AVOIDED CONVERSION CERRADO

Document prepared by:

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CONTENTS

1 PROJECT DETAILS

1.1 Summary Description of the Project

The Avoided Conversion Cerrado is a grouped program located in the Cerrado biome, the main breadbasket of Brazil. Since 1985, the Cerrado biome has lost 46.8% of its native vegetation to agriculture according to MapBiomas[1]. Conversion of native vegetation is predominantly occurring in private lands in the Cerrado biome because of Brazilian land-use regulation. The central piece of legislation regulating land use and management on private properties is the Brazilian Forest Code and requires that landholders maintain a percentage of native vegetation. Currently, there are negligible economic incentives for landholders to maintain surplus native vegetation on their land, other then what is legally required. According to the data calculated by Soares-Filho et al. (2014)[2], there is approximately 40 million hectares of surplus native vegetation in the Cerrado that could be converted. If this happens, there will be major consequences on watersheds, rains, soil health, biodiversity habitat, impacting local communities that depend on a healthy biome. The main objective of this program is to provide landholders, the primary agent of conversion, with an economic alternative that incentivizes the maintenance of surplus native forests and grasslands, through carbon payments. The landholder has an opportunity cost when looking at land-use alternatives. The surplus native vegetation is competing directly with soy and cattle. Therefore, to reduce conversion and forego their legal right to convert, the landholder must receive carbon payments that are competitive with their opportunity cost of commercial agriculture.

The mechanisms employed by the project developer to reduce conversion is an enforceable and irrevocable agreement with the landholder to preserve the land for 30 years, as well as a financial proposal showing estimated annual carbon payments over the 30 years. The project proponent and landholder use a variety of surveillance mechanisms to ensure no conversion has occurred, such as guards, drones, field patrols, satellite imagery, and public Brazilian conversion alert databases. Additional conservation activities include agroforestry, ecotourism, as well as forest fire prevention and combating (monitoring, planning, training, purchasing equipment, etc.). The project proponent and landholder dedicate a portion of carbon revenues to social-environmental co-benefits and activities, which are being monitored using the SocialCarbon standard, whereby 18 indicators have been selected. See SocialCarbon monitoring report for more details.

Currently, the program has two properties in the initial project activity instance (PAI) with a total project accounting area of 11,509.20 hectares. The average annual ex-ante estimate is 47,698 tCO2e/year for a total of 1.4 million credits over the 30-year crediting period, from 2017-2047. The first monitoring period, from 2017 to 2021, generated 316,782 eligible VCUs for issuance.

[1] Mapbiomas 2021, Accessed at: https://mapbiomas.org/infograficos-1?cama_set_language=pt-BR

[2] Soares-Filho et. al (2014) Available at: http://lerf.eco.br/img/publicacoes/Soares_Filho_etal_2014_artigo_Science.pdf

1.2 Sectoral Scope and Project Type

Project Scope: 14: Agriculture, Forest and other Land Use (AFOLU)

Project Category: Avoided Planned Deforestation (APD) & Avoided Planned Grassland Conversion (ACoGS)

Grouped Project: Yes

1.3 Project Eligibility

The project is eligible under VCS Standard v4.1:

- The project meets all applicable rules and requirements set out under the VCS Program;
- The project applies a methodology eligible under the VCS Program;
- The implementation of this project activity does not lead to the violation of any applicable law;
- This is an eligible AFOLU project category under the VCS Program: avoided conversion of grassland and shrubland (ACoGS);
- This project is not located within a jurisdiction covered by a jurisdictional REDD+ program;
- Implementation partners are identified in the project activity;
- This project does not convert native ecosystems to generate GHG emission reductions. The project area only contains native forests and grasslands for a minimum of 10 years before the project start date as per land-use maps presented in section 4.3.2, based on MapBiomas project, collection 5;
- This project does not occur on wetlands and does not drain native ecosystems or degrade hydrological functions based on soil maps provided in Section 1.12, based on IBGE data;
- Non-permanence risk will be analyzed in accordance with the VCS Program document AFOLU Non-Permanence Risk Tool.

1.4 Project Design

This project has been designed as a grouped project.

1.4.1 Eligibility Criteria

As per the VCS Standard v.4.1, Grouped Projects requirements, the following statements are provided:

- The grouped project has one clearly defined geographic area within which project activity instances are developed. The geodetic polygon of the Cerrado biome is provided in the supporting project documents folders, as well as in Section 1.12 below;
- The baseline scenario and demonstration of additionality are based upon the initial project activity instance and is described in Section 3;
- The project does not incorporate multiple project activities;

- A single baseline scenario was determined for the project activity over the entirety of the selected geographic area;
- Demonstration of additionality was determined for the project activity over the entirety of the selected geographic area;
- Relevant factors such as common practice, laws, and policies were used to determine the baseline scenario and demonstration of additionality across the Cerrado biome;
- The initial PAI does not exceed the one percent capacity limit, therefore no clusters were created.

The following criteria have been established by the project proponent to assess the eligibility of new Project Activity Instances (PAIs) according to the applicability conditions set out in the VM0009 methodology. Each new PAI must adhere to these requirements using the means of validation provided.

Table 1: Grouped Project Eligibility Criteria

#	Eligibility Criteria	Means of Validation
1	The driver and agent of conversion in the baseline scenario must be consistent with those described in Section 3: planned conversion by the primary agent (the landholder) for agricultural purposes. The eligible end land-uses for forest areas are agriculture or cattle (in the case of APD). The eligible end land-use for grassland areas is only agriculture (in the case of APC).	The PP will analyze the agricultural aptitude of the proposed PAA, through the following means: a. The PAI must have road access. b. The topography must not have a slope greater than 25% as described in the Law 12.651 Article 11. c. Neighboring agricultural activity with a demonstrated historical advancement of agriculture using land-use maps.

2	The forested areas must meet the definition of forest established by the FAO[3], and therefore will apply the F-P2 baseline scenario. The grassland and shrubland areas must meet the definition of grassland and shrubland established by the FAO[4] and therefore apply the G-P2 baseline scenario.	The PP will use remote sensing and GIS tools to classify vegetation classes as per the FAO definitions. A field team will ground-truth the classification during the forest inventories to ensure accurate classification.
3	The PAI must be located within the geographic boundary of the Cerrado biome as defined by the Brazilian Institute for Statistics and Geography (IBGE). The geodetic polygon of the Cerrado biome is provided in the supporting project documents folder, as well as in Section 1.12 below.	The PP will check to ensure the PAI project boundary is within the Cerrado boundary by analyzing KMZ files using GIS tools.

[3] FAO definition of forest: "area ≥ 0.5 ha; Tree canopy cover ≥10%; Tree height ≥ 5 m at maturity in situ; Width > 20 m. Excludes land that is predominantly under agricultural or urban land use." Accessed at: https://www.fao.org/3/ap152e/ap152e.pdf (see page Table 4 page 21)

[4] FAO definition of grassland and shrubland: area "area ≥ 0.5 ha; Tree canopy cover 5-10% with trees >5m at maturity in situ or shrubs/bushes canopy cover ≥10% or combined cover of bush, shrubs and trees ≥10%. Excludes land that is predominantly under agricultural or urban land use." Accessed at: https://www.fao.org/3/ap152e/ap152e.pdf (see page Table 4 page 22)

4	The project activity instance shall be additional per the application of the VCS AFOLU Project activities (VT0001) version 3.0 in Section 3.5.	a. The project activity instance must be within privately held land with all ownership documents described in Section 1.7 b. The project accounting area shall be designated for planned conversion as per Brazil's revised Forest Code and shall not overlap with areas defined as Legal Reserves (RL) or Permanent Protection Areas (APPs). c. In the absence of participating in the Avoided Conversion Cerrado Program, commercial agriculture would proceed, resulting in revenues from commodity sales. d. The project accounting area shall not overlap with any federal or state protected areas such as parks, indigenous lands, quilombos, or other privately held lands.
5	The project accounting areas (PAAs) must be in an unconverted state (ie. forest or native grassland) for at least 10 years prior to the project start date.	The PP will use the MapBiomas historical land use database to evaluate the vegetation class stratums within the project accounting area, to validate that the PAA is native Cerrado 10 years prior to the project start date.
5	The PAI shall not contain peat soils.	The PP will use the IBGE database to evaluate the soil class stratums within the project accounting area, to validate that the PAA does not contain peat soil.
6	The PAA shall not include the grazing of livestock.	The PP will evaluate this eligibility criteria by interviews with the property owner, field visits, with photographs, videos and drone technology.
7	The PAI shall not include commercial logging in the baseline scenario.	The PP will evaluate this eligibility criteria by interviews with the property owner, field visits, satellite imagery. and GIS tools to assess conversion patterns.

8	Project activities are planned or implemented to mitigate ecosystem conversion by addressing the primary agent as described in Section 8.3.1 of the methodology, through a: 1) Signed legally enforceable and irrevocable agreement, called the "Commercial Partnership for Carbon Credit Generation Agreement" (The Agreement) (Appendix B), that includes contractual mechanisms to assure, as much as possible, the perpetuity of the project between the landholder(s) of the property and the project proponent for 30 years. 2) Fire Management Plan	The PP will ensure that a Commercial Partnership for Carbon Credit Generation Agreement has been signed by the landholder and the PP. The PP will ensure the standard operating procedure (SOP) for Fire Management has been adopted.

- The inclusion of new project activity instances subsequent to the initial validation of the project will adhere to ALL Eligibility Criteria defined above, as well as all the criteria under Section 3.5.16 of the VCS Standard v.4.1
- AFOLU non-permanence risk analyses are assessed for the geographic area, the Cerrado biome.
- Activity-shifting and market leakage assessments are applied as set out in Section 3.14.5-3.14.15 of the VCS Standard v.4.1 and the VM0009 methodology and will be reassessed where new instances of the project activity are included.

As per the VM0009 grouped project eligibility requirements, the following information is provided:

I. A list and description of the initial enrolled project activity instances to the grouped project.

II. A map of the designated geographic area within which all project activity instances will be located

III. A map of the common reference area, proxy area, activity-shifting leakage area and market leakage area.

Table 2: Initial Project Activity Instance

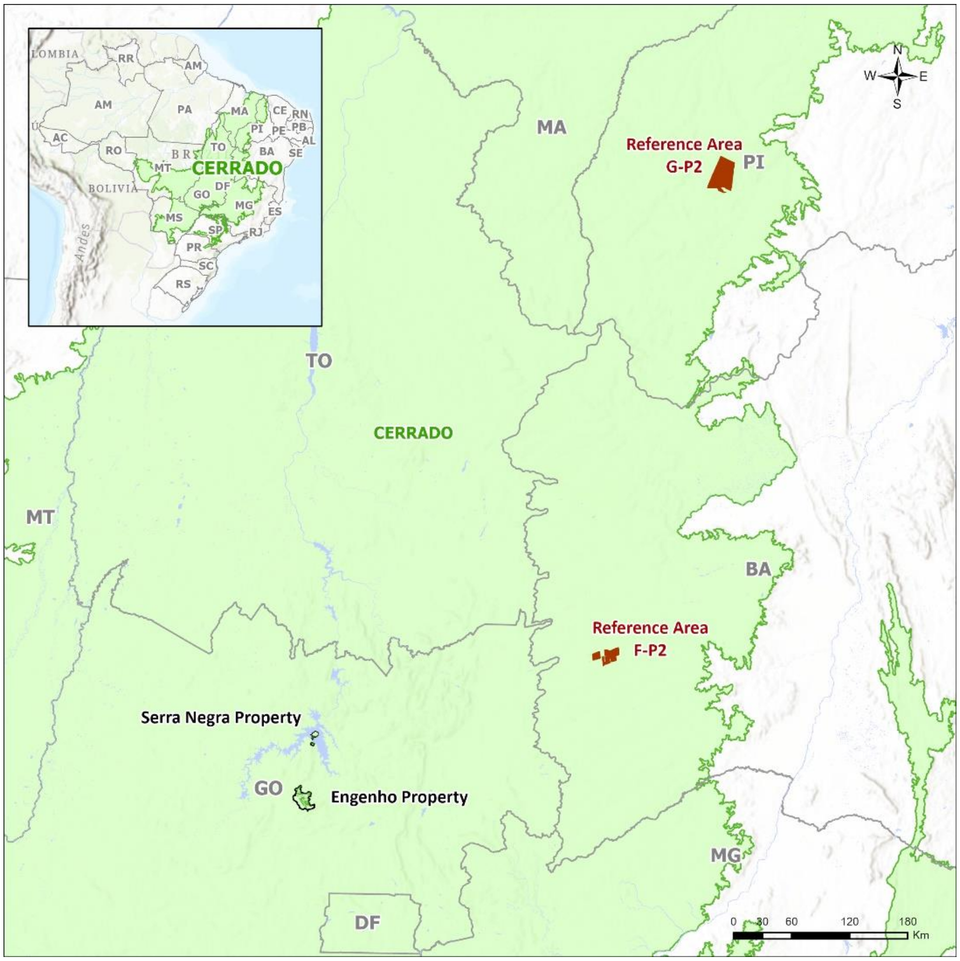
Project Identifier Code	Property Name	Municipality/State	Property Size	Project Accounting Area
			hectares	
REDD_PAI1_01	Serra Negra	Niquelandia, Goias	5,158	1,336.5
REDD_PAI1_02	Engenho	Niquelandia, Goias	27,958	10,172.7
Total				11,509.2

Table 3: 2021 Land-Uses at the Initial PAI

Land-Use	Serra Negra	Engenho
Total area	5,158	27,958
Project Accounting Area (PAA)	1,336.5	10,172.7
Legal Reserve	2,061	7,745
Permanent Protection Areas (PPA)	2,100	3,273
Slope > 25%	1,423	3,700
Consolidated & Agriculture	3	3,011
Lakes & River		56

The grouped project is located within the geographic boundary of the Cerrado biome, see *Figure 1* below. A KMZ shapefile (GIS-based map) of the Cerrado biome is provided in Appendix F. Figure 1 also provides the location of the initial PAI, the reference area, proxy area, and leakage area.

Figure 1: Geographical Distribution of the Cerrado Biome by Brazilian States



1.5 Project Proponent

Organization name	ERA Assessoria e Projetos Ambientais e Agrícolas Ltda.
Contact person	Hannah Simmons
Title	Founder & CEO
Address	Alameda Jaú n° 1177, 7° andar, Jardim Paulista, São Paulo - SP, CEP: 01420-903
Telephone	+55 11 93375-0914
Email	hannah@erabrazil.com

1.6 Other Entities Involved in the Project

Organization name	Companhia Brasileira de Alumínio (CBA)
Role in the project	Landowner of the initial PAI and manager of the Legado Verdes do Cerrado (LVC), which will be further described in section 1.8.
Contact person	Marco Túlio Xavier Lanza
Title	Operations Manager
Address	Acampamento Macedo, Zona Rural, s/n. CEP 76420-000. Niquelândia. GO. Brasil
Telephone	(62)3354-6140
Email	marco.lanza@cba.com.br

Organization name	ECCON Soluções Ambientais LTDA.
Role in the project	Landholder engagement, remote sensing, monitoring, field work.
Contact person	Yuri Rugai Marinho
Title	Founder & CEO
Address	Rua Fradique Coutinho 212 CJ 34, CEP 05416 000 São Paulo/SP, Brasil
Telephone	+ 55 11 3898-0175
Email	yuri@ecconsa.com.br

1.7 Ownership

Based on the VCS Standard Section 3.6.1, the project demonstrates that the proponents have clear, uncontested ownership and or control over the emission reductions under subsection 6:

"An enforceable and irrevocable agreement with the holder of the statutory, property or contractual right in the land, vegetation or conservational or management process that generates GHG emission reductions or removals which vests project ownership in the project proponent."

Each participating landholder signed a legally enforceable and irrevocable **Agreement** that includes contractual mechanisms to assure, as much as possible, the perpetuity of the project between the landholder(s) of the property and the project proponents. The Agreement must be duly registered in the municipal land bureau to ensure project longevity and transparency. As part of this Agreement, landholders grant the powers to the project proponents in order for these to be the only duly authorized project proponents to generate, commercialize and manage the carbon credits arising from Project activities.

As a grouped project, the Avoided Conversion Cerrado Program will only include PAIs that provide the following documents to prove ownership:

1) **Environmental Registry for Rural Properties** ("CAR", in Portuguese) - This is the official registry before the Federal Environmental Public Authorities, which registers all relevant environmental information of the property, such as legal reserves, surplus native vegetation and agricultural land use (Appendix D).

2) **Updated Land Registry Certificate** – This is an official public instrument that registers all deeds, liens and any other documents or activities pertaining the property (Appendix D).

3) **Updated Certificate from the Institute for Agrarian Reform ("INCRA", in Portuguese)** - This is the document expedited from the official public authority that oversees agrarian regularization, which includes the analysis of overlapping geographical coordinates with public federal properties, indigenous reserves, natural reserves and other categories of properties, public or private (Appendix D). CBA signed a legally enforceable and irrevocable **Agreement** that includes contractual mechanisms to assure, as much as possible, the perpetuity of the project between the landholder(s) of the property and the project proponent. The Agreement must be duly registered in the municipal land bureau to ensure project longevity and transparency. As part of this Agreement, landholders grant the powers to ERA, the lead project proponent to be the only duly authorized project proponent to generate, commercialize and manage the carbon credits arising from Project activities. CBA is legally bound under the aforementioned Agreement, has a 2-month deadline to register it before the Land Registry of the Municipality of Niquelândia, after the successful validation and verification of the project.

Table 4: Ownership Documentation

Property	Corresponding nº in the Land Registry	Size of the Area (hectares)	Project Accounting Area (hectares)
Serra Negra I & II	Land Registry nº 17.931 Land Registry nº 17.932	5,158.80 hectares	1,336.5
Engenho	Land Registry nº 17.393 Land Registry nº 17.395	27,958.10 hectares	10,172.7

Each subsequent PAI will have the above table completed in the monitoring reports.

1.8 Project Start Date

The project start date is defined as February 2nd, 2017.

On February 2nd, 2017, CBA formally established the Cerrado Green Legacy, or Legado Verdes do Cerrado (LVC) in Portuguese, through a formal Protocol of Intent (Protocolo de Intenções, see Appendix D) signed with the State of Goiás to establish a balanced model for sustainable economic development. The Protocol states in Section 2.6 and 2.7 the intention to apply economic instruments and mechanisms to compensate conservation efforts. It is important to clarify that LVC is a business unit of CBA.

LVC started the journey to pursue carbon finance to maintain the conservation activities, which include social programs, research initiatives, native seedling production and biodiversity monitoring; however, carbon projects require many years to obtain data, registration and issuance. The landholder needs to maintain the property and has large costs associated with doing so. The conversion of native vegetation to agriculture during the first monitoring period was required to cover the costs of conservation activities and sustain the farm economically, while the carbon project documentation and processes were being developed. The landholder deforested 76 hectares between 2017/2018 to expand soy production in order to cover the costs associated with maintaining such a large property and conservation reserve. If the landholder did not have the intention to pursue carbon finance since 2017, the deforestation would have been much higher. The landholder had a deforestation license in 2017 and did not use the license to the full extent for the purposes of pursuing carbon finance. Conservation project activities initiated in 2017, such as formally establishing the Sustainable Development Private Reserve, building the tree nursery and forming a research partnership to measure above-ground biomass and soil carbon stocks.

Pursuing carbon finance takes time, resources, and research. The Cerrado is a biome with no prior REDD+ carbon initiatives, meaning the aforementioned research partnership for carbon stocks was key to support the feasibility analysis provided in 2020. With this said, the project “Alometria no Cerrado”, coordinated by Dr. Fabio Venturoli, began its organization and contracting in the second semester of 2017, which was a crucial effort for the project’s validation and verification.

The Table below highlights the milestones:

Milestone	Date
CBA Board of Directors approves the creation of the LVC	2016
CBA formalizes the creation of the LVC by signing the Protocol of Intentions with the State of Goais Conservation project activities begin including: 1) Giving up their legal right to expand agricultural activities by 450 hectares in 2017 to only converting 76 hectares. 2) Building the biodiversity center and tree nursery at LVC 3) Supporting the research partnership signed with Professor Fabio Venturoli (Brasilia Federal University) to study Allometry in the Cerrado using LVC properties.	2017

LVC approaches consulting companies to assess the carbon project development opportunity	2018
Carbon stock field research initiated, led by Guimaraes	2019
ECCON & ERA form a partnership and pursue a feasibility assessment of the LVC project	2020
ECCON, ERA & LVC sign the Carbon Agreement	2021

1.9 Project Crediting Period

The Project crediting period begins February 2nd, 2017, and continues until February 1st, 2047, for a total 30-year crediting period.

Per the VCS guidelines, a mandatory baseline re-evaluation is to be executed at a minimum of every 10 years after the project start. Therefore, there will be a mandatory baseline re-evaluation on or before February 2nd, 2027, and on or before February 2nd, 2037.

The first monitoring period extends from the project start date of February 2nd, 2017, through to August 16th, 2021. It is anticipated that subsequent monitoring periods will occur annually. Therefore, the timeline of subsequent monitoring periods is the fourth quarter of 2022, 2023, 2024, 2025, and so on until 2046.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

Table 5: Project Scale

Project Scale	
Project	X
Large project	

Table 6: Estimated GHG Emission Reductions

Year	Estimated GHG emission reductions or removals (tCO_2e)
2017	68,775
2018	78,819

2019	78,936
2020	78,070
2021	76,239
2022	73,560
2023	70,218
2024	66,432
2025	62,423
2026	58,385
2027	54,477
2028	50,811
2029	47,458
2030	44,454
2031	41,808
2032	39,509
2033	37,533
2034	35,851
2035	34,429
2036	33,234
2037	32,236
2038	31,405
2039	30,715
2040	30,145
2041	29,673
2042	29,285
2043	28,965
2044	28,703

2045	28,487
2046	28,310
2047	1,586
Total estimated ERs	1,430,933
Total number of crediting years	30
Average annual ERs	47,698

1.11 Description of the Project Activity

The project will lead to the protection of native Cerrado that was destined for planned conversion. The following project activities were implemented at the initial PAI to achieve GHG emission reductions:

a) Irrevocable-Enforceable Contract to Avoid Planned Conversion

A 30-year irrevocable agreement was signed between the project proponent and the landholder, CBA, ensuring the long-term conservation of LVC, the initial project activity instance. CBA will receive annual carbon payments after annual verifications of avoided conversion. This agreement is the primary project activity to prevent legal conversion of native Cerrado vegetation within the LVC private property, which establishes the financial compensation to the landholder for conservation efforts, therefore competing with the opportunity cost of commercial agriculture.

b) On-Ground Management & Supervision Teams

The initial PAI has a dedicated on-ground management and supervision team that patrols the property entrances as well as the area.

c) Fire Management

Fires are native to the Cerrado biome during the dry season but have increased due to manmade fires. A fire management plan is in place, fire breaks are maintained, and fire-fighting equipment was purchased for the fire-fighting brigade. Since 2018, LVC has partnered with the fire department to conduct training sessions with the community on fire prevention techniques, fighting forest fires and making forest fire dampers (do-it-yourself firefighting equipment). During the dry season, LVC mobilizes its brigade to help fight fires on neighbouring properties.

d) Biodiversity Center

In 2017, a nursery was built to produce native Cerrado seedlings. In 2018, a partnership was established with the Secretary of Environment for the donation of 200,000 native Cerrado seedlings for community reforestation. Since then, an additional 87,700 native Cerrado seedlings have been donated.

e) Research

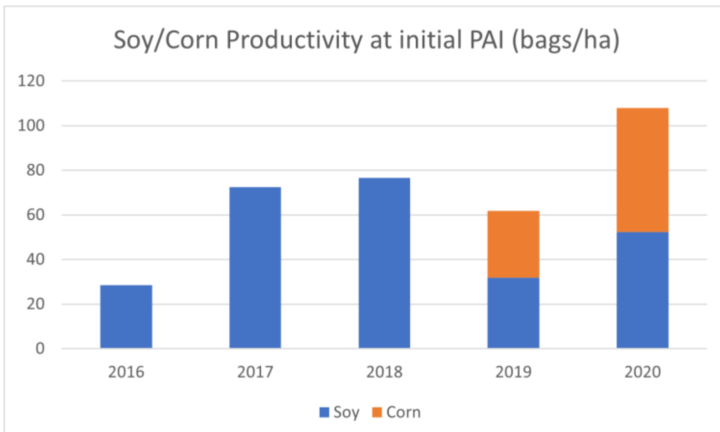
Research partnerships with universities are supported. In 2018, a research partnership was signed with FAPEG to perform a forest inventory and calculate carbon stocks using biomass plots. This research was lead by Dr. Fábio Venturoli and Dr. Iris Roitman, and supporting by Luana Elis Guimarães, who measured above-ground biomass which was used to calculate project carbon stocks.

Biodiversity research resulted in the discovery of new species at the LVC and water quality research showed that the LVC supports clean drinking water to the community.

f) Improved Agriculture

The LVC management team has been increasing productivity of the crop production, through adopting best practices and soil management techniques. An agroforestry system has also been implemented to diversify production systems. Legado Verdes do Cerrado Agroforestry project was implemented in partnership with Instituto Tiradentes and consists of a six-hectare agroforestry system in the Engenho property.

Figure 2: Agricultural Productivity at the Initial PAI



g) Social Programs

The Votorantim Education Program (or Programa Votorantim pela educação "PVE", in Portuguese) supports cultural and educational actions aimed at the population of Niquelândia and other nearby municipalities.

The Volunteer Challenge Program supports voluntary charitable actions, such as improving infrastructure in schools, lectures, collecting food and donating to charities.

The Environmental Education Program encompasses a variety of educational activities aimed at generating knowledge and training the local population.

1.11.1 Forest Reference Emission Level (FREL)

The project is an Avoided Planned Conversion (APC) project, with known agents of conversion. In the case of APC projects, it is crucial to understand that the drivers of conversion are the private landholders that hold the legal right to deforest their surplus forest above the legal required percentages of the Brazilian Forest Code. This means that the rate of conversion is context specific and therefore applying the FREL to estimate emission reductions is not applicable.

Furthermore, the Brazilian government recognizes the contribution of the voluntary forest carbon market, especially for forest and native vegetation projects as REDD+, and encourages its functioning and development, as per the Resolution nº 518/2020[5] of the Ministry of Environment and the CONAREDD Resolution nº 3/2020[6].

1.12 Project Location

The initial PAI is located in the municipality of Niquelandia, in the state of Goais, roughly 270 kilometeres from Brazil's capital, Brasilia. The initial PAI is located within the grouped project geographic boundary, the Cerrado biome, as shown in Figure 1, Section 1.4.1.

The geographic boundaries of the initial PAI are shown in the Figures below and Appendix F provides KMZs shapefiles. The Figures clearly delineate the following requirements from VM0009:

- Name of the project area including geographic coordinates of vertices.
- Total land area and project accounting area.
- Topography.
- Roads.
- Major rivers and perennial streams.
- Land use/vegetation type classification. As per the land use categories in figures 3 to 10, the "consolidated areas" are, as defined by the Brazilian Forest Code, the areas with anthropogenic influence in which there are pasture, farming, or infrastructure, with no native vegetation left, therefore, not part of the PAA.

[5] Accessed at: https://www.in.gov.br/en/web/dou/-/portaria-n-518-de-29-de-setembro-de-2020-280524591

[6] Accessed at: https://www.gov.br/mma/pt-br/assuntos/servicosambientais/florestamais/Resoluon3de22deJulhod.pdf

Figure 3: Serra Negra Property, Project Map

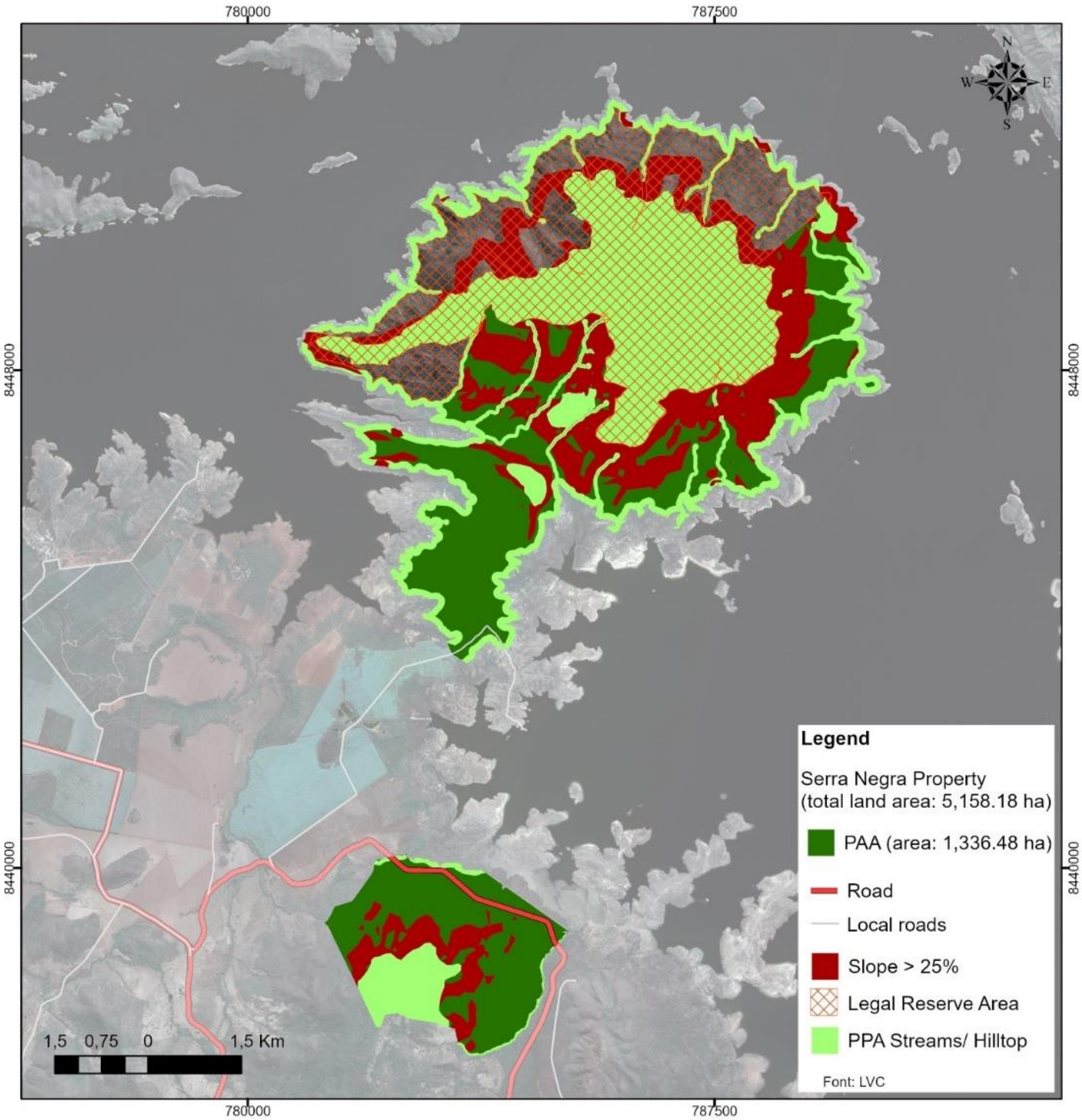


Figure 4: Serra Negra Property, Vegetation Map

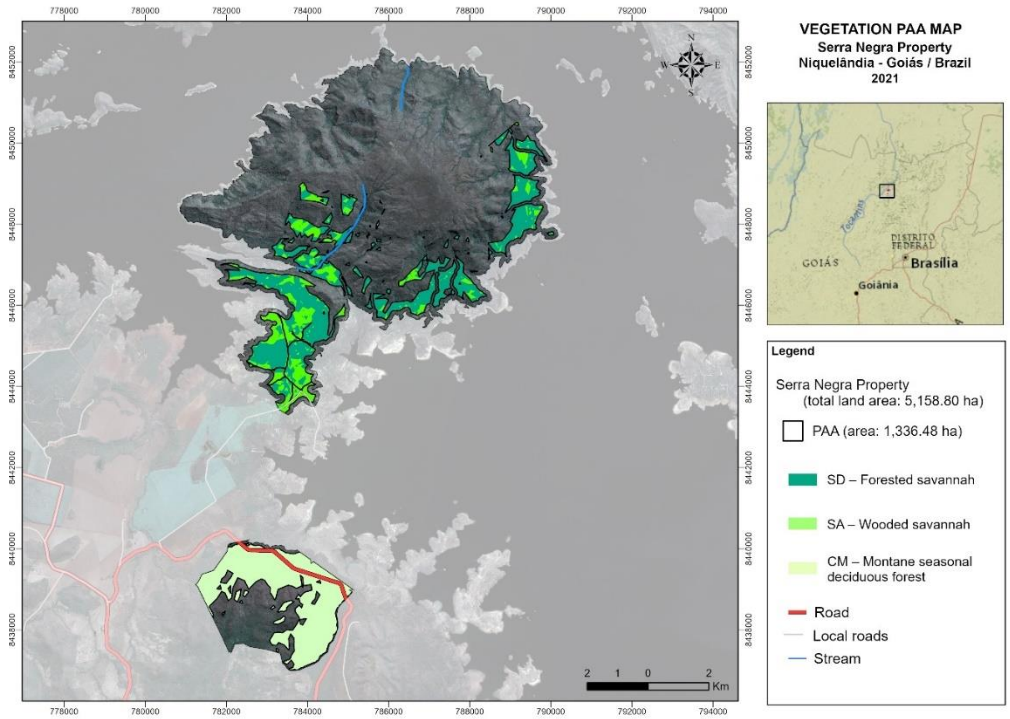


Figure 5: Serra Negra Property, Slope Map

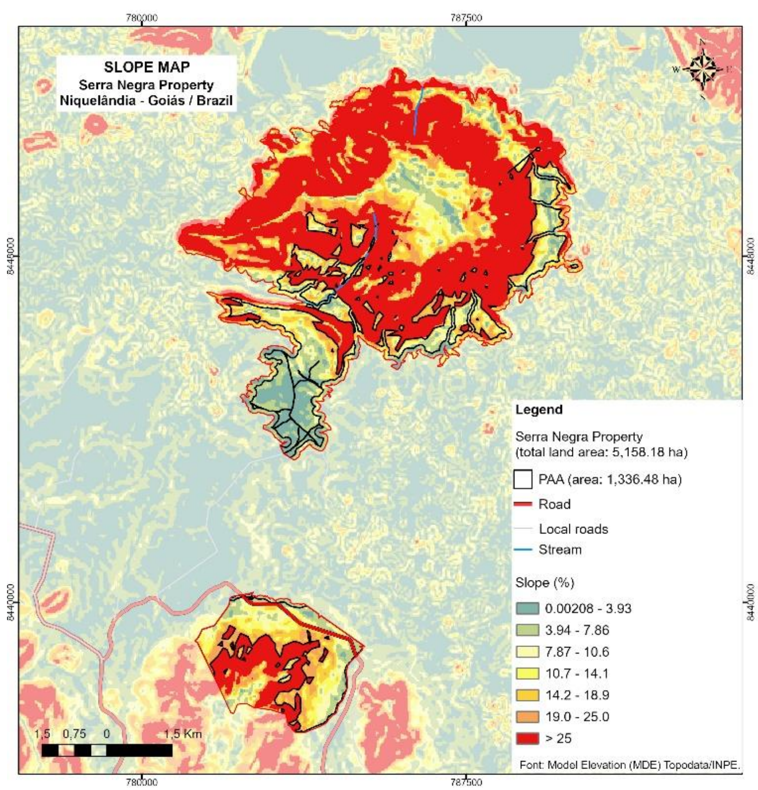


Figure 6: Serra Negra Property, Soil Map

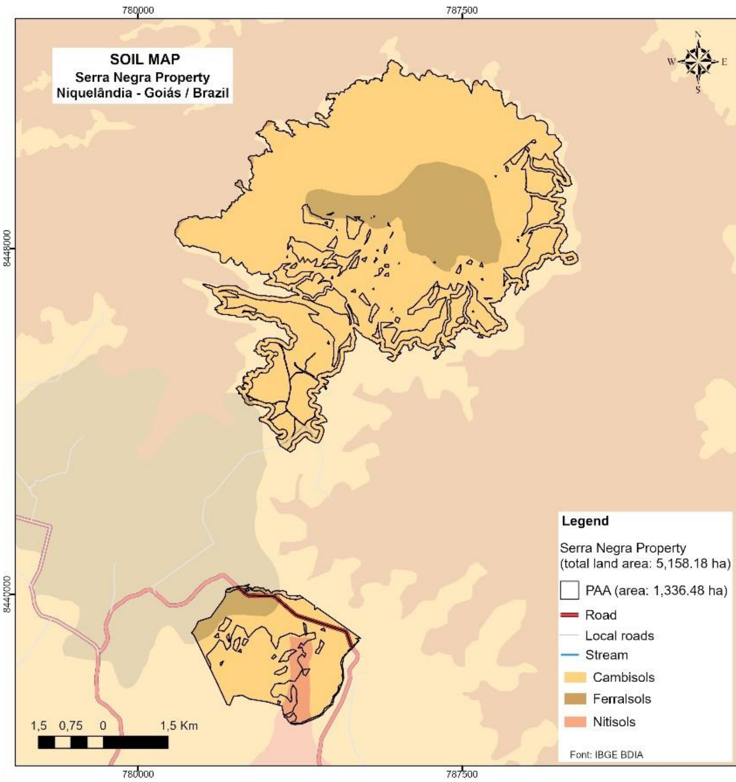


Figure 7: Engenho Property, Project Map

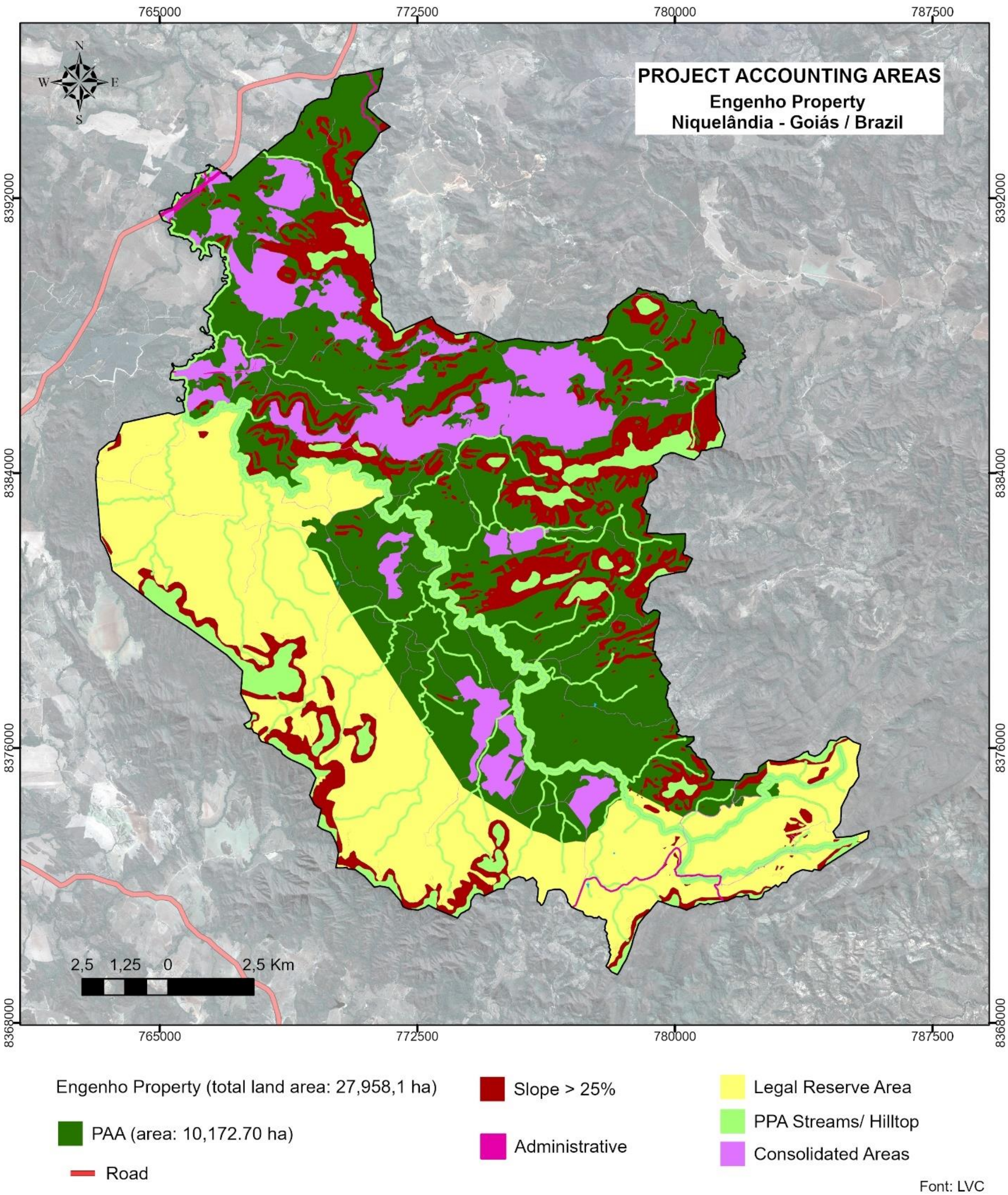


Figure 8: Engenho Property, Vegetation Map

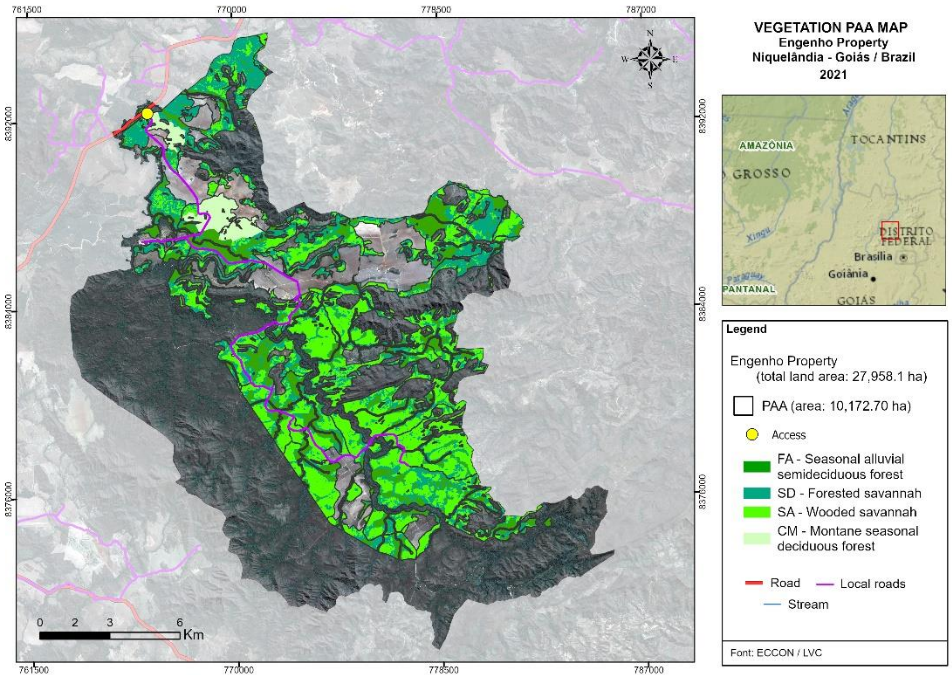


Figure 9: Engenho Property, Slope Map

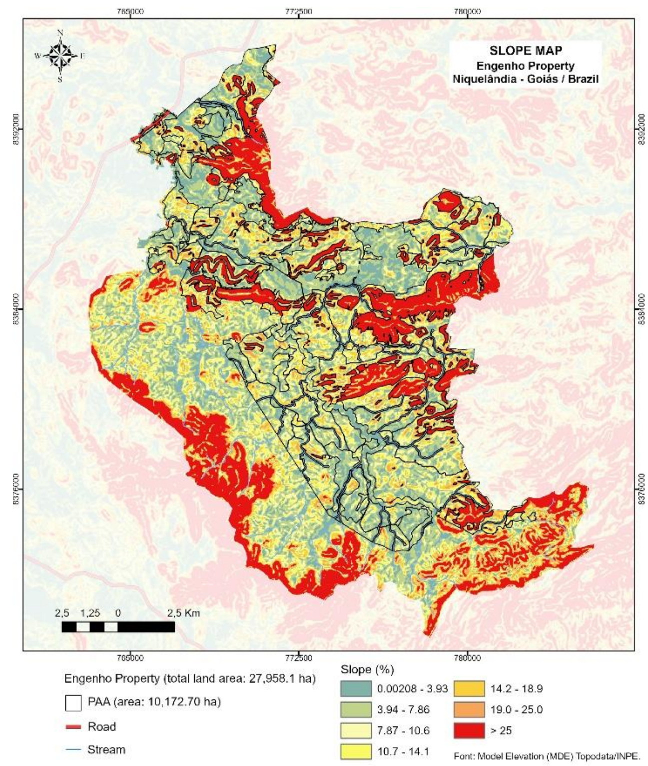
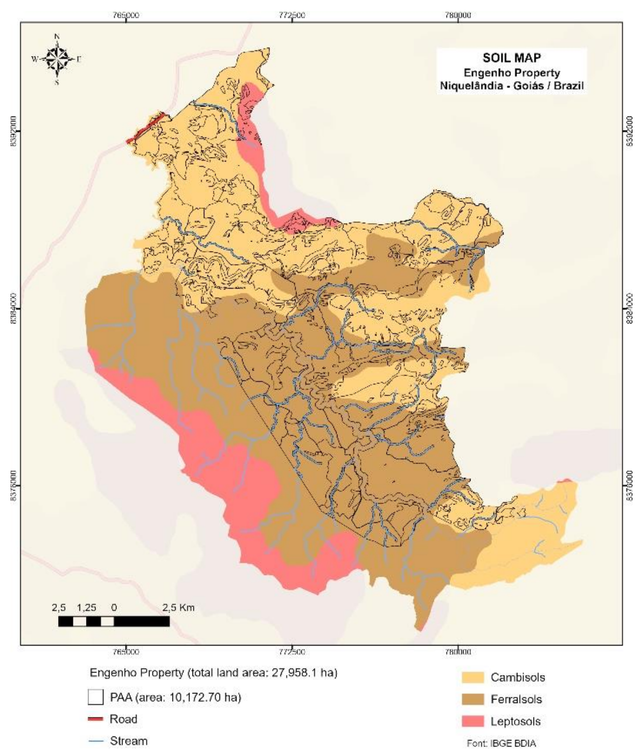


