,409	11,626	82,672	17,266	117,323	636	4,523	47,336	321,661	1,744	12,401	260,221	1,771,172	215,474	1,467,105	44,747	304,063
2029	313,795	2,458,204	11,381	94,053	17,168	134,491	623	5,146	47,069	368,731	1,707	14,108	258,609	2,029,781	214,114	1,681,219	44,494	348,557
2030	312,051	2,770,255	11,141	105,193	17,073	151,564	610	5,755	46,808	415,538	1,671	15,779	257,031	2,286,812	212,784	1,894,003	44,247	392,804
2031	310,344	3,080,599	10,905	116,099	16,979	168,543	597	6,352	46,552	462,090	1,636	17,415	255,486	2,542,298	211,481	2,105,484	44,005	436,808
2032	304,492	3,385,091	10,675	126,774	16,659	185,202	584	6,936	45,674	507,764	1,601	19,016	250,649	2,792,947	207,473	2,312,957	43,175	479,983
2033	296,593	3,681,685	10,450	137,224	16,227	201,429	572	7,508	44,489	552,253	1,567	20,584	244,188	3,037,135	202,132	2,515,089	42,055	522,038
2034	282,679	3,964,364	9,927	147,150	15,466	216,895	543	8,051	42,402	594,655	1,489	22,073	232,706	3,269,841	192,624	2,707,713	40,082	562,120
2035	276,623	4,240,987	9,723	156,874	15,134	232,030	532	8,583	41,494	636,148	1,459	23,531	227,728	3,497,569	188,505	2,896,218	39,223	601,344
2036	270,698	4,511,685	9,524	166,398	14,810	246,840	521	9,104	40,605	676,753	1,429	24,960	222,857	3,720,427	184,474	3,080,692	38,383	639,727
2037	264,899	4,776,584	9,329	175,727	14,493	261,333	510	9,614	39,735	716,488	1,399	26,359	218,091	3,938,517	180,529	3,261,221	37,561	677,288
2038	259,416	5,036,000	9,138	184,865	14,193	275,526	500	10,114	38,912	755,400	1,371	27,730	213,578	4,152,095	176,794	3,438,015	36,783	714,071
2039	253,977	5,289,977	8,951	193,815	13,895	289,421	490	10,604	38,097	793,497	1,343	29,072	209,103	4,361,199	173,091	3,611,106	36,012	750,083
2040	241,727	5,531,704	8,489	202,304	13,225	302,646	464	11,068	36,259	829,756	1,273	30,346	198,994	4,560,192	164,718	3,775,824	34,275	784,359
2041	236,689	5,768,393	8,320	210,624	12,950	315,596	455	11,524	35,503	865,259	1,248	31,594	194,853	4,755,045	161,292	3,937,116	33,561	817,920
2042	231,757	6,000,150	8,155	218,780	12,680	328,275	446	11,970	34,764	900,022	1,223	32,817	190,799	4,945,845	157,937	4,095,053	32,862	850,781
2043	226,927	6,227,077	7,993	226,773	12,415	340,691	437	12,407	34,039	934,062	1,199	34,016	186,830	5,132,675	154,653	4,249,706	32,177	882,958
2044	222,375	6,449,452	7,835	234,608	12,166	352,857	429	12,836	33,356	967,418	1,175	35,191	183,083	5,315,758	151,551	4,401,257	31,531	914,489
2045	217,850	6,667,301	7,679	242,287	11,919	364,776	420	13,256	32,677	1,000,095	1,152	36,343	179,361	5,495,118	148,471	4,549,728	30,890	945,379
2046	207,043	6,874,344	7,271	249,558	11,328	376,104	398	13,654	31,056	1,031,152	1,091	37,434	170,441	5,665,559	141,083	4,690,811	29,357	974,736
2047	202,853	7,077,197	7,131	256,690	11,098	387,202	390	14,044	30,428	1,061,580	1,070	38,503	166,998	5,832,558	138,235	4,829,046	28,763	1,003,499
2048	198,748	7,275,945	6,995	263,685	10,874	398,076	383	14,426	29,812	1,091,392	1,049	39,553	163,625	5,996,183	135,444	4,964,490	28,181	1,031,680
2049	194,727	7,470,672	6,861	270,545	10,654	408,730	375	14,802	29,209	1,120,601	1,029	40,582	160,320	6,156,503	132,709	5,097,199	27,611	1,059,291
2050	190,949	7,661,621	6,729	277,275	10,447	419,177	368	15,170	28,642	1,149,243	1,009	41,591	157,211	6,313,715	130,135	5,227,334	27,075	1,086,367
2051	187,186	7,848,806	6,600	283,875	10,241	429,418	361	15,531	28,078	1,177,321	990	42,581	154,116	6,467,830	127,574	5,354,908	26,542	1,112,908
2052	87,207	7,936,013	3,077	286,951	4,771	434,189	168	15,699	13,081	1,190,402	461	43,043	71,801	6,539,632	59,435	5,414,343	12,365	1,125,274

Table 59. Summary of net GHG Emission Reductions and Removals

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	*Ex ante* buffer credits (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2022	185,585	10,154	27,838	25,298	122,295
2023	347,813	19,029	52,172	47,426	229,185
2024	345,281	18,891	51,792	47,108	227,490
2025	342,805	18,755	51,421	46,797	225,831
2026	340,382	18,623	51,057	46,493	224,209
2027	338,012	18,493	50,702	46,195	222,621
2028	327,203	17,902	49,080	44,747	215,474
2029	325,176	17,791	48,776	44,494	214,114
2030	323,192	17,682	48,479	44,247	212,784
2031	321,250	17,576	48,187	44,005	211,481
2032	315,167	17,243	47,275	43,175	207,473
2033	307,043	16,799	46,056	42,055	202,132
2034	292,606	16,009	43,891	40,082	192,624
2035	286,347	15,666	42,952	39,223	188,505
2036	280,222	15,331	42,033	38,383	184,474
2037	274,228	15,003	41,134	37,561	180,529
2038	268,554	14,693	40,283	36,783	176,794
2039	262,928	14,385	39,439	36,012	173,091
2040	250,215	13,690	37,532	34,275	164,718
2041	245,010	13,405	36,751	33,561	161,292
2042	239,912	13,126	35,987	32,862	157,937
2043	234,921	12,853	35,238	32,177	154,653
2044	230,210	12,595	34,531	31,531	151,551
2045	225,529	12,339	33,829	30,890	148,471
2046	214,313	11,725	32,147	29,357	141,083
2047	209,985	11,489	31,498	28,763	138,235
2048	205,743	11,256	30,861	28,181	135,444
2049	201,588	11,029	30,238	27,611	132,709
2050	197,678	10,815	29,652	27,075	130,135
2051	193,786	10,602	29,068	26,542	127,574
2052	90,283	4,940	13,542	12,365	59,435
Total	**8,222,965**	**449,888**	**1,233,445**	**1,125,274**	**5,414,343**

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	CF
Data unit	tC/tdm
Description	Default value of carbon fraction in biomass
Source of data	Values from the literature, e.g. IPCC 2003. Good practice guidance for land use, land-use change and forestry. Kanagawa: IGES, 2003. Available at: <http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html>.
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	The default IPCC value was used.
Purpose of Data	This parameter is used to calculate the baseline, project and leakage emissions from deforestation occurred in the baseline and project scenarios. Provides an estimate of the carbon content of the vegetation biomass within the project reference region.
Comments	If new and more accurate carbon fraction data become available, these can be used to estimate the net anthropogenic GHG emission reduction of the subsequent fixed baseline period.