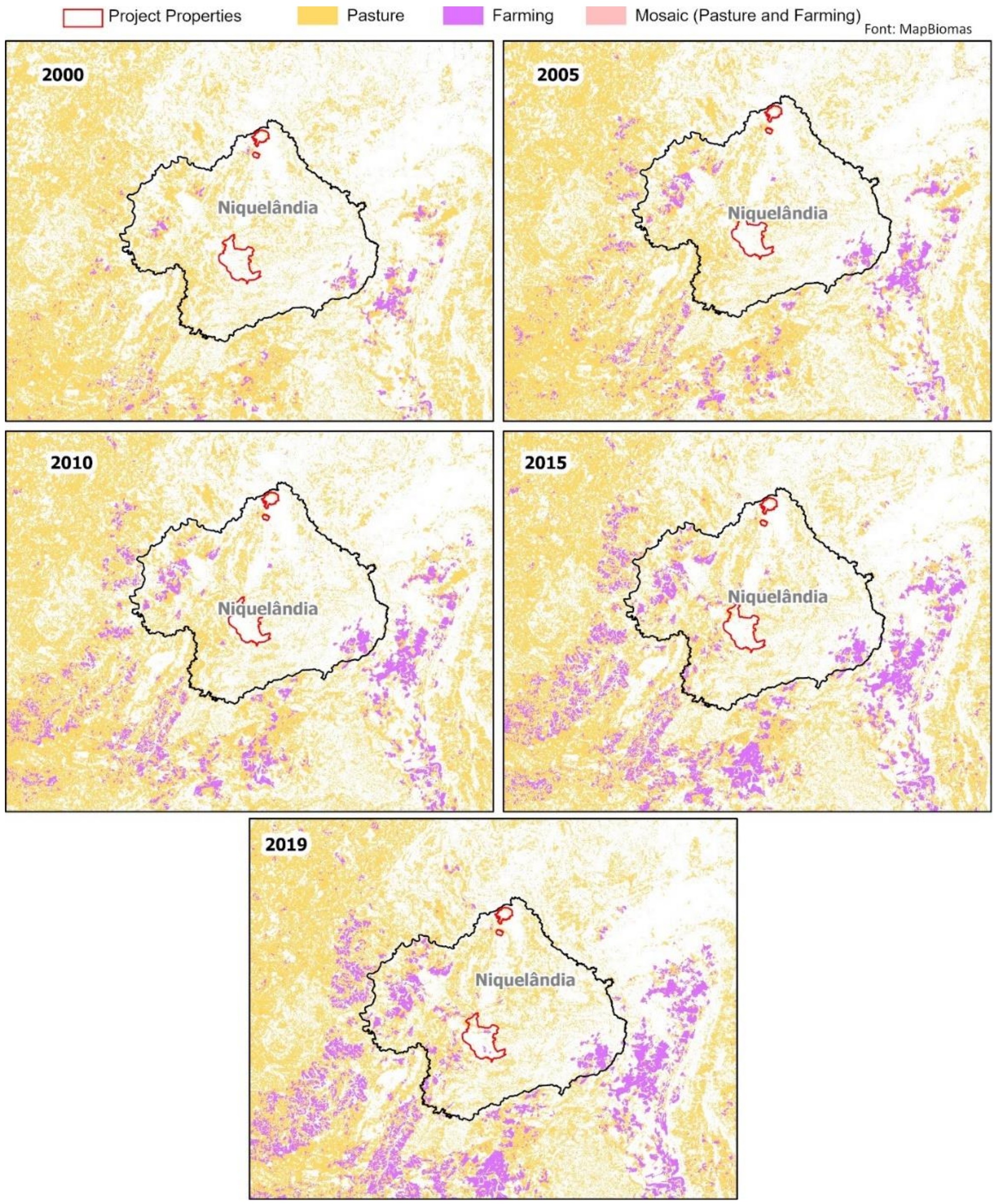
Figure 10: Engenho Property, Soil Map



1.13 Conditions Prior to Project Initiation

The conditions prior to project initiation are the same as those identified in the baseline scenario, as described in Section 3.4 (Baseline Scenario). The figure below shows the expansion of agriculture and cattle raising in the initial PAI region in the past 20 years.

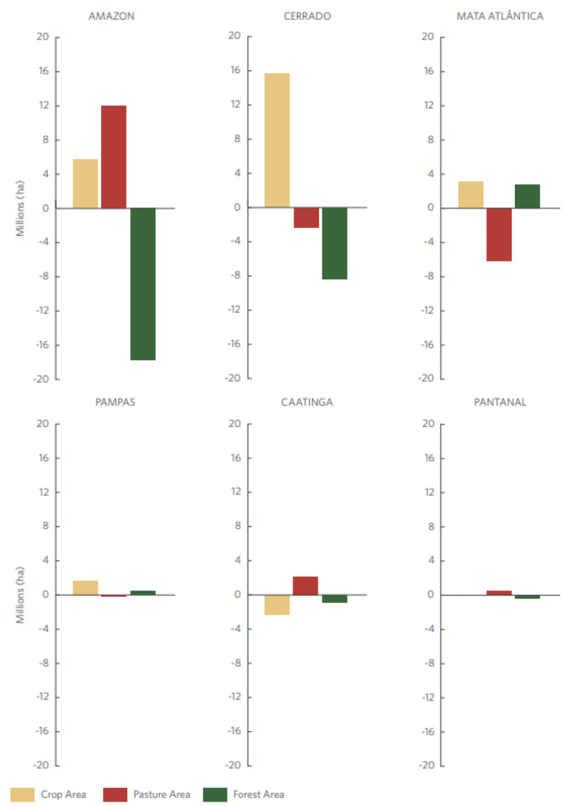
Figure 11: Agricultural Advancement in Niquelandia, Goais



The conditions prior to the project initiation are the continuation of incremental conversion of native vegetation for agricultural production until the legal limit, known as the Legal Reserve.

Since the 1950s, the rapid expansion of soy and beef production has driven the loss of about 50% of the Cerrado's native vegetation. *Figure 12* shows the land-use conversion patterns across the six Brazilian biomes between 2002-2018, demonstrating that the Cerrado biome has experienced the largest growth of crop area as well as the second largest loss of native vegetation. By 2030, the Cerrado is projected to lose tens of millions of hectares of native vegetation due to the increased global demand for commodities. Additionally, studies show that parts of the Cerrado biome are suffering desertification due to changing rainfall and sun intensity, lowering of groundwater levels, land-use change, and poor farming practices[7], impacting soil organic material and agricultural productivity.

Figure 12: Land-use Variations by Brazilian Biome (2002-2018)[8]



According to Annual Deforestation Report of Brazil (Mapbiomas[9], 2020), in 2019 33.5% of Brazil's ecosystem conversion occurred in the Cerrado biome with a total deforested area of 408,646 hectares. Table 7 below presents a variety of indicators related to deforestation in Brazil. In 2019, on average in Brazil, 156 new deforestation events were detected and validated per day, with a mean estimated deforestation rate of 0.28 hectares per day for each event. In the Cerrado, the findings were 20 new deforestation events/day with a rate of 0.99 hectares per day for each event. In 2019, for the Cerrado

[7] Horn & Baggio (2011). Desertification processes in the eastern central highlands of Brazil. See Reference in Appendix G.

[8] Source: Climate Policy Initiative using data from MapBiomas. https://www.climatepolicyinitiative.org/wp-content/uploads/2021/01/DQ-The-Impact-of-Rural-Credit-on-Agriculture-and-Land-Use.pdf

[9] Annual Deforestation Report of Brazil (MapBiomas 2019) Accessed at: https://s3.amazonaws.com/alerta.mapbiomas.org/relatrios/MBI-deforestation-report-2019-en-final5.pdf

biome, on average 1,119 hectares were deforested per day or 46 hectares per hour. The rate of deforestation for each alert is calculated by dividing the deforested area by the number of days between images from before and after the deforestation event. This rate is always underestimated, since it is not always possible to obtain a good image from the precise days at the beginning or at the end of vegetation suppression, especially in those periods and regions with high cloud cover. It is, however, a good approximation of the rate at which these events take place.

Table 7: Deforestation Rates per biome in 2019 (Mapbiomas, 2020)[10]

Biome	Mean rate per alert (ha/alert/day)	Maximum rate (ha/alert/day)	Mean number of alerts per day	Deforested area per day (ha)	Deforested area per hour (ha)
Amazon	0.17	40	130	2,110.0	87.92
Caatinga	0.42	9	1	33.3	1.39
Cerrado	0.99	60	20	1,119.6	46.65
Atlantic Forest	0.12	19	4	29.0	1.21
Pampa	0,12	2	0	1.8	0.007
Pantanal	0.87	13	1	45.3	1.89
Brazil	0.28	60	156	3,339	139

1.13.1 Climate and Hydrography

The Cerrado is characterized by the presence of dry winters and rainy summers. The Köppen climate classification system for the Cerrado is Aw[11]. It has an average annual rainfall of the order of 1500 mm, ranging from 750 to 2000 mm. Rains are practically concentrated from October to March (rainy season), and the average temperature of the coldest month is over 18°C. There is a quite large thermal diversification between the lower altitudes (less than 300 m), and the long plateaus (between 900 and 1600 m) of the Cerrado biome.

The climate of the project region, comprised in the municipality of Niquelândia, is in a tropical zone classified as tropical central Brazil, according to the climate Map of Brazil (IBGE, 2006)[12]. The data show that the most part of Niquelândia is covered by hot temperatures, in average, above 18°C all months, is a semi moist area and has 4 to 5 dry months. A small part is characterized with subhot temperatures, with

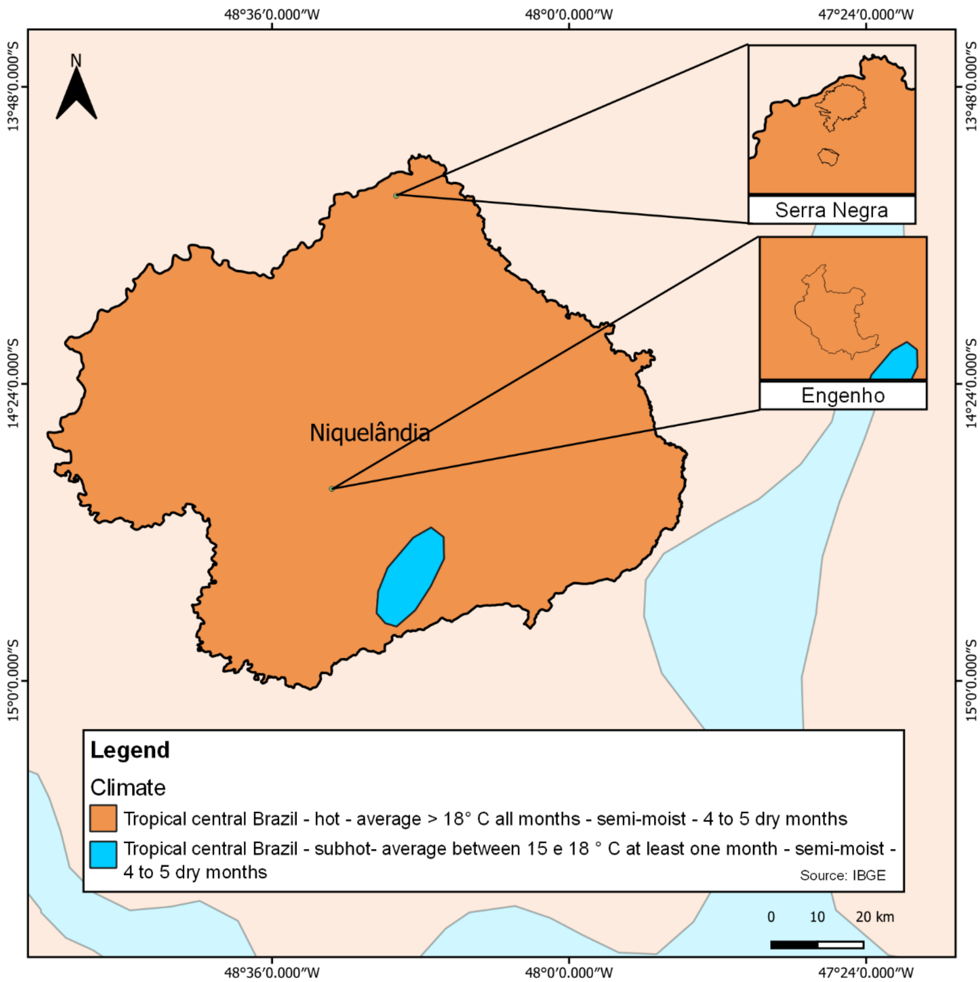
[10] MapBiomas. Annual Report on Deforestation 2020. Accessed at: https://s3.amazonaws.com/alerta.mapbiomas.org/rad2020/RAD2021 - MapBiomasAlerta EN.pdf

[11] Köppen-Geiger Climate System. Accessed at: http://www.gloh2o.org/koppen/

[12] Accessed at: https://www.ibge.gov.br/geociencias/downloads-geociencias.html

average between 15°C and 18°C at least one month, as semi-moist area and has 4 to 5 dry months. The Figure 13 shows the distribution of the climatic aspects that affect the region.

Figure 13: Climate Map of Brazil for Niquelândia



According to seasonally data about average temperature and average precipitation, for the period from 1981 to 2010, obtained with National Institute of Meteorology (INMET)[13], the Niquelândia region has an average of 20 to 24 °C in summer months and an average of 18 to 22 °C in winter months, as shown in Figure 14 and Figure 15. Regarding precipitation, it is noticed that summer months have an average between 600 and 900 mm and that it is registered an average between 0 and 50 mm in winter months, as shown in Figure 16 and Figure 17.

[13] Accessed at: https://portal.inmet.gov.br/

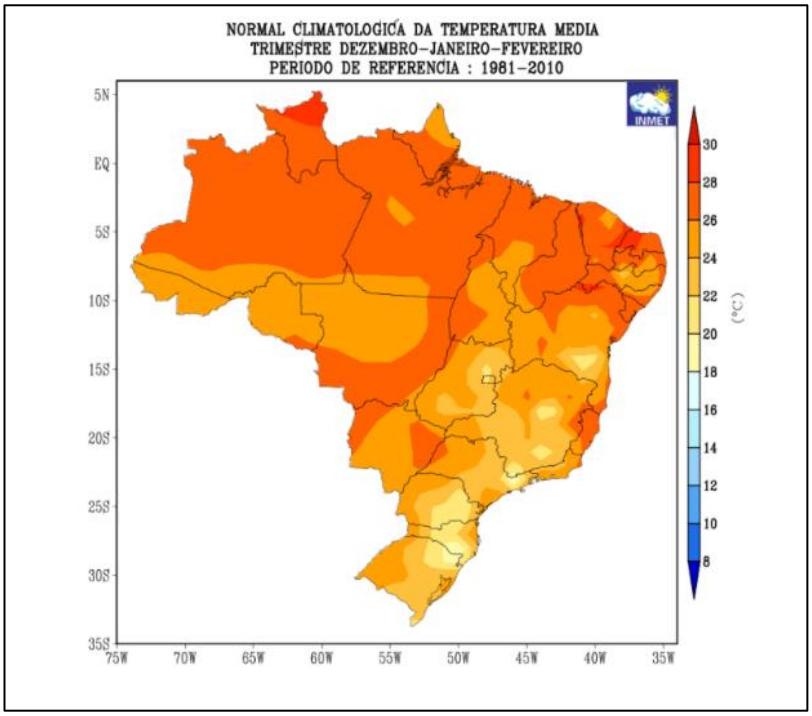


Figure 14: Average temperature in a December, January, February period (1981-2010)

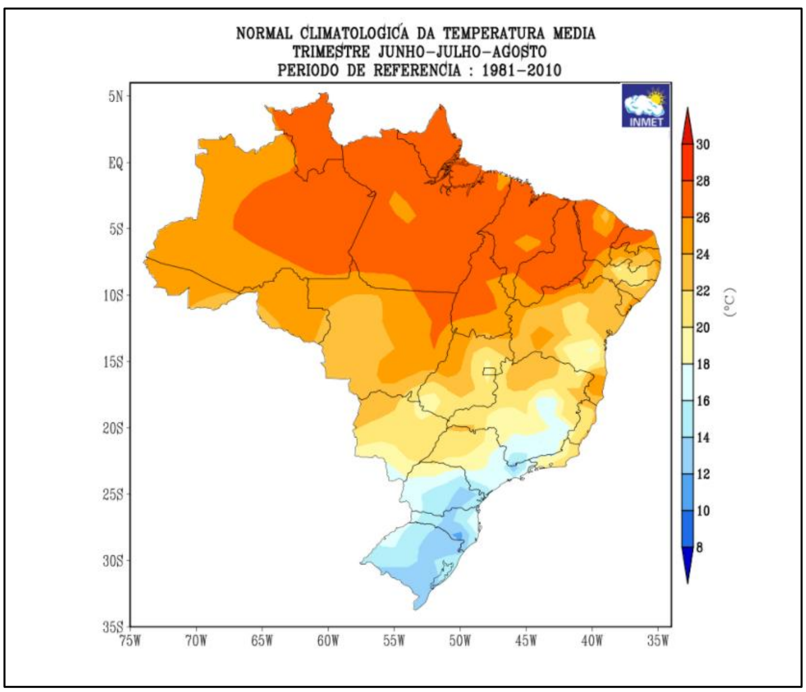


Figure 15: Average temperature in a June, July, August period (1981-2010)

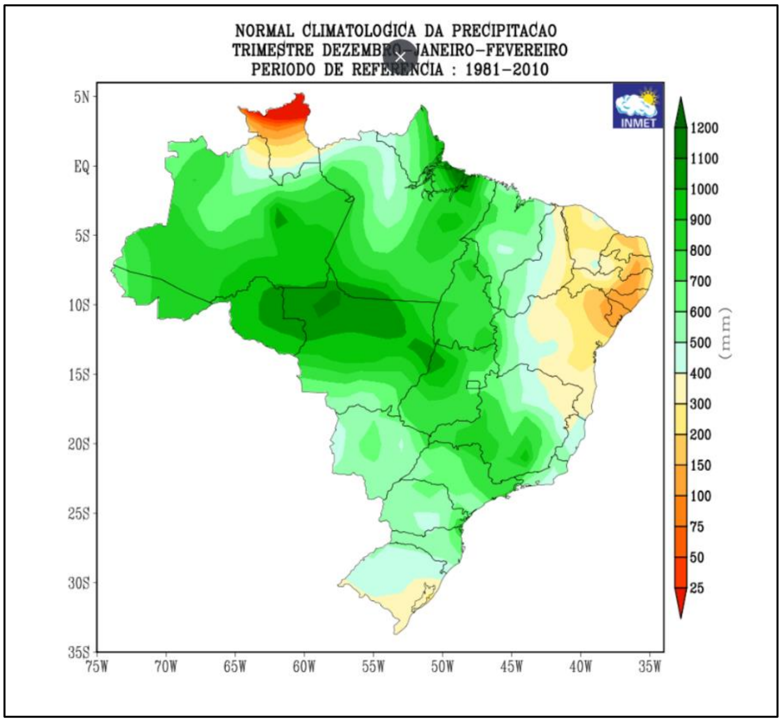


Figure 16: Average precipitation in a December, January, February period (1981-2010)

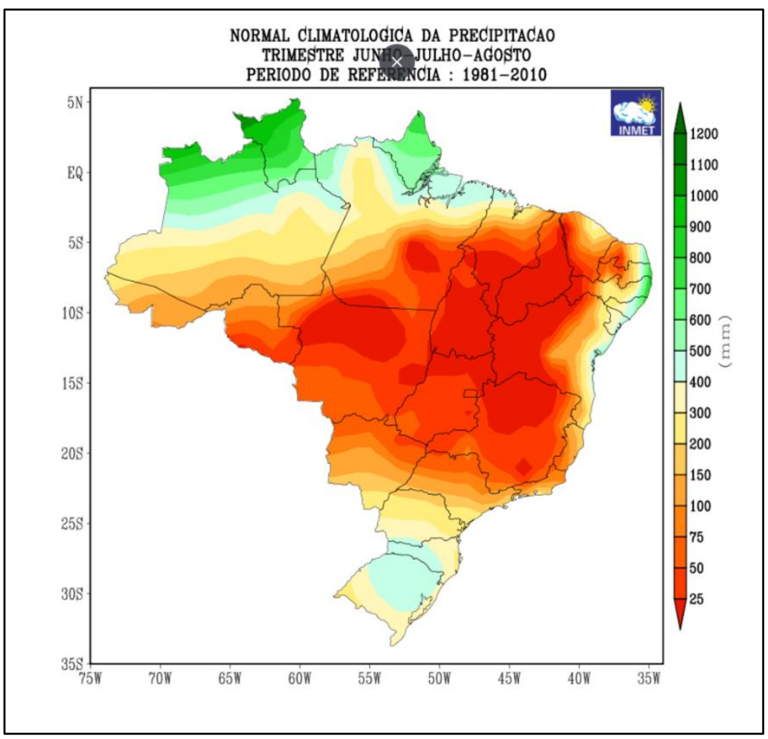


Figure 17: Average precipitation in a June, July, August period (1981-2010)

Analyzing the data from the closest meteorological station from Niquelândia, the station of Formosa, is possible to verify an accumulated amount of 1,420.2 mm of precipitation, considering the years from 1981 to 2010. The Table 8 presents the monthly accumulated precipitation for Formosa station and the sum of a year.

Table 8: Climatological Normal of Brazil 1981-2010 - Accumulated Precipitation (mm)

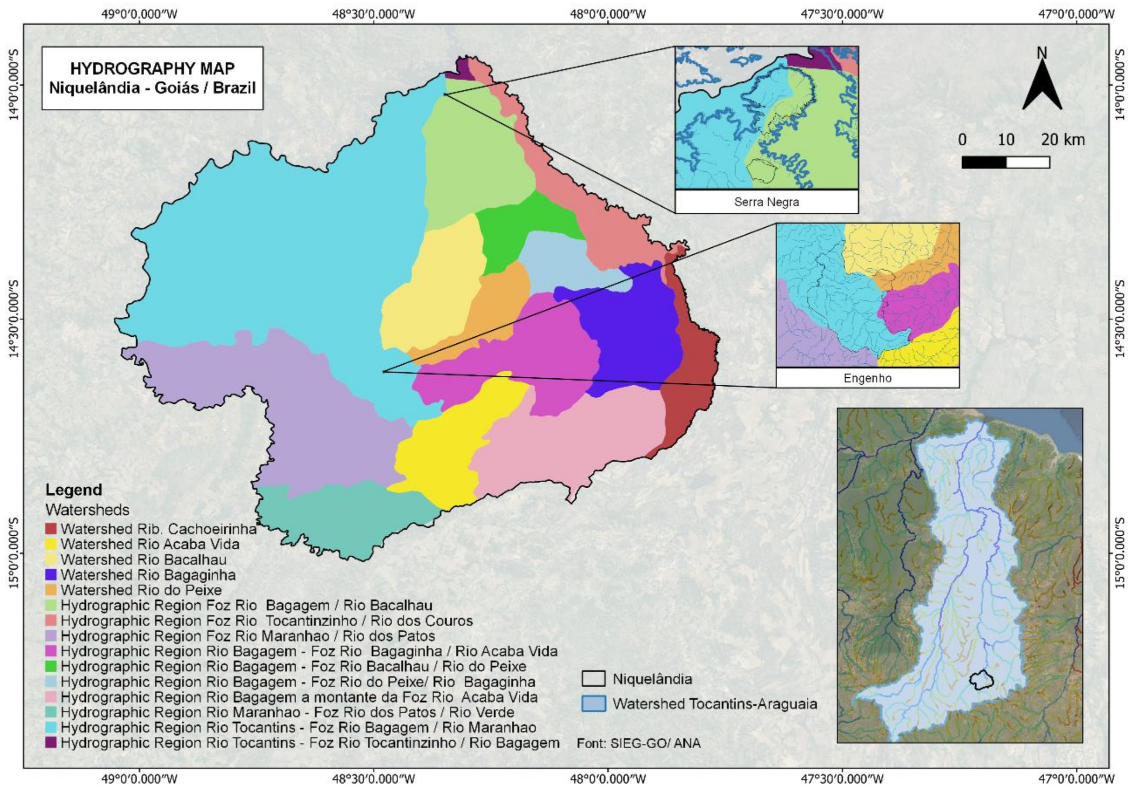
Climatological Normal of Brazil 1981-2010 - Accumulated Precipitation (mm)	
Station code	83379
Station Name	FORMOSA
Federation Unity	GO
January	235.6
February	200.4
March	211.7
April	93.9
May	20.6
June	4.2
July	3.2
August	11.8
September	35.3
October	123.7
November	201.9
December	277.9
Year	**1,420.2**

Regarding hydrography, the municipality of Niquelândia is located within the Watershed of Tocantins – Araguaia which follows the direction of its main rivers: Tocantins and Araguaia, that unite and disembogue, at North, in Pará State.

The Tocantins River has full extension of approximately 2,400 km and it is formed in central Brazil in the Plateau of Goiás, near to the country capital, Brasilia. It has drainage area of 306,310 km², before the confluence with Araguaia, and 764,996 km² at the river mouth. Along its length, the river has several hydroelectric plants such as: Serra da Mesa, Cana Brava, Peixe-Angical, Luís Eduardo Magalhães (Lajeado) e Tucuruí[14]. The municipality of Niquelândia is located near the region of origin of the river, as shown in Figure 18.

The watershed of Tocantins- Araguaia is divided into several sub-basins. The Figure 18 presents the sub-basins that are part of Niquelândia limits, the hydrography comprised in the Serra Negra and Engenho areas, and the layout of the watershed Tocantins-Araguaia. It is noticed that the hydrography comprised in the Engenho and Serra Negra areas is composed by non-wide rivers that are tributaries of the Tocantins River.

Figure 18: Hydrography of Niquelândia and Watershed Tocantins- Araguaia



1.13.2 Geology, Topography and Soils

Slope maps were produced using geomorphometric data from Brazil made available by the National Institute of Space Research (INPE) through the Topodata project[15]. The maps were downloaded using a webportal[16].

[14] https://www.to.gov.br/semarh/plano-da-bacia-hidrografica-do-rio-tocantins-e-araguaia/13qdka1qq2w5

[15] Accessed at: http://www.dsr.inpe.br/topodata/

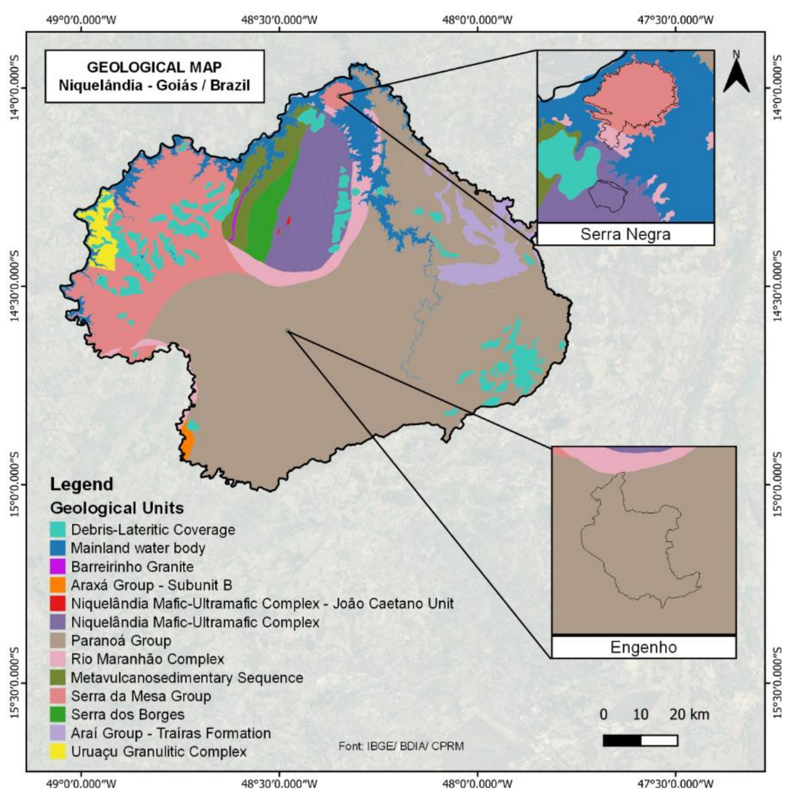
[16] Accessed at: http://www.webmapit.com.br/inpe/topodata/

The altitude base derived from the Digital Elevation Model (DEM) offered by the Topodata project was used, and elaborated from the Shuttle Radar Topography Mission (SRTM) data provided by the United States Geological Survey (USGS) on the worldwide computer network.

The altitude base received treatment in specialized geographic information system (GIS) software, and its slope classification was performed in percentage (%), especially areas with slopes greater than 25%, which are unfavorable to agricultural practice, needing to be excluded from the areas directed to the REDD project.

According to the Geology of the State of Goiás and Federal District obtained from Explanatory Text of the Geological Map of the State of Goiás and Federal District (Goiânia, 2008)[17], the municipality of Niquelândia has mostly 12 geological units that characterizes the region, such as Debris Lateritic Coverage; Barreirinho Granite, Araxá Group; Niquelândia Mafic-Ultramafic Complex (João Caetano Unit); Niquelândia Mafic-Ultramafic Complex; Paranoá Group; Rio Maranhão Complex; Metavulcanosedimentary Sequence; Serra da Mesa Group; Serra dos Borges; Traíras Formation and Uruaçu Granulitic Complex. Figure 19 shows the mainly units of Niquelândia and shows the units that occur in Serra Negra and Engenho areas.

Figure 19: Geological Map of Niquelândia



[17] http://www.cprm.gov.br/publique/Geologia/Geologia-Basica/Cartografia-Geologica-Regional-624.html

The main unit in Niquelândia, which encompasses all the Engenho area, is called **Paranoá Group**, which is a depositional system composed by a thick psamo-pelitic succession and by an important contribution of carbonate rocks. The group is exposed in extensive areas of Goiás, mainly along a broad north-south range, and it occurs from the Federal District to the south of Tocantins State (Goiânia, 2008). The unit is grouped into four megacycles that are, from bottom to top: Lower Rhythmic Quartzitic Conglomeratics Unit; Siltic-Ardosian Unit; Intermediate Quartzitic Rhythmic Unit; and Pelite-carbonated Rhythmic Unit (CPRM)[18].

The **Serra da Mesa Group** and **Niquelândia Mafic-Ultramafic Complex** are two other major units occurring in Niquelândia, also encompassing most of the area of Serra Negra. The Serra da Mesa Group is composed by metasedimentary rocks that occur in the north part of Goiás and sustain the homonymous mountain range. The type-section of the unit is located in the Serra da Mesa mountain range, region of rugged terrain of north-south general direction and with a maximum apparent thickness of 1,700 meters. The Niquelândia Mafic-Ultramafic Complex has a north-south orientation, with approximately, 40 km of length and 15 km wide, and is limited to the south and north by transient faults (east-west) and to the west and east by zones of contractile shear with the Juscelândia Sequence and with the gneisses of Maranhão River Diorite-Granodiorite Complex, respectively. The complex is divided in Inferior Mafic Zone, Superior Mafic Zone and Ultramafic Zone (Goiânia, 2008).

According to the digital elevation model obtained in the TopoData/ INPE platform, the altitude in the Niquelândia region is, in average, 662 meters, not exceeding 1293 meters in the southeast portion of the municipality, where the highest altitudes are located. The Figure below shows the distribution of altitudes along the municipality and within Engenho and Serra Negra areas.

Regarding geomorphology, the North of Goiás Plateau and the Uruaçu-Ceres Intermontane Surfaces are predominant in the most part of the municipality where the altitudes are average. The highest altitudes correspond to the Bagagem River Plateau, as shown in the Figure below regarding the local geomorphology.

[18] http://www.cprm.gov.br/publique/Geologia/Geologia-Basica/Estado-de-Goias-399.html

Figure 20: Altitude Map of Niquelândia

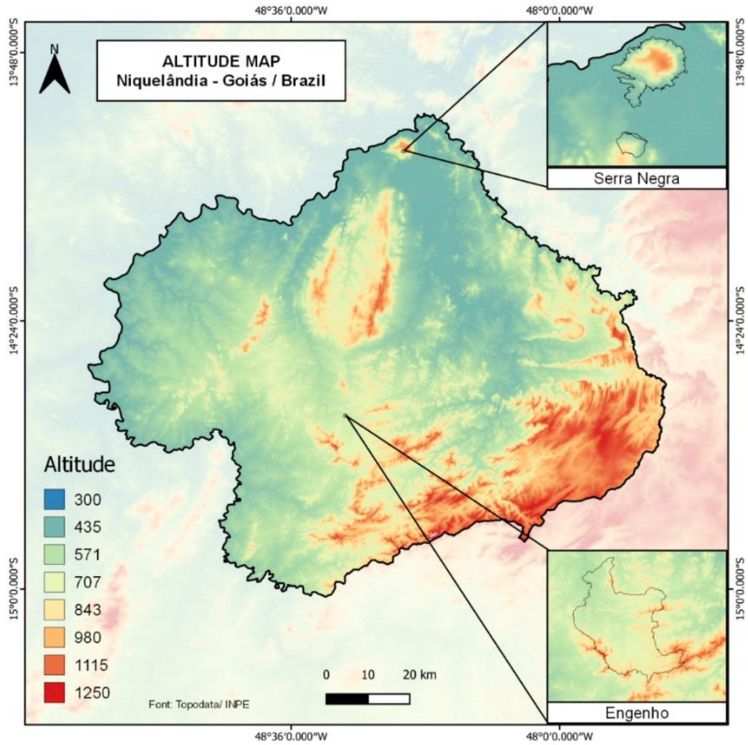
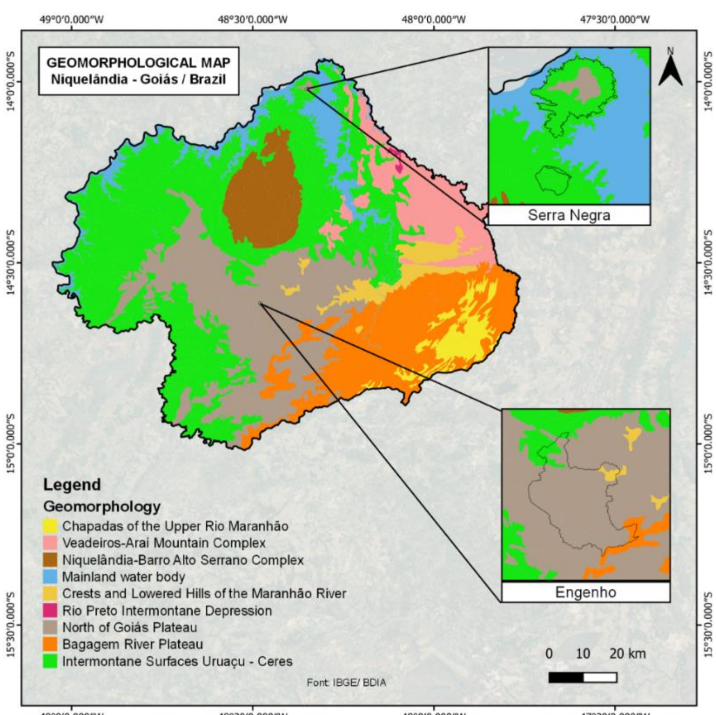
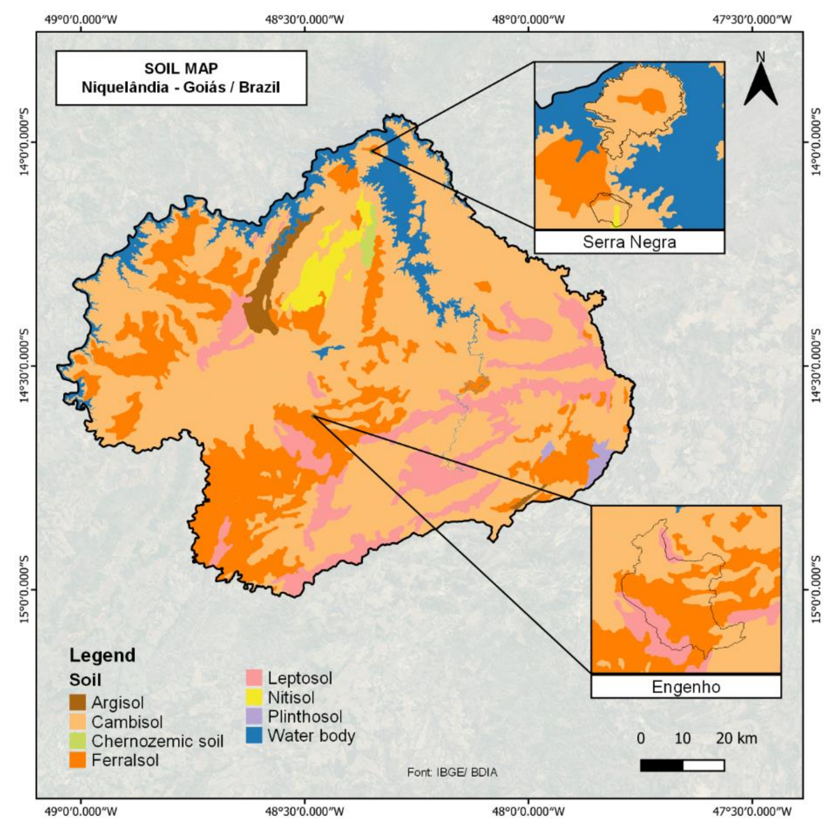


Figure 21: Geomorphological Map of Niquelândia



The predominant soil type in Niquelândia is the **Cambisol**, which, according to Brazilian soil classification system, is constituted by mineral material with an incipient B horizon underlying to any of superficial horizon, except for the hystical ones with 40 cm or more in thickness), or chernozemic A horizon, when incipient B horizon presents clay with high activity and high saturation by bases. Plinthite and/or petroplinthite, glei horizon and vertic horizon, if present, do not meet the requirements for plinthosols, Gleisol and Vertisol, respectively. The **Ferralsol** is also a predominant soil type in the region and is characterized as soil constituted by mineral material, which presents a latosolic B horizon preceded by any type of A horizon within 200 cm of the soil surface or within 300 cm, if the A horizon is more than 150 cm thick (Embrapa, 2018)[19]. The Figure 22 presents the Soil Map of Niquelândia and shows the predominance of Cambisol and Ferralsols in the Engenho and Serra Negra areas as well.