Data / Parameter	$Ctot_{fcl}$
Data unit	tCO_2e/ha
Description	Average carbon stock per hectare in anthropic areas in equilibrium of post-deforestation class fcl in tCO_2e/ha
Source of data	Long-term average carbon stocks per hectare of post-deforestation LU/LC classes present in the reference region were taken from the following study: FEARNSIDE, Philip M. Amazonian deforestation and global warming: carbon stocks in vegetation

	replacing Brazil's Amazon forest. **Forest Ecology And Management,** Manaus, v. 80, p.21-34, 1996.
Value applied	46.93
Justification of choice of data or description of measurement methods and procedures applied	Fearnside (1996) is one of the most recognized studies for the Brazilian Amazon about long term carbon stocks in deforested areas. Following a literature review, the use of Fearnside value for non-forest vegetation carbon stocks in equilibrium is conservative because it is based on several land-use types in the Amazon, including agriculture, pasturelands and secondary vegetation, reaching a final value of 46.93 tCO2/ha. Meanwhile, based on the Brazilian Government data available in the 3rd National GHG Inventory from 2019, the weighted average for carbon stocks in other land uses (mainly agriculture and pasturelands) was 32.99 tCO2e. Therefore, the most conservative value between these two data was used.
Purpose of Data	This parameter is used to calculate the baseline emissions from deforestation occurred in the baseline scenario. Provides an average of the post-deforestation carbon stock per hectare within the reference region.
Comments	If new and more accurate biomass stock data become available, these can be used to estimate the net anthropogenic GHG emission reduction of the subsequent fixed baseline period.

Data / Parameter	DLF
Data unit	%
Description	Displacement Leakage Factor
Source of data	According to VCS requirements, where the applied methodology requires the quantification of activity-shifting leakage, projects may apply the optional default activity-shifting leakage deduction of 15 percent to the gross GHG emission reductions and/or removals.
Value applied	15%
Justification of choice of data or description of measurement methods and procedures applied	The DLF was estimated as 15%, based on default value of the VCS requirements, where the applied methodology requires the quantification of activity-shifting leakage.
Purpose of Data	This parameter is used to calculate leakage emissions in the baseline scenario due to activity displacement leakage, providing

	an *ex ante* estimation of the decrease in carbon stocks and increase in GHG emissions. This value estimates the percentage of deforestation expected to be displaced outside the project boundary due to the implementation of the AUD project activity.
Comments	*Ex post* monitoring of the leakage belt will be done to determine deforestation rate outside the project area and the leakage emissions and carbon stock decrease. This parameter will be updated at each renewal of fixed baseline period.

Data / Parameter	$\Delta CBSLLK_t$
Data unit	tCO_2e
Description	Annual carbon stock changes in leakage management areas in the baseline case at year t
Source of data	- Planned interventions proposed by the project proponent. - Remote sensing and GIS.
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	Leakage prevention activities generating a decrease in carbon stocks should be estimated *ex ante* and accounted. The leakage prevention measures proposed by the present project do not include decrease in carbon stocks due to activities implemented in the leakage management area.
Purpose of Data	This parameter was used to calculate leakage emissions in the baseline scenario due to leakage prevention measures implemented in the leakage management area. It provides an *ex ante* estimation of the decrease in carbon stocks due to the activities implemented.
Comments	*Ex post* monitoring of the leakage management area will be done to determine the carbon stock decrease and the leakage emissions. This parameter will be updated at each renewal of fixed baseline period.

Data / Parameter	$EBBBSLPA_t$
Data unit	tCO_2e

Description	Sum of (or total) baseline non-CO2 emissions from forest fire at year t in the project area
Source of data	Remote sensing data and GIS, supervisor reports.
Value applied	9,678.21 (Annual average actual non-CO_2 emissions due to biomass burning within the project area during the crediting period)
Justification of choice of data or description of measurement methods and procedures applied	Slash-and-burn deforestation to clear the area is carried out for cattle ranching, which is the main cause of deforestation within the project area. Therefore, baseline deforestation in the project area involves fire and all above ground biomass is burnt. Non-CO_2 emissions from biomass burning are calculated according to requirements of methodology VM0015 v1.1. In order to estimate non-CO_2 emissions from forest fires, the average percentage of the area which contemplates the municipalities within the RR that was cleared by burning for other land uses involving deforestation, such as cattle raising and farming (Fburnt), and the average of biomass that has commercial value, and could be removed prior to clear cutting and burning (Pburnt,p) were estimated, either for the baseline and project case. Therefore, this parameter is estimated as the multiplication of the annual area of deforestation of initial forest classes in the project area in the baseline scenario (ABSLPAicl,t) times the total GHG emission from biomass burning in initial forest classes (EBBtoticl,t).
Purpose of data	This parameter is used to calculate non-CO_2 emissions due to forest fires within the project area in the baseline scenario, providing an ex-ante estimation.
Comments	Ex post monitoring of forest fires and non-CO_2 emissions (EBBPSPAt) will be done to determine GHG emissions within the project area (when the forest fire was significant).

Data / Parameter	$Fburnt_{icl}$
Data unit	%
Description	Proportion of forest area burned during the historical reference period in the forest class.
Source of data	Measured or estimated from literature. *Fburnt data source:*

	- Heat spots: Data from the municipalities within the reference region during the historical reference period. <https://queimadas.dgi.inpe.br/queimadas/bdqueimadas> - Deforestation: <http://terrabrasilis.dpi.inpe.br/downloads/>
Value applied	89.94
Justification of choice of data or description of measurement methods and procedures applied	The Fburnt analysis was carried out on the municipalities of the reference region, as it is where the Project Area is fully inserted in. Heat spots were considered during the historical reference period (prior to 2014, the data has no fire risk classification, and therefore, was not taken into account). For the assessed years, the fire risk predicted for the day of detection of the outbreak was considered, contemplating only outbreaks with a fire risk of >= 0.5 as, according to INPE's methodology, fire risk higher than 0.4 is considered as medium to critical (=1). By overlapping these fire outbreaks with the deforestation mapping of the same time period, it was possible to verify the tendency of fire outbreaks being directly related to areas with recent and/or consolidated deforestation. This can also be verified by the proximity of deforestation detection dates by satellite and the close or overlapping heat spots. Thus, it is possible to assume that these outbreaks are related to anthropic actions to open pastures/crops. Thereby, there was an overlap of 89.94% of the pixels analysed during the reference period in the municipalities.
Purpose of data	This parameter is the average percentage of the area which contemplates the three municipalities within the reference region that was cleared by burning for other land uses involving deforestation, such as cattle raising and farming, and is used to calculate baseline and project non-CO_2 emissions from forest fire at year t in the project area (parameter EBBBSLPAt).
Comments	Monitoring is done only once at project start.

Data / Parameter	$Pburnt_{p,icl}$
Data unit	%
Description	Average proportion of mass burnt in the carbon pool in the forest class
Source of data	Measured or estimated from literature.

	Pburnt data source: Anderson LO, Aragão LE, Gloor M, et al. **Disentangling the contribution of multiple land covers to fire-mediated carbon emissions in Amazonia during the 2010 drought.** Global Biogeochem Cycles. 2015; 29 (10):1739-1753. Doi: 10.1002/2014GB005008. Available at <https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2014GB005008>.
Value applied	78
Justification of choice of data or description of measurement methods and procedures applied	Pburnt was estimated using the average biomass per hectare that has commercial value and could be removed prior to clear cutting and burning. Based on literature, an average value of 61.6 m^3/ha was obtained, which would correspond to approximately 11% of the total biomass in 1 ha. In this way, the remaining is burned to clear the area, therefore, its new value is 88.6%. However, due to the lack of literature estimates, a study from the Brazilian Amazon in the Cerrado vegetation was used for the comparison. This study reported that the total biomass consumed by fires varies from 72% to 84% (average 78%) in denser Cerrado types, which is a forest vegetation. The most conservative value between these two estimates were used, i.e., Pburnt was estimated as 78%. It is important to note that slash and burn practices are commonly used in the Amazon region to clear the area for other land uses thus, when burning an area, the main objective is to completely remove all the remaining biomass. Therefore, assuming that 78% of the biomass is combusted, there would still be a 22% remaining biomass that shall be left to decompose, which also emits GHG to the atmosphere in this process.
Purpose of data	This parameter is the average of biomass that has commercial value, and could be removed prior to clear cutting and burning, and is used to calculate baseline and project non-CO_2 emissions from forest fire at year t in the project area (parameter EBBBSLPAt).
Comments	Monitoring is done only once at project start.

Data / Parameter	EI
Data unit	%
Description	*Ex ante* estimated effectiveness index

Source of data	Estimate from project proponent based on verified reports of similar VM0015 REDD projects in Brazil up to date. Available in VERRA database.
Value applied	94.53%
Justification of choice of data or description of measurement methods and procedures applied	Based on the comparison between *ex post* and *ex ante* deforestation of similar REDD projects developed in Brazil, available in verified reports in VERRA database up to date.
Purpose of Data	This parameter is used to calculate project emissions in the baseline scenario. Provides an *ex ante* estimation of the carbon stock changes due to unavoidable unplanned deforestation within the project area, based on the effectiveness of the proposed project activities to reduce the deforestation.
Comments	*Ex post* monitoring of the project area will be done to determine deforestation rate and the project emissions. This parameter will be updated at each renewal of fixed baseline period.

5.2 Data and Parameters Monitored

Data / Parameter	ab_{icl}
Data unit	Mg/ha
Description	Average biomass stock per hectare in the above-ground biomass pool of initial forest class icl in Mg/ha.
Source of data	Average values for the above-ground biomass were taken from the following study: HIGUCHI, Francisco Gasparetto. Dinâmica de volume e biomassa da floresta de terra firme do Amazonas. 2015. 201 f. Tese (Doutorado) - Curso de Engenharia Florestal, Setor de Ciências Agrárias, Universidade Federal do Paraná, Curitiba, 2015.
Description of measurement methods and procedures to be applied	The following sources will be monitored: - Biomass stock surveys - Periodic reports from area supervisor - Local Forest Inventories
Frequency of monitoring/recording	At each monitoring report.

Value applied	<table><tr><th colspan="4">Above-ground biomass</th></tr><tr><th colspan="4">ab_{icl} (Mg/ha)</th></tr><tr><th>Vegetation</th><th>Reference Region</th><th>Project Area</th><th>Leakage Belt</th></tr><tr><td>Forest (Dense Lowland Tropical Rainforest)</td><td>327.40</td><td>327.40</td><td>327.40</td></tr></table>
Monitoring equipment	No monitoring equipment is used to determine this parameter.
QA/QC procedures to be applied	Data shall be in accordance to VM0015 v1.1 requirements
Purpose of data	This parameter is used to calculate baseline emissions, project emissions and leakage emissions in both baseline and project scenarios.
Calculation method	Following a literature search the above-ground biomass values of this study was used because it accurately represents the values of vegetation within the project reference region.
Comments	The values will be reassessed every 6 years or when data is more than 6 years old, whichever occurs first.

Data / Parameter	bb_{icl}
Data unit	Mg/ha
Description	Average biomass stock per hectare in the below-ground biomass pool of initial forest class icl in Mg/ha.
Source of data	Average values for the below-ground biomass were taken from the applied methodology VM0015 v1.1, which estimates a root-to-shoot ratio of 0.24 for tropical rainforest having above ground biomass values above 125 tons/ha, and 0.20 for values below 125 tons/ha.
Description of measurement methods and procedures to be applied	The following sources will be monitored: - Biomass stock surveys - Periodic reports from area supervisor - Local Forest Inventories
Frequency of monitoring/recording	At each monitoring report.
Value applied	

	Below-ground biomass bb_{icl} (Mg/ha) Vegetation | Reference Region | Project Area | Leakage Belt Forest (Dense Lowland Tropical Rainforest) | 78.58 | 78.58 | 78.58
Monitoring equipment	No monitoring equipment is used to determine this parameter.
QA/QC procedures to be applied	Data shall be in accordance to VM0015 v1.1 requirements
Purpose of data	This parameter is used to calculate baseline, project and leakage emissions in the baseline and project scenarios.
Calculation method	Calculation according to the applied methodology VM0015 v1.1, which estimates a root-to-shoot ratio of 0.24 for tropical rainforest having above ground biomass values above 125 tons/ha, and 0.20 for values below 125 tons/ha.
Comments	The values will be reassessed every 6 years or when data is more than 6 years old, whichever occurs first.

Data / Parameter	ACPAt
Data unit	Ha
Description	Annual area within the Project Area affected by catastrophic events at year t.
Source of data	- Remote sensing data and GIS, - Forest management team and other field data.
Description of measurement methods and procedures to be applied	In addition to field data from the management team, the following sources will also be monitored: - INMET[143] - INPE[144]
Frequency of monitoring/recording	At each time a catastrophic event occurs.
Value applied	The value will be calculated ex-post at each time a catastrophic event occurs, when significant.

[143] INMET. Instituto Nacional de Meteorologia. Available at: <https://portal.inmet.gov.br/>.
[144] INPE. Instituto Nacional de Pesquisas Espaciais. Available at: <http://www.inpe.br/>.

Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS. Furthermore, the following sources will be also monitored to confirm the data obtained from remote sensing and GIS: - INMET - INPE - Field data from the management team
Purpose of data	This parameter is used to calculate project emissions in the project scenario. Provides an ex post estimation of the area affected by catastrophic events within the project area.
Calculation method	Remote sensing and GIS
Comments	Decreases in carbon stocks and increases in GHG emissions (e.g. in case of forest fires) due to natural disturbances (such as hurricanes, earthquakes, volcanic eruptions, tsunamis, flooding, drought, fires, tornados or winter storms) or man-made events, including those over which the project proponent has no control (such as acts of terrorism or war), are subject to monitoring and must be accounted under the project scenario, when significant.