Figure 22: Soil Map of Niquelândia

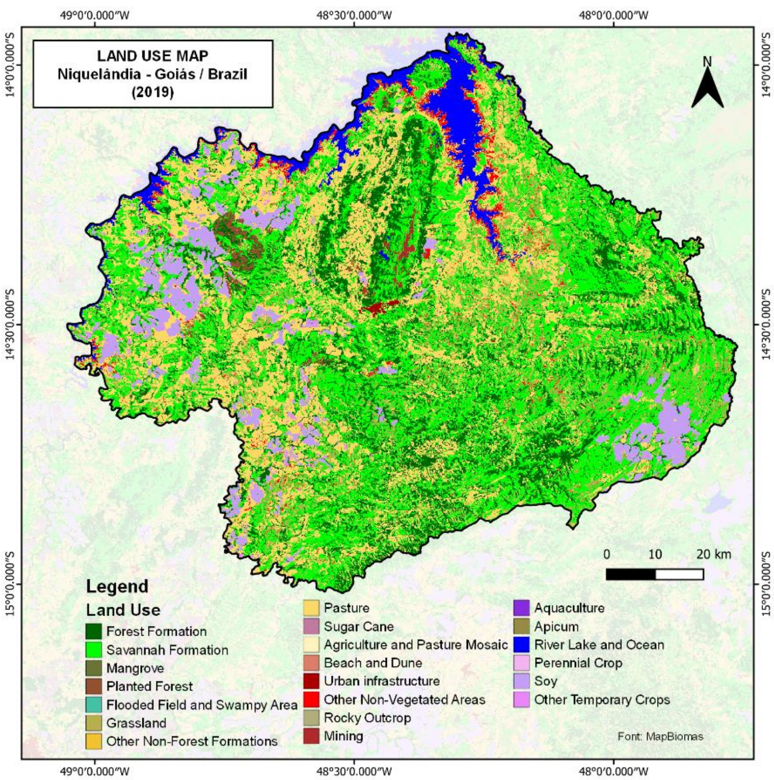


[19] https://www.embrapa.br/solos/sibcs/solos-do-brasil

1.13.3 Land-Use & Vegetation

Confirming the land use for the municipality, the Figure 23 presents the distribution of types of land use across Niquelândia for the year of 2019 obtained in the MapBiomas platform. It is noted that the use for agriculture and cattle raising is well spread in the region, corresponding to, approximately, 31% of municipal land use, a category that has increased its reach over the years, exerting pressure on land and natural vegetation, which in turn, has reduced its ground cover over the years.

Figure 23: Land Use in Niquelândia (2019) according to MapBiomas



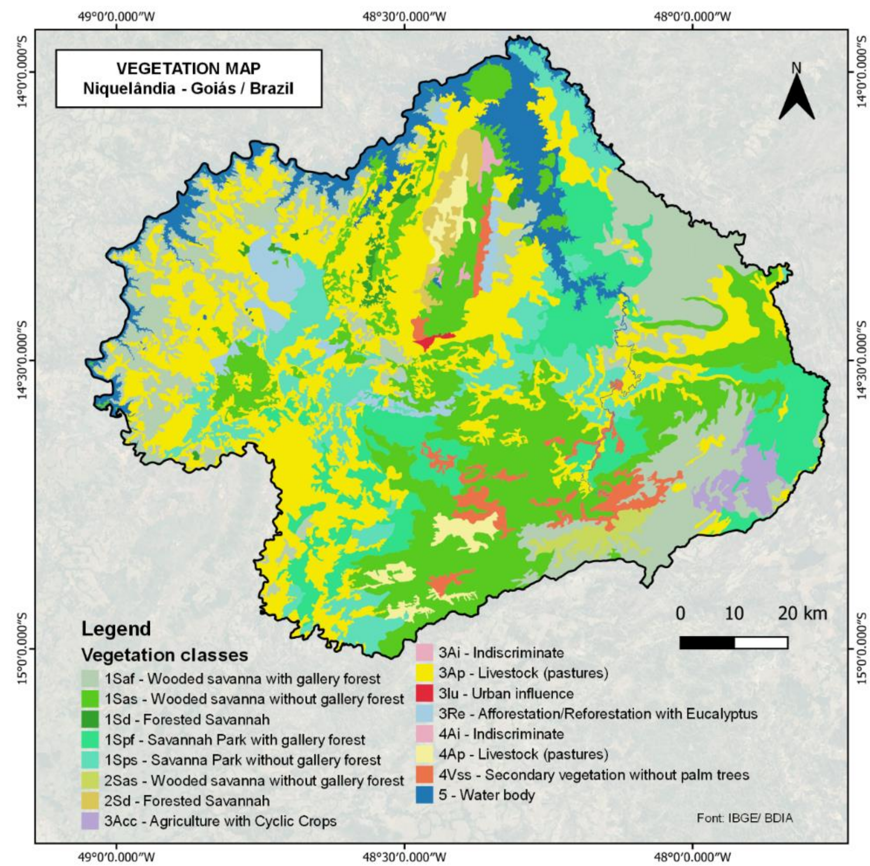
According to IBGE vegetation cover mapping there are predominance of vegetation classes and lad use such as Wooded Savanna, Forested Savanna, Savanna Park, Agriculture, Livestock, Afforestation/ Reforestation with Eucalyptus and secondary vegetation, as shown in Figure 24.

The Technical Manual of Brazilian Vegetation from IBGE describes the vegetation classes as the following. **Wooded Savanna** (Portuguese: Savana Arborizada) is either natural or anthropized formation subgroup characterized by presenting a thin nanophanerophytic physiognomy and a continuous gramoid hemicryptophytic physiognomy, liable to annual fire. The dominant synusias form more open physiognomies (Campo Cerrado), sometimes with the presence of a dense scrub, Cerrado properly said. The floristic composition, despite being similar to the Forested Savanna, has dominant species that characterize the environments according to the geographic space occupied.

Forested Savanna (Portuguese: Savana Florestada) is a formation subgroup with typical physiognomy and characteristic restricted to leached sandstone areas with deep soil, occurring n an eminently tropical climate seasonal. It presents woody synusias of micro and nanophanerophytes, tortuous with irregular branching, provided with perennial or semideciduous sclerophyte macrophytes, rigid corticosterous exfoliated rhytidoma or softly suberous cortex, with organs of underground reserve or xylopods, whose heights vary from 6 to 8 m.

Savana Park (Portuguese: Savana Parque) is a formation subgroup consisting essentially of a graminoid stratum, integrated by hemicryptophytes and geophytes of natural or anthropic floristic, interspersed with isolated nanophanerophytes, with typical connotation of an English Park (Parkland). The Savana Park of anthropic nature is found throughout the country, while the natural occurs sometimes with the feature of lithosolic fields and/or rocks[20].

Figure 24: Vegetation classes Map of Niquelândia



[20] https://biblioteca.ibge.gov.br/visualizacao/livros/liv63011.pdf

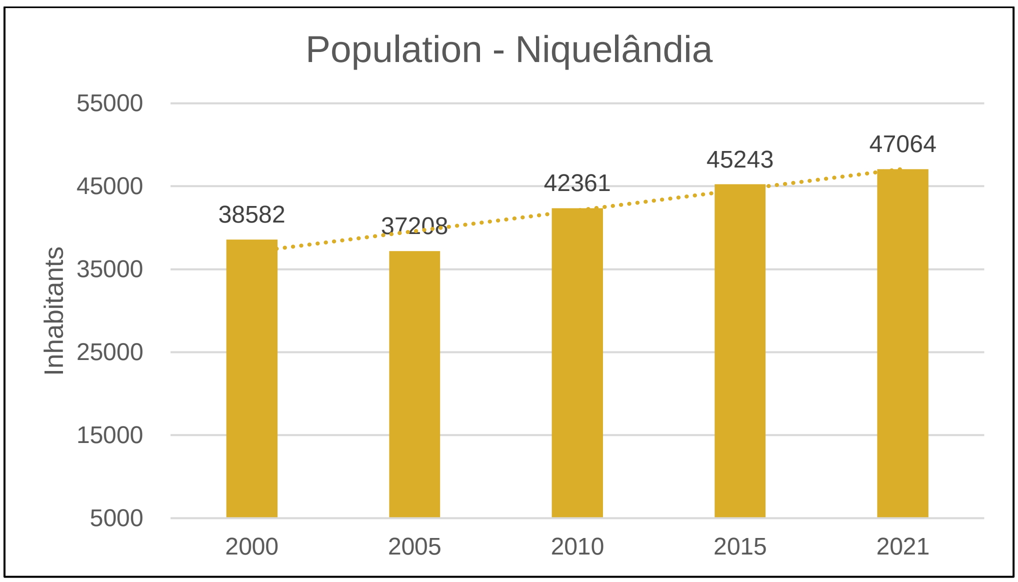
1.13.4 Socio-Economic Conditions

The following socioeconomic analyses considers data from the municipality of Niquelândia obtained through the Brazilian Institute for Geography and Statistics (IBGE)[21].

Niquelândia is a municipality with an estimated population of 47.064 people for the year of 2021, with a demographic density of 4,3 inhabitants per square kilometer according to the 2010 census survey. For the year of 2019, the average monthly salary of formal workers was 2,3 times the basic salary, and the proportion of people with formal employment in relation to the municipal total was 13%. Approximately 40% of the municipal population lived with less than half basic salary, according to the 2010 census.

The municipal population has been increasing over the years, as shown in the graphic of Figure 25, which presents the census numbers for the years of 2000 and 2010 and estimates for the rest of them.

Figure 25: Populational growth in Niquelândia



Agricultural activities occur in all areas in the municipality of Niquelândia, except those defined as urbanized or zoned for urbanization expansion, defined by municipal zoning laws.

The law nº 714/91, of August 30, 1991, provides for the municipal zoning categories for Niquelandia:

1) **Urban Area:** all divided and not divided areas but defined by the limits of allotments and established in specific Municipal Law.

2) **Urban Sprawl Area 1:** all that defined by higher points of the sequence of hills to the north and south; to the west, bounded by the allotment Vila Bela; to the east by the Sanitáia Lagoon. This perimeter must be precisely established by the Law of the Municipal Executive.

21

3) **Urban Sprawl Area 2:** all that between the bounding line of urban sprawl area 1 and the circumference line that staggers the urban perimeter. This area must be precisely stipulated by specific Municipal Law.

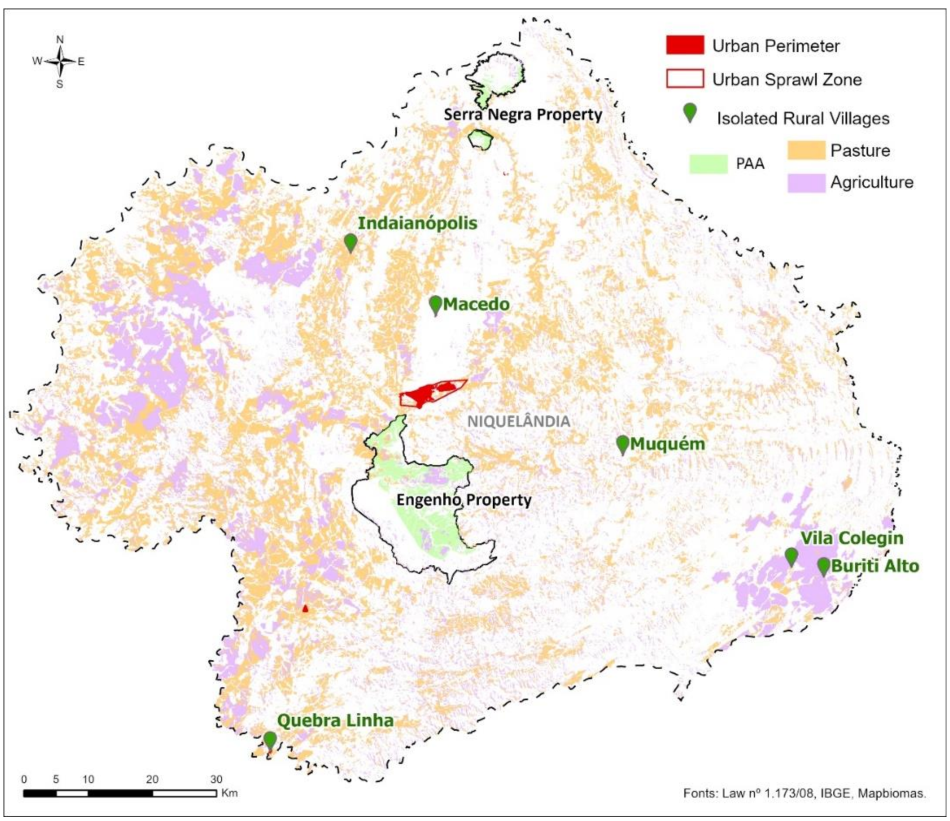
4) **Rural Area:** It is the entire part of the territory of the Municipality, excluding urban areas of urban expansion areas.

In turn, the Democratic Master Plan of Niquelândia (or Plano Diretor Democrático de Niquelândia, in portuguese), law nº. 1,173/08, of April 15, 2008, delimits the urban perimeter and characterizes urban and rural areas.

According to the law, the urban zone is all area in installments and occupied with housing and urban infrastructure. The Urban Sprawl Area is delimited according to the geographic coordinates of the vertices described in the Law.

The Figure below shows the urbanized areas, areas of urban expansion and location of the main rural villages, in addition to the range of land occupation by agricultural activity, mainly through intensive livestock and soybean cultivation, an important economic activity of the State of Goiás.

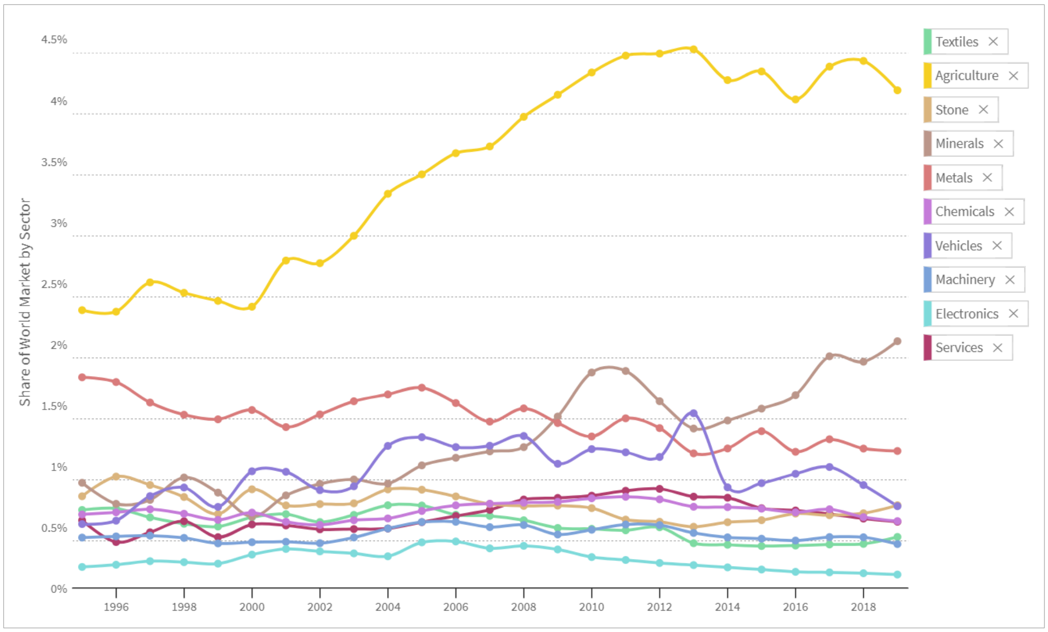
Figure 26: Urban areas and rural land use in Niquelândia



The rural areas of Niquelândia are configured beyond the limits of urban areas defined in the Master Plan (Plano Diretor in portuguese), where agricultural activities are developed. The Engenho and Serra Negra properties are located in rural areas, with environments conducive to the development of agriculture. The agriculture sector have been the most important sector in Brazilian economy, currently participating with more than 30% by the products to exportation.

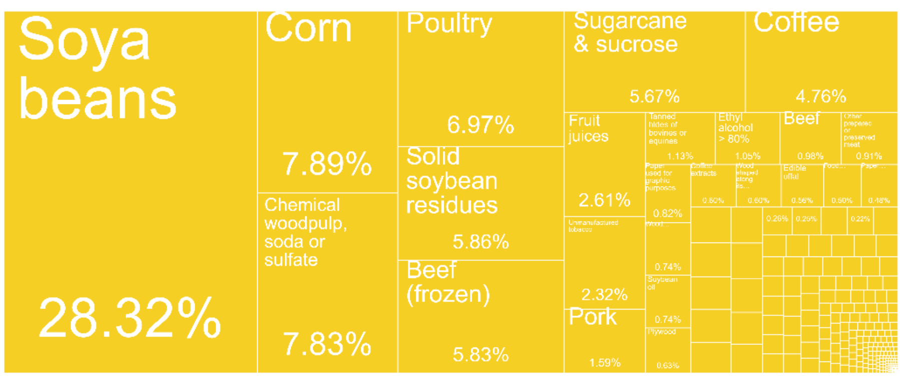
The Figure below shows what Brazil exported between 1995 and 2019.[22]

Figure 27: Brazilian exports



The production of the soybean and corn have been incrementing year by year and nowadays represent more than 35% of the brazilian commodities, with 91.8 million tons of soy and derivatives exported in 2020.

Figure 28: Proportion of Brazilian agricultural commodities for export in 2019[28]



The Cerrado biome have been the most significant environment used by grain producers in the increasing production process in the country, and the State of Goiás is the fourth producer of the soybean, hitting an

[22] The Atlas of Complexity. Accessed at: https://atlas.cid.harvard.edu/

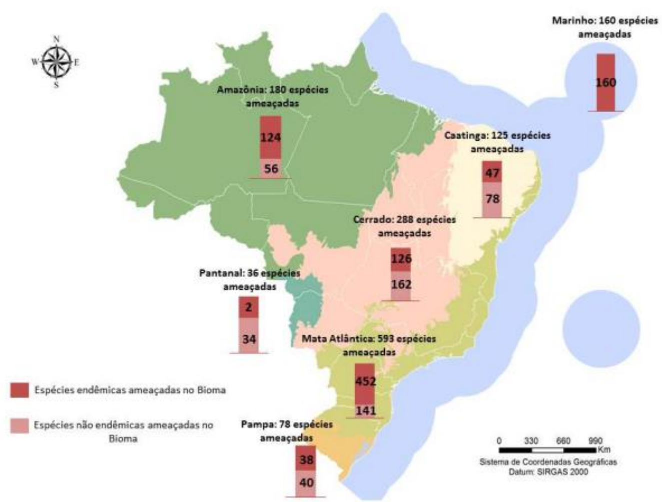
farming area of the 3.694 million hectares in 2020, according to Brazilian Agricultural Research Company (EMBRAPA).

1.13.5 Biodiversity

The Cerrado biome is recognized as the most biodiverse grassland in the world. However, the recent conversion has led to the classification of a conversion hotspot[23]. It presents 5% of all species in the world, 30% of species in the country, 837 species of birds, 13 thousand species for flora, 199 types of mammals, 1,200 of fish, 120 of reptiles and 150 of amphibians[24].

The Chico-Mendes Institute released Brazil's Red List, following the International Union for Conservation of Nature (IUCN) methodology to define threatened, vulnerable, and endangered species. The Cerrado biome is the second most threatened biome, with 288 threatened species, of which 126 are endemic, see Figure below[25].

Figure 29: Brazil's Red List per Biome



Brazil covers almost half of South America and one of the greatest biodiversity in the world. The different Brazilian climatic zones favor the formation of its biomes as the Cerrado, where the project is located, with its savannas and woods. The Brazilian great abundance of life harbours over 20% of the

[23] Biodiversity Hotspots Revisited, Conservation International 2004. Accessed at: https://databasin.org/datasets/e5e1b415498249d0b511b0eef8625c12/

[24]Policy Strategies for the Cerrado. Accessed at: https://ispn.org.br/site/wp-content/uploads/2018/09/Political_Strategy_Cerrado-30Nov_Baixa_Resol.pdf

[25] Source: Livro Vermelho da Fauna Brasileira Ameaçada de Extinção volume I. Accessed at: https://www.gov.br/icmbio/pt-br/centrais-de-conteudo/publicacoes/publicacoes-diversas/livro-vermelho/livro-vermelho-da-fauna-brasileira-ameacada-de-extincao-2018

total of species in the world, making biodiversity an important source of resources for the country due to environmental services, opportunities with conservation, sustainable use, and genetic heritage.[26]

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

Considering a wide perspective on regulatory frameworks, the program directly contributes to an ecologically pristine environment, as per the main environmental pillar of the Brazilian Federal Constitution[27], edified in its article 225. Notwithstanding, the program raises the ambition beyond mere compliance and legal environment requirements.

Still considering a wider overview, the program is also in absolute alignment with the National Environmental Policy Law[28] (nº 6938 /1981), considering general national objectives of conservation and recovery of ecosystem services and many other major principles exposed by the law.

Furthermore, the program and all PAIs are compliant with all relevant local, state, and national laws, statues and regulatory frameworks, such as:

National Law and Regulatory Frameworks

- **Law on the Protection of Native Forests "Forest Code" (Law 12,651/2012)**[29]: Created in 1965, the Forest Code requires landowners to conserve native vegetation on their rural properties, setting aside a Legal Reserve (LR) that occupies 80% of the property area in the Amazon, 35% in the Cerrado biome (within the Legal Amazon) and 20% in other biomes. The law also designated environmentally sensitive areas as Areas of Permanent Preservation (APPs), aiming to conserve water resources and prevent soil erosion. APPs include both Riparian Preservation Areas (RPAs) that protect riverside forest buffers, and Hilltop Preservation Areas (HPAs) at hilltops elevations greater than 45%.

- ***Legal Reserve Compensation (CRA):*** The Environmental Reserve Quota (in Portuguese, Cota de Reserva Ambiental, or CRA) is a mechanism that was instituted by the current Brazilian Forest Code, Law Nr. 12,651/2012 (article 44) to allow landholders who do not have the minimum necessary Legal Reserve, a means of compliance through compensation, generating the following benefits:
    - *Keep areas productive;*
    - *Access to agricultural credit;*
    - *Lower cost for environmental compliance; and*

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[26] https://www.gov.br/mma/pt-br/assuntos/biodiversidade

[27] Accessed at: http://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm

[28] Accessed at: http://www.planalto.gov.br/ccivil_03/leis/l6938.htm

[29] Accessed at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm

- *Suspension of sanctions brought about by vegetation suppression infringements previous to July 22nd 2008.*

The CRA quotas are nothing more than titles that represent an area of surplus native vegetation of a property with an excess of Legal Reserve that can be acquired by a landholder with a Legal Reserve deficit, in order to regularize the rural property. Trades must be made between areas in the same biome and the same state.

To be commercialized, the quotas must be registered with the state or district environmental agency and can be acquired by the beneficiary who will use it on your property or by third parties who do the intermediation and acquire the quotas to pass on to the owners.

To be commercialized, the quotas must be registered with the state or district environmental agency. Even though its creation in 2012, only in 2018 it was regulated by Decree Nr. 9,640/2018. Such rule defined that CRAs should be granted by the Brazilian Forestry Service (in Portuguese, Serviço Florestal Brasileiro, or SFB). The main requirements for landowners to receive a CRA credit include:

I – the property must be registered in the Rural Environmental Registry (CAR);

II – the property must demonstrate a surplus through the CAR system;

III – the property must receive a technical verification report by the competent state agency or through the CAR system;

IV – the property must receive authorization regarding the location of the legal reserve area.

The CRA titles may be transferred, either for a fee or free of charge, to individuals or companies, through a transfer agreement. So far, the CRA market in Brazil is in the early stage, with very few transactions.

- **National Policy on Climate Change (Law 12,187/2009)[30]:** Continuing the regulatory actions, Law No. 12,114 of December 9, 2009 was created - Creates the National Fund on Climate Change (Fundo Nacional sobre Mudança do Clima – FNMC, in portuguese), Law No. 12,187 - Institutes the National Policy on Climate Change (Política Nacional sobre Mudança do Clima – PNMC, in portuguese), Decree No. 7,343 of October 26, 2010 - Regulates the FNMC and Decree No. 7,390 of December 9, 2010. The PNMC defines actions and measures aimed at mitigating as well as adapting to climate change, with the following specific objectives about conversion: I) Seek a sustained reduction in conversion rates, in their four-year average, in all Brazilian biomes, until zero illegal conversion is reached; ii) Eliminate the net loss of the forest cover area in Brazil, by 2020.

[30] Accessed at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm

- **Payment for Ecosystem Services Law [31](nº 14.119/2021):** Although Brazil has recently passed a Law for Payment for Environmental Services (nº 14.119/2021), this law does not create any executable mechanisms that pay farmers for environmental services, still being very much aligned with the main problem of this sector, it does not guarantee a feasible financial flow to the necessary nature protection activities. However, on the other hand, some articles of the law establish a foundational legal framework that gives legal security to many types of projects, as for example, REDD+ projects.

Worker's Rights

The project, as well as each landholder (legal entity or private individual), property management personnel, and any other employee category directly linked to the property operation will operate under Brazilian Labor legislation)[32].

Anti-Corruption Laws

As per Section 12 of the **Agreement** both ERA, ECCON and the landholder are obliged to fully observe Law nº. 12,846 / 2013[33] ("Brazilian Anti-Corruption Law") and declare that they are aware of all the terms and definitions provided for in the Brazilian Anti-Corruption Law, which define as a harmful act to promise, offer or give, directly or indirectly, an undue advantage to a public agent or the third person related to it, among others. In addition to the provisions of the Brazilian Anti-Corruption Law, ECCON and ERA are obliged to observe and respect all the provisions of the Owner's Anti-Corruption Policy, as well as the main laws in force that deal with anti-corruption matters, notably the following, when applicable: OECD Convention on Combating Bribery of Foreign Public Officials in International Business Transactions 1997 (OECD Convention); (ii) the United Nations Convention against Corruption 2003; (iii) the Foreign Corrupt Practices Act of 1977 of the United States of America (FCPA); (iv) the Bribery Act 2010 of the United Kingdom (UK Bribery Act).

The project developer maintains free, prior, and informed consent (FPIC) with each landholder.

Bill in progress in Brazil

Bill No. 3,117, 2019[34]: Provides for the use of the Cerrado biome, as well as its conservation, preservation, protection, use and regeneration. In May 2019, the bill for more rigorous protection of the Cerrado vegetation was proposed. However, it is still under analysis in the Senate, and we have no estimate, and no certainty, that it will be fully approved.

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[31] Accessed at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/L14119.htm

[32] Accessed at: http://www.planalto.gov.br/ccivil_03/decreto-lei/del5452.htm

[33] Accessed at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2013/lei/l12846.htm

[34] The bill is available at: https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=2204604

1.15 Participation under Other GHG Programs

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

The project is not currently seeking registration, nor has it ever been registered under any other GHG programs.

1.15.2 Projects Rejected by Other GHG Programs

The project has not 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 is not involved in any other emissions trading program, and no activities that reduce GHG emissions are involved in any other emissions trading programs. VCS is the only program with which the project will be involved or trade emissions credits.

1.16.2 Other Forms of Environmental Credit

The project has neither sought nor received any other form of GHG-related environmental credit.

1.17 Additional Information Relevant to the Project

1.17.1 Leakage Management

Activity-shifting leakage will be managed by monitoring conversion events of a neighbouring property owned by the same landholder, when and where necessary. A market leakage deduction will be applied using the *VCS Global Commodity Leakage Module: Production Approach,* see Section 4.3.2, when and where necessary.

1.17.2 Commercially Sensitive Information

The project has excluded commercially sensitive information in Section 3.5 Additionality regarding the simple cost analysis.

1.17.3 Sustainable Development

The LVC conservation reserve contributes to Brazil's sustainable development priorities such as reducing emissions from land-use change, maintaining conservation areas and corridors to improve biodiversity habitat and watersheds, and water quality. The project proponent has adopted the SocialCarbon Standard to monitor and report on co-benefits achieved by the project. 18 indicators have been monitored across 6 themes, including social, human, financial, natural, biodiversity and carbon. The SocialCarbon report, found in the supporting project documents folder, provides the monitoring results of the 18 indicators and associated SDGs.

Recognizing its role in society and adherence to the Sustainable Development Goals (SDGs), the LVC, is actively contributing to the following[35]:

1. Ensure the integrity of the forest, recognizing water (SDG 6) and biodiversity (SDG 15) as the main conservation assets;
2. Promote actions to combat climate change (SDG 13), through sustainable production techniques (SDG 12; 2) that are models for society (SDG 11) and contribute to maintaining the genetic diversity of species (SDG 2);
3. Promote local development through social programs, such as support for public management and education (SDG 4), and job and income generation (SDG 8), seeking partnerships with society and other stakeholders (SDG 17).
4. Disseminate and generate new knowledge through investment in Research, Development and Innovation, creating opportunities to involve the community and promote the popularization and dissemination of science and technology (SDG 4;17).

1.17.4 Further Information

There is no further information.

2 SAFEGUARDS

This section describes the safeguards that the project adopts vis-à-vis the landholder and community engagement process and the expected environmental impacts. As discussed above, the project applies the Social Carbon Standard to safeguard continuous improvement and adaptive management.

2.1 No Net Harm

The project does not expect any negative environmental impacts as the project activity prevents the conversion of native vegetation, the release of carbon dioxide to the atmosphere, degradation of soil health, the loss of wildlife habitat as well as the pollution of watersheds from pesticides and fertilizer use. The project will have positive outcomes for both climate change mitigation (through carbon storage and sequestration) as well as biodiversity impacts (through the preservation of key habitats and wildlife corridors). Conservation of the native vegetation in the project area will not only improve forest health but will also preserve many endemic and endangered flora and fauna of the species-rich region.

The project proponent also does not expect any negative socio-economic impacts. CBA, the owner of LVC, is the only stakeholder directly impacted by the project because conservation efforts are within the

[35] Evidence provided in the Social Carbon monitoring report.

private land reserve. No legal or customary tenure or access right to territories and resources were identified, as the CBA, owner of LVC is the only stakeholder directly impacted. The surrounding communities, outside the private property are positively impacted, as per below (these benefits are discussed and quantified in the supporting SocialCarbon report):

- Stable microclimate;
- Clean water supply;
- Biodiversity and wildlife habitat;
- Native seedling disbursement for restoration;
- Educational and job opportunities; and
- Technical support for the implementation of agroforestry systems.

2.2 Local Stakeholder Consultation

Due to Covid-19 restrictions[36], the stakeholder consultation was delayed, occurring during project validation and was conducted online. To ensure participation and virtual access, LVC invited local representatives recognized by the community and active in the territory, as they are multipliers of information about the project for the community. All participants had internet access.

Invitations were sent on September 21st, 2021, and phone calls were made to inform them about the meeting. Invitations were sent to municipal government and secretaries, as well as association groups and universities. The invitations can be found in the attached project folder.

The stakeholder consultation meeting occurred on September 30th, 2021, where the participants received the following information[37]:

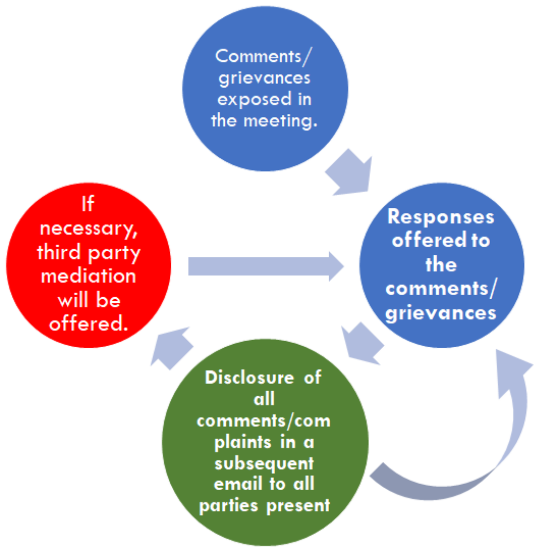
- The project design and implementation, including the results of monitoring.
- The risks, costs and benefits the project may bring to local stakeholders.
- All relevant laws and regulations covering workers' rights in the host country.
- The process of VCS Program validation and verification and the validation/verification body's site visit.

The following Standard Operating Procedure (SOP) for grievance mechanisms was created:

[36] The municipal decree can be found in the attached project folder.

[37] Stakeholder consultation presentations can be found in the attached project folder.

Figure 30: Standard Operating Procedure for Stakeholder Consultation



All the questions, concerns and outcomes raised during the meeting were documented and saved in the attached "Stakeholder Consultation" project folder. In synthesis, there were some comments and inquiries received during the stakeholder consultation, which were all directly and satisfactorily addressed in the meeting. There were no grievances. There were no comments or grievances received after the stakeholder consultation, nor were any received throughout the first monitoring period. LVC has an official grievance process that records all complaints and grievances through a form (saved in the Stakeholder Consultation project folder).

On-going communication with local stakeholders will occur via newsletters, and social media platforms such as Instagram as well as proponent & landholder websites. Considering the grouped project structure, the project proponent created a dedicated email to receive questions, concerns and grievances: faleconosco@erabrazil.com.

Stakeholders can also contact the landholder directly, through LCV direct telephone (62) 3354-6060/ 3354-6007, or email contato@legadoverdesdocerrado.com.br, or personally at the LVC headquarters in Niquelandia.

2.3 Environmental Impact

Environmental impact will be assessed within the scope of the SocialCarbon standard indicators. Environmental impact assessments will take place using satellite imagery, drones, camera traps to record fauna, bio-acoustic sensors to record birds, various fauna survey techniques carried out by researchers, participatory monitoring techniques and contracted experts.

The diversity of species in the project area was and will be assessed, focusing on the plants, birds, mammals, reptiles, and amphibians (and some specific flagship species like the jaguar and other large felines). Several research partnerships were made to assess the biodiversity and endemism occurring in the PAA.

In this respect, the research conducted by Dr. Marcos José da Silva[38], from the UFG University, identified 851 plant species in the PAI that were native to the Cerrado, including 60 that were totally endemic and 30 with varied medicinal and therapeutical purposes.

This research also identified 16 news species, 8 of which are undergoing scientific description for official publication and 1 which has already been officially published, named the *Erythroxylum niquelandense*.

Furthermore, this biodiversity research also identified and catalogued frog, fly, algae and cianobacteria species.

Also, the PAA of PAI 1 was used as part of the on-going scientific research called “Alometria do Cerrado”[39] (in English, “Cerrado´s Allometry”), coordinated by the Dr. Fábio Venturóli, of the Federal University of Goiás.

Water quality is also being measured as outlined in the SocialCarbon report. This is part of the research called “Aquatic Biomonitoring”[40], conducted by Dr. Thiago Lopes Rocha, of the Federal University of Goiás.

The results of monitoring will be available on the project proponent’s website and social media channels, on VERRAs website and will be disseminated among communities and other stakeholders relevant to the project in specific workshops.

The project does not expect any negative environmental impacts, as the main project activity is conservation. As such, the project has no requirement for an environmental impact assessment as per Brazil law/regulation.

Conversion and its associated GHG emissions, is 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 agriculture and utilization of natural resources. The Program will result in positive environmental benefits by conserving forest and grassland leading to less environmental degradation than would have occurred when lands are converted to pasture or cropland. The conservation of the Cerrado biomes is vitally important to humankind and the global environment, as well as the local environment, as these ecosystems provide a wide range of critical services including their ability to:

- Water provision (eight of the twelve Brazilian hydrographic regions receive water from the Cerrado biome, thus, the geographical area occupied by the Cerrado has a fundamental role in the distribution of water resources throughout the country, feeding mostly of the Brazilian and South American large river basins;

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[38] Accessed at: https://cba.com.br/imprensa/pesquisa-cientifica-realizada-em-reserva-goiana-mapeia-biodiversidade-da-fauna-e-flora-do-cerrado/

[39] Accessed at: https://cba.com.br/imprensa/pesquisa-mede-quantidade-de-carbono-absorvido-pelo-bioma-cerrado-e-seu-impacto-no-clima/

[40] Accessed at: https://cba.com.br/imprensa/no-berco-das-aguas-goias-tem-pesquisa-pioneira-para-analise-de-rios/

- Improve local air and water quality by filtering pollutants;
- Help regulate water supply and nutrient cycles (phosphorous and nitrogen);
- Control flooding by minimizing runoff and soil loss;
- Provide habitat for biodiversity and nutrition to wildlife;
- Provide aesthetical, spiritual and cultural benefits to local communities;
- Produce oxygen – without which life would not be possible; and
- Absorb and store carbon dioxide, a greenhouse gas, to mitigate climate change.

2.4 Public Comments

The project (ID # 2465) was available on the Verra registry[41] for its 30-day public comment period, which ran from 05 August 2021 - 05 September 2021.

The project proponent did not receive any comments throughout the public comment period.

2.5 AFOLU-Specific Safeguards

The following steps were followed to identify the local stakeholders likely impacted by the project.

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

a) Identify the Landholders Local Network: list the stakeholders that are part of the landholder's network of contacts, identified through ERA's *Pre-Visit Questionnaire* SOP.

b) Snowball Method: contact the stakeholders identified in step a) via phone calls, emails, whatsapp or during the first field visit. Request additional contacts of key community members or institutions that fall into the categories described in the Table below.

c) Database Search: to locate stakeholders who were not mentioned in the previous step, ERA conducted a search on Google with the terms "Environmental Organization"; "Environmental Conservation"; "Community Association"; "NGO", combined with the municipality and project region.

d) Classification: classify the actors according to the Table below, separated by influence.

Category	Description	Standard Operating Procedure	Contact Info

[41] https://registry.verra.org/app/projectDetail/VCS/2465

A: Direct Stakeholders	Communities with land ownership rights within or adjacent to the project area. Communities with statutory or customary rights in the project area (e.g., customs, traditions and the exercise of religious practices). Residents' associations or other community organizations.	Direct Stakeholders will: a) Participate in the Stakeholder Consultation and follow ERA's SOP #3. b) Receive information about project implementation, monitoring results and verifications. c) Defer Free, Prior and Informed Consent (FPIC)	Include the stakeholders name, phone, address.
B: Other Stakeholders	Communities without land ownership rights or statutory/customary rights in or adjacent to the project area. Municipal government agencies. Universities that carry out research or extension projects in the project area. Extension agencies, non-governmental organizations or institutions that carry out work on social or socio-environmental issues in the region.	Other Stakeholders will: d) Participate in the Stakeholder Consultation and follow ERA's SOP #3. e) Receive information about project implementation, monitoring results and verifications.	Include the stakeholders name, phone, address, and if applicable, affiliate institution.

The results of the Stakeholder Identification Process above produced the Table below, including a list of all the stakeholders:

Stakeholder Category	Role
Direct Stakeholders	

ERA	Project proponent
ECCON	Other entity involved in the project
LVC/CBA	Landholder
RINA	Auditor
Other Stakeholders	
Secretaria de Meio Ambiente	Municipality Environmental representant
Secretaria de Turismo	Municipality Tourism representant
Secretaria de Governo	Municipality representant
Sebrae – serviço apoio a empresas	Governamental agency
Serviço Nacional de Aprendizagem Industrial	Governamental agency
Serviço Nacional de Aprendizagem Rural	Governamental agency
Sindicato Rural de Niquelândia	Rural union
Associação Comercial de Niquelândia	Commercial Association
Federação da Agricultura e Pecuária de Goiás - Jovem Niquelândia	Rural producer representative
Instituto Educacional Tiradentes	NGO
Oficina de Comunicação	NGO

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

No legal or customary tenure or access right to territories and resources were identified, as the CBA, owner of LVC is the only stakeholder directly impacted.

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

The social, economic and cultural diversity within local stakeholder groups of the municipality of Niquelandia are described in Section 1.13.4. The population is around 42.000 habitants (IBGE, 2010), with roughly 80% urban population, and the average income is two minimum wage salaries (roughly R$2000 per month). According to IBGE 2021, 100% of the population has potable water and less than 25% of the population has sanitary systems. The mortality rate of new-borns is 2,3 per 1000 thousand babies. (IBGE, 2021). The main economy of the municipality is agriculture, livestock and nickel mining, which influence the cultural events, that are mainly around cattle and horses.