Data / Parameter	$ABSLLK_t$
Data unit	Ha
Description	Annual area of deforestation within the leakage belt at year t.
Source of data	Remote sensing and GIS.
Description of measurement methods and procedures to be applied	Deforestation in the leakage belt area may be considered activity displacement leakage. Activity data for the leakage belt area will be determined using the same methods applied to monitoring deforestation activity data in the project area.
Frequency of monitoring/recording	Annually
Value applied	568.15 (annual average deforestation projected in the leakage belt during the crediting period).
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing.

Purpose of data	This parameter is used to calculate leakage emissions in the project scenario. Provides the *ex post* value of the deforested area within the leakage belt.
Calculation method	Analysis of satellite images and maps.
Comments	Where strong evidence can be collected that deforestation in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation will not be attributed to the project activity, thus not considered leakage.

Data / Parameter	ABSLPAt
Data unit	Ha
Description	Annual area of deforestation in the project area at year t
Source of data	Remote sensing and GIS
Description of measurement methods and procedures to be applied	Forest cover change due to deforestation will be monitored through periodic assessment of classified satellite imagery covering the project area.
Frequency of monitoring/recording	Annually
Value applied	391.61 (annual average projected deforestation in the project area during the crediting period).
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing.
Purpose of data	This parameter will be used to calculate baseline emissions and project emissions in both baseline and project scenarios. Provides the ex ante and ex post values of the deforested area per forest class within the project area.
Calculation method	Analysis of satellite images and maps.
Comments	N/A

Data / Parameter	$ABSLRR_t$
Data unit	Ha

Description	Annual area of deforestation in the reference region at year t
Source of data	Remote sensing and GIS
Description of measurement methods and procedures to be applied	Forest cover change due to deforestation will be monitored through periodic assessment of classified satellite imagery covering the reference region.
Frequency of monitoring/recording	Annually
Value applied	5,985.32 (annual average projected deforestation within the reference region during the crediting period).
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing.
Purpose of data	This parameter will be used to calculate baseline emissions and project emissions in both baseline and project scenarios. Provides the *ex ante* and *ex post* values of the deforested area per forest class within the reference region.
Calculation method	Analysis of satellite images and maps.
Comments	N/A

Data / Parameter	$\Delta CADLK_t$
Data unit	tCO_2e
Description	Total decrease in carbon stocks due to displaced deforestation at year t
Source of data	Remote sensing and GIS.
Description of measurement methods and procedures to be applied	Deforestation in the leakage belt area may be considered activity displacement leakage. Activity data for the leakage belt area will be determined using the same methods applied to monitoring deforestation activity data in the project area.
Frequency of monitoring/recording	Annually

Value applied	40,161.21 (Annual average projected decrease in carbon stocks due to displaced deforestation in the leakage belt during the crediting period)
Monitoring equipment	Remote sensing and GIS.
QA/QC procedures to be applied	Best practices in remote sensing.
Purpose of data	This parameter will be used to calculate leakage emissions in the project scenario. Provides the *ex post* value of the decrease in carbon stocks due to displaced deforestation in the leakage belt.
Calculation method	Emissions from deforestation are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.
Comments	Where evidence can be collected that deforestation in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation may not be attributed to the project activity and therefore, not considered leakage.

Data / Parameter	∆CPAdPAt
Data unit	tCO2e
Description	Total decrease in carbon stock due to all planned activities at year t in the project area
Source of data	Documents, remote sensing and GIS.
Description of measurement methods and procedures to be applied	The planned activities in the project area that result in carbon stock decrease will be subject to monitoring, when significant.
Frequency of monitoring/recording	Annually
Value applied	0.00 (Annual average decrease in carbon stocks due to all planned activities within the project area during the crediting period)
Monitoring equipment	Remote sensing and GIS SFMP reports, including the post-harvesting annual report.

QA/QC procedures to be applied	- Best practices in remote sensing. - Internal procedures required by the SFMP and forest certification
Purpose of data	This parameter is used to calculate project emissions in the project scenario. Provides the ex post value of the decrease in carbon stocks due to planned activities in the project area.
Calculation method	This parameter is the sum of: carbon stock decrease due to planned deforestation, carbon stock decrease due to planned logging activities, and carbon stock decrease due to planned fuel-wood and charcoal activities.
Comments	The 1st project activity instance does not include sustainable forest management plan activities.

Data / Parameter	$\Delta CPSLK_t$
Data unit	tCO_2e
Description	Total annual carbon stock change in leakage management areas in the project case at year t
Source of data	- Activities report related to leakage prevention measures - Field assessment - Remote sensing and GIS
Description of measurement methods and procedures to be applied	The planned activities in leakage management areas that result in carbon stock decrease will be subject to monitoring, when significant.
Frequency of monitoring/recording	Annually
Value applied	0
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing.
Purpose of data	This parameter will be used to calculate leakage emissions in the project scenario. Provides the *ex post* value of the change in carbon stocks due to leakage prevention measures in the leakage management area.

Calculation method	Emissions from deforestation are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.
Comments	The leakage prevention measures proposed by the present project do not include decrease in carbon stocks due to activities implemented in the leakage management area.

Data / Parameter	$\Delta CUDdPA_t$
Data unit	tCO_2e
Description	Total actual carbon stock change due to unavoided unplanned deforestation at year t in the project area
Source of data	- Remote sensing and GIS - Field reports.
Description of measurement methods and procedures to be applied	Forest cover change due to unplanned deforestation will be monitored through periodic assessment of classified satellite imagery covering the project area.
Frequency of monitoring/recording	Annually
Value applied	14,648.45 (Annual average decrease in carbon stocks due to unavoided unplanned deforestation within the project area during the crediting period)
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing.
Purpose of data	This parameter will be used to calculate project emissions in the project scenario. Provides the *ex post* value of the change in carbon stocks due to unavoided unplanned deforestation within the project area.
Calculation method	Emissions from deforestation at each forest class are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.
Comments	N/A

Data / Parameter	$EADLK_t$
Data unit	tCO_2e
Description	Total *ex post* increase in GHG emissions due to displaced forest fires at year t.
Source of data	Remote sensing data and GIS.
Description of measurement methods and procedures to be applied	Forest fires in the leakage belt area may be considered activity displacement leakage. GHG emissions due displaced forest fires will be subjected to monitoring, when significant.
Frequency of monitoring/recording	Annually
Value applied	1,451.73 (Annual average increase in GHG emissions due to displaced forest fires within the leakage belt during the crediting period)
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS.
Purpose of data	This parameter will be used to calculate leakage emissions in the baseline and project scenario. Provides the *ex post* value of the increase in GHG emissions due to displaced forest fires in the leakage belt.
Calculation method	GHG emissions from deforestation are estimated by multiplying the detected area of forest loss in the leakage belt times the average forest carbon stock per unit area.
Comments	Where strong evidence can be collected that deforestation in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation will not be attributed to the project activity, thus not considered leakage.

Data / Parameter	$EBBPSPA_t$
Data unit	tCO_2e
Description	Sum of (or total) of actual non-CO_2 emissions from forest fire at year t in the project area
Source of data	- Remote sensing data and GIS,

	- Forest management team and field data.
Description of measurement methods and procedures to be applied	If forest fires occur, these non-CO_2 emissions will be subject to monitoring and accounting, when significant. In addition to remote sensing data and GIS, which can identify the area affected by forest fire, the forest management team could also confirm the obtained data. No forest fire will be used by the project owner for conducting planned deforestation or timber harvesting activities. However, it is expected that some unplanned deforestation within the project area will occur during the crediting period, which conversion of forest to non-forest may involve fire. The effect of fire on carbon emissions is counted in the estimation of carbon stock changes in the parameter $\Delta CUDdPA_t$; therefore CO_2 emissions from forest fires were ignored to avoid double counting. However, non-CO_2 emissions (CH_4 and N_2O) from forest fires must be counted in the project scenario, when they are significant. In order to be conservative, it will be assumed that all unplanned deforestation within the project area will involve fire. Therefore, non-CO_2 emissions from forest fires will be quantified and deducted from emission reductions.
Frequency of monitoring/recording	Annually
Value applied	529.51 (annual average actual non-CO_2 emissions due to biomass burning within the project area during the crediting period)
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS.
Purpose of data	This parameter will be used to calculate *non-CO_2* emissions due to forest fires within the project area in the project scenario, providing an estimate of the *ex post* value for each vegetation type.
Calculation method	If forest fires occur, *non-CO_2* emissions from biomass burning will calculated according to requirements of methodology VM0015 v1.1. Therefore, this parameter will be calculated as the multiplication of the annual area of deforestation of initial forest classes in the project area in the project scenario times the total GHG emission from biomass burning in initial forest classes ($EBBtot_{icl,t}$), when significant.

Comments	N/A

Data / Parameter	$EBBtot_{icl,t}$
Data unit	tCO2e/ha
Description	Total GHG emission from biomass burning in forest class icl at year t
Source of data	Calculated according to methodology VM0015 v1.1.
Description of measurement methods and procedures to be applied	This parameter was calculated according to requirements and default values established by the VM0015 v1.1 methodology. In order to estimate non-CO_2 emissions from forest fires, the average percentage of the area which contemplates the municipalities within the RR that was cleared by burning for other land uses involving deforestation, such as cattle raising and farming (Fburnt), and the average of biomass that has commercial value, and could be removed prior to clear cutting and burning (Pburnt,p) were estimated, either for the baseline and project case. These average percentage values are assumed to remain the same in the future, according to the applied methodology
Frequency of monitoring/recording	Annually
Value applied	24.71
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS.
Purpose of data	This parameter is used to calculate the baseline, project and leakage non-CO_2 emissions from biomass burning occurred in the baseline and project scenarios
Calculation method	This parameter was calculated according to requirements and default values established by the VM0015 v1.1 methodology.
Comments	GWP for CH_4 and N2O were obtained according to the most recent version of the VCS Standard.

Data / Parameter	$EgLK_t$
Data unit	tCO_2e
Description	Emissions from grazing animals in leakage management areas at year t.

Source of data	- Activities report related to leakage prevention measures - Field assessment - Remote sensing data and GIS.
Description of measurement methods and procedures to be applied	GHG emissions from grazing animals in the leakage management area (i.e. enteric fermentation or manure management) will be subjected to monitoring, when significant.
Frequency of monitoring/recording	Annually
Value applied	0
Monitoring equipment	Remote sensing and GIS Field assessment data
QA/QC procedures to be applied	Best practices in remote sensing and GIS.
Purpose of data	This parameter will be used to calculate GHG emissions from activities implemented in the leakage management area in the project scenario, providing an *ex post* value.
Calculation method	Described in the methodology VM0015 v1.1, section 8.1.2: *Ex ante* estimation of CH_4 and N_2O emissions from grazing animals.
Comments	The 1st project activity instance does not include any activity that could result in GHG emissions from grazing animals in leakage management areas. GWP for CH_4 and N2O should be obtained according to the most recent version of the VCS Standard.

Data / Parameter	RF_t
Data unit	%
Description	Risk factor used to calculate VCS buffer credits
Source of data	- VCS Non-Permanence Risk Report; - Remote sensing data and GIS; - SFMP data; - Literature data.
Description of measurement methods and procedures to be applied	All sources of data from the VCS Non-Permanence Risk Report will be used to measure the various risk factors.

Frequency of monitoring/recording	Annually
Value applied	15
Monitoring equipment	Remote sensing and GIS.
QA/QC procedures to be applied	Best practices in remote sensing and GIS. The VCS Non-Permanence Risk Report will be verified together with the monitoring report at each verification event.
Purpose of data	This parameter represents the non-permanence risk rating of the project, which was used to determine the number of buffer credits that shall be deposited into the AFOLU pooled buffer account.
Calculation method	This parameter was calculated using the last available version of the AFOLU Non-Permanence Risk Tool. All the risk factors described in the VCS Non-Permanence Risk Report will be assessed.
Comments	N/A

5.3 Monitoring Plan

This monitoring plan has been developed according to the VCS Methodology VM0015 version 1.1.

Organizational structure

According to the contract stipulated between Future Carbon and the landowner, the landowner is responsible for the costing and implementation and/or maintenance of the project's forest management and activities to reduce deforestation and degradation, surveillance, fire prevention, illegal extraction of wood, prevention of invasions, among others, implementation and maintenance of social and environmental activities to reduce leakage, decrease the risks of non-permanence of carbon and improve the results of SOCIALCARBON, or other Standard for the assessment of social and environmental co-benefits.

In addition, it is responsible for keeping all documentation required by the project in order, as well as project maintenance expenses; Execute, monitor and maintain in full operation the structure that authorizes and serves as the basis for the development of the Project, ensuring the reduction of deforestation and degradation, the implementation and maintenance of social and environmental activities (or designating and hiring third parties responsible for the activities).

The owner is responsible for establishing prospects in each Social Carbon report, as well as complying with at least 50% of the proposed actions, under penalty of losing the Social Carbon standard.

Future Carbon is responsible for the development of the project documents, assessment of the mapping files for application of the methodology, and internal auditing.

- **Revision of the baseline**

The current baseline is valid for 6 years. The baseline will be reassessed every 6 years, and it will be validated at the same time as the subsequent verification.

Technical description of the monitoring task

The baseline scenario will be monitored through the assessment of agents and drivers variables and satellite images to project expected deforestation. Information on agents, drivers and underlying causes of deforestation in the reference region will be collected at the end of each fixed baseline period, as these are essential for improving future deforestation projections and the design of the project activity. In addition, in the same frequency, the projected annual areas of baseline deforestation for the reference region will be revisited and eventually adjusted for the subsequent fixed baseline period.

The location of the projected baseline deforestation will be reassessed using the adjusted projections for annual areas of baseline deforestation and spatial data. All areas credited for avoided deforestation in past fixed baseline periods will be excluded from the revisited baseline projections as these areas cannot be credited again.

Baseline monitoring task will be done in accordance with the applied methodology, VM0015, version 1.1 or the most recent.

Data to be collected

Data will be collected to comply with the parameters used in the VM0015 v1.1, listed in Appendix 5, or the most recent.

Overview of data collection procedures

Data will be collected according to measurement methods and procedures described in section 5.1 and 5.2 above. All *ex ante* and *ex post* parameters will be reassessed at the moment of revision of the baseline.

Quality control and quality assurance procedures

QA/QC will be done according to best practices in remote sensing and as stated by VM0015 methodology.