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

In the past 5 years, there have been no significant changes to the stakeholder groups identified.

Step 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:

There are no negative risks to local stakeholders from the project implementation, because the project boundary is private property and does not contain any other direct stakeholders living within or having access to the area, other than the landholder. Other stakeholders in the area were identified by the LVC management team and include other private landholders, smallholder settlements, municipal organizations, and Quilombos. None of the other stakeholders have their resource use affected. On the contrary – the positive implications for the local community due to the various conservation actions that were and will be implemented, such as:

- Environmental education programs;
- Technical assistance to support smallholder agroforestry systems;
- Native seedlings production to support community reforestation along degraded riparian areas;
- Job opportunities associated with the management of the conservation area, including fire brigade, guards & supervision, ecotourism; and
- Water quality and quantity protection. The main river that provides the local people their water begins in the conservation area, and therefore the local people's water supply is secured due to the conservation project.

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

Figure 26 in Section 1.13.4 shows the nearby towns and communities. The communities mentioned in the map are far away and will not be impacted by the project activities.

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

There are no territories surrounding the initial PAI with customary access.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

The grouped project applies the Verra VCS VM0009 *Methodology for Avoided Ecosystem Conversion v3.0, VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3.0,* the AFOLU Non-Permanence Risk Tool v4.0 as well as the *Calculation of the number of sample plots for measurements within A/R CDM project activities* methodological tool v2.1.

3.2 Applicability Conditions

All applicability conditions were met as required by VM0009 methodology and the VT0001 Tool for Additionality. The other tools applied did not have any applicability conditions. The following statements are issued to show the applicability of the VM0009 methodology to the project:

1. The drivers of conversion in the baseline scenario are consistent with those described in section 6 of the methodology for F-P2 and G-P2. This is an avoided planned conversion by the primary agent, the private landholder. This makes the project activities eligible for Avoided Planned Deforestation (APD) and Avoided Conversion of Grassland and Shrublands (ACoGS) under VCS Standard v4.0.
2. All project accounting areas (PAAs) quality as native Cerrado vegetation (Cerrado forest, Cerrado savanna, or Cerrado grassland) for at least 10 years prior to project start, as shown by GIS analysis in the attached project folder, Appendix F GIS Maps.
3. The baseline type is F-P2 & G-P2 (planned conversion), thus condition 3 is not applicable.
4. The baseline type is F-P2 & G-P2 (planned conversion), thus condition 4 is not applicable.
5. The baseline type is F-P2 & G-P2 (planned conversion), thus condition 5 is not applicable.
6. The baseline type is F-P2 & G-P2 (planned conversion), thus condition 6 is not applicable.
7. The eligibility criteria for project activity instances in Section 1.4 require that the project area does not contain peat soil. This is justified by the PAA soil maps provided in Section 1.12 and the soil maps of the municipality of Niquelandia, which are provided in Section 1.13.
8. A reference area has been delineated for the baseline type F-P2 & G-P2. This reference area meets the methodology requirements, including the minimum size requirements, of section 6.8.1 of the methodology. Section 3.4.6.1 provides evidence and justification that the selected reference area is larger than the initial project accounting area. KMZ files are provided in Appendix G in the supporting project folder.
9. As of the project start date, historic imagery of the reference area exists with sufficient coverage to meet the double-coverage requirements of section 6.8.4 of the methodology (see Section 3.4.6.2 for justification).
10. Project measures are planned to mitigate ecosystem conversion by addressing the primary driver of conversion (private landholder) by providing annual financial payments from carbon credit sales that will encourage the protection and maintenance of native Cerrado rather than carrying out conversion to agriculture to generate a revenue stream.
11. The project proponent has access to activity-shifting leakage area(s) and proxy area(s) to implement monitoring. The proxy area is within the LVC, therefore access is not an issue, see Section 3.4.4 for details. The activity-shifting leakage area is owned by the landholder and within the same municipality, and therefore access is also not an issue, see Section 4.3.1 for details.

12. There is no logging considered in the project activity; however, the project proponent applies market leakage deductions as per the VCS Global Commodity Leakage Module: Production Approach, see Section 4.3.2.
13. SOC is a selected carbon pool and the project applies a Brazil specific default factor from Brazil's Fourth National Communication on Greenhouse Gases to calculate soil decay.[42]
14. No livestock are being grazed within the project area in the project scenario as per the Eligibility Criteria specified in Section 1.4.1.
15. All GHG emissions from project activities that are not *de minimus* will be monitored and deducted from emissions reductions. Initial project activities including monitoring do not result in significant GHG emissions.

The following statements are issued to show the applicability of the VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3.0

a) The project activities for forest and grassland conservation are not in violation of any applicable laws, as discussed in Section 1.14.
b) The VT0001 Tool includes all the steps to define the most plausible baseline scenario.

The definition of forested areas must meet the definition of forest established by the FAO[43]:

> "area ≥ 0.5 ha; Tree canopy cover ≥10%; Tree height ≥ 5 m at maturity in situ; Width > 20 m. Excludes land that is predominantly under agricultural or urban land use."

The definition of grassland and shrubland areas must meet the definition of grassland and shrubland established by the FAO[44]:

> "area ≥ 0.5 ha; Tree canopy cover 5-10% with trees >5m at maturity in situ or shrubs/bushes canopy cover ≥10% or combined cover of bush, shrubs and trees ≥10%. Excludes land that is predominantly under agricultural or urban land use."

The definition of conversion adopted refers to any conversion of natural areas to agriculture land-use categories. The Cerrado biome is constituted by a vegetation complex composed of forest, savanna and grassland vegetation classes. For the Cerrado biome, the classification of the vegetation in the field, is supported by Ribeiro and Walter (2008)[45] who define forests as environments with a predominance of tree species and continuous or discontinuous canopy formation, while savanna formations are characterized by the coexistence of arboreal, shrub and herbaceous layers. The grassland formations are characterized by

[42] Brazil's Fourth National GHG Inventory. Accessed at: https://issuu.com/mctic/docs/quarta_comunicacao_nacional_brasil_unfccc

[43] FAO. Accessed at: https://www.fao.org/3/ap152e/ap152e.pdf (see page Table 4 page 21)

[44] FAO. Accessed at: https://www.fao.org/3/ap152e/ap152e.pdf (see page Table 4 page 22)

[45] Ribeiro, J.F. & Walter, B.M.T. 1998. Fitofisionomias do bioma Cerrado. Accessed at: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/554094/fitofisionomias-do-bioma-cerrado

the prevalence of herbaceous and shrub species, with fewer trees and a lack of canopy formation. Project accounting areas with native Cerrado savanna or grassland must have the same vegetation class at least 10 years prior to the project start date, as shown in the maps in Appendix F.

3.3 Project Boundary

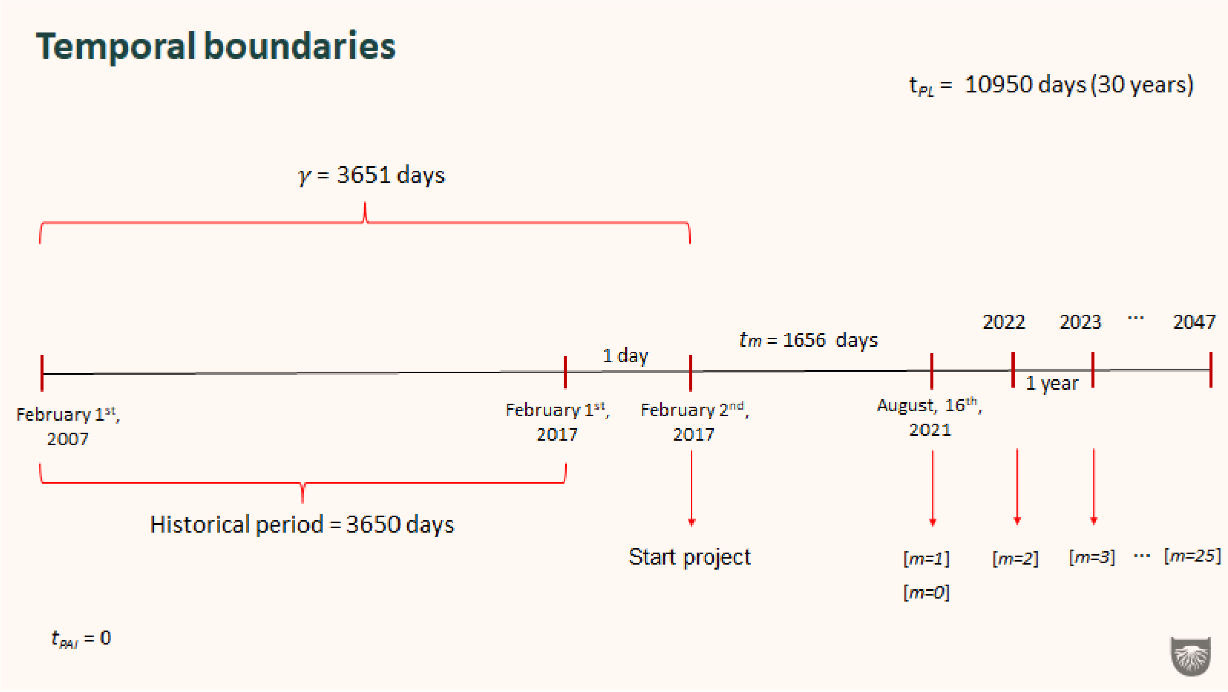
3.3.1 Delineating the Spatial Boundaries

The project area consists of multiple contiguous and non-contiguous parcels of native Cerrado, which comprises of forests, woodlands, grasslands and savana vegetation classes. All project accounting areas meeting the definition of native Cerrado forest or grassland, as classified the FAO and the Brazilian Institute of Geography and Statistics. A shapefile is provided in the attached project folder defining the Cerrado biome polygon. A digital based map of each project accounting area as well as credible ownership documentation is also provided in the attached project folder. Maps are provided in Section 1.12 and land registry numbers are provided in Section 1.7.

3.3.2 Defining the Temporal Boundaries

Temporal boundaries define the period of time when the conversion in the project area is mitigated by project activities. The figure below shows temporal boundaries schematically.

Figure 31: Temporal Boundaries



- The start of the project is February 2, 2017.
- The project crediting period goes from 02/02/2017-01/02/2047 for a total of 10,950 days.
- The first monitoring period from from 02/02/2017 – 16/08/2021 for a total of 1,656 days.

- The baseline will be re-evaluated every 10 years. The next baseline evaluation will be 2027.

3.3.3 Gases

Table 9: GHG Emission Sources Included in the Project Boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Flux in carbon pools	CO_2	Yes	Major pool considered in the project scenario
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	n/a	n/a
	Burning of biomass	CO_2	No	Conservatively excluded
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	n/a	n/a
	Livestock	CO_2	n/a	n/a
		CH_4	Yes	A required source when emissions from grazing are not *de minimis*
		N_2O	No	Conservatively excluded
		Other	n/a	n/a
Project	Burning of biomass	CO_2	No	Not considered as a project activity.
		CH_4	No	Not considered as a project activity.
		N_2O	No	Not considered as a project activity.
		Other	n/a	n/a
	Livestock	CO_2	No	Excluded on the basis of applicability condition 14
		CH_4	No	Excluded on the basis of applicability condition 14
		N_2O	No	Excluded on the basis of applicability condition 14

Source		Gas	Included?	Justification/Explanation
		Other	n/a	n/a
	Synthetic Fertilizer	CO_2	No	Synthetic fertilizer application is not considered in the project scope
		CH_4	No	Synthetic fertilizer application is not considered in the project scope
		N_2O	No	Synthetic fertilizer application is not considered in the project scope
		Other	n/a	n/a

3.3.4 Selecting Carbon Pools

Table 10: Required and optional carbon pools for grassland project accounting areas

Pool	Required	Inclusion	Justification
Above-ground Merchantable Tree (AGMT)	No, the baseline or project activity does not include the harvest of long-lived wood products	No	Baseline scenario is GP-2 and FP-2 (Planned Non-Commercial Conversion)
Above-ground Other Tree (AGOT)	Yes	Yes	Major pool considered in a grassland biome.
Above-ground Non-Tree (AGNT)	Yes	No	May be conservatively excluded, since the baseline scenario not includes perennial tree crops.
Below-ground Merchantable Tree (BGMT)	Optional, the baseline or project activity does not include the harvest of long-lived wood products	No	Baseline scenario is FP-2 & GP-2.

Pool	Required	Inclusion	Justification
Below-ground Other Tree (BGOT)	Optional	Yes	Major pool considered in a grassland biome.
Below-ground Non-Tree (BGNT)	Optional	No	May be conservatively excluded.
Litter (LTR)	No	No	This pool is conservatively excluded.
Deadwood (DW)	No	No	This pool is conservatively excluded.
Standing Deadwood (SD)	Optional	No	This pool is conservatively excluded.
Lying Deadwood (LD)	Optional	No	This pool is conservatively excluded.
Soil Organic Carbon (SOC)	Optional	Yes	Major pool considered in a grassland biome.
Long-lived wood products (WP)	No	No	This pool is conservatively excluded.

The baseline and project activities does not include logging, therefore no evidence to support the definition of a merchantable tree is provided.

3.3.5 Grouped Projects

The list and description of the initial PAI is provided in Section 1.4 and Section 1.11.

The designated geographic area for this project is the administrative boundaries of the Cerrado biome, as defined by the Brazilian Institute of Geography and Statistics. A GIS-based map (shapefiles/kmz) is provided in the attached project folder.

A map of the common reference area, proxy area, and leakage area is provided in Figure 1, Section 1.4.

3.4 Baseline Scenario

3.4.1 Identifying the Agents and Drivers

The baseline scenario includes one agent of conversion: the landholder. There are no secondary agents of conversion.

According to Table 11 from page 23 of the PPCerrado 2019[46], 84% of the observed conversion in the Cerrado biome occurred within private lands, whereby landholders are converting for agricultural purposes as this is the principle economic activity:

[46] Available at: http://combateaodesmatamento.mma.gov.br/images/Doc_ComissaoExecutiva/Balano-PPCDAm-e-PPCerrado_2019_aprovado.pdf

"The distribution of conversion in the Cerrado, according to land tenure categories, shows that the dynamics in this biome are more homogeneous, with greater concentration of conversion in private areas."

The data shows that landholders fulfill their legal right to convert native Cerrado for the pursuit of commercial agricultural activities. The majority of land in the Cerrado is in under private control, and since 1985, forty-seven per cent (47%) of the Cerrado's area (95.8M ha) has been anthropized[47]. In 2019, the Cerrado produced 66.8 M tons of soy, of which eighty per cent (80%) is exported. Between 2000 and 2019, the total area devoted to soy production increased by 291%, from 7.5M hectares to 18.2M hectares.[48] This trend will continue due to the high demand for global commodities combined with little legal protection of native vegetation. Private landholders are only required to maintain either 20 or 35% of native vegetation according to the Forest Code, that governs land-use in private properties in the Cerrado. Considering how suitable it is for intensive and industrial agriculture, the Cerrado has been targeted for farming and industrial expansion. MATOPIBA, an area that covers parts of the states of Maranhão, Tocantins, Piauí, and Bahia, is one of Brazil's top soy producers and has 4.6M hectares of surplus native vegetation that is suitable for agriculture/soy according to research by Solidaridad[47].

The Figure and Table below display important data regarding the drivers of conversion in the Cerrado.

[47] Mapbiomas Col. 5, base year 2019 (2020).

[48] Solidaridad 2021. Regional Potential for the Expansion of Soy Crops in MATOPIBA. Accessed at: https://www.solidaridadnetwork.org/wp-content/uploads/2021/07/regional_potential_for_the_expansion_of_soy_in_matopiba.pdf

Figure 32: Properties with Surplus Legal Reserve (SLR) ie. Native Vegetation Eligible for Soy Crop Expansion[47]

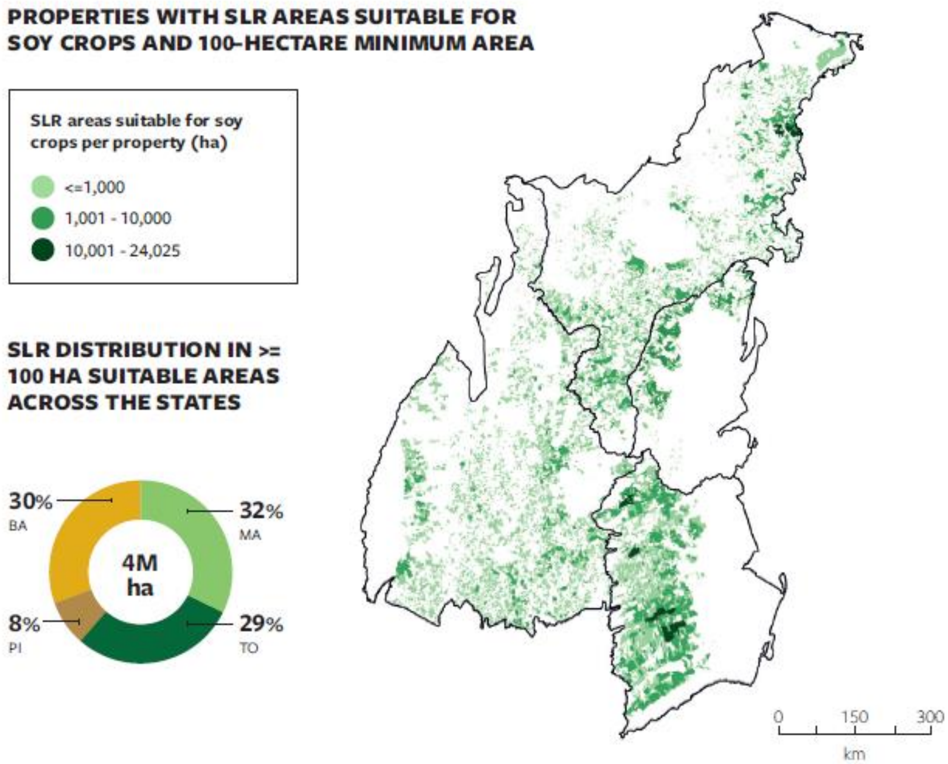


Table 11: Distribution of Conversion by Land-Use Category, in 2019[49]

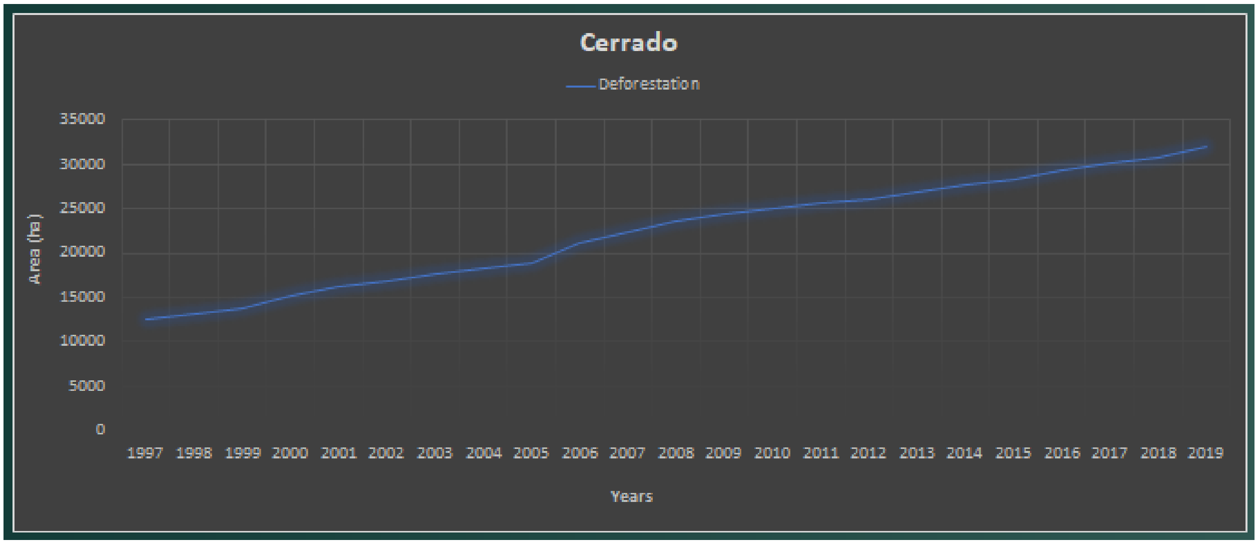
English translation of columns from left to right: State / Indigenous Land / Conservation Units (Federal & State Parks) / Settlements / Rural Land / Private Land / Contribution per State in km2

Estado	Terra Indígena	Unidades de Conservação	Assentamento	Glebas	Área Privada/Sem Informação	Contribuição do Estado (km²)
BA	0%	26%	3%	0%	72%	832
DF	0%	95%	0%	0%	5%	2
GO	0%	7%	6%	0%	87%	651
MA	2%	3%	6%	2%	87%	1.309
MT	1%	6%	9%	6%	78%	931
MS	1%	0%	1%	0%	98%	294
MG	0%	1%	5%	0%	93%	496
PR	0%	26%	0%	0%	74%	1
PI	0%	0%	1%	0%	99%	463
RO	0%	0%	0%	99%	1%	0,24
SP	0%	6%	0%	0%	94%	6
TO	0%	10%	3%	7%	80%	1.495
Contribuição da Categoria (%)	1%	8%	5%	3%	84%	6.484

[49] Source: PPCerrado, 2019

No external covariates were employed in the development of the conversion model because there is only one agent of conversion, the landholder. This is a conservative approach because there is no variable that affects the deforestation rate over time, according to a long-term data analysis of the Cerrado by MapBiomas. The following Figure shows a linear conversion, even though commodity prices and other environmental factors (eg. Weather patterns, droughts, etc.) have fluctuated.

Figure 33: Deforestation trends in the Cerrado (Source: MapBiomas)



3.4.2 Delineating Project Accounting Areas

Project accounting areas were delineated based on certain constraints to conversion, as described below. All PAIs must be privately held lands that fulfill all Eligibility Criteria (Section 1.4.1).

The project accounting areas were identified by applying the following procedure to PAI boundary:

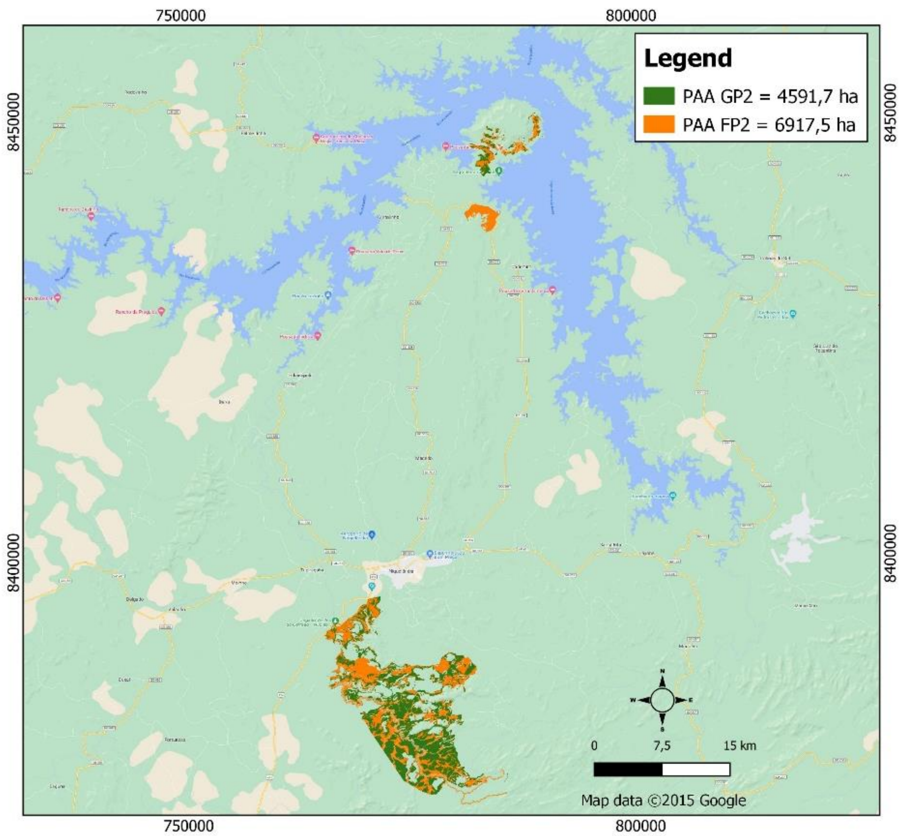
1. Subtract conservation areas required by law (the Forest Code), such as the legal reserve and permanent preservation areas (APP).
2. Subtract any areas that overlap areas with conservation units (parks), indigenous lands, or other private lands in dispute.
3. Subtract areas that are not fit for agriculture, defined by areas having a slope greater than 25% declivity or rocky soils.

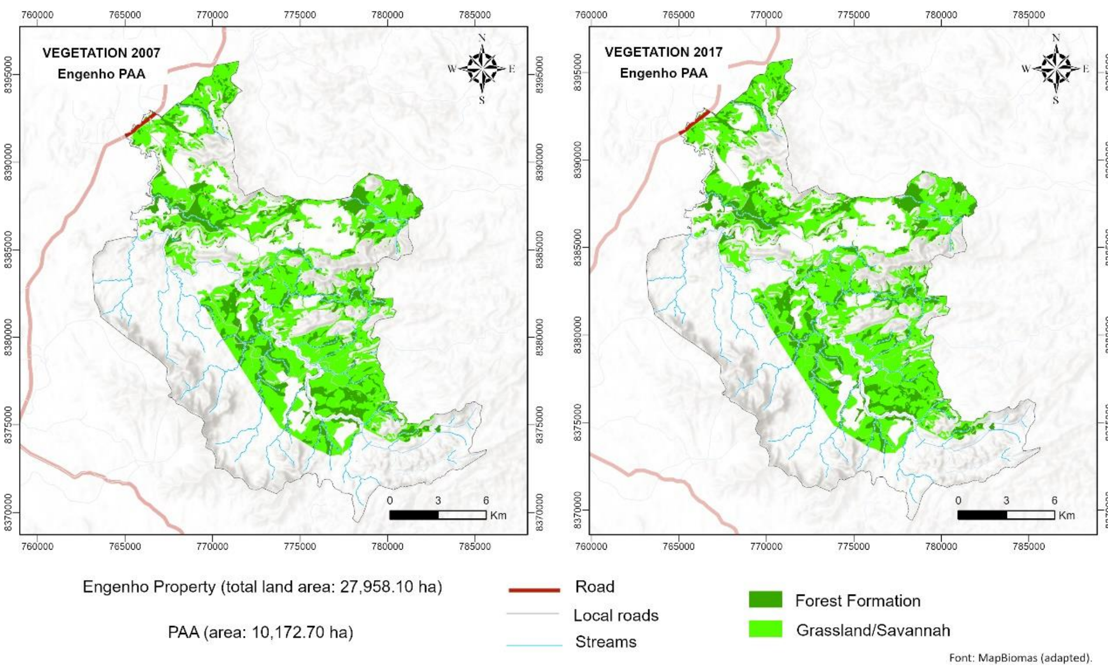
The applicability and relevancy of the procedure to define the PAA is demonstrated by Figures 3 to 11 in Section 1.12, addressing all pertinent categories of topography, roads, rivers and perennial streams, land use/vegetation type classification and total area, as well as the general encroachment of pasture and farming in the municipality where the PAA is located. Moreover, the evidence that the PAA has been on a native state for at least 10 years prior to the project start date is provided in the maps below. The same procedure applies indiscriminately to both APD and APC components of the project.

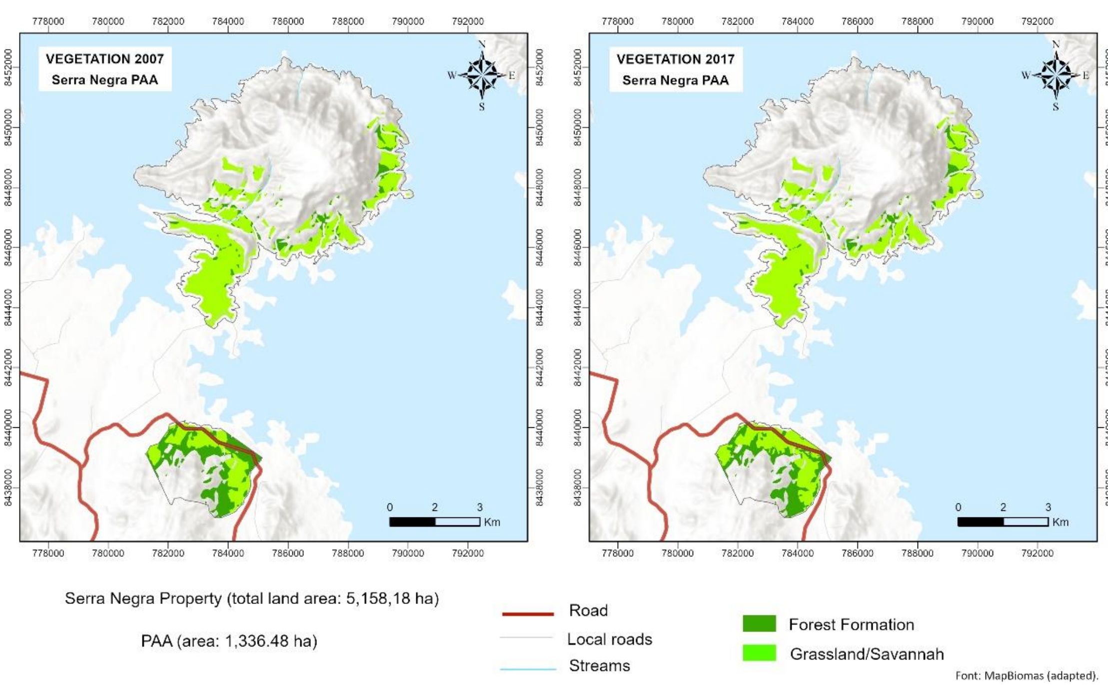
Because this is an avoided planned conversion project (F-P2 & G-P2 baseline types), selection of patch size at which land conversion typically occurs and justification of patch size for delineation of PAA is not applicable.

Figure 34 shows the spatial boundaries to GP2 PAA and FP2 PAA. A digital (GIS-based) map of the project accounting areas are provided in Appendix F in the attached project folder.

Figure 34. PAA for the G-P2 and F-P2 baseline types







3.4.3 Identifying Baseline Types

The project proponent established two baseline types after applying the VM0009 methodology Decision Tree to Determine Baseline Type. For forested areas, F-P2 baseline type will be applied and for grassland areas, G-P2 baseline type will be applied.

As an F-P2 & GP-2 project, the baseline scenario is the conversion of native Cerrado in private properties by the primary agent, the landholder. There is no secondary agent of conversion.

Per Eligibility Criteria #1, all landholders will be required to demonstrate that the project accounting areas could be legally cleared for agricultural use, prior to joining the project, making this the most plausible baseline scenario. This section provides justification for the baseline type being the most plausible and that the project is additional. The landholder of the initial Project Activity Instance, presented a deforestation license, showing that the surplus native vegetation in the project area (excluding the Legal Reserve and Permanent Protection Areas) is eligible for legally sanctioned deforestation (therefore, clearly “legally zoned” for agriculture) and that the landholder had plans and intention to deforest.

The project meets the definition of Avoided Planned Deforestation (APD) and Avoided Planned Conversion (APC) as per the VCS Standard v4.1:

“Planned conversion may include decisions by ***individual landowners****, governments, or community groups, whose land is* ***legally zoned for agriculture*** *or other development, not to convert their land(s).”*

As per the Eligibility Criteria in Table 1, Section 1.4.1, all PAIs will be constrained to privately held lands that are legally zoned for agriculture, established by the Forest Code, as well as apt for crop production, established by suitable topography.

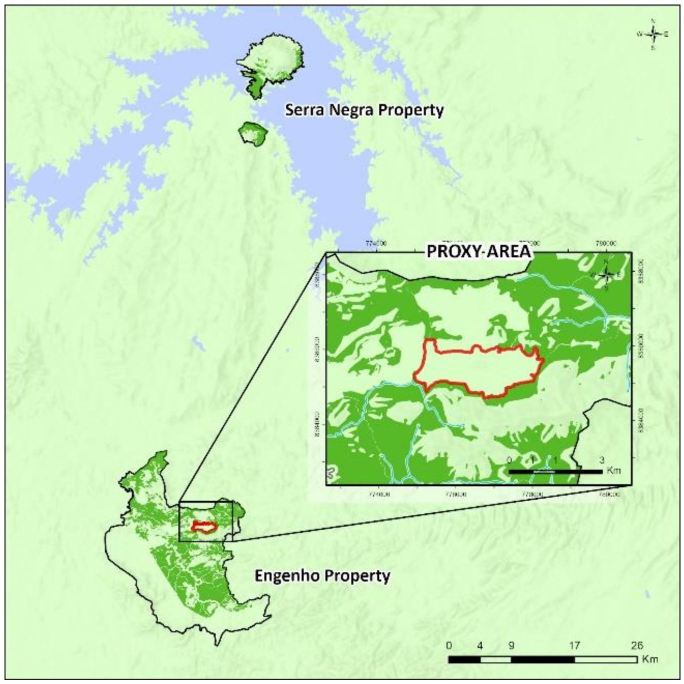
3.4.4 Delineating Proxy Areas

The VM0009 methodology requires an inventory of a proxy area to estimate post-conversion carbon stocks in the baseline scenario. The following section demonstrates that the selected proxy area is sufficiently similar to the initial PAA and explains how the proxy area was delineated.

The proxy area is used to estimate residual carbon stocks of the end land use in the baseline scenario associated with a particular project accounting area. As per Section 6.4 of the VM0009 methodology, each identified project accounting area, both forest accounting areas and grassland accounting areas have a proxy area. The proxy areas share identical boundaries, as the proxy area characterizes the end-land use scenario for both F-P2 & G-P2 baseline scenarios. It must be located in the same general region as the project area, but not necessarily adjacent to the project area. The proxy area must also be physically accessible to the project proponent. The following maps are included as required by the methodology.

The proxy area selected for the initial PAI is an agricultural field within the Engenho property, in order to characterize the baseline scenario. The proxy area selected is within the same property boundary as the PAA and therefore, under the same ownership, but do not overlap. The proxy area was selected because of the similar characteristics shared with each PAA, because of its location within the same property, meaning is shares similar vegetation classes, soils, topography, as well as same road access.

Figure 35: Proxy Area and Initial PAI



The following characteristics were taken into consideration when defining the proxy area boundary:

- Vegetation;
- Climatic conditions;
- Topographic constraints to conversion;
- Land use and/or land cover;
- Soil;
- Applicable infrastructure;
- Ownership/tenure boundaries that influence conversion.

Figure 36: Proxy Area, Slope

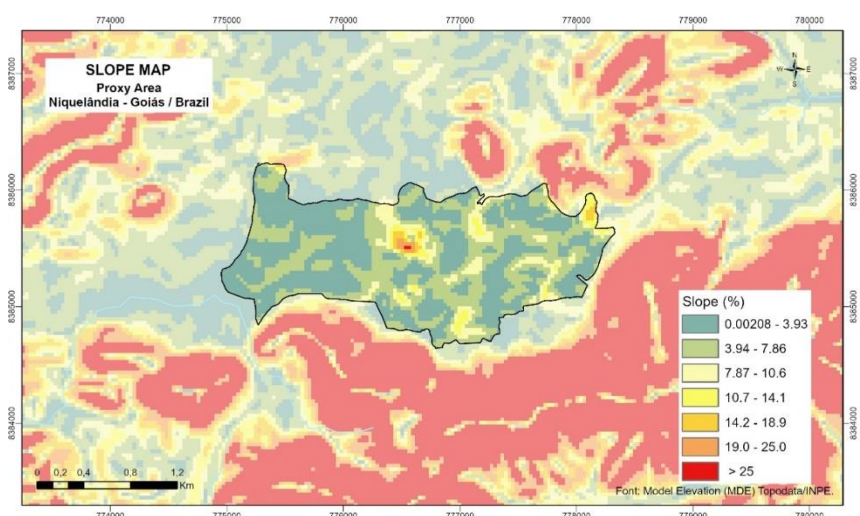


Figure 37: Proxy Area, Soils

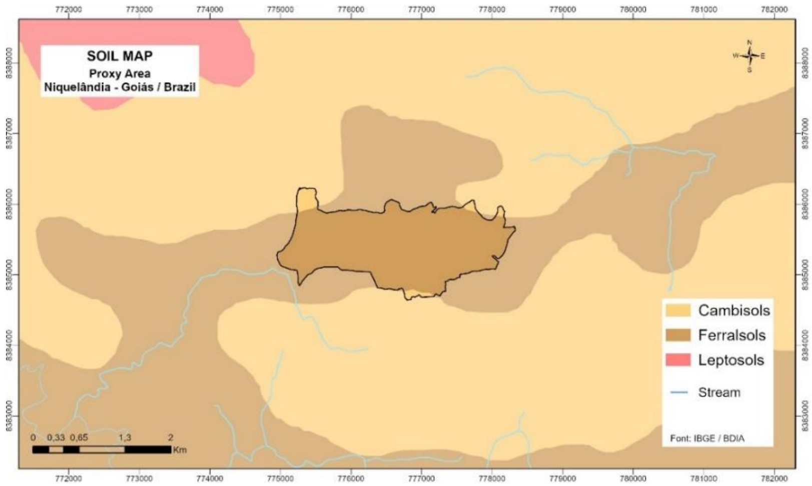
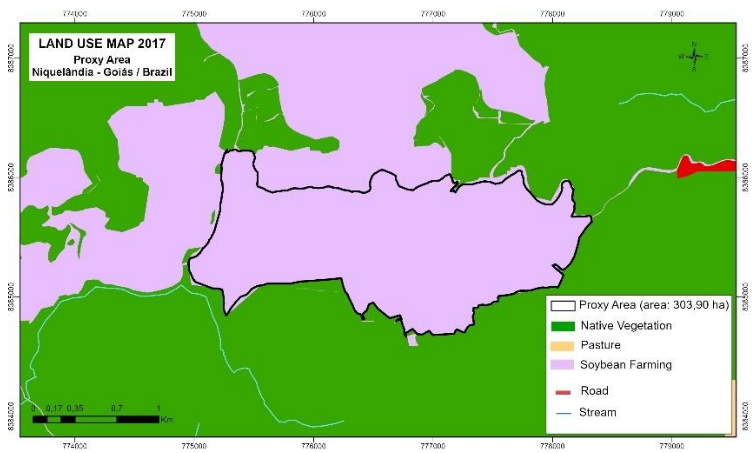


Figure 38: Proxy Area, Land Use in 2017



3.4.5 Baseline Scenarios for Selected Carbon Pools

The following section describes how the baseline emissions model is applied to each pool as well as the additional assumptions used in identifying the baseline scenario for the project. All baseline biomass carbon stock values come from field inventories, remote sensing, LIDAR and literature.

Baseline for AGOT

The AGOT and AGNT pool are converted by the primary agent. In baseline types F-P2 & G-P2 above-ground portions of trees that are not commercially viable (ie, other trees that are not merchantable) and above-ground non-tree biomass are assumed to be immediately burned during the clearing of the land or converted to fuel wood and burned[25]. It is common practice for the primary agent to use the "correntões" method for converting native Cerrado. Two large tractors tied together by a giant chain link, can devastate large areas taking down trees and shrubs in a few hours. After, the biomass is piled and burned. The correntões method has caused the rapid conversion of the Cerrado[50].

Baseline for BGOT

In the baseline scenario, below-ground biomass is assumed to be entirely removed at the time of conversion in order to pursue agricultural activities, the soil is greatly disturbed to remove roots and other debris[51]. The baseline scenario for below-ground biomass is directly related to the baseline emissions model. It is assumed that below-ground biomass is released to the atmosphere. The BGOT pools is calculated from AGOT pools using the specific ratio root-to-shoot for each vegetation class provided by Brazil's Fourth National Communication on Greenhouse Gases, submitted to the UNFCCC[52]. Such values are spatialized within the Cerrado and the average was used for each vegetation class.

Baseline for SOC

In the baseline scenario, a large part of the soil organic carbon will be released to the atmosphere after the conversion even. During the soil preparation phase, the soil layers from 0-10 cm and from 10-20 cm will be largely impacted by tractors and tilling in order for agriculture production to follow. The baseline scenario is agricultural for crop production The most common commodity exported from the Cerrado biome is soy.

3.4.6 Determining Historical Conversion (α, β, and θ)

3.4.6.1 Reference Area

The reference area is used to determine the landscape pattern of conversion while the reference period is used to determine the change in the cumulative proportion of conversion over time. According to VM0009 Methodology, the definition of reference area should follow a few requirements, specially (1) Native vegetation area larger than the PAA areas; (2) Current land use must be crop production; (3) Historical vegetation class must be native Cerrado; (4) Biophysical conditions in the reference area must be similar to the PAA; (5) The property must have road access; (6) A reference area to each baseline type.

1. The location and size of the reference area relative to the project accounting area

Initially, the reference areas were defined based on combined analysis using:

[50] To view the "correntões" method watch: https://www.youtube.com/watch?v=xDmAnM_9dxE

[51] Grupo do Trabalho Cerrado. Análise Geoespacial da Dinâmica da Soja no Bioma Cerrado: 2014 a 2017. Accessed at: https://abiove.org.br/wp-content/uploads/2019/02/12022019-125848-12.02.2019._analise_geoespacial_da_dinamica_da_soja_no_bioma_cerrado_2014_a_2017_v02.pdf

[52] BRASIL. IV Inventário - LULUCF (Uso da Terra, Mudança do Uso da Terra e Florestas, atualizado em 24/05/2021. Brasília, DF: Ministério da Ciência, Tecnologia e Inovação. 291p., 2020. Pages 121-127. https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/relatorios-de-referencia-setorial.