Data archiving

All data sources and processing, classification and change detection procedures will be documented and stored in a dedicated long-term electronic archive maintained by the instance owner. Future Carbon will also keep a digital copy of all documents generated during the development of the VCS PD (first fixed baseline period) and the first monitoring period, as well as further monitoring reports in case it participates in the development of subsequent monitoring periods in the future.

Given the extended time frame and the pace of production of updated versions of software and new hardware for storing data, electronic files will be updated periodically or converted to a format accessible to future software applications, as needed.

All maps and records generated during project implementation will be stored and made available to VVBs at verification for inspection. In addition, any data collected from ground-truth points (including GPS coordinates, identified land-use class, and supporting photographic evidence) will be recorded and archived.

Organization and responsibilities of the parties involved in all the above

Future Carbon is responsible for the development of the Project Design Document and the first Monitoring Report. Therefore, it is responsible for the organization and calculation of items related to the methodology.

The instance owner is responsible for the development of the project activity, monitoring of the required parameters in section 5.2 above, and for the development of subsequent monitoring reports. In addition, it is also responsible for forest surveillance and generation of socioenvironmental activities to local communities.

Future Carbon and/or a related partner is responsible for all GIS related information.

- **Monitoring of actual carbon stock changes and GHG emissions within the project area**
    - **Monitoring of project implementation**

The instance owner is responsible for the implementation of the project activity. The monitoring of the sustainable management plan is carried out by the municipal and state secretariats.

Information from the sustainable forest management plan and post-exploratory reports will be used to update parameters related to planned deforestation and will be verified during the validation and verification of the carbon project.

Updating Forest Carbon Stocks Estimates

If new and more accurate carbon stock data become available, these can be used to estimate the net anthropogenic GHG emission reduction, provided that these data are in accordance to the requirements established by the applied methodology VM0015. New data on carbon stocks will only be used if they are validated by an accredited VVB.

Methods for generating, recording, aggregating, collating and reporting data on monitored parameters

All data sources and processing, classification and change detection procedures will be documented and stored in a dedicated long-term electronic archive maintained by Future Carbon.

Future Carbon will also keep a digital copy of all documents generated during the development of the VCS PD (first fixed baseline period) and the subsequent baseline reports and monitoring periods.

Given the extended time frame and the pace of production of updated versions of software and new hardware for storing data, electronic files will be updated periodically or converted to a format accessible to future software applications, as needed.

All maps and records generated during project implementation will be stored and made available to VCS verifiers at verification for inspection. In addition, any data collected from ground-truth points (including GPS coordinates, identified land-use class, and supporting photographic evidence) will be recorded and archived.

Monitored data will be kept for two years after the end of the crediting period or the last issuance of carbon credits for this project activity, whichever occurs later. For this purpose, the authority for the registration, monitoring, measurement and reporting will be Future Carbon Ltda. Monitored parameters are described in Section 5.2 and will be monitored with the frequency described further below.

Quality Assurance/Quality Control

To ensure consistency and quality of results, spatial analysts carrying out the image processing, interpretation, and change detection procedures will strictly adhere to the steps detailed in the Methodology.

All of this reliable data, which will be collected and documented, will be used as a technical support tool for decision-making in order to improve project outcomes, and to adapt the project according to the current needs and realities. Project activities implemented within the project area must be consistent with the management plan of the PD.

The implementation of the project activity will be monitored by continuous monitoring activities using remote sensing techniques. Additionally, field studies will also be used. The land-use monitoring will be carried out with remote sensing methods, using images generated by Mapbiomas, INPE (PRODES)[145] and LANDSAT satellite images (or other available source accepted by the methodology), which will be subject to digital processing to perform the interpretation and classification of the land cover classes studied.

The management structure will also rely on the local community to help monitor the area. All the monitored parameters will be checked with the frequency detailed in the Section 5.2 above, as requested in the VCS Methodology VM0015, version 1.1.

[145] Available at: <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>

With the carbon credits income, in order to complement the monitoring of the project area and its surroundings, the project proponent intends to improve the remote sensing methods and data used, which meet the accuracy assessment requirements laid out in the methodology.

The present REDD project will also implement the sustainability report following the SOCIALCARBON methodology, which was developed by *Instituto Ecológica* and focus on implementing environmental and social activities within the project area. This methodology follows the SOCIALCARBON Guidelines available at: http://www.socialcarbon.org/documents/.

In addition, the SOCIALCARBON Reports will be available on the VCS Registry once the project is registered.

Procedures for handling internal auditing and non-conformities

The procedures for handling internal auditing and non-conformities are going to be established by both project developer and project proponent. All the necessary taskforce and procedures will be in place to meet the highest levels of control.

A project information quality management system will be implemented, the main purpose of which is to minimize the risk of error, obtaining reliable data on which to base the monitoring results, and thus, minimizing non-conformities. It includes the training of general staff in the different roles to play within the framework of the present REDD Project; In-field verification, which basically consists of monitoring the procedures set out in the methodological guidelines and review of the monitoring reports prior to its delivery to the VVB, in order to confirm that the calculations, analysis and the conclusions are accurate and measured. This work is in charge of Future Carbon.

If non-conformities exist during the internal or external auditing processes, the data should be reviewed, and the non-conformities addressed.

- **Monitoring of land-use and land-cover change within the project area**

Forest cover change due to unplanned deforestation is monitored through periodic assessment of classified satellite imagery covering the project area. Emissions from deforestation are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.

The project boundary, as set out in the PD, will serve as the initial “forest cover benchmark map” against which changes in forest cover will be assessed over the interval of the monitoring period.

The entire project area has been demonstrated to meet the forest definition at the beginning of the crediting period. For subsequent monitoring periods, change in forest cover will be assessed against the preceding classified forest cover map marking the beginning of the monitoring interval. The resulting classified image is compared with the preceding classified image (forest cover benchmark map marking the start of the monitoring interval) to detect forest cover change over the monitoring interval, and subsequently becomes the updated forest cover benchmark map for the next monitoring interval. Thus, the forest benchmark map is updated at each monitoring event.

The increase or decrease in carbon stocks due to planned activities in the project area will also be monitored through documents and periodic assessment of classified satellite imagery covering the project area. In case of planned deforestation, emissions are estimated by multiplying the area of forest loss by the average forest carbon stock per unit area.

The results of monitoring shall be reported by creating *ex post* tables of activity data per stratum; per initial forest class *icl*; and per post-deforestation zone *z*, for the reference region, project area and leakage belt.

In addition, a map showing Cumulative Areas Credited within the project area shall be updated and presented to VCS verifiers at each verification event. The cumulative area cannot generate additional VCUs in future periods.

Other applied methodologies for monitoring of deforestation are listed below:

Monitoring bases

The instance owner is responsible for the implementation of monitoring bases, if necessary, to guarantee the standing forest and carbon stock.

Satellite images and remote sensing monitoring

The land use and land use cover change will be analyzed through remote sensing methods, using data from INPE (PRODES – deforestation; Queimadas – fire monitoring; TerraClass – qualification of Amazon deforestation), MapBiomas data, and satellite images (LANDSAT, Sentinel, CBRES).

All reliable data collected and documented will be used as a technical support tool for decision making in order to improve project outcomes, and to adapt the project according to the current needs and reality. These decisions will be made during periodic meetings to review the Action Plan – that will be developed as part of the SocialCarbon Methodology. On these occasions, the design of the Monitoring Plan will be analyzed according to its efficiency in generating reliable feedback and all the necessary information. If any changes in the Monitoring Plan or management actions are identified, a corrective action will be designed and implemented.

Security procedures

The instance owner is responsible for the security procedures and reporting illegal activity to responsible authorities.

These actions are planned to avoid unplanned deforestation and carbon stock changes in the project area. Related parameters shall be monitored and reassessed at every verification and revalidation point.

SOCIALCARBON Report will also monitor the relationship between the company and the communities, and its evolution on mitigating unplanned deforestation caused by these agents.

- **Monitoring of carbon stock changes and non-CO2 emissions from fires**

In addition to the mentioned above, the instance owner is responsible for training monitoring, management, safety and health personnel. This may include periodic fire brigade training, including first aid, fire procedures, training of new monitoring personnel and those responsible for management during harvests.

If forest fires occur, these non-CO2 emissions will be subject to monitoring and accounting, when significant.

- **Monitoring of impacts of natural disturbances and other catastrophic events**

The monitoring of natural impacts and other catastrophic events is responsibility of the instance owner. The landowner shall notify Future Carbon so that it can include the related impacts in the carbon project reports, updating the related parameters, including the non-permanence risk report. Where an event occurs that is likely to qualify as a loss event, the project proponent shall notify Verra within 30 days of discovering the likely loss event.

Decreases in carbon stocks and increases in GHG emissions (e.g. in case of forest fires) due to natural disturbances (such as hurricanes, earthquakes, flooding, drought, fires or storms) or man-made events, including those over which the project proponent has no control (such as acts of terrorism or war), are subject to monitoring, when significant. If the area (or a sub-set of it) affected by natural disturbances or man-made events generated VCUs in past verifications, the total net change in carbon stocks and GHG emissions in the area(s) that generated VCUs will be estimated, and an equivalent amount of VCUs will be cancelled from the VCS buffer. No VCUs can be issued for the project until all carbon stock losses and increases in GHG emissions have been offset.

- **Monitoring of Leakage**

Monitoring of the leakage belt and leakage management area will be carried out as in the project area and reference region.

The most recent VCS guidelines on this subject matter shall be applied. Furthermore, as the leakage belt was determined using Option 1 (Opportunity cost analysis), the boundary of the leakage belt will have to be reassessed at the end of each fixed baseline period using the same methodological approaches used in the previous period. The calculation procedure for estimating leakage emissions in the project scenario will be done by monitoring the following sources of leakage:

- Carbon stock changes and GHG emissions associated with leakage prevention activities.

The carbon stock decrease or increase in GHG emissions due to leakage prevention measures, which will probably take place inside the leakage management area, will be monitored through documents and field assessment. In areas undergoing carbon stock enhancement, the project conservatively assumes stable stocks and no biomass monitoring is conducted.

- Carbon stock decrease and increases in GHG emissions due to activity displacement leakage

Deforestation in the leakage belt area above the baseline may be considered activity displacement leakage. Activity data for the leakage belt area will be determined using the same methods applied to monitoring deforestation activity data in the project area. Leakage will be calculated by comparing the *ex ante* and the *ex post* assessment. However, where strong evidence can be collected that deforestation in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation will not be attributed to the project activity, thus not considered leakage.

- **Organizational structure, responsibilities and competencies**

Monitoring will be done by the project proponent and outsourced to a third party having sufficient capacities to perform the monitoring tasks. To ensure the operation of the monitoring activities, the operational and managerial structure will be established according to the table below.

For all aspects of project monitoring, the project proponent will ensure that data collection, processing, analysis, management and archiving are conducted in accordance with the monitoring plan. The authority for the registration, monitoring, measurement and reporting will be Future Carbon.

Table 60. Type of Monitoring and Party Responsible

Variables to be monitored	Responsible	Frequency
Reassessment of the baseline	Future Carbon and external institutions qualified for the GIS analysis and monitoring	Every 6 years
Monitoring Deforestation and Project Emissions	Instance owner together with Future Carbon and external institutions qualified for the GIS analysis and monitoring	Prior to each verification
Monitoring of non-CO_2 emissions from forest fires	Instance owner together with Future Carbon and external institutions qualified for the GIS analysis and monitoring	Prior to each verification
Monitoring Leakage emissions	Instance owner together with Future Carbon and external institutions qualified for the GIS analysis and monitoring	Prior to each verification
Monitoring of Natural Disturbance and catastrophic events	Instance owner and Future Carbon	When a natural event occurs
Updating Forest Carbon Stocks Estimates	Future Carbon	At least, every 10 years, only if necessary.

APPENDIX I – METHODOLOGICAL PROCEDURES FOR LU/LC CHANGE ANALYSIS

According to the applied methodology, in order to achieve a consistent time-series of LU/LC-change data over the crediting period, the detailed methodological procedures used in pre-processing, classification, post classification processing, and accuracy assessment of the remotely sensed data shall be carefully documented in the VCS PD. Therefore, the information below describes the methodological procedures applied during the current monitored period.

Data sources and pre-processing

The historic deforestation of the reference region should be analyzed through maps from MapBiomas (version 5.0, which was the last available version), available in raster format, which can be downloaded from the *http://mapbiomas.org/* website. MapBiomas is a multi-institutional initiative of the Greenhouse Gas Emissions Estimation System (SEEG - http://seeg.eco.br/en/) promoted by the Climate Observatory. MapBiomas co-creation involves NGO's, universities and technology companies.

Table 61. Source of the remotely sense data used for historical reference period

Vector	Sensor	Resolution		Coverage	Acquisition date	Scene	
		Spatial (m)	Spectral (µm)	(Km²)		Path/ Latitude	Row/ Longitude
Satellite	Landsat TM	30	0.45 - 2.35	34,225	2011 – 2021	224	63
Satellite	Landsat TM	30	0.45 - 2.35	34,225	2011 – 2021	224	62

The forest dynamics data, the deforestation vectors and other base data from the studied region, which were used for the project's baseline construction, should be organized in a spatialized database. For this purpose, the software used in this baseline reassessment was the File Geodatabase format from ArcGIS 10.6. The files are stored in vector and matrix format (raster). In order to standardize spatial references, all data has been projected for the UTM and Datum WGS84, Zone 22S projection.