1) The Rural Environmental Register (CAR database), a government system that identifies rural properties and their owners, areas and production processes; and

2) The MapBiomas database*, Annual Mapping of Land Cover and Land Use in Brazil*[53] a public consultation web platform. MapBiomas is a project that maps the annual coverage and land use in Brazil from remote sensing and GIS technology, by classifying anthropic and natural coverage into land use classes. The data from Collection 5 of MapBiomas presents the 35 years (1985 to 2019) of the annual maps of coverage and land use in Brazil, in matrix format (30x30m pixel), with improvements in accuracy in biomes. In this collection, the new limit of biomes on a scale 1: 250,000 from IBGE has already been used. The MapBiomas Project is an initiative that involves a collaborative network of biomes, land use, remote sensing, GIS and computer science experts that rely on Google Earth Engine platform and its cloud processing and automated classifiers capabilities to generate Brazil's annual land use and land cover time series. All biomes generated Landsat cloud free composites based on specific periods of time in order to optimize the spectral contrast to help within the discrimination of LCLU classes. The cloud/shadow removal script takes advantage of the quality 15 assessment (QA) band and the GEE median reducer. When used, QA values can improve data integrity by indicating which pixels might be affected by artefacts or subject to cloud contamination (USGS, 2017). In conjunction, GEE can be instructed to pick the median pixel value in a stack of images. By doing so, the engine rejects values that are too bright (e.g., clouds) or too dark (e.g., shadows) and picks the median pixel value in each band over time. For each chart, a specific temporal mosaic of Landsat images was built, based on the following selection criteria/parameters: 1. The selected Landsat data must allow an annual analysis, and 2. The period for Landsat scenes selection (day/month/year) must provide enough spectral contrast to better distinguish LCLU classes.

3) The F-P2 reference area must have as much forest as the forest project accounting area at some point in time during the historic reference period. The G-P2 reference area must have as much native grassland as the grassland project accounting area at some point in time during the historic reference period. If a reference area based on a single agent cannot by located to meet this requirement, landholdings from multiple agents in the class of agents were combined to meet this criteria.

Regarding the Cerrado Biome, the classification system within the MapBiomas platform consists of applying a decision-tree to generate annual maps of the native vegetation types, which are distinguished in three classes: Cerrado forest, Cerrado savannah, and Cerrado grassland, according to gradients of woody and herbaceous layers. These classes are compatible with the IBGE and FAO classification, according to description of the vegetation classes, see Table below. The others main classes are: Farming, Other non-vegetated area, Water and Non-observed[54].

The selected reference area for F-P2 showed the following MapBiomas classes: Forest (ID 3), Savannah (ID 4), Grassland (ID 12), Other non vegetated area (ID 25), River,Lake and Ocean (ID 33), Pasture (ID 15), Soy

[53] https://plataforma.brasil.mapbiomas.org/,

[54] Accessed at: https://mapbiomas-br-site.s3.amazonaws.com/Cerrado_Appendix_-_ATBD_Collection_5_v1.pdf.

(ID 39) and Other temporary crops (ID 41). Considering the IBGE classification, the forest project accounting area represents 60% of the total PAA.

The selected reference area for G-P2 showed the following MapBiomas classes: Forest (ID 3), Savannah (ID 4), Grassland (ID 12), Other non vegetated area (ID 25), Pasture (ID 15), Soy (ID 39) and Other temporary crops (ID 41). The 'Non-observed' class was not found in the area. Considering the IBGE classification, the grassland project accounting area represents 40% of the total PAA.

Table 12: Harmonization Among Vegetation Classifications Systems[55]

MapBiomas	Description	FAO Classes	IBGE Classes
Cerrado Forest Formation	Vegetation with predominance of arboreal species	FSP (primary semi-deciduous forest), FDP (primary deciduous forest)	Cm (montane seasonal deciduos forest), Fa (seasonal alluvial semideciduos forest), Sd (forested savannah)
Cerrado Savannah Formation	Savannah formations with defined arboreal and shrub-herbaceous strata	WS (shrubs)	Sa (wooded savannah)
Cerrado Grassland	Savannah formations with a predominance of herbaceous strata	WG (wooded grassland)	Sp (parkland savannah) Sg (woody-grassland savannah)

The Brazilian Cerrado is constituted by three main vegetation types (grasslands, savannah and forest), with different carbon stocks in relation to the degree of woodiness of the vegetation, although variations in relation to the structure and degree of deciduousness are observed, as the scale is reduced. In terms of Biome, the floristic matrix becomes homogeneous, with the rich flora, with Leguminosae and Myrtaceae very prevalent in the tree and shrub canopies. The most common species are Caryocar brasiliense, Curatella americana, Kielmeyera coriacea and Qualea spp (FAO 2001)[56]. In some areas there is the Forested Savannah, the Cerradao, a short semi-deciduous forest, 10 to 15 m tall, of medium density. In others, it occurs patches of Semideciduous Forest, a type with tree species that occupy sites with specific conditions of climate and water flux. Comparing the reference area and the project area, both are embedded in a similar vegetation matrix, with most areas composed of savannah formations. In terms of

[55] Accessed at: https://storage.googleapis.com/mapbiomas-public/brasil/coverage/classes-description/classes-description_pt-BR.pdf.

[56] FAO. Chapter 42. South America: Ecological Zones. Accessed at: https://www.fao.org/3/Y1997E/y1997e1b.htm#TopOfPage

environments elements as soil and topography, the two areas present the same characteristics, as shown previously.

According to the Methodology VM0009, “a grassland includes indigenous grass species, and may include some density of trees too low to be defined as forest (such as a woodland). There may exist some patches of forest which meet the definition of forest, but an area defined as native grassland does not meet the definition of forest, on average, across the area.” The FAO[57] definition to Brazilian Cerrado is an ecoregion covered by a mosaic of grasslands, tree savannahs and woodlands with patches of semi-deciduous forest. The Ribeiro and Walter classification[58], on which the IBGE mapping and the Fourth National Communication from Brazil to UNFCCC is based, represents the Cerrado as a mosaic of savanna woods, deciduous or semi-deciduous forests, and perennial riparian forests, in a grassland and shrubland matrix. By cross-checking the definitions of the methodology, the vegetation classes included in the Cerrado Biome according to MapBiomas and the definitions of these classes by IBGE and FAO, it is assumed in this project that the Brazilian Cerrado is suitable for the classification of native grassland, for the purpose of ecosystem conversion analysis and to baseline type GP-2.

Therefore, from of spatial analysis with CAR and MapBiomas data, the reference areas selected are private properties that have converted native Cerrado to agriculture within the designated geographic area, the Cerrado Biome, with native vegetation areas larger than PAA.. Reference area for baseline type FP-2 was formed by nine private properties to meet the requirement regarding the minimum area.

Table 13: Reference areas, identified by CAR-code

Reference Areas	Baseline Type	Baseline Type Area (ha)	City	State	Reference Area (ha)
BA-2909307	F-P2	6,917.5	Correntina	Bahia	24,252.66
PI-2203230	G-P2	4,591.7	Currais	Piauí	68,562.54

Since 2007, conversion of native Cerrado to agriculture has significantly expanded in each Reference Area, see Table below.

Table 14: Areas (ha) of Cerrado and Farming in each reference area at 10-year intervals throughout the reference period

Reference Area	Area in 2007 (ha)	Area in 2017 (ha)	Land-Use and Land-Cover
F-P2:	10,737.09	7,117.83	Forestry Formations (Class 3)
	2,430.45	8,369.64	Farming (classes 15, 39 and 41)

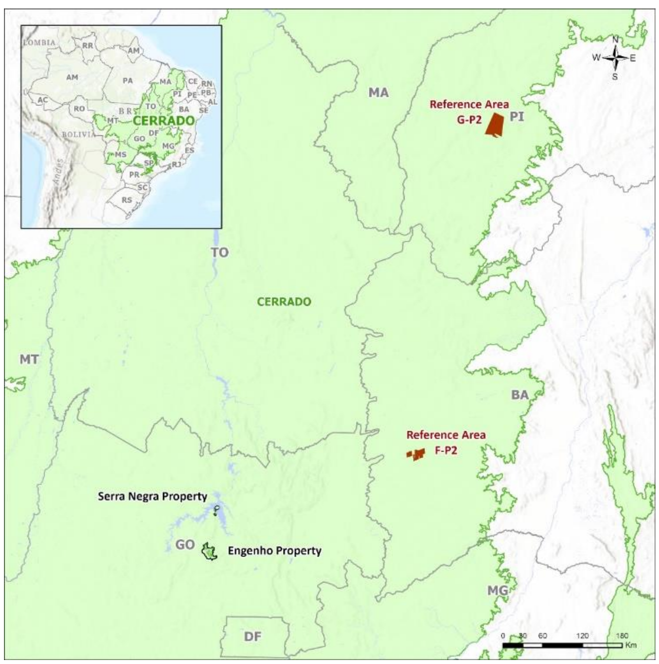
57 FAO. Chapter 42. South America: Ecological Zones. Accessed at: https://www.fao.org/3/Y1997E/y1997e1b.htm#TopOfPage

58 Ribeiro, J.F. & Walter, B.M.T. 1998. Fitofisionomias do bioma Cerrado. Accessed at: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/554094/fitofisionomias-do-bioma-cerrado

BA-2909307	10,468.44	8,015.85	Other Vegetation (4 and 12)
	616.68	749.34	Other Non-Vegetated Areas (25 and 33)
Total	24,252.66	24,252.66	
G-P2: PI-2203230	64,135.98	44,163.63	Native Cerrado Formations (classes 4 and 12)
	3,193.29	23,087.07	Farming (classes 15, 39 and 41)
	1,216.53	1,212.66	Other Vegetation (3)
	16.74	99.18	Other Non-Vegetated Areas (25)
Total	68,562.54	68,562.54	

The Figure below displays the spatial arrangement of the project areas and the reference areas.

Figure 39: Reference Areas in Cerrado Biome



The spatial analysis was performed in two points in the time, 2007 and 2017, to demonstrate that the area of vegetation in reference area is larger than in the PAA, see Table below. The analysis was carried out based on the Cerrado vegetation classes of the MapBiomas project platform, where forest (class 3) is the vegetation class for baseline type FP-2, whereas savannah and grassland (classes 4 and 12) are vegetation classes used for GP-2. The areas were calculated from counting the number of pixels extracted from MapBiomas maps.

Table 15: Table of native vegetation areas (ha) in the PAA and reference area for each baseline type, in two points in time

	GP-2		FP-2	
Year	PAA	Reference Area	PAA	Reference Area
2007	8,185.5	64,135.98	3,368.34	10,737.09
2017	8,219.52	44,163.63	3,237.03	7,117.83

2. A description of the drivers of conversion, including the following, relative to the project area

All agents in a class share the same drivers of conversion: maximize economic returns through agricultural production. Therefore, the MapBiomas land use and land cover annual maps, from 2007 to 2017, were analyzed to assess the trajectories of farming and Cerrado classes over the historic period. Geoprocessing techniques were applied to the data to draw trajectories of changes among years, based on vegetation classes of Cerrado (forest, savannah and grassland formations) and farming classes. The analysis resulted in the determination of the historic pattern of conversion for the baseline scenario for a private property considering the same drivers of conversion and that demonstrates the temporal trajectory from Cerrado vegetation to farming.

The evidence to support that the management practices of the baseline agent in the reference area are similar to those that would have been applied to the PAI in the baseline is demonstrated by the end land-use scenario: crop production. The Engenho property is actively producing crops such as soy and the reference area is also actively producing soy crops.

The analysis of the temporal dynamics of land use change between 2007 and 2017 indicate the progression of conversion from Cerrado vegetation to farming classes, see Table below.

Table 16: Table of land use conversion trend from2007 to 2017 based on MapBiomas classes

	GP-2			FP-2		
Year	Native Vegetation	Soybean	Other temporary crops	Native Vegetation	Soybean	Other temporary crops
2007	65,352.51	2,189.88	1,001.43	21,205.53	84.51	1,432.26
2017	45,376.29	6,931.62	15,987.33	15,133.68	1,956.87	5,363.64
2007	65,352.51	2,189.88	1,001.43	21,205.53	84.51	1,432.26
2017	45,376.29	6,931.62	15,987.33	15,133.68	1,956.87	5,363.64

In addition, a social, economic, and cultural analysis to validate the drivers and conversion agents acting in these areas. The table below presents information that indicate the impacts of soybean cultivation on the social and economic parameters of the municipalities.

Table . Socioeconomic parameters of the municipalities. Source: IBGE

Social-Economic parameters	Currais - PI	Correntina - BA	Niquelandia - GO
Population (2021)	4,982 people	32,243 people	47,064 people
Area (Km²)	3,157	11,504	9,846
GNP per capita (2017)	R$ 32.120	R$ 37.930	R$ 21.811
Average monthly salary of workers (2020)	2.5 basic salaries	2.6 basic salaries	2.0 basic salaries
Percentage of soybean crops within the farms (2017)	20,4%	24,1%	8,8%
HDI (2010)	0,542	0,603	0,715

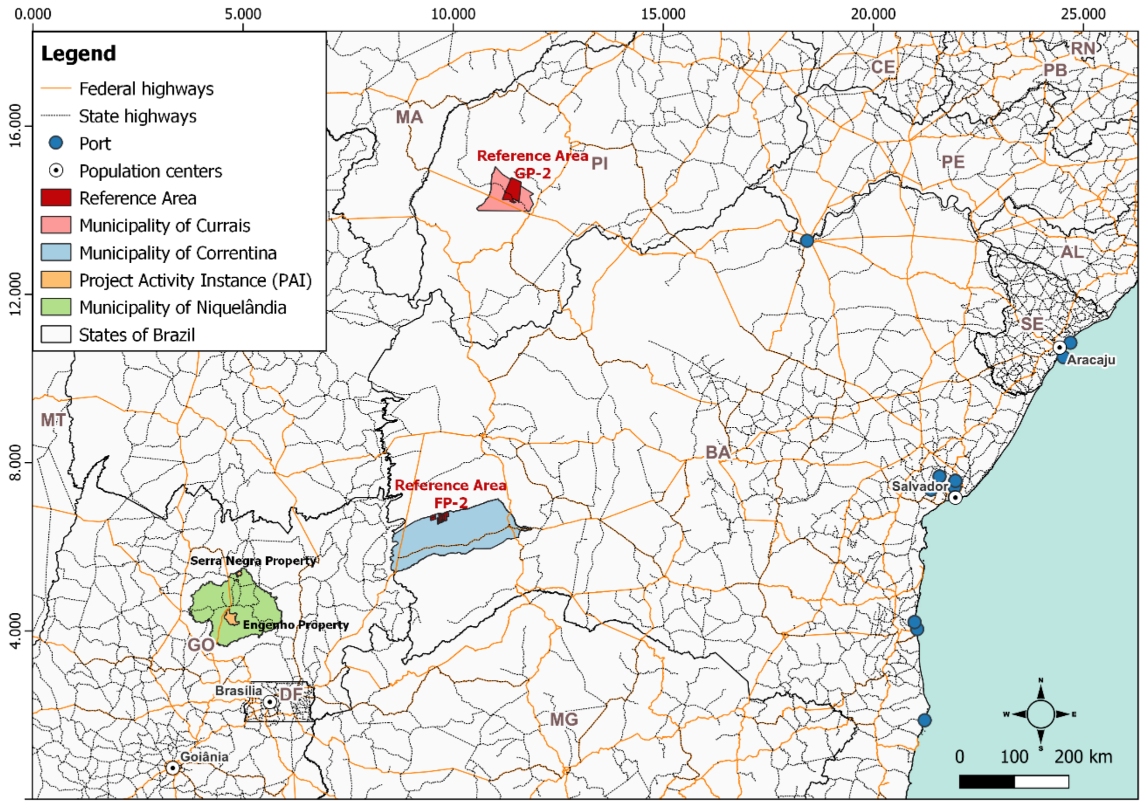
The socio-economic analysis among the municipalities of the reference areas and project accounting area was carried out, based on data from the Institute of Geography and Statistics (IBGE), freely available on the website.: https://www.ibge.gov.br/cidades-e-estados. The two cities where the reference areas are located present values of gross domestic product (GNP) and average monthly salary of workers that validate the financial relationship among these two parameters and the percentage of soybean crops within the farms. Comparing with the municipality where the project accounting areas are located, it is possible to verify the influence of soy expansion on the municipality's economy. At the same time, the human development index (HDI) shows an inverse relationship with financial parameters, indicating that soybean expansion may not necessarily improve the basic health, education, and income distribution indices.

Regarding cultural characteristics, there are few data available in relation to cultural issues in the municipalities. Information freely available on the city halls website are limited to traditional festivals, related to religiosity and typical music and dance, which mostly take place throughout the Brazilian territory.

3. The location(s) of the agents of conversion relative to the project accounting area and surrounding region.

In the baseline scenario, only the primary agent is responsible for converting Cerrado vegetation into soybean crops. The agents have a wide network of transport infrastructure to move production and supplies. Furthemore to the straightforward flow of production to large population centers and ports for export, all cities where the areas are located have grain storage silos, which reflect in the mobility of agents. The next Figure shows the location of reference areas and PAA in relation to roads, ports, and state capitals.

Figure : Location of areas and transport infrastructure in the region



4. The mobilities of the agents of conversion relative to the project accounting area

In the baseline scenario, only the primary agent is responsible for converting Cerrado vegetation into soybean crops. This agent has a wide network of transport infrastructure to move production and supplies. Furthermore to the straightforward flow of production to large population centers and ports for export, all cities where the areas are located have grain storage silos, which impact in the mobility of agents.

Table . Logistics information for the mobility of the agents in the municipalities. Source: IBGE

Municipality	Number of grain storage buildings	Total capacity (tn)	Distance from nearest seaport Km)
Currais - PI	3	62,609	883
Correntina - BA	45	634,599	728

Niquelandia - GO	4	29,430	1,043

5. Landscape configuration of the reference area and the project accounting area

The reference areas are within the grouped project's geographic boundary: Cerrado biome and are similar to the project area in regard to the agents and drivers of conversion and landscape configuration. The reference area was selected mainly based on the following characteristics:

1. Current land-use must be crop production;
2. Historical vegetation class must be native Cerrado;
3. The property must have road access.
4. The soil class must be Oxisols, Neossols, Argisols, Plintosols, or Cambisols, or another soil profile characteristic of the Cerrado biome;
5. The land under production must have less than 25% slope; and

The first three requirements have already been discussed previously. The figures below indicate that the reference areas and the PAA have similar biophysical characteristics, regarding to vegetation type, soils and slope.

Figure 40: Land-use map of the reference area of baseline type GP-2

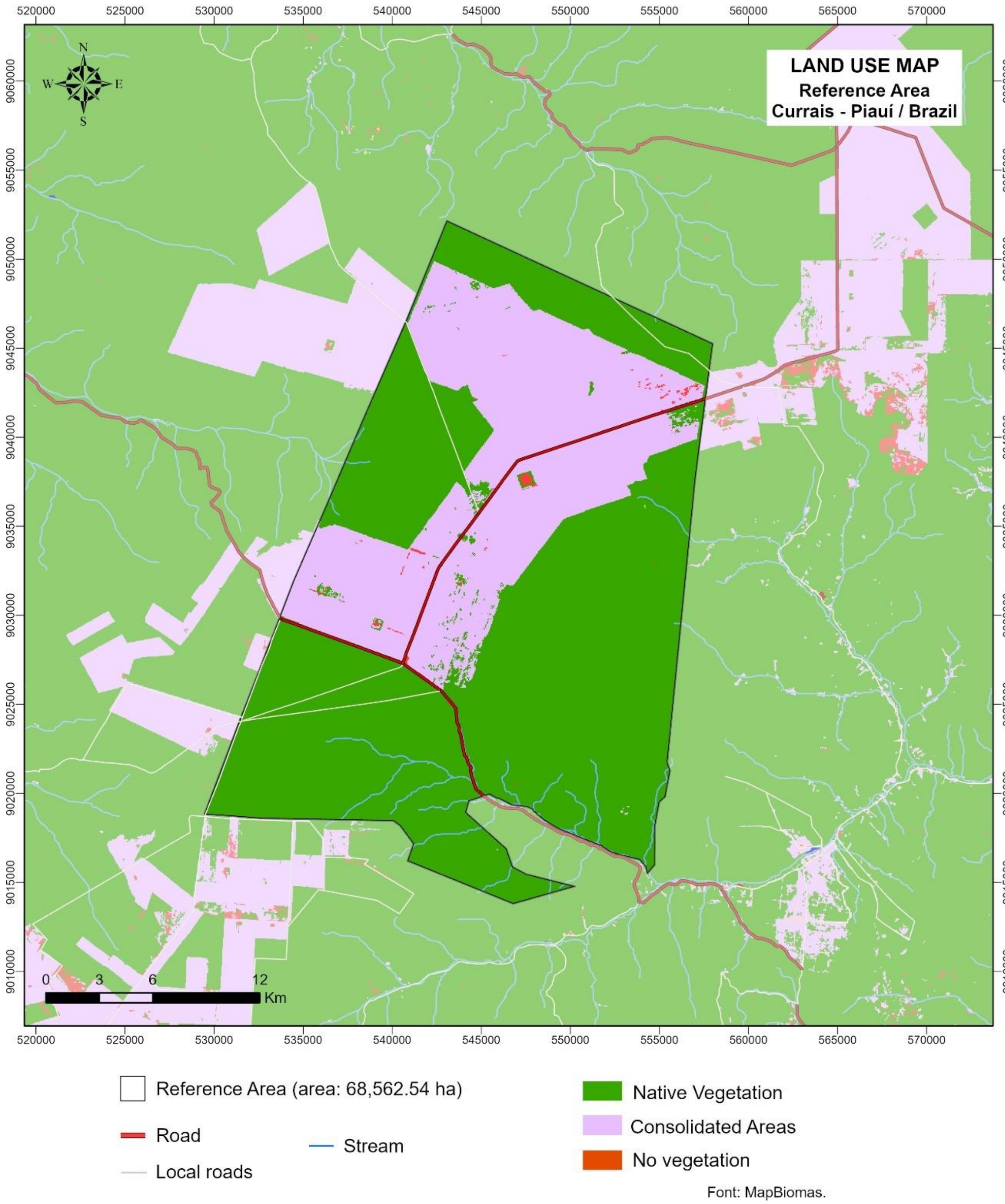


Figure 41: Cerrado Vegetation Classification of GP-2 reference area

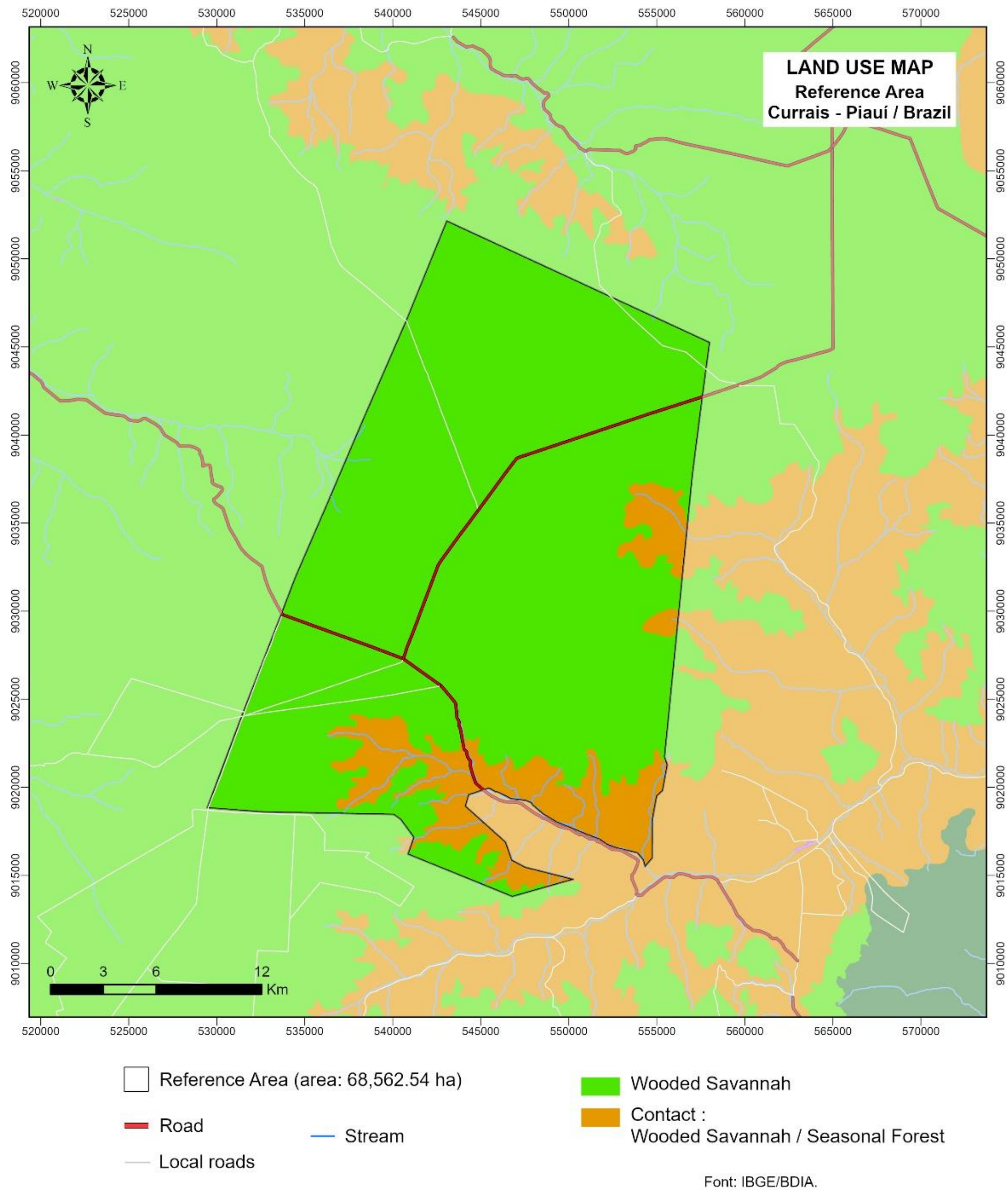


Figure 42: Soils classification and slope of the GP-2 reference area

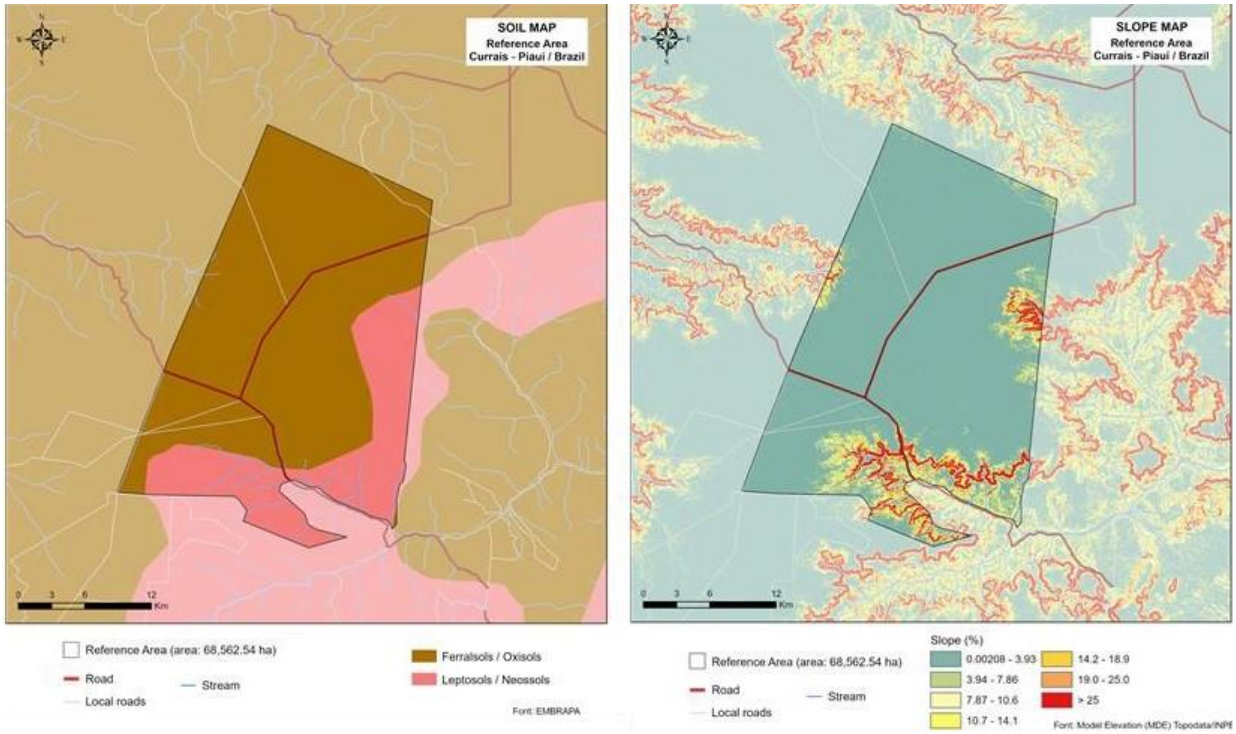


Figure 43: Land-use map of the reference area of baseline type FP-2

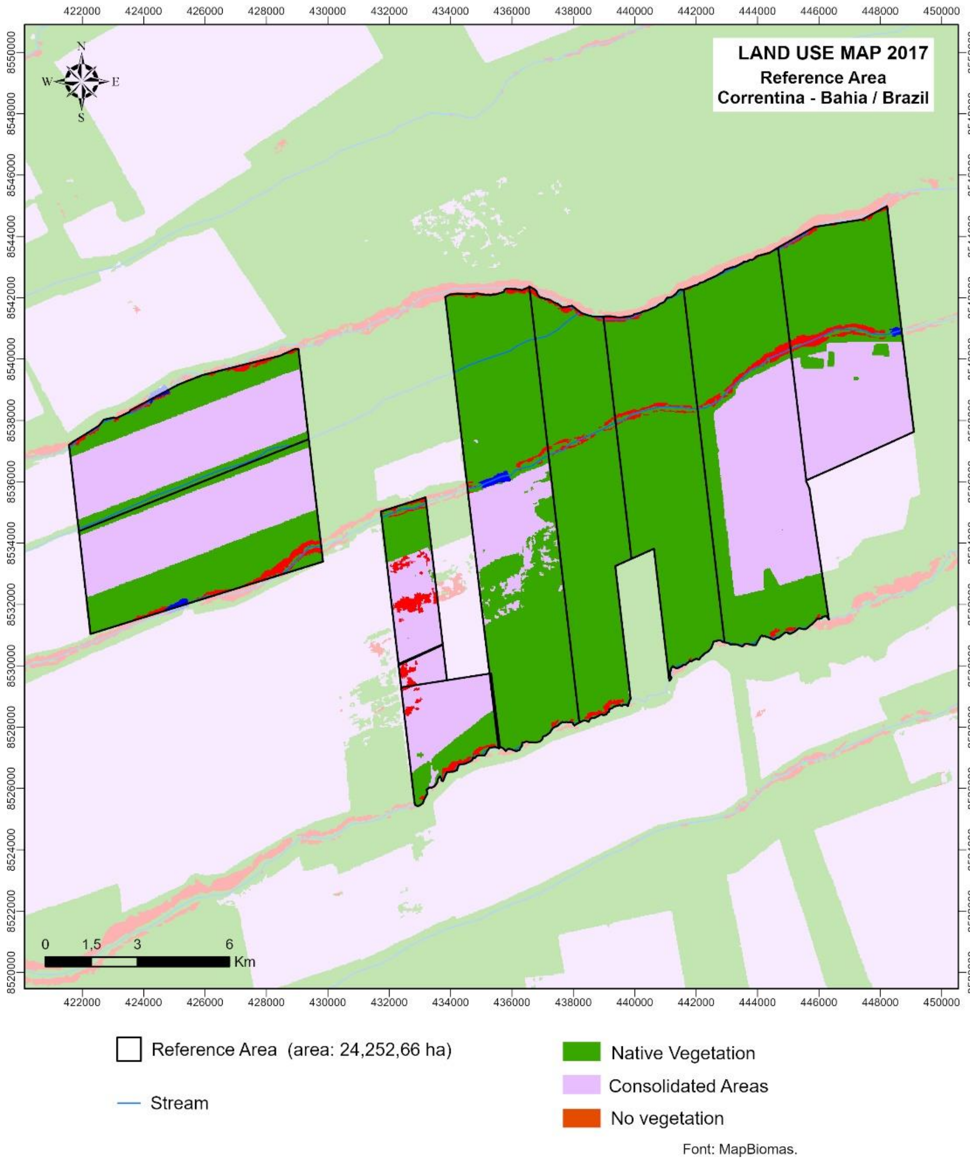


Figure 44: Cerrado Vegetation Classification of FP-2 reference area

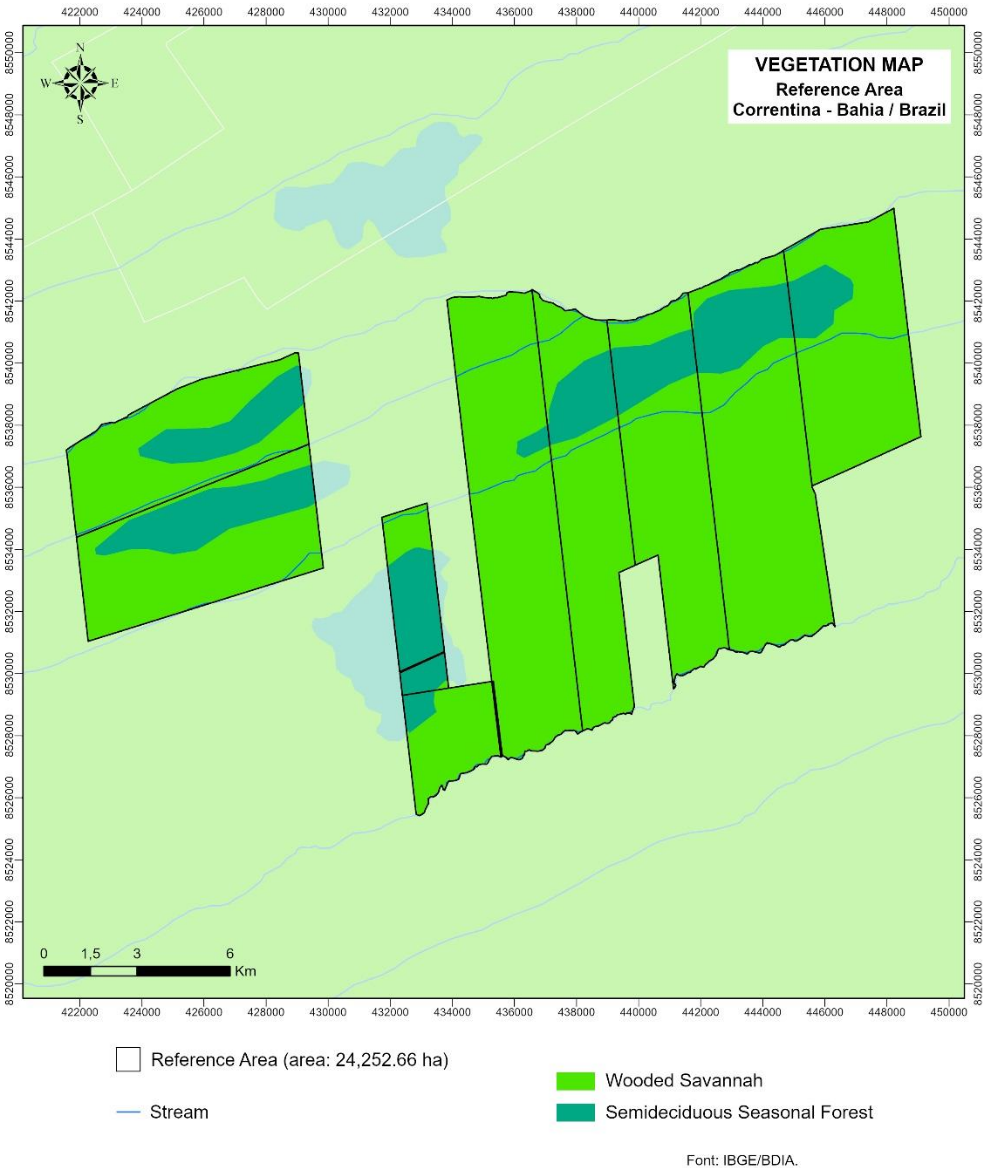
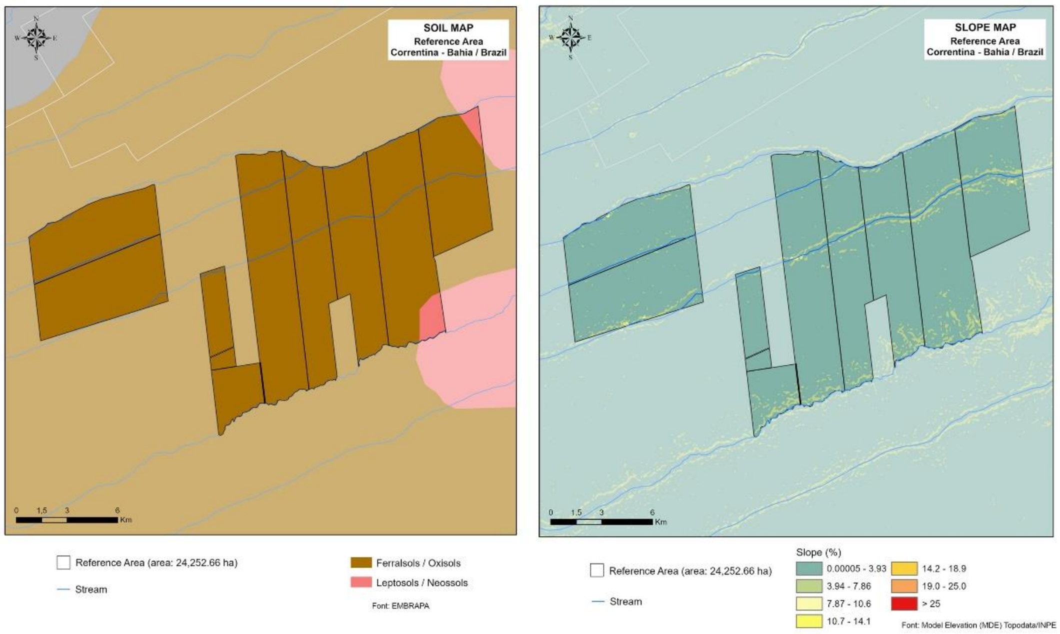


Figure 45: Soils classification and slope of the FP-2 reference area



In summary, the combined analysis of data from the CAR platform and MapBiomas project allowed selecting the reference area that meets the criteria of the same converting agent (farmer on private land) and current land use for agricultural production. In addition, the defined reference areas and the project's accounting area are located in the same Biome, with similar environmental characteristics.

According analysis of available data presented in this section, the agents and drivers of conversion, represented by selected reference areas, are similar to those of the project accounting areas, as well as to indicated that those agents performed similarly in the reference area to the way they would have performed in the project accounting area under the baseline scenario.
The following statements give the reasons for that conclusion:

- Similar biophysical characteristics, such as soil, slope and vegetation type;
- Large areas of native vegetation at the beginning of the historical period;
- Temporal trajectory clearly shows the trend of land use changes for the baseline assumed in this project;
- Wide infrastructure network facilitates agents' access to consumer centers across the country, as well as to export ports;
- Economic index that indicate the importance of soy in the municipalities' economy.

Therefore, the reference area selected meet the relevant eligibility criteria.

3.4.6.2 Defining the Historic Reference Period

The historical reference period is from February 1st, 2007 to February 1st, 2017.

The reference period was chosen to determine the cumulative proportion of conversion over time. The beginning of the reference period was established in 2007, when the land management practice changes were initiated. This is justified by the temporal analysis of the MapBiomas data that shows in 1997 there were no soybean crops areas, in neither of the two baseline types. However, in 2007, 3.19% and 0.35% of the reference area had been converted to soybean, in the GP-2 and FP-2, respectively, by following a continuous flux of conversion over time, with increasing of both soybean and other temporary crops areas, in both baseline types (Figure 43 and 44). To capture the most applicable conversion rate possible, the reference period was extended through 2017, the same year of start of project.