The MapBiomas methodology for land use classification uses 105 input variables, including the original Landsat bands, indexes, fractional and textural information derived from these bands, which are detailed in the Figure below:

Figure 22. List, description and reference of bands, fractions and indexes available in the feature space

	band or index name	formula	Reducer median	median_dry	median_wet	amplitude	std Dev	min	Reference
bands	blue	B1 (L5 e L7); B2 (L8)							
	green	B2 (L5 e L7); B3 (L8)							
	red	B3 (L5 e L7); B4 (L8)							
	nir	B4 (L5 e L7); B5 (L8)							
	swir1	B5 (L5 e L7); B6 (L8)							
	swir2	B7 (L5); B8 (L7); B7 (L8)							
	temp	B6 (L5 e L7); B10 (L8)							
index	ndvi	(nir - red)/(nir + red)							
	evi2	(2.5 * (nir - red)/(nir + 2.4 * red + 1)							
	cai	(swir2 / swir1)							
	ndwi	(nir - swir1)/(nir + swir1)							
	gcvi	(nir / green - 1)							
	hall_cover	(-red*0.017 - nir*0.007 - swir2*0.079 + 5.22)							
	pri	(blue - green)/(blue + green)							
	savi	(1 + L) * (nir - red)/(nir + red + 0,5)							
	textG	('median_green') .entropy(ee.Kernel .square({radius: 5}))							
fraction	gv	fractional abundance of green vegetation within the pixel							
	npv	fractional abundance of non-photosynthetic vegetation within the pixel							
	soil	fractional abundance of soil within the pixel							
	cloud	fractional abundance of cloud within the pixel							
	shade	100 - (gv + npv + soil + cloud)							
MEM index	gvs	gv / (gv + npv + soil + cloud)							
	ndfi	(gvs - (npv + soil))/(gvs + (npv + soil))							
	sefi	(gv+npv_s - soil)/(gv+npv_s + soil)							
	wefi	((gv+npv) - (soil+shade)) /((gv+npv) + (soil+shade))							
	fns	((gv+shade) - soil) / ((gv+shade) + soil)							
slope		ALOS DSM: Global 30m							

Where,

Median - Median of the pixel values of the best mapping period defined by each biome.

Median_dry = median of the quartile of the lowest pixel NDVI values.

Median_wet = median of the quartile of the highest pixel NDVI values.

Amplitude = amplitude of variation of the index considering all the images of each year.

stdDev = standard deviation of all pixel values of all images of each year.

Min = lower annual value of the pixels of each band.

In addition, Landsat Images used in MapBiomas were accessible via Google Earth Engine, and most of them are composed by the Collection 1 Tier 1 from USGS. This is the highest quality Level-1 products suitable for pixel-level time series analysis. These images are radiometrically calibrated and orthorectified using ground control points (GCPs) and digital elevation model (DEM) data to correct for relief displacement.

<u>Data classification and post-processing</u>

The LU/LC classes defined for this project activity were: Forest, Non-Forest and Hydrography. In addition, the established LU/LC-change categories were:

a) Forested areas that remains as forested areas (Conservation);

b) Forest that are converted to non-forested areas (Deforestation); or

c) Non-forested areas that remains as non-forested areas.

The image classification methodology for each year involves all Landsat images available for each period (Landsat 5 [L5], Landsat 7 [L7] and Landsat 8 [L8]) or other sensor available) with a cloud cover less than or equal to 50%, and in accordance with its 30m resolution, the minimum mapping unit was defined at 30x30m (0.09ha), therefore falling easily to the methodology requirement that the MMU cannot be larger than 1ha. Thus, a representative mosaic of each year could be generated, selecting cloud free pixels from the available images. Metrics should be extracted for each pixel that describes its behavior during the year and could contain up to 105 layers of information. The mapping should be done with an artificial intelligence classifier, such as the Randon Forest. The Landsat images acquisition could be made through Google Earth Engine, with data from NASA and USGS (U.S. Geological Survey).

The algorithm may use samples obtained by reference maps, stable collections from previous MapBiomas series and/or direct collection by visual interpretation of Landsat images in order to classify a single map per class. This classification should then go through spatial filter, applying neighborhood rules and temporal filters to reduce spatial and temporal inconsistencies. The software used in this baseline reassessment was the ArcGIS 10.6. In addition, high resolution images from Google Earth software (https://earth.google.com/) were also utilized to perform some LU/LC-change analysis.

Due to the pixel-based classification method and the long temporal series, the MapBiomas applies a chain of post-classification filters. The first post-classification action involves the application of temporal filters. Then, a spatial filter was applied followed by a gap fill filter. The application of these filters removes classification noises. These post-classification procedures were implemented in the Google Earth Engine platform and are described below:

Gap Fill

The Gap fill is a temporal filter used to fill possible no-data values. In a long time series of severely cloud-affected regions, it is expected that no-data values may populate some of the resultant median composite pixels. In this filter, no-data values (“gaps”) are theoretically not allowed and are replaced by the temporally nearest valid classification

Spatial Filter

Spatial filter was applied to avoid unwanted modifications to the edges of the pixel groups (blobs), a spatial filter was built based on the “connectedPixelCount” function. This function locates connected components (neighbours) that share the same pixel value.

Temporal Filter

The temporal filter uses sequential classifications in a three-to-five-years unidirectional moving window to identify temporally non-permitted transitions. Based on generic rules (GR), the temporal filter inspects the central positions of three to five consecutive years, and if the extremities of the consecutive years are identical but the centre position is not, then the central pixels are reclassified to match its temporal neighbor class.

Frequency Filter

This filter takes into consideration the occurrence frequency throughout the entire time series. Thus, all class occurrence with less than given percentage of temporal persistence (eg. 3 years or fewer out of 33) are filtered out. This mechanism decreasing the number of false positives and preserving consolidated trajectories.

Incident Filter

An incident filter was applied to remove pixels that changed too many times during the analyzed period. All pixels that changed more than eight times and are connected to less than 6 pixels were replaced by the MODE value of that given pixel position in the stack of years.

Classification accuracy assessment

The MapBiomas results go through an accuracy evaluation, which remains 95% for the entire Amazon Biome. However, to meet the particularities of the project’s region, an independent evaluation was carried out for the reference region.

Thus, in order to assess the accuracy of the maps produced by the MapBiomas methodology, a confusion matrix was generated calculating the percentages of user and producer correctness, as well as omission and commission errors.

A total of 300 random points was drawn on the reference region (100 points for each land use class – Forest, Non-Forest and Hydrography) and the degree of correctness of the classification was verified. High resolution images from Google Earth should also be used as reference, in which land use was visually possible at the drawn points.

The table below shows the final accuracy analysis carried out for each year and each land use class during the analyzed monitoring period.

Table 62. Summary of confusion matrices from the evaluation of MapBiomas

	Producer Accuracy				User Accuracy			
Year	Forest	Hydrography	Pioneer Formation	Deforestation	Forest	Hydrography	Pioneer Formation	Deforestation
2011	97.96%	97.96%	94.00%	92.31%	96.00%	96.00%	94.00%	96.00%
2012	97.78%	100.00%	94.23%	88.68%	88.00%	100.00%	98.00%	94.00%
2013	95.74%	98.04%	88.89%	89.58%	90.00%	100.00%	96.00%	86.00%
2014	97.62%	96.15%	90.38%	87.04%	82.00%	100.00%	94.00%	94.00%
2015	97.83%	98.04%	95.74%	85.71%	90.00%	100.00%	90.00%	96.00%
2016	91.67%	92.31%	85.45%	88.89%	88.00%	96.00%	94.00%	80.00%
2017	95.24%	96.15%	88.68%	81.13%	80.00%	100.00%	94.00%	86.00%
2018	93.88%	96.00%	96.08%	92.00%	92.00%	96.00%	98.00%	92.00%
2019	88.00%	92.45%	95.65%	86.27%	88.00%	98.00%	88.00%	88.00%
2020	97.62%	98.00%	85.71%	80.77%	82.00%	98.00%	96.00%	84.00%
2021	98.77%	95.15%		86.21%	80.00%	98.00%		100.00%