Figure 46: Graph conversion trends from Cerrado vegetation to farming classes over time in GP-2 reference area

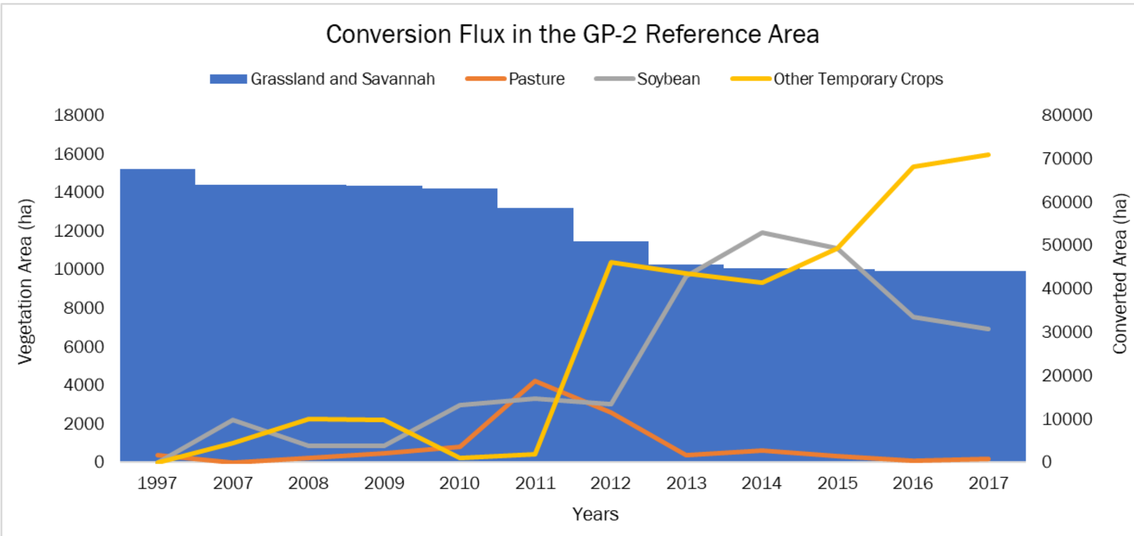
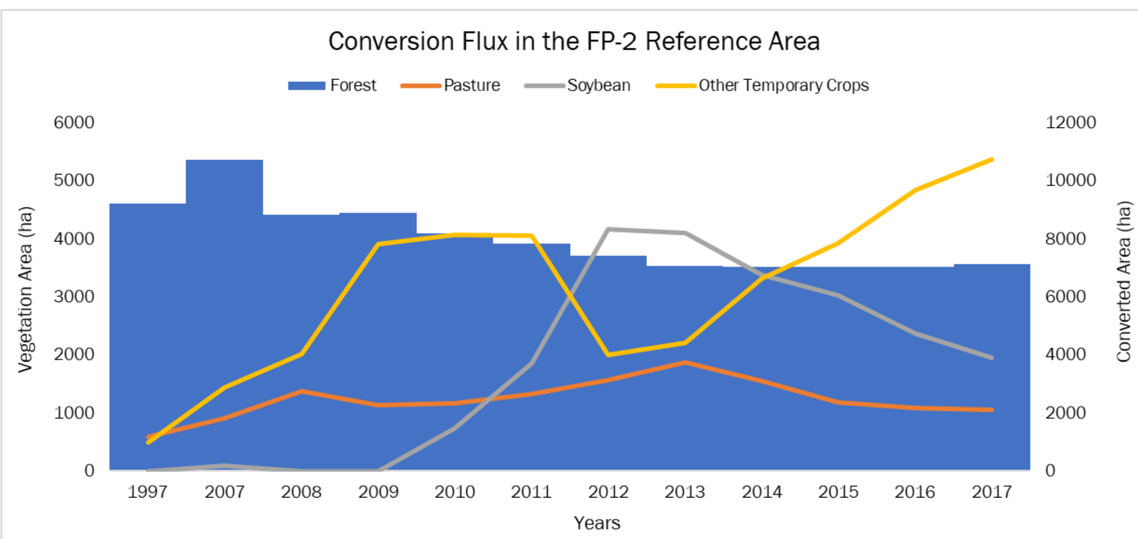


Figure 47: Graph conversion trends from Cerrado vegetation to farming classes over time in FP-2 reference area



The reference areas and historic reference period are used to find α, β, and θ, the parameters that are used to depict the historic pattern of ecosystem conversion to be applied to the PAA in each the baseline scenario. The parameter β is the effect of time on the cumulative. The parameter α is related to the combined effects of the other parameters at the start of the historic reference period. The parameter θ is related to the covariates and is not employed because there is only one agent of conversion, the private landholder. The methodological strategy adopted was supported on the MapBiomas database, by handling the farming and Cerrado vegetation classes to build trajectories of changes over time. Therefore, the first step was to download the annual images from the MapBiomas collection 5, from 2007 to 2017. Accordingly, satellite images have not been applied directly to interpret the changes, but a historical series of annual maps of land cover and land use in Brazil. This step was designed to comply with section 6.8.4 of the V0009 methodology.

Over the 2007 map, it was carried out an analysis to select the pixels classified as 'forest formation', 'savannah formation' or 'grassland', which they are classes from MapBiomas that represent the Cerrado and its phytophysiognomies. Pixels classified as other classes have been excluded since conversion can not be observed without initially observing Cerrado vegetation. In the sequence, these pixels were converted in a shapefile of points, from which it was performed a random sampling of select 5000 points, in GP-2 reference area, and 2000 points in FP-2 (section 6.8.5). The sample size was arbitrarily defined and later confirmed through the results of Equation F12 and F13. The superposition of the sampling points on the MapBiomas annual images allowed to extract the observed class in each sample point, by applying geoprocessing tools. The result was exported as a table to excel and from there worked on to meet the requirements and parameterize α, β, and θ, (sections 6.8.6 and 6.8.7). Finally, the fit of the logistic function was performed, allowing to model the cumulative conversion as a proportion of an area and from that, can be used to predicted for future times (sections 6.8.8 through 6.8.10).

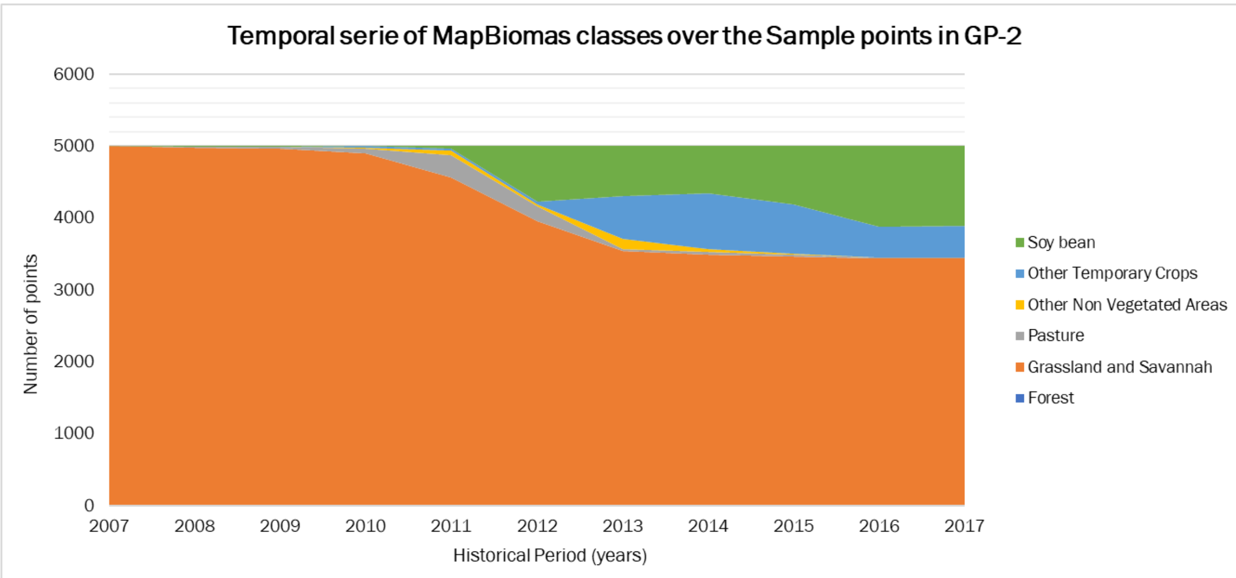
3.4.6.3 Historic Imagery to Parameterize α, β, and θ

The baseline scenario is characterized by observing ecosystem conversion in the reference area assuming the same would occur in the project accounting area in the absence of the project activity. The parameters **α and β** were estimated from observations of land cover change in the reference area over the reference period based on a logistic function (see Reference Area modelling spreadsheet in the attached project folder). Once estimated, these parameters depicted the shape of the logistic function and the cumulative emissions that would have occurred at any point in time after the project start date.

As previously mentioned, the annual images from MapBiomas were used to identify the transitions between Cerrado vegetation and anthropogenic conversion (farming), throughout the period from 2007 to 2017. The methods applied to produce annual land cover and use maps (LCLU) in Brazil involve some steps among pre and post processing. The first step was to generate annual Landsat mosaics comprising specific temporal-windows to optimize the spectral contrast, and better discriminate the LCLU classes across the biomes. The second step was to derive from the Landsat bands the spectral and temporal attributes to guide the random forest classifier (feature space definition). The acquisition of training samples was defined based on reference maps, stable maps of earlier MapBiomas collections (invariant pixel class), or visual interpretation. Each biome and cross-cutting theme adjusted their training dataset according to its information availability and its statistical needs. Based on the adjusted training dataset, the random forest algorithm was used to generate one LCLU map per year. In this way, the maps were produced annually, linearly in time. All data, classification maps, software, statistics and further analyses are openly accessible through the MapBiomas Platform[59].

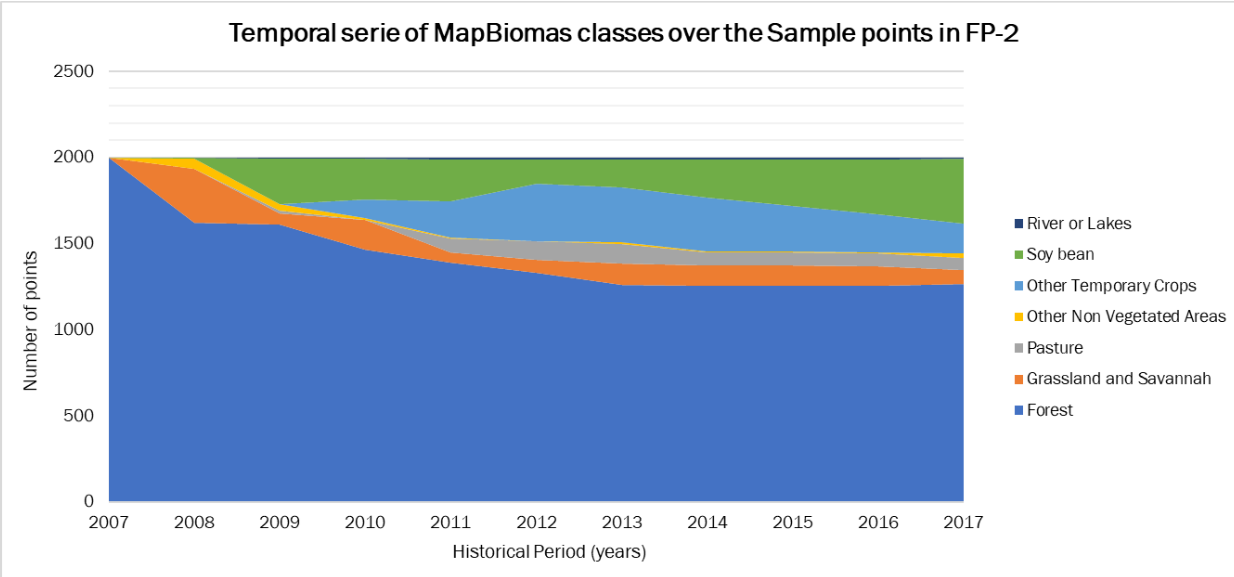
Therefore, the time series is stationary, since image dates are evenly distributed over the entire period and all sampling points found a class in all years. The Figures below show the results of spatial-temporal analysis of MapBiomas land use and land class over sample points, where all sample points points received a classification in all years of historic period.

Figure 48: Temporal series of MapBiomas classes over the sample points in GP-2 reference area



[59] Accessed at: http://mapbiomas.org

Figure 49: Temporal series of MapBiomas classes over the sample points in FP-2 reference area



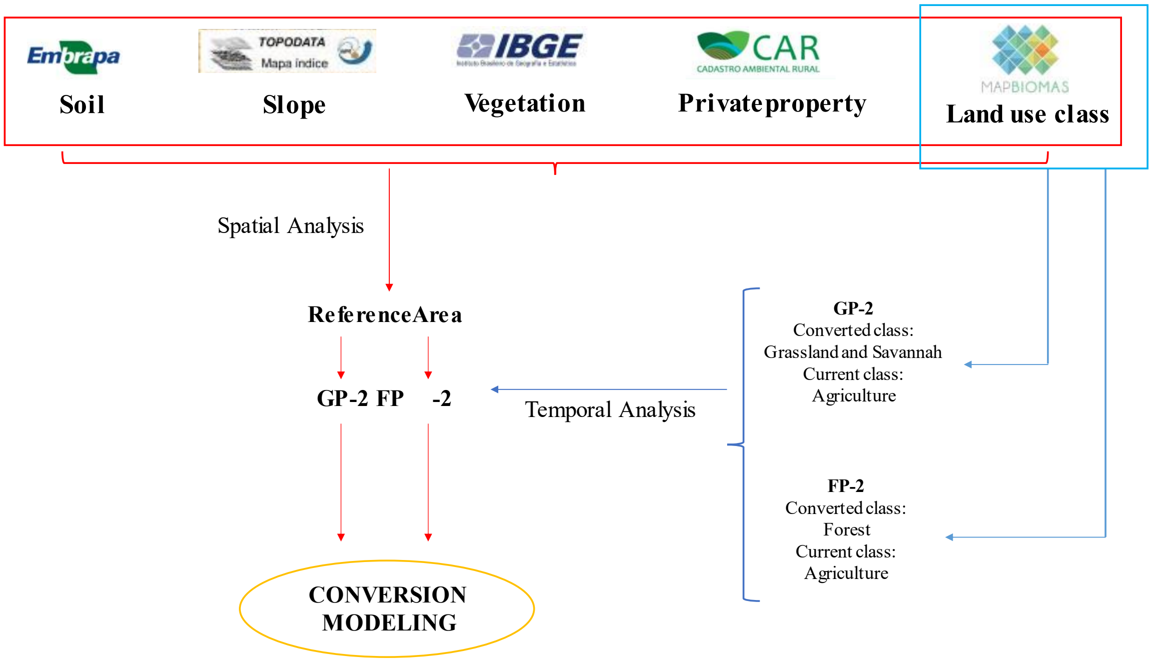
Eleven MapBiomas maps were taken at annual intervals from 2007 to 2017, with information about land use and land cover classes over the entire reference area. The overlap between the sampling points and the LULC maps did not return any pixel classified as 'non-observed'. According MapBiomas project, 'non-observed' class represents areas blocked by clouds or atmospheric noise or absent of observation. Therefore, all sampling points cover the same count of time periods, by covering more than 2 consecutive years. In summary, the stationarity is linear and uniform on the time, with a sequence of 11 images in regular 1-year intervals.

MapBiomas products have a spatial resolution of 30 meters, according documentation available on the public platform. Thus, the pixels of the satellite images were 30m x 30m, which fulfils this PDR. More details can be reached in this link: *https://mapbiomas.org/visao-geral-da-metodologia*.

Accuracy analysis is the main way of assessing the quality of mapping performed by Mapbiomas. In addition to telling the overall classification accuracy, the analysis also reveals the accuracy and error rate for each classified class. MapBiomas evaluated global and per-class classification accuracy for each year between 1985 and 2019. Accuracy estimates were based on the evaluation of a pixel sample, which we call the reference database, consisting of ~ 75,000 samples. The number of pixels in the reference database was predetermined by statistical sampling techniques. Each year, each pixel from the reference database was evaluated by technicians trained in visual interpretation of Landsat images. Accuracy was assessed using metrics that compare the mapped class with the class evaluated by the technicians in the reference database. At Level 1 classes the LCLU mapping product in the Collection 5 presented 91,2% of global accuracy and 6.9% of allocation disagreement with 1,9% of area disagreement. More details can be reached in this link: https://mapbiomas.org/analise-de-acuracia .

Schematically, the process of parameterization of the conversion model, with the data used, followed the strategy shown in the figure below.

Figure 50: Scheme of the parameterization of the conversion model



3.4.6.4 Determining Sample Size

According to the methodology, sample size determination is optional, but a minimum sample size may be estimated within +/- 15% of the estimated proportion of conversion in the reference area, or 300 points, in a way that the sample should be large enough to obtain an estimate of the population variance. After an initial pilot sample of 1000 without reaching the necessary sampling sufficiency, according to the results of applying Equations F12 and F13, a larger sample size of 5000 (GP-2) and 2000 (FP-2) points was applied in order to ensure a representative sampling. These points applied on the annual images of land use and land cover, spatially superimposed, allowed the identification of the corresponding class, in each year of the period of reference.

The resulting was exported to excel in order to verify the trajectories of classes over time as well as calculate the weight of the observation (Equation A.6), the minimum sample size (Equation F.12) and the standard deviation of observed conversion (Equation F.13). In the excel, the land-use classes extracted previously for each point in each year were reclassified into ‘0’ to vegetation classes of Cerrado, ‘1’ to Farming classes and ‘x’ to other classes. Table 17 shows the original classes from MapBiomas and the result after the re-classification.

Table 17: Reclassification of MapBiomas classes

Land-Use Classes	ID	Reclassified
Forest (FP-2)	3	0
Forest (GP-2	3	x
Savannah (GP-2)	4	0
Savannah (FP-2)	4	x
Grassland (GP-2)	12	0
Grassland (FP-2)	12	x
Pasture (2008-2016)	15	1
Pasture (2017)	15	x
Soy bean	39	1
Other Temporary Crops	41	1
Other Non Vegetated Areas	25	x
River and Lakes	33	x

Next, those points for which the observation is 'x' (other classes) in any entry of the table (year) were excluded since the baseline scenario represents only the conversion from native grassland to farming classes. In addition, points in current land-use (2017) that represent 'pasture' (ID 15) were excluded as well, because they don't represent crop production considered in baseline scenario, notwithstanding pastures are intermediate classes of conversion. Points that did not experience conversion during the reference period were kept. The result is a binary matrix where each point represents an observation (0 or 1) in the time (each year), defined by equation F. 11.

Initially, a random sampling of 5000 points was carried out; however, after the removal of the unwanted points, the final sample size used in the conversion modelling was 4752 points, in the GP-2 reference area. In the FP-2 reference area, the final sample size was 1322, after the exclusion of 'x' points. The rows of non-discarded points were aggregated into a single master table, one for each baseline type, with rows that correspond to observations of state vector ($\boldsymbol{o}$) and the time vector ($\boldsymbol{t}$), which will be used to parameterize α and β. The V0009 methodology also guides the calculation of weights for each non-discarded point in order to reduce the bias of the spatial-temporal variability of the sample, since in the process of image interpretation the probability of observing any one sample point in the same space and time is not uniform. The weight is calculated based on equation A.6.

However, as stationarity is homogeneous throughout the period and the 'double coverage' is 100%, the weight is the same for all observations. Therefore, despite the calculation of the weights having been made for all valid observations and applied in Equation 13, the master table does not contain the weight vector (**w**).

The sample sufficiency calculation was based on equations F.13 and F.12. The first refers to the Standard deviation of observed conversion calculation, while the second equation allows the calculation of the minimum sample size in the reference area required for fitting the logistic function. Table 18 shows that the sample size in the reference area is higher than the minimum requested.

Table 18: Number of points launched and discarded in each reference areas.

Reference area	Sample size	Minimum sample	Standard deviation
PI-2203230	4752	1723	0,357973
BA-2909307	1322	449	0,182738

The next Figures show the sample points with Land use and Land cover 2007 and 2017 in background, by meeting the requirements in relation to class in beginning of historic period (Cerrado classes and farming land-use classes). The sampling points were launched only in areas where ianda had not converted in 2007 and on pixels classified as 'grassland' or 'savannah', in the GP-2 reference area, and 'forest' in FP-2 reference area, according to MapBiomas maps.

Figure 51: Sampling points and land-use classes in GP-2 reference area

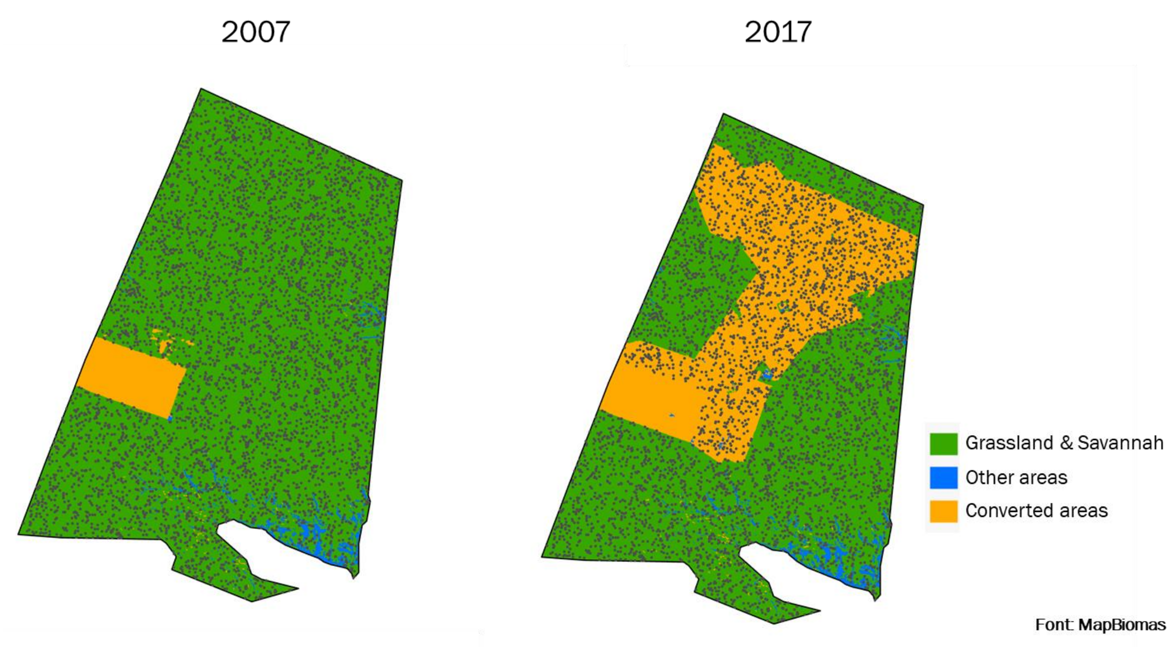
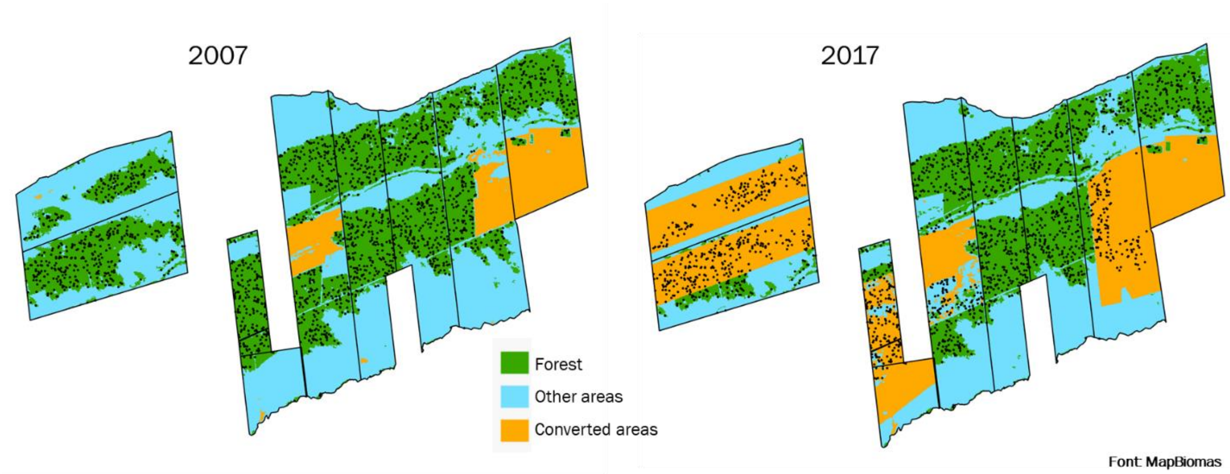


Figure 52: Sampling points and land-use classes in FP-2 reference area



3.4.6.5 Sampling Conversion

Table 19 presents the final sample stratified into Native Cerrado and 'farming classes', in each year of historic period, for reference area. In 2017, the Farming class is represented by class 39 and 41. In the other years, Farming class is composed by classes 15, 39 and 41.

Table 19: Sample final stratified by land-use, in all the year of historic period

	GP-2		FP-2	
Year	Grassland & Savannah	Farming	Forest	Farming
2007	4752	0	1322	0
2008	4737	15	1313	9
2009	4721	31	1313	9
2010	4691	61	1312	10
2011	4394	358	1278	44
2012	3807	945	1250	72
2013	3516	1236	1250	72
2014	3465	1287	1250	72
2015	3344	1308	1250	72
2016	3428	1324	1250	72
2017	3428	1324	1250	72

3.4.6.6 Discarded Sample Points

They were discarded 248 points of the initial points, in the GP-2, and 678 points in the FP-2 sampling.

3.4.6.7 Parameterizing α and β(Logistic function fit)

The logistic function defined by equation [A.4] is fit using the sample data depicting patterns of conversion in the reference area as well as conversion data for the historic reference period. Based on the reference area, a master table was created as discussed in section 4.1.3.2, and it was used for parameterization of α and β. No external covariates were employed in the development of the conversion model because there is only one agent of conversion, the landholder. The decision to convert native Cerrado areas into agricultural land is a direct consequence of the owner's will, based on an attempt to make a profit, rather than keeping the land unproductive, without financial return.

The results of a logistic function fitting are summarized in Table 20 below.

Table 20: Results of logistic equation fitting

	GP-2		FP-2	
Parameter	Value	Standard Error	Value	Standard Error
α	-0.4135	0.01968	-2.471	0.06888
β	0.0009201	0.00001364	0.0005802	0.00004444

Equation A.4 in the methodology states that '**n**' is the linear predictor of conversion given time. Parameter 'q' is not required for baseline type GP-2. Regarding FP-2, the 'q' wasn't applied as well since degradation has not been considered in the baseline scenario and there is no selective logging prior to conversion. Agricultural cultivation is started as soon as the vegetation is cut off and the area is cleared. Therefore, conservatively, the default of zero was applied, by following the recommendation of the methodology. As such equation 5 returned the following result:

$$n = -0.4135 + 0.0009201 * t \qquad (GP\text{-}2)$$

$$n = -2{,}471 + 0.0005802 * t \qquad (FP\text{-}2)$$

Given that no covariates were employed the final model is as follows:

$$FDP = 1 / (1 + exp^{-n})$$

Figure 53: Logistic function used in projection of conversion in GP-2 reference area

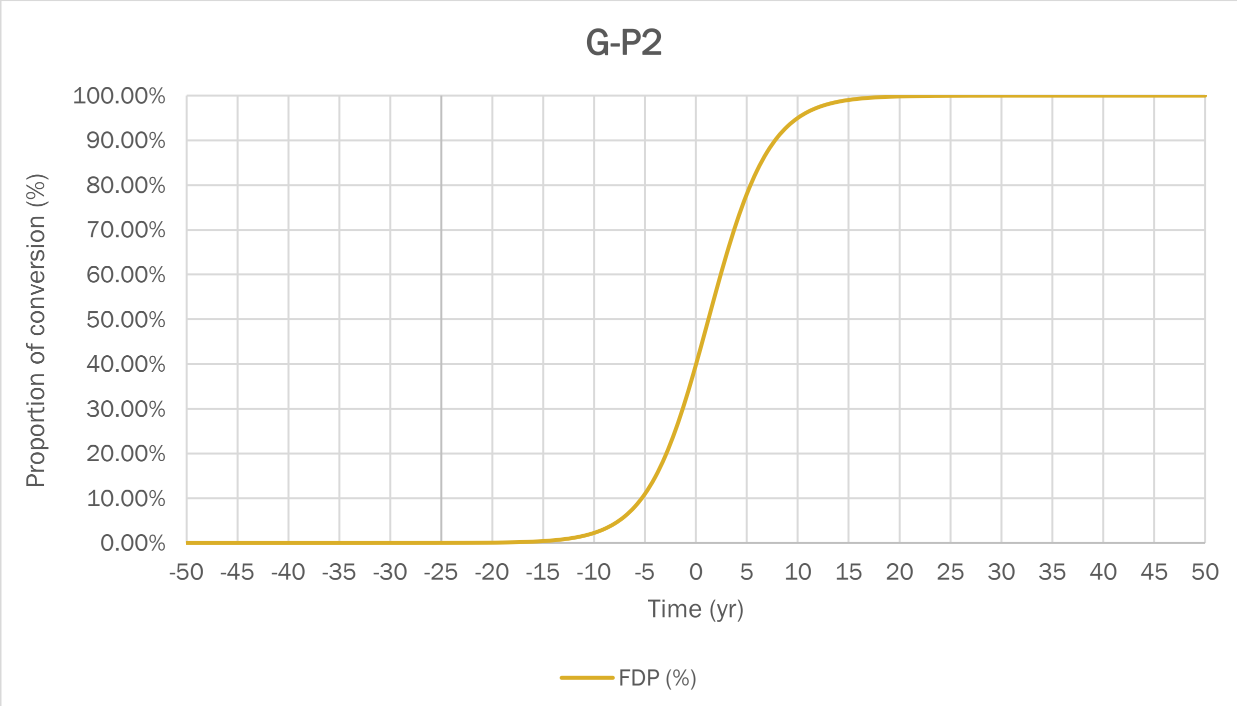
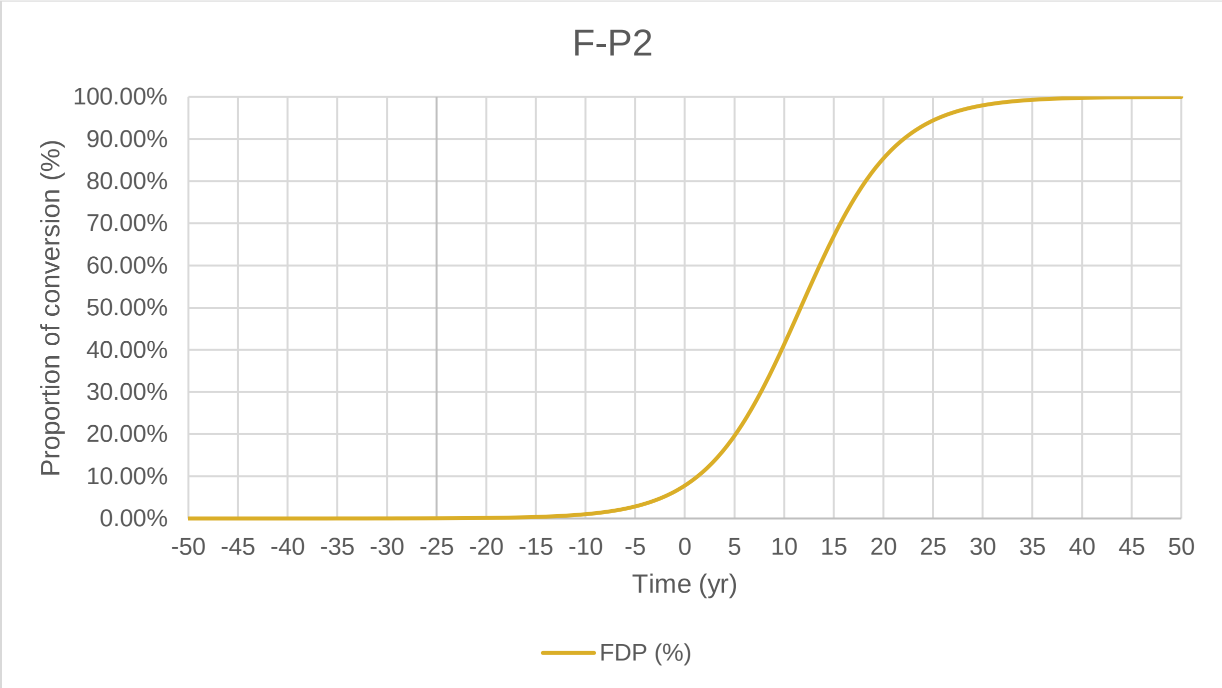


Figure 54: Logistic function used in projection of conversion in FP-2 reference area.



The PAA of GP-2, based on grassland and savannah areas, is 4,591.8 ha and by applying the fit logistic function, the converted area projected in 30 years of the beginning of the project is 99.99%. In relation to FP-2, the PAA is 6,917.4 ha and the converted area avoided in 30 years is 97.98%. The Figures below show the converted area projected over time, since the project beginning, in grassland & savannah areas and forest areas.

Figure 55: Logistic function used in projection of converted area over time in GP-2 PAA

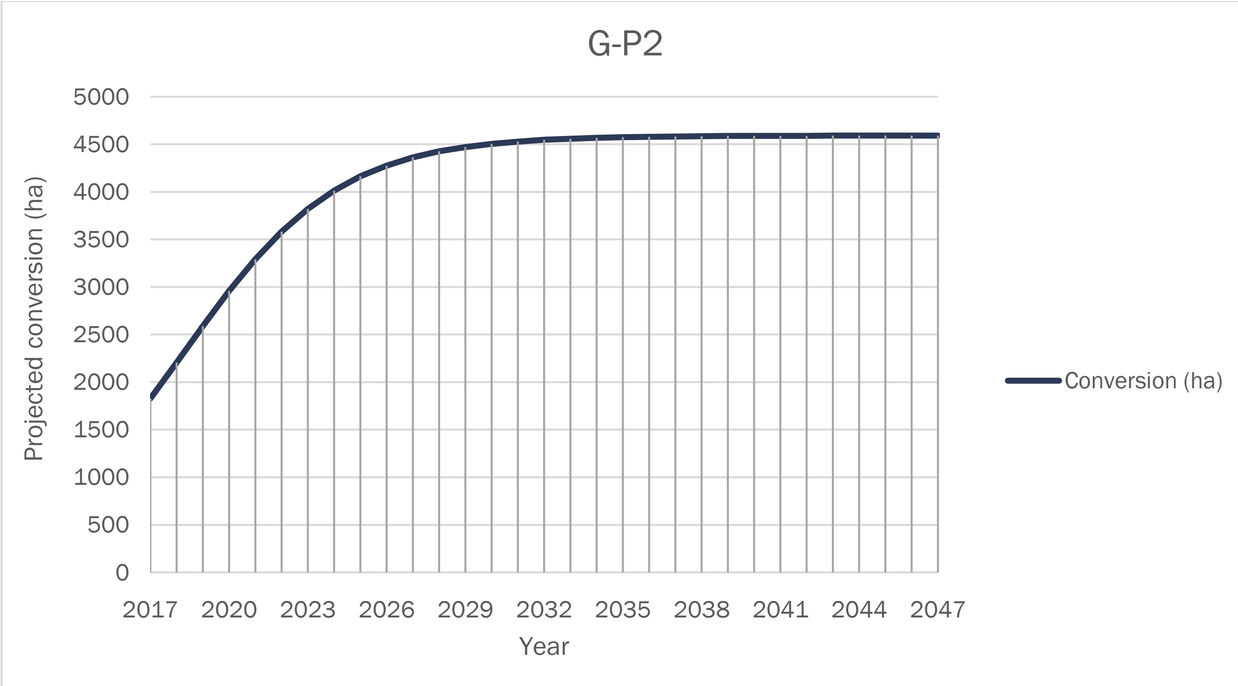
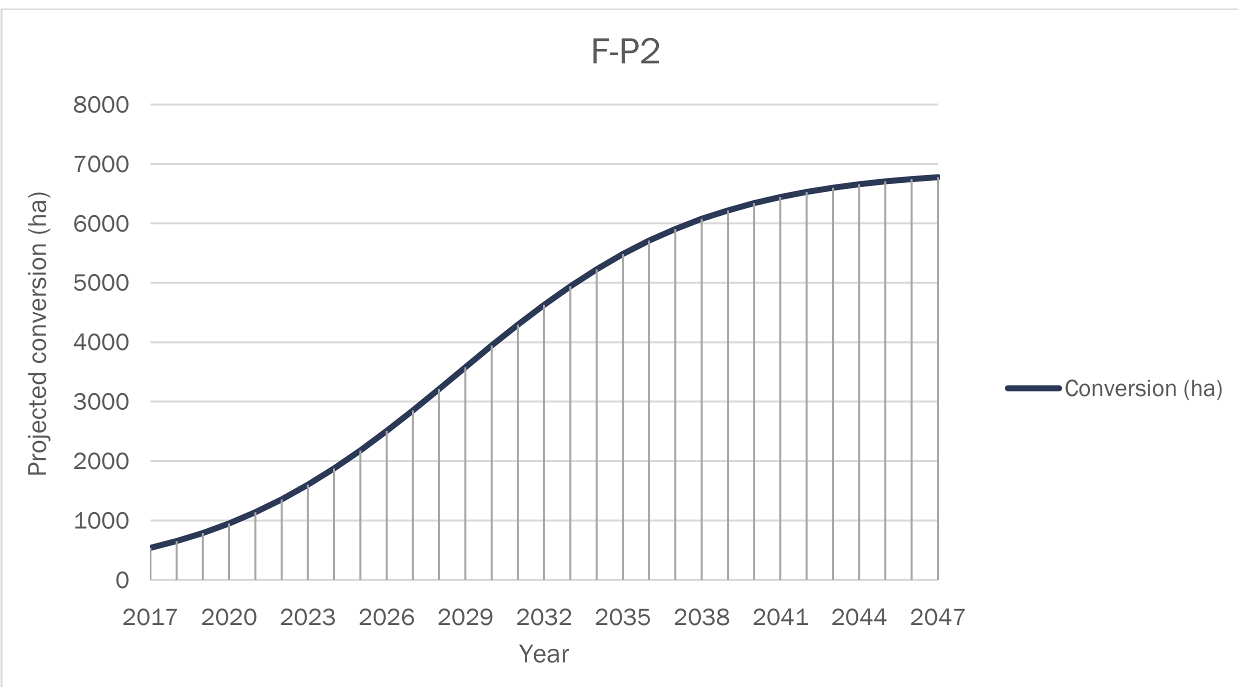


Figure 56: Logistic function used in projection of converted area over time



Classifications were produced independently for each region and year, and the resulting time-series was post-processed using filters to enhance temporal and spatial coherence. Intermediate versions were evaluated based on visual inspection to identify regions presenting spatial discontinuities with neighbouring regions, or marked omission/commission errors for a given class. Those cases were reclassified considering a modified distribution of sample size per class, which was set by an interpreter to compensate for the proportional excess/lack of area of a given class in the evaluated version. Finally, maps representing cross-cutting themes were integrated with the final version of the Cerrado biome time-series to produce MapBiomas Collection 5.0. Full protocol can be found at: https://mapbiomas-br-site.s3.amazonaws.com/Cerrado_Appendix_-_ATBD_Collection_5_v1.pdf.

Accuracy analysis was performed based on the dataset produced by LAPIG (Image Processing Laboratory and Geo) comprising about 25k reference sample-pixels for the Cerrado. One of the classes of the MapBiomas legend was assigned to each sample in each year (1985 - 2019) by an interpreter trained by experts in Cerrado vegetation (for details on the sampling design please consult the ATBD and Accuracy Methodological Report: https://mapbiomas.org/en/analise-de-acuracia?cama_set_language=en.

3.4.6.8. Minimizing Uncertainty

According to section of 6.8.9. of Methodology, Observation error must be mitigated as much as possible by developing a protocol for the interpretation of land cover state from remotely-sensed imagery. As mentioned before, the land use temporal classes were obtained from the MapBiomas platform. The methodology used is described in all its steps with full transparency. For more details, visit https://mapbiomas.org. In summary, the requirements can be met according to the following paragraphs taken from the aforementioned website:

PDR 63.

"The overall approach for the classification of the Cerrado native vegetation consisted of multiple steps: 1) defining the optimum period of the year to build annual Landsat mosaics that is most useful for our purpose; 2) defining a set of remote sensing metrics to be included as potential predictors (feature space); 3) generating reference training samples to calibrate the classification algorithm; 4) applying a post-classification treatment, which includes a series of filters (gap-fill, incidence, temporal, spatial, frequency) to generate a consistent time series and eliminate noise; and finally, 5) integrating the resulting maps with the other cross-cutting themes. Visual inspection and sample-based validation analysis of the results were then conducted to evaluate the results of the classification. Several tests were conducted to define the optimum period of images to compose the annual mosaics. Due to the effect of seasonality on the Cerrado vegetation spectral response, compositions of images from the rainy and dry seasons were evaluated. The tests included classifying images from the end of the rainy season when the Cerrado vegetation is still vigorous, and there is a higher probability of getting images with lower cloud cover when compared to the peak of the rainy season. The basic classification unit in the first four collections was a grid at the scale of 1:250.000, and the classification algorithm was run independently for each grid cell (n=172 tiles). These artificial classification units tend to produce inconsistencies in the contact lines between grids. Since Collection 5.0, a new set of classification units were adopted, based on regional variation of biophysical and land-use attributes. The Cerrado 19 ecoregions proposed by Sano et al. (2019) were further subdivided, considering Brazil major watersheds and the regional-scale spatial pattern of land-use/land-cover classes in Collection 3.1 (2017). A total of 38 final regions were defined this way to substitute the need for regular grids and to better compartmentalize the environmental heterogeneity typical of the Cerrado biome, which potentially affects the spectral signatures of NV, even within the same NV class."

PDR 64.

"MapBiomas evaluated global and per-class classification accuracy for each year between 1985 and 2019. The number of pixels in the reference database was predetermined by statistical sampling techniques. In each year, each pixel from the reference database was evaluated by technicians trained in visual interpretation of Landsat images. Each sample was inspected by three independent interpreters, in case of confusion a senior interpreter decided the final class of the pixel. This evaluation was based on the web platform Temporal Visual Inspection (TVI - tvi.lapig.iesa.ufg.br), developed by LAPIG/UFG. The TVI platform allowed the evaluation of all the classes mapped by since MapBiomas Collection 3.1 (https://mapbiomas.org/accuracy-statistics?cama_set_language=en). The interpreters had access to Landsat images, MODIS and precipitation time-series, and Google Earth. The global accuracy for each level of LCLU classes in the Collection 5 legend was calculated for each year, class, and biome (more details can be explored in the MapBiomas web platform (https://mapbiomas.org/en/accuracy-analysis)."

PDR 65.

"Classifications were produced independently for each region and year, and the resulting time-series was post-processed using filters to enhance temporal and spatial coherence. The first post-classification action involves a gap fill filter and the application of temporal filters followed by a spatial filter. All the scripts to classify and post-process the Cerrado biome are available at: https://github.com/mapbiomas-brazil/cerrado. The application of these filters removes classification noises. Intermediate versions were evaluated based on visual inspection to identify regions presenting spatial discontinuities with neighboring regions, or marked omission/commission errors for a given class. Those cases were reclassified considering a modified distribution of sample size per class, which was set by an interpreter to compensate for the proportional excess/lack of area of a given class in the evaluated version. "

3.4.6.8 Estimating Uncertainty in Parameters â and β

Uncertainty (Standard Error) is reported in Table 20. Results of applying a logistic equation to the sampling points from the statistical software R version 3.6.3

Figure 57: Default result from the statistical software R version 3.6.3, applied for GP-2 data

```
> summary(ajuste)

Call:
glm(formula = Classe ~ ., family = binomial(link = "logit"),
    data = ajuste)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.0076  -0.6577  -0.3496  -0.2517   2.6335

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -4.135e-01  1.968e-02  -21.01   <2e-16 ***
time         9.201e-04  1.364e-05   67.46   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 44359  on 52271  degrees of freedom
Residual deviance: 38509  on 52270  degrees of freedom
AIC: 38513

Number of Fisher Scoring iterations: 5
```

Figure 58: Default result from the statistical software R version 3.6.3, applied for FP-2 data

```
> summary(ajuste)

Call:
glm(formula = Classe ~ ., family = binomial(link = "logit"),
    data = ajuste)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.4029  -0.3282  -0.2404  -0.1756   2.9628

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.471e+00  6.888e-02  -35.87   <2e-16 ***
time         5.802e-04  4.444e-05   13.06   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 4372.8  on 14541  degrees of freedom
Residual deviance: 4180.2  on 14540  degrees of freedom
AIC: 4184.2

Number of Fisher Scoring iterations: 6
```

The estimated uncertainty σEM from F.13 is in Figure 57 and the statistical summaries from model fitting software is available in Figure 58.

3.4.7 Determining Parameters for the BEM

The BEM for the baseline GP-2 and FP-2 are given by [F.3] and are considered for AGOT and BGOT.

<table>
<tr><td colspan="2">

$$BEM_{P2}(c_P, c_B, t, x) = \frac{(c_P - c_B)A_{PAA} + \frac{HA_{P2}(c_P, c_B)t}{t_{PL} - t_{PAI}}}{1 + e^{-\alpha - \beta(t + \gamma + 0.5q - t_{PAI}) - \theta(x - x_{PAI})^T}} - HA_{P2}(c_P, c_B) \quad [F.3]$$

where

$$HA_{P2}(c_P, c_B) = \frac{(c_P - c_B)A_{PAA}}{1 + e^{-\alpha - \beta(\gamma + 0.5q - t_{PAI}) - \theta(x_0 - x_{PAI})^T}}$$

</td></tr>
<tr><td>Variables</td><td>$m, c_P^{[m]}, c_B^{[m]}, t_{PA}, t, \alpha, \beta, \gamma, q, \theta, x, A_{PAA}, t_{PL}, t_{PAI}$</td></tr>
<tr><td>Section References</td><td>8.1.1, 6.6</td></tr>
<tr><td>Comments</td><td>BEM for Type F-P2 and G-P2</td></tr>
</table>

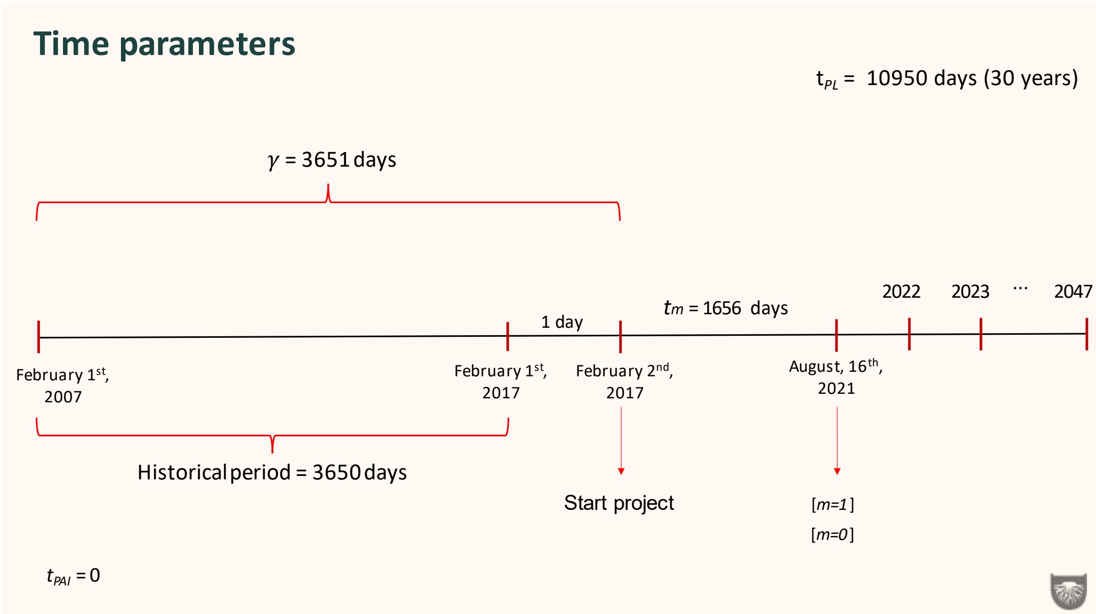
3.4.7.1 Determining t_{PAI}

This parameter is 0 for the initial project activity instance.

3.4.7.2 Determining γ

The historical reference period began on February 1st 2007 and goes until February 1st 2017. The project start date is February 2nd 2017. Therefore, the value of γ is 3651 as depicted in the Figure below.

Figure 59: Start date and time parameters for the Baseline Emissions Model



3.4.7.3 Determining q

The conservative methodological default value of zero days was selected for baseline type FP-2. For GP-2 this parameter is not required.

3.4.8 The Decay Emissions Model

The decay emissions model for carbon in the BGB pools are not considered because it is assumed that roots are removed during the conversion event to prepare the soil for agricultural activities. Research by the Cerrado Working Group outlines the process of conversion of native Cerrado to agriculture, in the report called "Geospatial Analysis of Soy Dynamics in the Cerrado Biome: 2014 to 2017"[60]:

[60] Abiove. 2018. Accessed at: https://abiove.org.br/wp-content/uploads/2019/02/12022019-125848-12.02.2019._analise_geoespacial_da_dinamica_da_soja_no_bioma_cerrado_2014_a_2017_v02.pdf

The process of converting native vegetation to agriculture goes through several stages such as the removal, tilling, raking, and burning of remnants of native vegetation (stems and roots), the correction of the soil with limestone and the cultivation of rice for one or more crops.

As such, emissions from BGB pools are assumed to occur immediately together with conversion and emissions from ABG, due to the burning of biomass, which is considered typically practice in the Cerrado.

A national default value from Brazil's 4th GHG Inventory was applied to calculate soil decay emissions as described below.

3.4.8.1 Determining λ_{SOC}

Carbon not decayed in SOC is estimated using a default value from the Fourth Brazilian National GHG Inventory for Cerrado (λ_{SOC} = 0.84) as per section 6.19.2 of the VM0009 methodology.[61]

3.4.9 The Soil Emissions Model

The soil emissions model is based on a logistic model of ecosystem conversion and assumes that soil organic carbon (SOC) begins to decay in the PAA at the point which the plot is clear to a converted state.

3.5 Additionality

The project applies the VCS Tool for Demonstration of Additionality in VCS AFOLU Project Activities (VT0001) version 3.0 to assess the additionality of the project and select the most likely baseline scenario. Project additionality and baseline scenario area assessed for the first project activity instance to conclude that all additional PAIs that fulfill all Eligibility Criteria are also additional. The initial monitoring report will demonstrate that the initial PAI fulfills the additionality criteria.

Step 1: Identification of alternative land use scenarios to the proposed VCS AFOLU project activity

Sub-step 1a(a): Identify credible alternative land use scenarios to the proposed VCS AFOLU project activity

1. Conservation of surplus native Cerrado without being registered as a VCS AFOLU project.
2. Conservation of surplus native Cerrado through the Legal Reserve Compensation (in Portuguese, "CRA") market.
3. Conversion to agricultural use to produce agricultural commodities.

Sub-step 1a(b): Credibility of identified land use scenarios

Scenario 1 is credible, albeit highly unlikely, as landholders try to maximize their financial returns per hectare of land by pursuing economic activities, typically agriculture in the Cerrado biome. There is a lack

[61] Fourth Brazilian National Inventory. *IV Inventário - LULUCF (Uso da Terra, Mudança do Uso da Terra e Florestas, updated 24/05/2021)*, see page 176. Accessed at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/relatorios-de-referencia-setorial.

of conservation funding in the area, and commercial agriculture is exceedingly more profitable than philanthropic conservation.

Scenario 2 is also credible, albeit highly unlikely to occur, as the CRA market in Brazil is still very undeveloped and incipient. The economic returns from CRA transactions are negotiated between buyers and sellers and prices vary from BRL$ 50-150/ha/yr.

Scenario 3 is credible and highly likely to occur, as well as applicable to all PAIs that fulfill the Eligibility Criteria as all PAIs will be required to demonstrate that the area was designated for commercial activity according to the Brazilian Forest Code law, which permits the conversion of surplus native vegetation above the minimum legal requirements of the code.

<u>Sub-step 1a(c): List of credible alternative land use scenarios</u>

- Conservation of surplus native *Cerrado* without being registered as a VCS AFOLU project.
- Conservation of surplus native *Cerrado* through the CRA market compensation.
- Landholders carry out conversion for commercial agriculture.

<u>Sub-step 1b(a): Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations</u>

- **Conservation of surplus native *Cerrado* without being registered as a VCS AFOLU project.**

Scenario 1 is consistent and aligned with all laws, statutes, regulatory frameworks or policies, especially as it represents a typical state of many lands in the agricultural belt of Brazil (MATOPIBA + surrounding states) prior to the conversion to agricultural land-use, where surplus vegetation is being conserved above the minimum legal requirements of the Brazilian Forest Code. As previously stated, this scenario is highly unlikely due to the lack of financial incentives to keep standing forests and/or native vegetation in the country.

- **Conversation of surplus native *Cerrado* through the CRA market compensation.**

Scenario 2 is consistent and aligned with the Brazilian Forest Code, as it is a mechanism created by article 44 of this law. It is not a mandatory legal requirement for landholders with surplus vegetation and still requires some robust regulatory frameworks to be fully implemented and developed in Brazil.

- **Landholders carry out conversion for commercial agriculture.**

Scenario 3 is consistent, plausible, and aligned with laws, statutes, regulatory frameworks or policies, since the Brazilian Forest Code permits the conversion of surplus native vegetation above the minimum legal requirements of the code, which is 35% of native *Cerrado* vegetation inside the Legal Amazon and 20% outside of the cited administrative zone.

To demonstrate that PAIs fulfil the Eligibility Criteria (Section 1.4.1), it will be necessary to demonstrate that the primary agent is able to legally implement an agricultural activity. Thus, by fulfilling the Eligibility Criteria, the baseline land use scenario will be credible.

<u>Sub-step 1b(b): Outcome of Sub-step 1b(a)</u>

List of consistent and plausible alternative land use scenarios to the VCS AFOLU activity that are in compliance with mandatory legislation and regulations taking into account their enforcement:

- Conservation of surplus native Cerrado without being registered as a VCS AFOLU project.
- Conservation of surplus native Cerrado through the CRA market compensation.
- Landholders carrying out conversion for commercial agriculture.

Sub-step 1c: Selection of baseline scenario

The most plausible baseline scenario is characterized by the most financially economic land-use alternative. The Table below compares the financial returns of the three alternative baseline scenarios:

Table 21: Comparison of the Financial Returns of the 3 Baseline Scenarios

Activity	Average Return per hectare per year	Justification
Scenario 1: Conservation of Cerrado without VCS	BRL$0/ha/yr	There are no economic incentives for the conservation of native Cerrado in Goais.
Scenario 2: Conservation with CRA	BRL$450/ha/yr	Based on data from the BV Rio platform regarding the average price of Legal Reserve (CRA) quotas for the State of Goais.[62]
Scenario 3: Commercial Agriculture	BRL$ 138-2,800/ha/yr	See page 8 of The Nature Conservancy's report called "Incentives for Sustainable Soy in the Cerrado".[63]

As such, the most plausible baseline scenario is **Scenario 3** above, namely the private landholders carry out conversion for commercial agriculture, which represents the most likely and credible scenario to occur on the absence of the VCS AFOLU activity due to the fact that the returns per hectare per year is by far the most lucrative for the landholder.

All PAAs that fulfill the Eligibility Criteria will have the selected baseline scenario of commercial agriculture.

The baseline scenario is F-P2 or G-P2, characterized by the legal conversion of native Cerrado for commercial agricultural use by the known primary agent, the private landholder.

The project developer elected to apply an investment analysis to demonstrate that the project is not the most economical option as identified in Step 2.

[62]Accessed at: https://www.bvrio.org/florestal/cra/plataforma/prepara.do

[63] Accessed at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_IncentivesforSustainableSoyinCerrado_Nov2019.pdf

Step 2: Investment Analysis

The VCS Additionality Tool requires that either Step 2 (investment analysis) or step 3 (barrier analysis) be undertaken (or both). The project activity, without the revenue from the sale of GHG credits, is financially less attractive than the baseline scenario, therefore it is not necessary to do a barrier analysis.

Simple Cost Analysis

As per the guidelines of the VCS AFOLU Additionality Tool, the Table below documents an exemplification of the yearly costs associated with the grouped project, using 2021 as a reference year. These and other associated costs can also be found in the Financial Model in Appendix A, "Risk Tool". As previously demonstrated, the activity produces no financial benefits other than VCS related income.

Figure 60: 2021 Project Costs

2021 Project Costs	BRL (Reais)	
Project Activities	BRL	4,718,129
Project Variable Costs	BRL	168,571
Project Infrastructure	BRL	1,492,564
Project Development	BRL	689,179
Certification	BRL	228,700
Total	**BRL**	**7,297,143**

A simple cost analysis is justified when comparing the average yearly costs of the project and also the returns per hectare from the baseline scenario to the project activity. The project activity generates carbon credit revenues for the 30-year project lifetime. The average annual carbon payment per hectare is less than the alternative land-use scenario of crop production.

Figure 61: Actual & Projected Costs (1st Baseline Period)

Costs (1st Baseline Period)	BRL (Reais)	
2017	BRL	2,840,074
2018	BRL	2,488,755
2019	BRL	4,837,702
2020	BRL	6,258,090
2021	BRL	7,297,143
2022	BRL	7,620,937
2023	BRL	4,819,096
2024	BRL	4,824,941
2025	BRL	4,830,439
2026	BRL	4,835,609
2027	BRL	4,843,337

The Figure below shows the price spread by land use in three different regions of the Cerrado biome: Southern Cerrado, Mato Grosso, and MATOBIPA. In all areas, land under native vegetation is cheaper to acquire, which in some cases offsets the conversion costs and yield-time curve advantages of conversion. The price gap between different land uses also generates short-term business opportunities, where the goal is not to produce crops, but rather to achieve capital gain by acquiring cheap land, developing it, and then selling it as already-cleared agricultral land[64].

Figure 62: Land Prices in the Cerrado, by Land Use and Region (in BRL/ha)

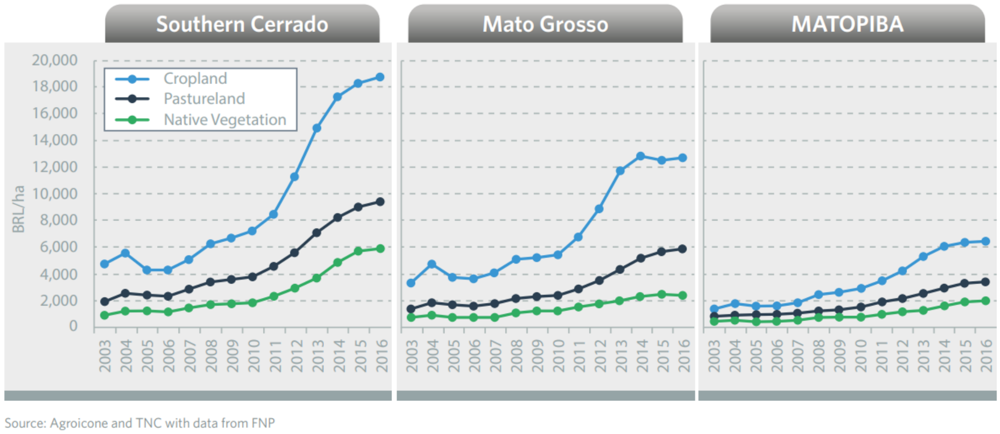
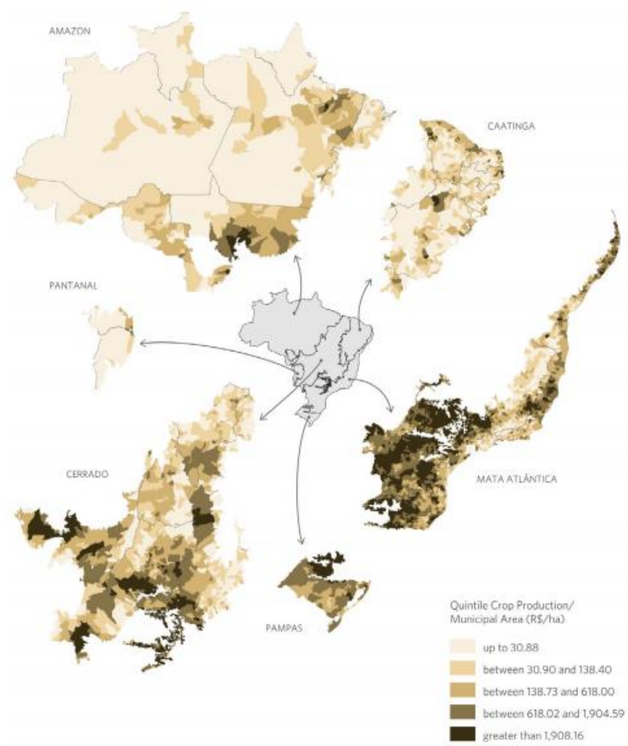


Figure 63: Crop returns per municipality and per biome



Source: *Climate Policy Initiative with data from IBGE*

According to the additionality tool applied, it is concluded that the proposed VCS AFOLU project produces no financial benefits other than VCS related income, therefore proceed to Step 4, below.

Step 4: Common practice analysis

Conservation of privately owned native vegetation in the Cerrado biome is not common practice unless required by law. As such, conservation efforts are generally limited to the legal reserve and designated areas of permanent protection (APP). The legal reserve is a requirement of the Brazilian Forest Code for landholders to maintain 20% of privately owned property as native vegetation, or 35% if the project area with Cerrado vegetation is within the limits of the Legal Amazon. Landowners typically convert the surplus vegetation to the cited legal reserve on the property in the baseline scenario to pursue agricultural activities that generate a return.

Evidence suggests that private properties with the following characteristics will eventually convert down to the legal reserve:

a) Located within the Cerrado biome.

b) Has suitable topography for crop production, defined by less than 25% declivity.

c) Has road/market access.

Conservation efforts within the Cerrado biome include a series of national, state, and local conservation areas (parks), and indigenous reserves. However, to our knowledge, there is not a widespread common practice of privately funded projects on private lands with the aim of stopping conversion without the aid of carbon finance. This grouped project is the first APC carbon project for the Cerrado biome.

With this said, in addition to REDD projects, one could observe the following other forms of conservation of private areas that are promoted in the country:

- “**Payment for Environmental Services” funding (in Portuguese, “PSA”):** Although the State of Goiás has its own law for PSA, there are few actual executable programs being developed by the state government, specially within the necessary large scale that is required and with significant funding available. For example, the farmers from the “Descoberto” drainage basin can voluntarily enrol in a governmental program called “Produtores de Água”, where they can receive payments for the adequate maintenance and protection of riparian forests. As with other programs, it is limited to local initiatives and financial resources are not substantial.

- Private Reserve of **Natural Heritage (in Portuguese, “RPPN”):** it is a category for privately-owned conservation areas. When the area is categorized as such, the owner is committed to ecological preservation, without common rural commercial activities. In Goiás State, there are about 80 registered RPPNs. These usually are no larger than 500 hectares, considering the costs of maintaining standing forests with no associated revenue. The total area of RPPN’s in the Cerrado biome is 169,000 hectares, which represents only 0.8% of the Cerrado biome[65].

[64] Accessed at: https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_IncentivesforSustainableSoyinCerrado_Nov2019.pdf

[65] Accessed at: https://reservasprivadasdocerrado.com.br/cerrado/

Although some public conservation areas and indigenous reserves have had some successes at maintaining native vegetation cover, the essential distinction between these lands and the project area is the project area is privately owned and does not have access to government resources to incentivize non-extractive land uses. As demonstrated above, private conservation projects in the Cerrado are rare, which confirms that the proposed project is additional.

3.6 Methodology Deviations

There are no methodological deviations at this time.

4 ESTIMATED GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

4.1.1 Baseline Emissions from Selected Pools

Cumulative baseline emissions were estimated using the Biomass Emissions Model (BEM) and Soil Emissions Model (SEM) of the VM0009 Methodology.

The assumptions applied in the calculations were based on the VM0009 methodology, in terms of equations, parameters and application of default values, as well as in the selected pools. The description of the equations applied in the calculation of the baseline, for each baseline type, is in the section 6 of the methodology, while the quantification of GHG emissions reductions is described in the section 8. The parameters applied refer to the first monitoring [m=1], since project validation and the first verification were developed together. Therefore, baseline and NER's were calculated from the monitored values. The default values assumed in this project refer to root-to-shoot, to estimate BGB, and SOC decay rate. Both were adopted from Brazil's 4th GHG Inventory to UNFCCC. The monitoring plan is detailed in section 5.3.

Carbon Pools				
POOL	**GP2**	**FP2**		
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)
AGB	26.84	60.46	132.04	195.87
r_{RS}	2.04	0.22	0.20	0.37
BGB	54.75	13.30	26.41	72.47
SOC	272.93	291.60	349.40	435.70

Baseline Emissions					
Monitoring period	GP2	FP2			Total
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	20,725	24,157	20,848	16,767	82,497
1/1/2018 to 12/31/2018	21,977	28,589	24,392	19,533	94,491
1/1/2019 to 12/31/2019	20,695	29,134	24,857	19,906	94,592
1/1/2020 to 12/31/2020	19,711	29,104	24,831	19,886	93,532
1/1/2021 to 08/16/2021	10,279	15,115	13,656	11,164	50,213

4.1.1.1 Calculating Baseline Emissions from Biomass

Cumulative baseline emissions from biomass for GP-2 and FP-2 project types are estimated using equation F.20 of the VM0009 methodology:

$$E_{B\,BM}^{[m]} = BEM_{P2}\left(c_{P\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}\right)$$	[F.20]
Variables	$c_{P\ BM}^{[m=0]}$, $c_{B\ BM}^{[m]}$, $t^{[m]}$, $x^{[m]}$
Section References	8.1.1, 8.1.1.2
Comments	cumulative baseline emissions from biomass, F-P2 and G-P2

Baseline Emissions from Biomass					
Monitoring period	GP2	FP2			Total
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	11,684	12,167	13,778	12,052	49,681
1/1/2018 to 12/31/2018	11,995	13,880	15,719	13,749	55,343
1/1/2019 to 12/31/2019	11,295	14,145	16,019	14,011	55,470
1/1/2020 to 12/31/2020	10,758	14,130	16,002	13,997	54,887
1/1/2021 to 08/16/2021	6,534	8,739	9,896	8,656	33,825

4.1.1.2 Calculating Carbon not Decayed in BGB

The project activity does not result in decay of the below-ground biomass carbon pool. Research by the Cerrado Working Group outlines the process of conversion of native Cerrado to agriculture, in the report called "Geospatial Analysis of Soy Dynamics in the Cerrado Biome: 2014 to 2017"[66]:

> *The process of converting native vegetation to agriculture goes through several stages such as the removal, tilling, raking, and burning of remnants of native vegetation (stems and roots), the correction of the soil with limestone and the cultivation of rice for one or more crops.*

As such, emissions from BGB pools are assumed to occur immediately together with conversion and emissions from ABG, due to the burning of biomass, which is considered typically practice in the Cerrado.

4.1.1.3 Calculating Baseline Emissions from SOC

Cumulative baseline emissions from SOC are estimated using equation F.25 of the VM0009 methodology:

$$E_{B\,SOC}^{[m]} = SEM_P\left(c_{P\,SOC}^{[m=0]} c_{B\,SOC}^{[m]}, t^{[m]}, x^{[m]}\right) \quad [F.25]$$	
Variables	$c_{P\,SOC}^{[m=0]}$, $t^{[m]}$, $c_{B\,SOC}^{[m]}$, $t^{[m]}$, $x^{[m]}$
Section References	8.1.2.1
Comments	cumulative baseline emissions from SOC, Types F-P1.a, F-P2, and G-P2

To calculate ex-ante soil carbon emissions, average soil carbon stock values were taken from the Brazilian Forest Service.[67]

Baseline Emissions from SOC					
Monitoring period	**GP2**	**FP2**			**Total**
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	30,058	39,860	23,503	15,676	109,097
1/1/2018 to 12/31/2018	30,859	45,473	26,813	17,883	121,028
1/1/2019 to 12/31/2019	29,059	46,340	27,324	18,224	120,948
1/1/2020 to 12/31/2020	27,677	46,293	27,296	18,206	119,471
1/1/2021 to 08/16/2021	16,811	28,629	16,881	11,259	73,579

[66] Abiove. 2018. Accessed at: https://abiove.org.br/wp-content/uploads/2019/02/12022019-125848-12.02.2019._analise_geoespacial_da_dinamica_da_soja_no_bioma_cerrado_2014_a_2017_v02.pdf

[67] Brazilian Forest Service. Accessed at: https://snif.florestal.gov.br/pt-br/estoques-das-florestas/627-metadados

4.1.1.4 Calculating Carbon not Decayed in SOC

Carbon not decayed in SOC is estimated using a default value from the Fourth Brazilian National GHG Inventory for Cerrado (λ_{SOC} = 0.84) as per section 6.19.2 of the VM0009 methodology.[68]

Baseline Emissions from SOC not decayed					
Monitoring period	GP2	FP2			Total
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	21,016	27,870	16,433	10,961	76,280
1/1/2018 to 12/31/2018	20,877	30,764	18,140	12,099	81,880
1/1/2019 to 12/31/2019	19,659	31,351	18,486	12,329	81,825
1/1/2020 to 12/31/2020	18,724	31,319	18,467	12,317	80,826
1/1/2021 to 08/16/2021	13,067	22,252	13,121	8,751	57,191

4.1.1.5 Calculating Cumulative Baseline Emissions

Cumulative total baseline emissions are estimated using equation F16 of the methodology. This equation provides an estimate of baseline emissions for each monitoring period by subtracting carbon stored in the BGB pools from the biomass emissions estimate provided by the BEM. The DW and WP pools were not included, therefor the corresponding values in [F.16] are zero. Only baseline emission from biomass and soils were selected.

$$E_{B}^{[m]} = E_{B\,BM}^{[m]} + E_{B\,SOC}^{[m]} - C_{B\,SOC}^{[m]} - C_{B\,BGB}^{[m]} - C_{B\,DW}^{[m]} - C_{B\,WP}^{[m]}$$	[F.16]
Variables	$E_{B\,BM}^{[m]}$, $\mathrm{E}_{\mathrm{B\,SOC}}^{[m]}$, $\mathrm{C}_{\mathrm{B\,SOC}}^{[m]}$, $C_{B\,BGB}^{[m]}$, $C_{B\,DW}^{[m]}$, $C_{B\,WP}^{[m]}$
Section References	8.1
Comments	cumulative baseline emissions

[68] Fourth Brazilian National Inventory. *IV Inventário - LULUCF (Uso da Terra, Mudança do Uso da Terra e Florestas, updated 24/05/2021)*, see page 176. Accessed at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/relatorios-de-referencia-setorial.

Baseline Emissions Cumulative					
Period	GP2	FP2			Total
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	20,725	24,157	20,848	16,767	82,497
2/2/2017 to 12/31/2018	42,702	52,746	45,240	36,301	176,988
2/2/2017 to 12/31/2019	63,397	81,880	70,097	56,207	271,581
2/2/2017 to 12/31/2020	83,108	110,985	94,928	76,092	365,112
2/2/2017 to 08/16/2021	93,386	126,100	108,584	87,256	415,325

4.2 Project Emissions

The VM0009 Methodology calculates project emissions from biomass from fire, burning, logging, or other disturbances. These emissions are calculated using equation [F.41} of the methodology.

$$E_{P\Delta}^{[m]} = E_{P\Delta BRN}^{[m]} + E_{P\Delta LS}^{[m]} + E_{P\Delta SF}^{[m]} + A_{PAA}\left(c_P^{[m-1]} - c_P^{[m]}\right) - C_{P\Delta WP}^{[m]}$$	[F.41]
Variables	A_{PAA}, $E_{P\,\Delta BRN}^{[m]}$, $E_{P\,\Delta\,LS}^{[m]}$, $E_{P\,\Delta\,SF}^{[m]}$, $C_{P\,\Delta\,WP}^{[m]}$, $c_P^{[m-1]}$, $c_P^{[m]}$
Section References	8.2
Comments	project emissions

Project Emissions					
Monitoring period	GP2	FP2			Total
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	756	0	0	0	756
1/1/2018 to 12/31/2018	8,179	7,819	0	0	15,998
1/1/2019 to 12/31/2019	19,407	0	62	1,786	21,255
1/1/2020 to 12/31/2020	196	0	0	0	196
1/1/2021 to 08/16/2021	0	0	0	0	0

4.2.1 Calculating Emissions from Changes in Project Stocks

Changes in project stocks are observed through monitoring of carbon stocks within each PAI during each monitoring period. Additional monitoring will include routine field patrols that will be supplemented with an analysis of remote sensing imagery to identify the full extent of disturbances.

The changes in carbon stocks are calculated as the difference between project stocks between the current and prior monitoring period. Loss from burning and leakage are accounted for separately as described below.

4.2.2 Calculating Emissions from Burning

No planned project activity will require burning of biomass and it is not included in carbon accounting. However, if any future activities lead to the burning of biomass they will be calculated using equation [F.42]:

$E_{P\,\Delta\,BRN}^{[m]} = \left(\frac{44}{12}\right) 0.66 \sum_{b \in W^{[m]}} r_{CF\,b}\, B_{b^{[m]}}$	[F.42]
Variables	$r_{CF\,b}$, $W^{[m]}$, $B_b^{[m]}$
Section References	8.2.2

Emissions from fire, a common natural disturbance in the Cerrado biome, are not considered because:

a) The Cerrado biome is adapted to fire and therefore has strong natural regeneration processes. Research from the University of Brasilia shows that carbon stocks fully regenerate around 2 years after a disturbance, see Figure below.

b) 95% of the combustion comes from grasses, leaves and dead branches, and not from the trees and shrubs, therefore carbon stocks are not significantly affected, see Figure[69] below.

[69] Source: extracted from scientific literature *Interactions between vegetation, microclimate, and fire in a Brazilian savanna: Process-based models* (Gomes et. al 2018). Available at: https://repositorio.unb.br/bitstream/10482/32603/1/2018_Let%c3%adciaGomesdaSilva.pdf

Figure 64: Regeneration Capacity post Fire Disturbance

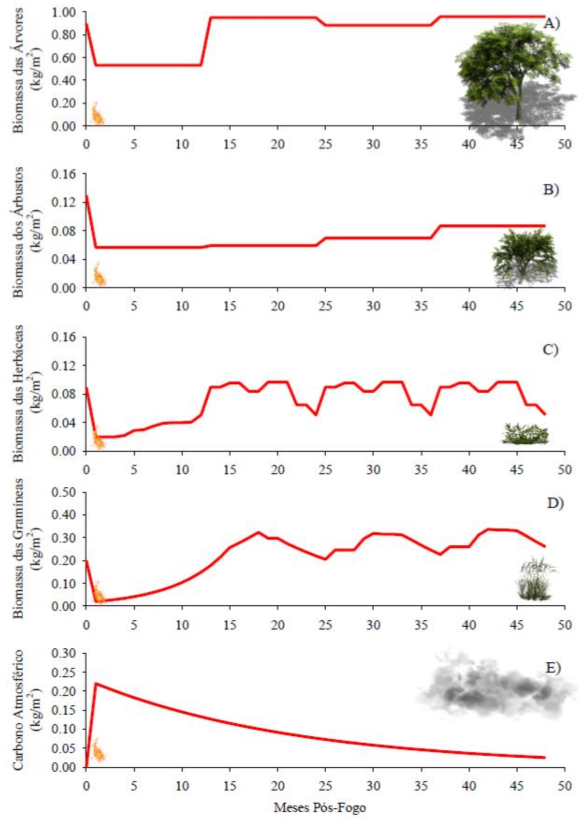


Fig. III- 6 Simulações da recuperação pós-fogo (uma queimada) da biomassa de A) árvore, B) arbustos, C) herbáceas, D) gramíneas e E) balanço de carbono atmosférico (*Uncommitted emissions*) para savanas brasileiras (cerrado típico) pelo modelo BEFIRE.

Figure 65: Fire Combustion Contribution per Vegetation Component

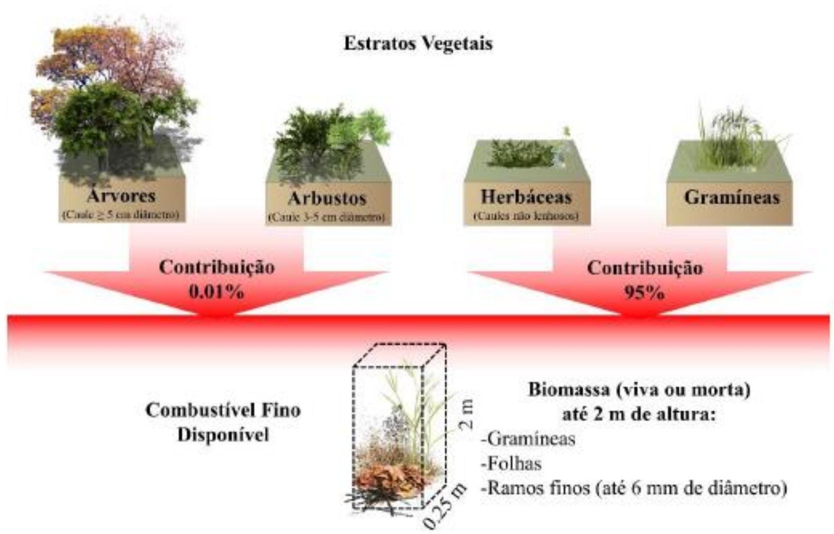


Fig. III- 2. Principais estratos vegetais e suas contribuições para a composição do combustível fino disponível para a queima em savanas brasileiras.

4.2.3 Calculating Carbon Stored in WP

No planned project activity includes timber harvesting for artisanal timber projects.

4.2.4 Calculating N2O Emissions from the Use of Synthetic Fertilizers

No planned project activity includes the use of synthetic fertilizers.

4.2.5 Ex-Ante Estimate of Project Emissions

No planned project activities will lead to project emissions, such as management plans, the use of equipment, or clearing of native vegetation for implementation of roads or other infrastructure. All participating landholders in the Program are under contract to not convert any project accounting areas; however, for conservativeness, the project proponent assumed some conversion may take place. As such, the project proponent, based on experience, applied a factor of 3% of baseline emissions to be calculate project emissions. Thus, ex-ante project emissions are estimated to be 15,862 tCO2e.

4.3 Leakage

4.3.1 Activity-Shifting Leakage

The VM0009 Methodology requires that activity-shifting leakage emissions be monitored within an activity-shifting leakage area where there are areas outside the project accounting areas subject to conversion and/or degradation by the same agents of conversion. Activity-shifting leakage emissions are estimated by monitoring changes in carbon stocks within the defined leakage area. The primary agent of conversion in the project accounting area in the baseline scenario is the private landholder. In some cases, the landholder owns multiple private properties. As such, the leakage area is defined as the surplus native vegetation with agricultural aptitude in another private property owned by the same landholder. If multiple properties exist, the closest property will be selected as the leakage area due to the similarity with the PAI in relation to environmental and economic conditions.

The selection of the Activity-Shifting Leakage areas followed the requirements of Appendix D of the methodology VM0009, taking into consideration similarities to the project accounting areas in relation to social and environmental factors (municipality, road access, soil, vegetation, slope). Two leakage plots were established, one for the forest accounting areas and one for grassland accounting areas, in the Macedo property, a private property owned by CBA in the same municipality. The following maps are provided to define the leakage plots and the KMZ files can be found in Appendix F of the attached project folder. The forest leakage plot is 55.52 hectares, and the grassland leakage plot is 925.18 hectares, which is the only remnant native vegetation with agricultural aptitude on the Macedo property. The other remnant vegetation does not have agricultural aptitude, due to the slope and soil characteristics.

Figure 66: Vegetation Cover of the Forest Leakage Area

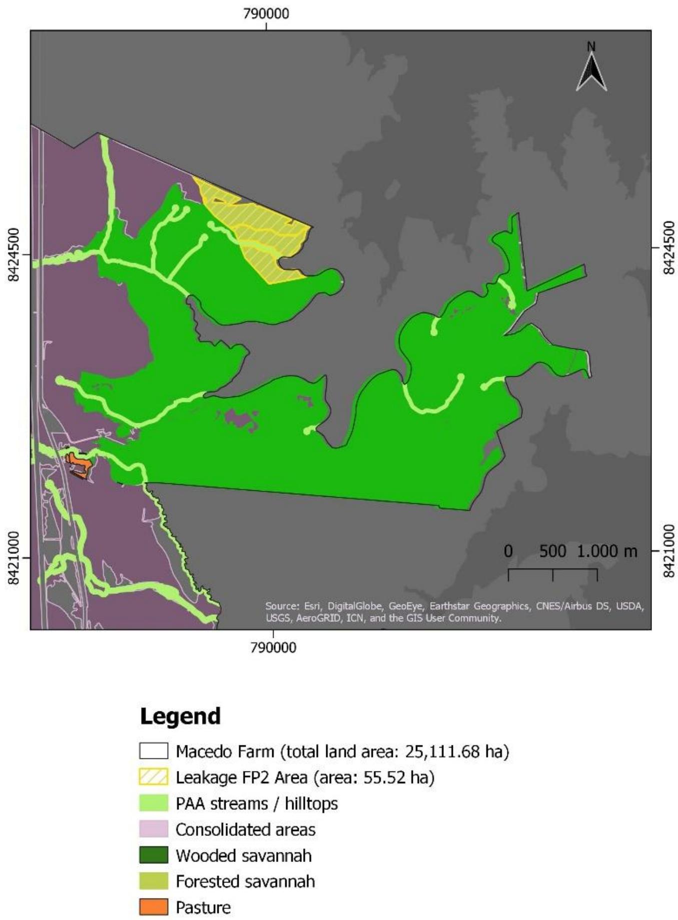


Figure 67: Vegetation Cover of Grassland Leakage Area

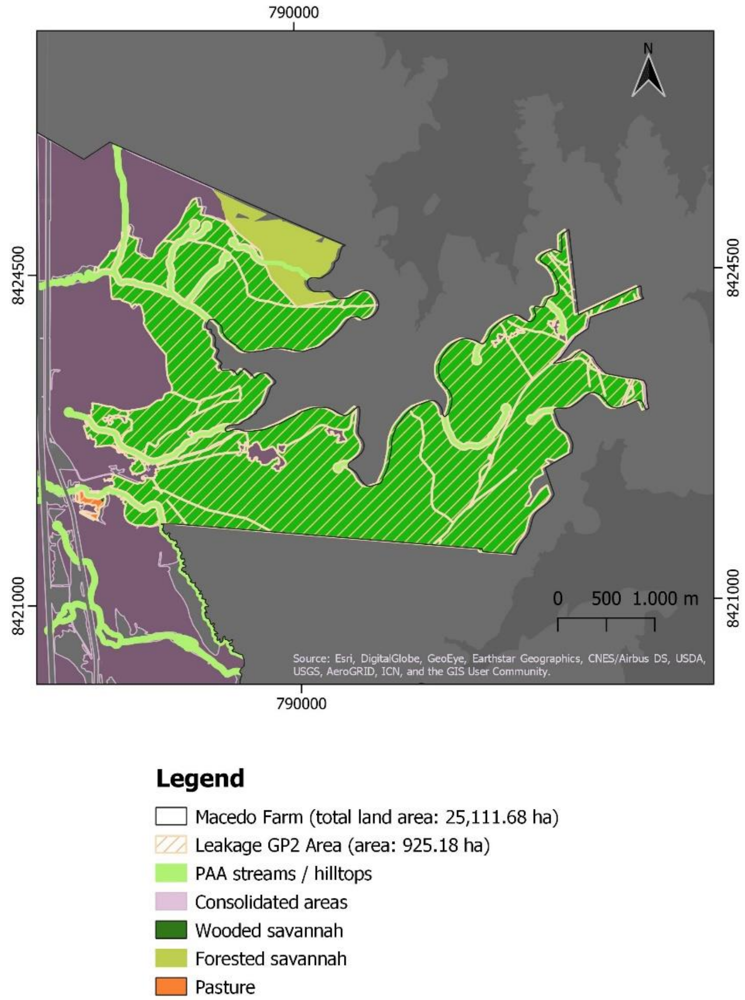


Figure 68: Slope Map of Forest Leakage Area

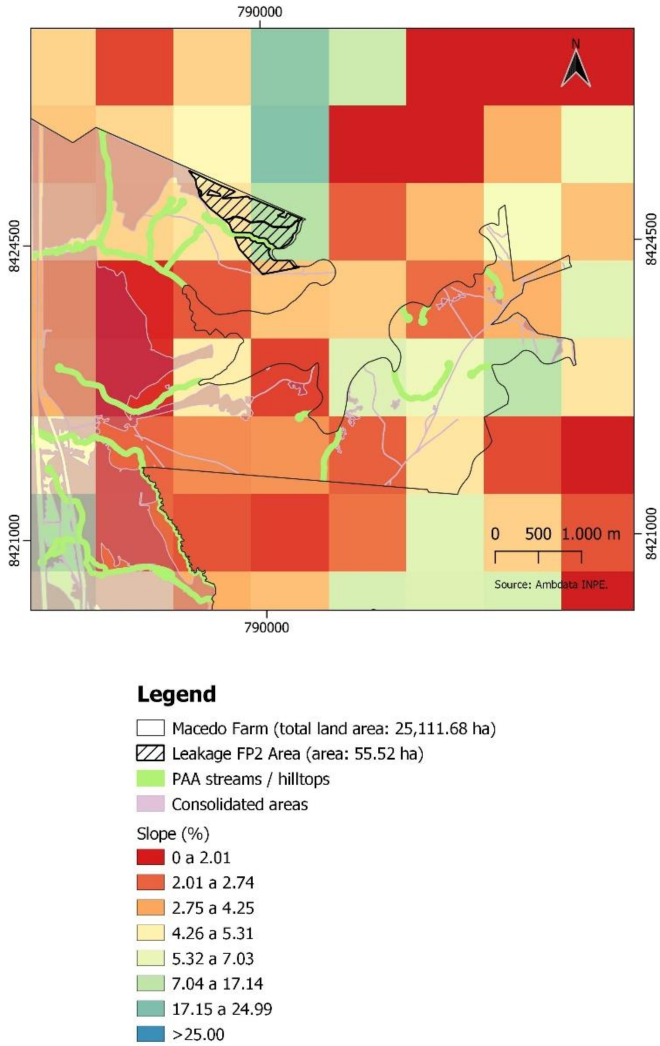


Figure 69: Slope Map for Grassland Leakage Area

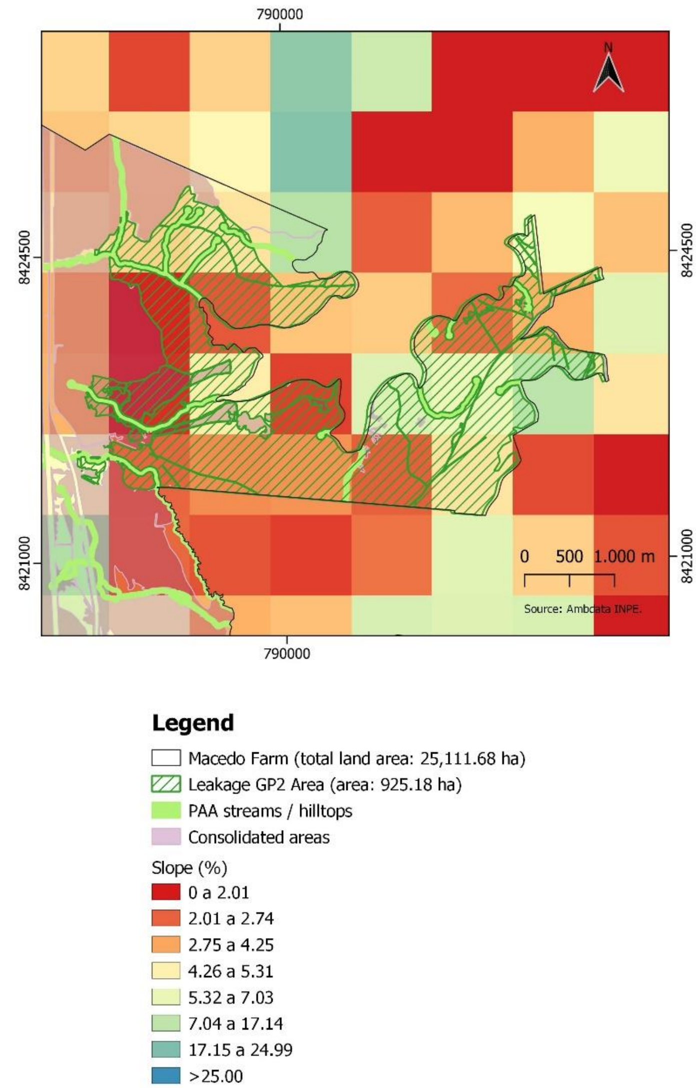


Figure 70: Soil Map for Forest Leakage Area

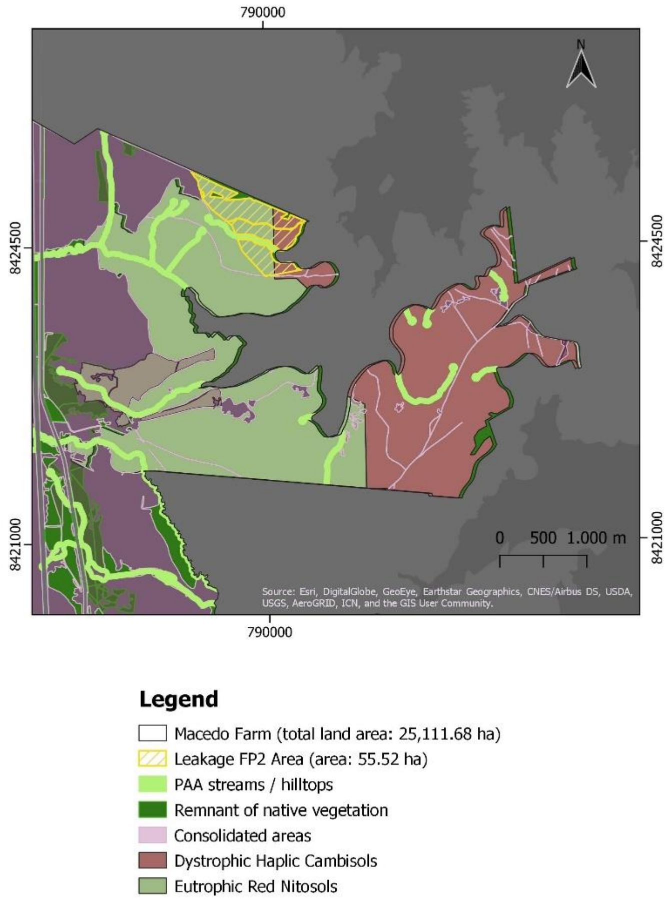


Figure 71: Soil Map for Grassland Leakage Area

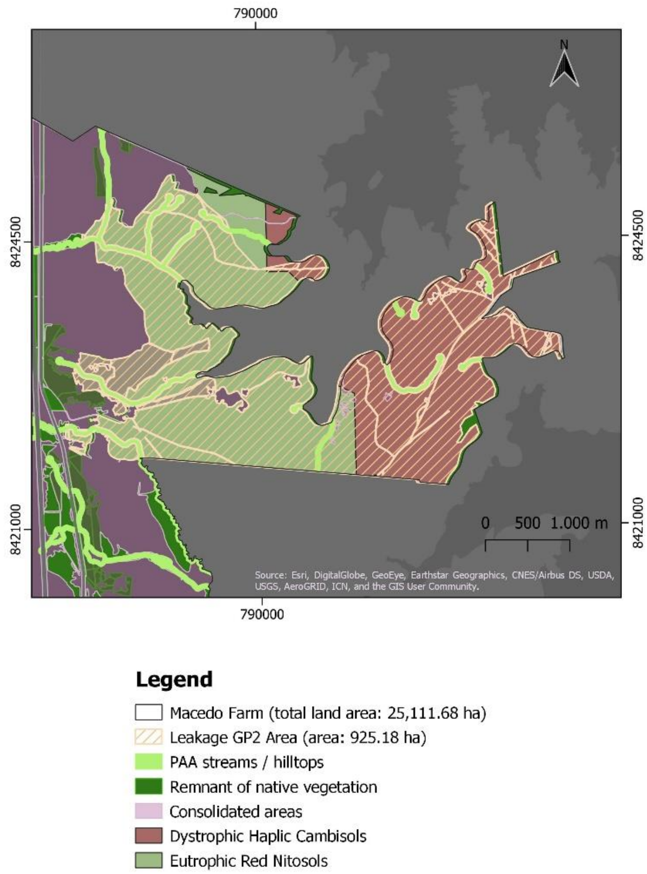
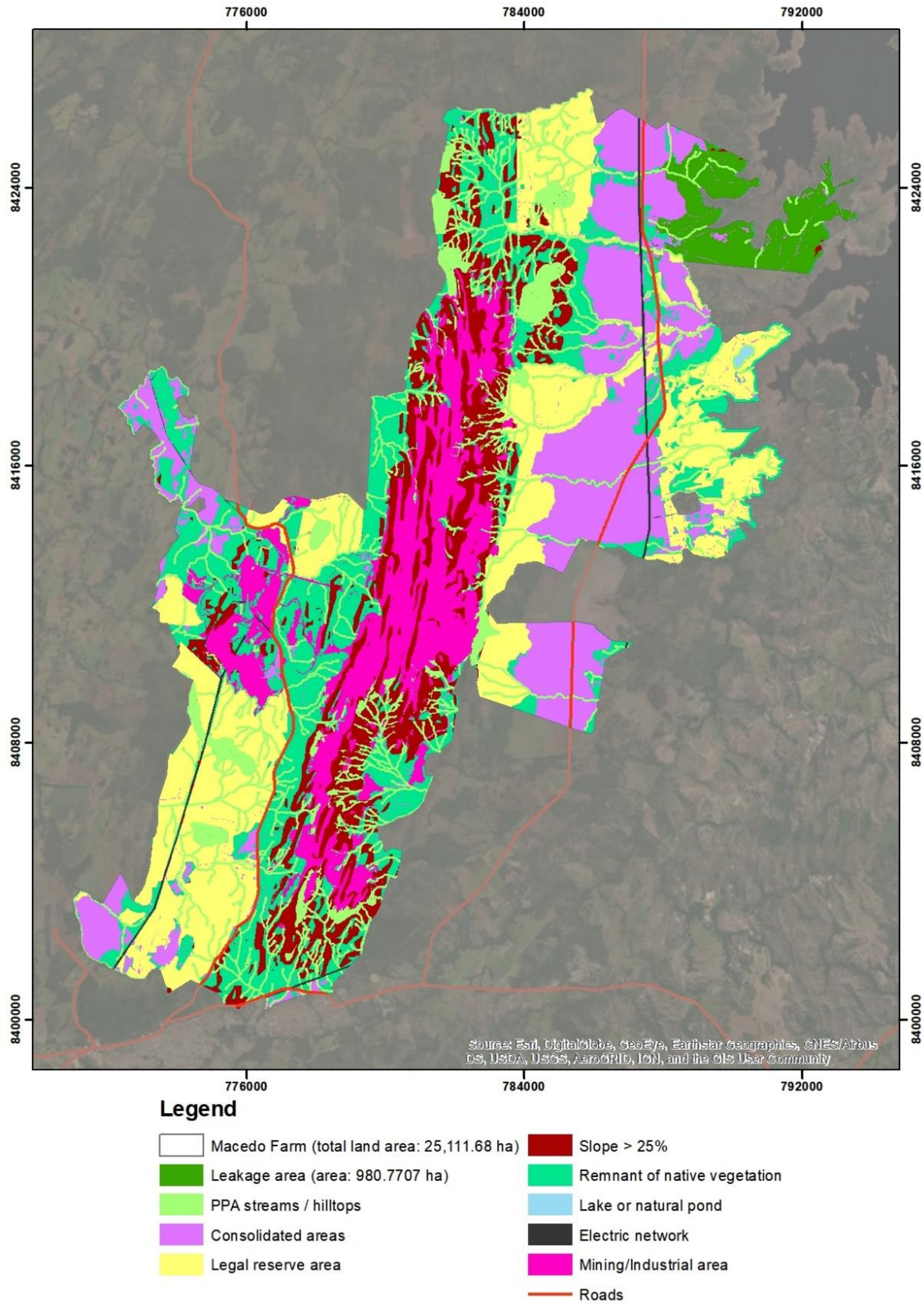


Figure 72: Land-Use & Road Access Map for the Activity-Shifting Leakage Area



Activity shifting leakage due to displacement of planned conversion was assessed using a series of equations. Equations [F.46], [F.47] [F.48] and [F.49] were applied for forest and grassland project accounting areas. Estimated emissions from activity-shifting leakage are zero, because the deforestation agent, the landholder, does not have any planned deforestation activities for the selected activity-shifting leakage area.

$E_{L\,ASF}^{[m]} = LEM\left(c_P^{[m]}, c_B^{[m]}, p_{L\,DEG}^{[m]}, t^{[m]}, x^{[m]}\right)$	[F.46]
Variables	$t^{[m]}$, $c_B^{[m]}$, $c_P^{[m]}$, $p_{L\,DEG}^{[m]}$, $x^{[m]}$
Section References	8.3.2
Comments	Cumulative emissions from activity-shifting leakage in forested areas

$E_{L\,ASG}^{[m]} = LEM\left(c_P^{[m]}, c_B^{[m]}, p_{L\,CON\,G}^{[m]}, t^{[m]}, x^{[m]}\right)$	[F.47]
Variables	$t^{[m]}$, $c_B^{[m]}$, $c_P^{[m]}$, $p_{L\,DEG}^{[m]}$, $x^{[m]}$
Section References	8.3.2
Comments	Cumulative emissions from activity-shifting leakage in grassland project accounting areas

$LEM_F(c_P, c_B, p_{L\,DEG}, t, x) = p_{L\,DEG}^{[m]} A_{AS}(c_P - c_B) - \dfrac{A_{AS}(c_P - c_B)}{1 + e^{\ln\left(\frac{1}{p_{L\,DEG}^{[m=0]}} - 1\right) - \beta t - \theta(x_0 - x)^T}}$	[F.48]
Variables	β, θ, t, x, x_0, $c_B^{[m]}$, $c_P^{[m]}$, $p_{L\,DEG}^{[m]}$, $p_{L\,DEG}^{[m=0]}$
Section References	8.3.2.2
Comments	Leakage Emissions Model for activity shifting leakage in forested project accounting areas

$LEM_G(c_P, c_B, p_{L\,DEG}, t, x) = p_{L\,CON\,G}^{[m]} A_{AS}(c_P - c_B) - \dfrac{A_{AS}(c_P - c_B)}{1 + e^{\ln\left(\frac{1}{p_{L\,CON\,G}^{[m=0]}} - 1\right) - \beta t - \theta(x_0 - x)^T}}$	[F.49]
Variables	β, θ, t, x, x_0, $c_B^{[m]}$, $c_P^{[m]}$, $p_{L\,DEG}^{[m]}$, $p_{L\,DEG}^{[m=0]}$
Section References	8.3.2.2
Comments	Leakage Emissions Model for activity shifting leakage in grassland project accounting areas

The project has been designed to mitigate the risk of activity-shifting leakage by including the following:

- Annual meetings with each landholder to discuss the project outcomes, as well as understand if the landholder has purchased any new properties. If the landholder has purchased a new area, this area will be monitored for activity-shifting leakage. Providing incentives to landholders to improve productivity (yield/hectare) through adopting best management practices and integrated crop, livestock, forestry systems, rather than clearing native vegetation to increase supply.

4.3.2 Market Leakage

According to the Decision Tree to Determine Market Leakage, Figure 12 of the VM0009 Methodology, the project applies the VCS Global Commodity Leakage Module: Production Approach, as per the following:

- Project has a planned baseline type
- Baseline operator management is constant
- Baseline type F-P2 or G-P2
- Project may change supply of agricultural commodities such as soy and livestock

Step 1: Amount of Production Subject to Leakage

1.1 Proportion of Conversion

The proportion of conversion from each driver of conversion described in the project description, must be estimated.

For all areas where conversion was avoided as reported in the project description or most recent monitoring report, consider what land uses would have occurred, and what commodities would have been produced.

- Soy (x%)
- Livestock (y%)

It is assumed that 100% of the conversion comes from relevant agricultural commodities.

1.2 Baseline Commodity Yields

The baseline commodity yields for the project area is based on an analysis of the historical commodity yields.

The baseline commodity yields are used to calculate amounts of forgone production caused by avoiding conversion.

The baseline commodity yields must be determined per-hectare for each relevant commodity included in the analysis.

The baseline commodity values must be determined by monitoring commodity yields on lands used to determine post-conversion carbon stocks, ie the proxy area.

The period used to calculate baseline commodity yields is called the "historical reference period." The historical reference period used to calculate baseline commodity yields may be different from the historical reference period used to calculate baseline emissions for the project. The most recent applicable and available data is used.

$$y_{j,t} = \frac{\sum_{h=1}^{H}(\bar{y}_{j,h})}{H} \times \left(1 + r_j\right)^t \quad (1)$$

Where:

$y_{j,t}$ = Baseline commodity yield for commodity *j* in year *t* (tonnes / ha)

$\bar{y}_{j,h}$ = Commodity yield for commodity *j*, in year *h* of the historical reference period (tonnes / ha)

H = Number of historical reference years

r_j = Growth rate of commodity yields for commodity *j* (percent), or the default value (2.5 percent)

t = Years since project crediting period start date

1.3 Foregone Production

The amount of foregone production is calculated using the area of avoided conversion achieved by the project, the baseline commodity yield and proportion of conversion for each relevant commodity as follows:

$$FP_{j,t} = d_t \times y_{j,t} \times PD_j \quad (2)$$

Where:

$FP_{j,t}$ = Foregone production for commodity *j* in year *t* (tonnes)

d_t = Area subject to production in year *t* (ha)

$y_{j,t}$ = Baseline commodity yield for commodity *j* in year *t* (tonnes / ha)

PD_j = Proportion of conversion driven by commodity *j* (percent)

The area subject to production, dt, includes the total area of conversion prevented as reported in the monitoring report.

1.4 Leakage Mitigation

Activities may be implemented as part of the broader project activities that help prevent commodity displacement in areas beyond the project area. Such activities are also referred to here as leakage mitigation activities. Leakage mitigation activities can avoid leakage by increasing production elsewhere, without associated conversion or degradation, to replace production forgone by the project. Leakage mitigation activities can reduce demand for the forgone goods and services. An example of replacing forgone supply is a program that helps farmers increase crop productivity thereby increasing the total amount of crops produced without increasing the area farmed

1.5 Amount of Production Subject to Leakage

The amount of production subject to market leakage is the amount of foregone production, minus the amount of leakage mitigation. If no leakage mitigation occurs, the potential amount of leakage will be the same as the amount of foregone production.

$$l_{j,t} = FP_{j,t} - LM_{j,t} \quad (4)$$

Where:

$l_{j,t}$ = Amount of production subject to leakage for commodity *j* in year *t* (tonnes)

$FP_{j,t}$ = Forgone production of commodity *j* in year *t* (tonnes)

$LM_{j,t}$ = Leakage mitigation of commodity *j* in year *t* (tonnes)

Step 2: Area Subject to Leakage

2.1 Area of New Land Brought into Production

Estimate the total area of new land brought into production outside the project in year t by applying the baseline commodity yields (as calculated above) in the following equation:

$$INL_{j,t} = \frac{l_{j,t} \times IS \times NL_j}{y_{j,t}} \quad (6)$$

Where:

$INL_{j,t}$ = Area of new land brought into production in year *t* (ha)

$l_{j,t}$ = Amount of production subject to leakage for commodity *j* in year *t* (tonnes)

IS = 75 percent; Share of leakage resulting in increased supply outside the project area

NL_j = Share of increased supply coming from new land brought into production for commodity *j*; or the default value (40 percent for non-forest products, 100 percent for forest products)

2.1.1 Amount of Increased Supply (IS) A fundamental premise of market leakage is that where production is decreased by one unit, then production in other locations will replace some, but not all, of the forgone production. This module uses a conservative default value of 75 percent for IS which assumes that 75 percent of the production lost due to the project is made up through increases in supply outside the project.

2.1.2 Amount from New Land Brought into Production (NL) For non-forest products, the increases in supply of these global commodities outside the project area but due to the project may or may not result in bringing new lands into production. Supply increases from bringing new non-forest land into production may result in conversion, while supply increases from agricultural intensification and increases in yields on non-forest lands will not lead to conversion. The conservative default value of 40 percent for NL for non-forest products is applied. This assumes that 40 percent of the increase in supply of non-forest products outside the project is made up through bringing new land into production.

2.2 Area Subject to Leakage

The total area subject to leakage as a result of the area of new land brought into production must be calculated across relevant global commodities and relevant domestic commodities.

$$AL_t = max\left(\sum_{j=1}^{NFP} INL_{j,t} \; , \sum_{j=1}^{FP} INL_{j,t}\right) \tag{8}$$

Where:

AL_t = Area subject to leakage in year *t* (ha)

$INL_{j,t}$ = Area of new land brought into production in year *t* (ha)

NFP = Total number of relevant commodities that are non-forest products

FP = Total number of relevant commodities that are forest products

Step 3: Domestic Share of Leakage

For relevant global commodities the next step is to estimate how much of this area subject to leakage is likely to occur outside the project area but within the country. UNFCCC policy establishes that countries are only responsible for their own GHG emissions. As such, a project, jurisdiction or country reporting GHG emission reductions or removals does not report emission increases that may occur in other countries as a result of the activities in the reporting country. Relevant global commodities must apply the country's share of global leakage from forests and grasslands, to estimate the leakage attributable to their country using the procedures in Section 5.4.3. Such reduction in leakage is not applicable to relevant domestic commodities as all leakage for such commodities are assumed to remain within the country.

3.1 Domestic Share of Grassland

Estimate the domestic share of global leakage from grassland, to determine how much of the global conversion of non-forest land is likely to occur within the country:

$$s_g = \frac{d_g}{g_g} \tag{13}$$

Where:

s_g = Domestic share of global leakage from grasslands (percent)

d_g = Area of grassland within the country (ha)

g_g = Area of grassland globally (ha)

3.2 Domestic Share of Global Leakage

Using the domestic share of at-risk forests and at-risk grasslands, calculate the domestic share of global leakage using the following equation:

$$s = (LFL \times s_f) + ((1 - LFL) \times s_g) \quad (14)$$

Where:

s = Domestic share of global leakage (percent)

LFL = Share of leakage going to forest lands; or the default value of 100 percent[7]

s_f = Domestic share of global leakage from forest lands (percent)

s_g = Domestic share of global leakage from grasslands (percent)

3.4 Domestic Area Subject to Leakage

Using the country's share of global leakage, calculate the domestic area subject to leakage:

$$DAL_t = (AL_{t,rgc} \times s) + AL_{t,rdc} \quad (16)$$

Where:

DAL_t = Domestic area subject to leakage in year *t* for relevant global commodities (ha)

$AL_{t,rgc}$ = Area subject to leakage in year *t* for relevant global commodities (ha)

s = Domestic share of global leakage (percent)

$AL_{t,rdc}$ = Area subject to leakage in year *t* for relevant domestic commodities (ha)

Step 4: Leakage Emissions

4.1 Leakage Emissions Factor

To convert the domestic area subject to leakage emissions the project must also determine leakage emission factors.

The project applies the default value for CS LA,nf of 72.6 tC / ha.

$$LEF_{nf,t} = CS_{LA,nf} \times 44/12 \quad (20)$$

Where:

$LEF_{nf,t}$ = Leakage emissions factor for non-forest lands in the country (tonnes CO_2e / ha)

$CS_{LA,nf}$ = Non-forest carbon stocks of the leakage area (tonnes C / ha)

4.1 Market Leakage

Calculate the market leakage emissions resulting from the domestic area subject to leakage as per the following equation:

$$ML_t = \left[\left(LFL \times LEF_f\right) + \left((1 - LFL) \times LEF_{nf}\right)\right] \times DAL_t \qquad (23)$$

Where:

ML_t = Market leakage emissions in year *t* (tonnes CO_2e)

LFL = Share of leakage going to forest lands; or the default value of 100 percent

LEF_f = Leakage emissions factor for forest lands in the country (tonnes CO_2e / ha)

LEF_{nf} = Leakage emissions factor for non-forest lands in the country (tonnes CO_2e / ha)

DAL_t = Domestic area subject to leakage in year *t* (ha)

4.4 Estimated Net GHG Emission Reductions and Removals

Gross Emissions Reductions (GERs) are calculated for each project accounting area at each monitoring period using equation [F.53] of the methodology.

$$E_{\Delta GER}^{[m]} = E_{B\Delta}^{[m]} - E_{P\Delta}^{[m]} - E_{L\Delta}^{[m]} - E_{U}^{[m]}$$

Equations for calculating baseline, project and leakage emissions have been described in above sections. Uncertainty deductions are calculated with equations [F.57] and should be documented for each monitoring period:

$$\mathrm{E}_{\mathrm{U}}^{[\mathrm{m}]} = \mathrm{E}_{\mathrm{B}\Delta}^{[\mathrm{m}]}\left[\frac{1.64}{\mathrm{E}_{\mathrm{B}\Delta}^{[\mathrm{m}]} + \mathrm{A}_{\mathrm{PAA}}^{[\mathrm{m}]}\mathrm{c}_{\mathrm{B}}^{[\mathrm{m}]} + \mathrm{A}_{\mathrm{PX}}\mathrm{c}_{\mathrm{B}}^{[\mathrm{m}]}}\sqrt{\left(\mathrm{U}_{\mathrm{EM}}^{[\mathrm{M}]}\right)^2 + \left(\mathrm{U}_{\mathrm{P}}^{[\mathrm{m}]}\right)^2 + \left(\mathrm{U}_{\mathrm{B}}^{[\mathrm{m}]}\right)^2} - 0.15\right]$$

Net Emissions Reductions (NERs) are estimated with equation [F.55]

$$E_{\Delta NER}^{[m]} = E_{\Delta GER}^{[m]} - E_{BA}^{[m]}$$

Ex-ante estimates are provided in *Table 22* below.

Table 22: Ex-Ante Estimations of Net GHG Emission Reductions from initial PAI

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
2017	82,497	622	0	68,775
2018	94,491	659	0	78,819
2019	94,592	621	0	78,936
2020	93,532	591	0	78,070
2021	91,330	569	0	76,239
2022	88,124	552	0	73,560
2023	84,132	539	0	70,218
2024	79,616	530	0	66,432
2025	74,836	523	0	62,423
2026	70,024	518	0	58,385
2027	65,368	514	0	54,477
2028	61,001	511	0	50,811
2029	57,007	509	0	47,458
2030	53,430	508	0	44,454
2031	50,278	507	0	41,808
2032	47,540	506	0	39,509
2033	45,187	505	0	37,533
2034	43,184	505	0	35,851
2035	41,491	504	0	34,429
2036	40,069	504	0	33,234
2037	38,880	504	0	32,236
2038	37,891	504	0	31,405
2039	37,070	504	0	30,715
2040	36,390	504	0	30,145

2041	35,829	504	0	29,673
2042	35,367	504	0	29,285
2043	34,986	504	0	28,965
2044	34,674	504	0	28,703
2045	34,417	504	0	28,487
2046	34,206	504	0	28,310
2047	1,915	27		1,586
Total	1,717,439	15,862	0	1,430,933

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	*α (GP-2)*
Data unit	unitless
Description	Combined effects of β and q at the start of the historic reference period
Source of data	Reference area and historic reference period
Value applied	-0.4135
Justification of choice of data or description of measurement methods and procedures applied	Based on the interpretation of changes in the state of the sampling point over time within the reference area, whether it has been converted or not.
Purpose of Data	Used in the equations F20 and F25.
Comments	R statistical software was used to fit the logistic function.

Data / Parameter	*α (FP-2)*
Data unit	unitless
Description	Combined effects of β and q at the start of the historic reference period
Source of data	Reference area and historic reference period
Value applied	-2.471
Justification of choice of data or description of measurement methods and procedures applied	Based on the interpretation of changes in the state of the sampling point over time within the reference area, whether it has been converted or not.
Purpose of Data	Used in the equations F20 and F25.
Comments	R statistical software was used to fit the logistic function.

Data / Parameter	*β (GP-2)*
Data unit	unitless
Description	Effect of time on cumulative proportion of conversion over time
Source of data	Reference area and historic reference period
Value applied	0.0009201
Justification of choice of data or description of measurement methods and procedures applied	Based on the interpretation of changes in the state of the sampling point over time within the reference area, whether it has been converted or not.
Purpose of Data	Used in the equations F20 and F25.
Comments	R statistical software was used to fit the logistic function.

Data / Parameter	*β (FP-2)*
Data unit	unitless
Description	Effect of time on cumulative proportion of conversion over time
Source of data	Reference area and historic reference period
Value applied	0.0005802
Justification of choice of data or description of measurement methods and procedures applied	Based on the interpretation of changes in the state of the sampling point over time within the reference area, whether it has been converted or not.
Purpose of Data	Used in the equations F20 and F25.
Comments	R statistical software was used to fit the logistic function.

Data / Parameter	θ
Data unit	unitless
Description	Effect of covariates on the cumulative proportion of conversion over time.
Source of data	Reference area and historic reference period

Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	No external covariates were employed in the development of the conversion model because there is only one agent of conversion, the landholder.
Purpose of Data	Use in the equations F3 and F6.
Comments	Parameter not used

Data / Parameter	γ
Data unit	days
Description	Time shift from beginning of historic reference period to project start date
Source of data	Historic reference period
Value applied	3651
Justification of choice of data or description of measurement methods and procedures applied	The historic period is 10 years, and the project start date is one day after.
Purpose of Data	Used in the equations F20 and F25.
Comments	

Data / Parameter	q
Data unit	days
Description	Lag between start of degradation and conversion.
Source of data	Default
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	There is no degradation in the baseline scenario.
Purpose of Data	Used in the equations F3 and F20.
Comments	Parameter not required for GP-2. In FP-2 was applied default '0', according to methodology.

Data / Parameter	$\hat{\sigma}_{EM}$ (GP-2)
Data unit	Standard deviation (unitless)
Description	The estimated standard deviation of the state observations used to fit the logistic function
Source of data	Sampling point set.
Value applied	0.357973
Justification of choice of data or description of measurement methods and procedures applied	Calculations completed in workbook provided to auditors (Baseline Emissions Model)
Purpose of Data	Used in equations F12 and F14.
Comments	Calculated in excel from equation F13.

Data / Parameter	$\hat{\sigma}_{EM}$ (FP-2)
Data unit	Standard deviation (unitless)
Description	The estimated standard deviation of the state observations used to fit the logistic function
Source of data	Sampling point set.
Value applied	0.182738
Justification of choice of data or description of measurement methods and procedures applied	Calculations completed in workbook provided to auditors (Baseline Emissions Model)
Purpose of Data	Used in equations F12 and F14.
Comments	Calculated in excel from equation F13.

Data / Parameter	$\mathcal{B}$
Data unit	set
Description	The set of all selected carbon pools in biomass. Is a subset of $\mathcal{C}$
Source of data	PD Section 3.3 Project Boundary

Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	AGOT and BGOT are the biomass carbon pools suitable to this project, since the baseline scenario does not include harvest of long-lived wood products or perennial tree crops.
Purpose of Data	Used in equations F17, F18 and F23
Comments	Selected carbon pools are listed in Table 6 of the PDD.

Data / Parameter	$\mathcal{C}$
Data unit	set
Description	The set of all selected carbon pools.
Source of data	PD Section 3.3 Project Boundary
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	The set of carbon pool are Biomass (AGOT, BGOT) and Soil (SOC).
Purpose of Data	Calculation of the baseline emissions from biomass and SOC.
Comments	Selected carbon pools are listed in Table 6 of the PDD.

Data / Parameter	$\mathcal{I}$ (GP-2)
Data unit	set
Description	The set of all observations of conversion.
Source of data	Sampling points set.
Value applied	52,272
Justification of choice of data or description of measurement methods and procedures applied	The set of all observations is represented by 11 years and 4,752 samples.
Purpose of Data	Used in the equation F13
Comments	4,752 samples were obtained after excluding unsuitable points. The initial sampling consisted of 5,000 points.

Data / Parameter	$\mathcal{I}$ (FP-2)
Data unit	set
Description	The set of all observations of conversion.
Source of data	Sampling points set.
Value applied	14,542
Justification of choice of data or description of measurement methods and procedures applied	The set of all observations is represented by 11 years and 1,322 samples.
Purpose of Data	Used in the equation F13
Comments	1,322 samples were obtained after excluding unsuitable points. The initial sampling consisted of 2,000 points.

Data / Parameter	$\mathcal{M}$
Data unit	set
Description	The set of all monitoring periods
Source of data	Monitoring records
Value applied	1
Justification of choice of data or description of measurement methods and procedures applied	The current monitoring period is the first one.
Purpose of Data	Used in the equations F33, F54 and F56.
Comments	

Data / Parameter	$\mathcal{T}$
Data unit	set
Description	The set of all species/categories of livestock.
Source of data	Monitoring report.
Value applied	N/A

Justification of choice of data or description of measurement methods and procedures applied	Although pasture is considered an intermediate conversion class between native Cerrado and agriculture, pasture is not the current class in the baseline scenario.
Purpose of Data	Used in equation F43
Comments	Parameter was not applied.

Data / Parameter	$f_{LS\ i}$
Data unit	kg CH_4 $head^{-1}$ yr^{-1}
Description	Emission factor for the defined livestook population, *i*
Source of data	IPCC default value
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Although pasture is considered an intermediate conversion class between native Cerrado forest and agriculture (for F-P2 baseline type), pasture is not the current class in the conversion process established.
Purpose of Data	Used in equation F43.
Comments	Parameter was not applied.

Data / Parameter	A_{PAA} (GP-2)
Data unit	ha
Description	Area of project accounting area.
Source of data	GIS analysis and measurement in the field .
Value applied	4,591.8
Justification of choice of data or description of measurement methods and procedures applied	Area accounted for by the exclusion of areas with a slope higher than 25% as well as the areas protected by law from the total area of native vegetation on the properties.
Purpose of Data	Used in the equations F20, F25, F52 and F57.
Comments	Total area of PAA covered by grassland or savannah vegetation classes, according to IBGE classification

Data / Parameter	A_{PAA} (FP-2)
Data unit	ha
Description	Area of project accounting area.
Source of data	GIS analysis and measurement in the field .
Value applied	6,917.4
Justification of choice of data or description of measurement methods and procedures applied	Area accounted for by the exclusion of areas with a slope higher than 25% as well as the areas protected by law from the total area of native vegetation on the properties.
Purpose of Data	Used in the equations F20, F25, F52 and F57.
Comments	Total area of PAA covered by forestry vegetation class, according to IBGE classification

Data / Parameter	A_{px}
Data unit	ha
Description	Area of proxy area
Source of data	GIS analysis.
Value applied	303.9
Justification of choice of data or description of measurement methods and procedures applied	The proxy area was selected in an agricultural field within the Engenho property, in order to characterize the baseline scenario.
Purpose of Data	Used in the equation F57.
Comments	See section 3.4.4.

Data / Parameter	n_d (GP-2)
Data unit	sample points
Description	Number of spatial points in the reference area
Source of data	GIS analysis applied over reference area.
Value applied	4,752

Justification of choice of data or description of measurement methods and procedures applied	The sample size was suitable according to the calculation of the minimum required (Equation F12).
Purpose of Data	Used in the equation F14.
Comments	The initial sample size was 5,000, which was reduced to 4,752 points, after discarding the unsuitable points. See section 3.4.6.3.

Data / Parameter	n_d (FP-2)
Data unit	sample points
Description	Number of spatial points in the reference area
Source of data	GIS analysis applied over reference area.
Value applied	1,322
Justification of choice of data or description of measurement methods and procedures applied	The sample size was suitable according to the calculation of the minimum required (Equation F12).
Purpose of Data	Used in the equation F14.
Comments	The initial sample size was 2,000, which was reduced to 1,322 points, after discarding the unsuitable points. See section 3.4.6.3.

Data / Parameter	O_i
Data unit	binary
Description	State observation for the $i\ t\ h$ sample point in the reference area
Source of data	Sampling points set.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	State observation was identified as '1', to converted sample point, and '0' to not converted, in each year of the historical period.
Purpose of Data	Used in the equations F12 and F13

Comments	In GP-2, not converted is grassland and savannah classes. In FP-2, not converted is forest class. Classification based on MapBiomas

Data / Parameter	$P_{L\ ME}$
Data unit	Unitless
Description	Portion of leakage related to market.
Source of data	N/A
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Used in the equation F51
Comments	Parameter not used.

Data / Parameter	r_{RS}
Data unit	unitless
Description	Expansion factor for above-ground biomass to below-ground biomass (root/shoot ratio)
Source of data	Average values of specialized values applied in the Fourth National Communication. Pages 121-127. BRASIL. IV Inventário - LULUCF (Uso da Terra, Mudança do Uso da Terra e Florestas, atualizado em 24/05/2021. Brasília, DF: Ministério da Ciência, Tecnologia e Inovação. 291p., 2020.
Value applied	2.04 (SA); 0.22 (SD); 0.2 (FA); 0.37 (CM)
Justification of choice of data or description of measurement methods and procedures applied	Spatialized data in the entire territory of the Brazilian Cerrado by vegetation class, based on scientific literature.
Purpose of Data	The root/shoot ratio was used to estimate the below-ground biomass from above-ground biomass measured in field.

Comments	Average of spatialized data by vegetation class.

Data / Parameter	r_u
Data unit	unitless
Description	Onset proportion of conversion immediately adjacent to project area.
Source of data	GIS analysis and image interpretation
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Parameter not required in BEM type GP2.
Purpose of Data	Used in the equation F4.
Comments	Parameter not used.

Data / Parameter	$r_{CF\ b}$
Data unit	Unitless
Description	Carbon fraction of biomass for burned wood or herbaceous material *b*
Source of data	N/A
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	It was not considered emission by fire.
Purpose of Data	Used in the equation F42.
Comments	Parameter not used.

Data / Parameter	λ_{Soc}
Data unit	Unitless
Description	Exponential soil carbon decay parameter

Source of data	IV Brazilian inventory of anthropic emissions and removals of greenhouse gases, submitted to UNFCCC in 2020 – LULUCF Reference Report, page 176.
Value applied	0.84
Justification of choice of data or description of measurement methods and procedures applied	Decay rate for Cerrado Biome is 0.90±0.06. Conversantly, it was used 0.84.
Purpose of Data	Used in the equation F9 and F33.
Comments	The report can be found here: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/relatorios-de-referencia-setorial.

Data / Parameter	$C_{L\,p}$
Data unit	tCO2e / ha
Description	Carbon stocks in project leakage area.
Source of data	Leakage area sampling
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	There was no emission in leakage area.
Purpose of Data	Used in equation F50
Comments	Parameter not used.

Data / Parameter	*m*
Data unit	T CO_2e / yr
Description	Average carbon in merchantable trees cut each year as a result of legally sanctioned commercial logging.
Source of data	Timber harvest plans
Value applied	N/A

Justification of choice of data or description of measurement methods and procedures applied	Commercial trees logging is not considered in baseline scenario.
Purpose of Data	Used in the equation F2
Comments	Parameter not used, since AGMT and BGMT are not included in baseline scenario.

Data / Parameter	t
Data unit	days
Description	Time since project start date.
Source of data	Monitoring records
Value applied	1,656
Justification of choice of data or description of measurement methods and procedures applied	Days from February, 2nd of 2017 to August, 16 of 2021.
Purpose of Data	Used in the equation F20 and F25.
Comments	Time parameter to be used in any monitoring period, according to the number of monitoring periods. In this moment, the value is 1,656 days because is from project start date to end the first monitoring period.

Data / Parameter	t_i
Data unit	days
Description	The point in time of the historic period of the observation made at point *i*
Source of data	Sampling points set.
Value applied	2007 to 2017
Justification of choice of data or description of measurement methods and procedures applied	The point in time for each observation encompasses the period from 2007 to 2017, in annual intervals, based on MapBiomas project.
Purpose of Data	Used in the equations F11 and A6.
Comments	

Data / Parameter	t_{PAI}
Data unit	days
Description	Number of days after the project start date for the start of a project activity instance in a grouped project
Source of data	PDD
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	All of the PAI of the grouped project has the same start date.
Purpose of Data	Used in the equation F20 and F25.
Comments	The first PAI has the same start date as the project start date. This parameter will be applicable to future PAIs included.

Data / Parameter	t_m
Data unit	days
Description	Length of project or logging in baseline scenario
Source of data	PD
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Parameter to be used when AGMT and BGMT are included in the set of biomass carbon pools.
Purpose of Data	Used in the equation F1.
Comments	Parameter not used, since AGMT and BGMT are not included in baseline scenario.

Data / Parameter	t_{PL}
Data unit	days
Description	Length of project crediting period.
Source of data	PD

Value applied	10,950
Justification of choice of data or description of measurement methods and procedures applied	The project crediting period is 30 years.
Purpose of Data	Used in the equation F20.
Comments	

Data / Parameter	t_{PA}
Data unit	days
Description	Time prior to the project start date when the primary agent began commercial logging in the project accounting area
Source of data	Harvest plans
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Commercial trees logging is not considered in baseline scenario.
Purpose of Data	Used in the equation F20 and F25.
Comments	Parameter not used.

Data / Parameter	W_I (GP-2)
Data unit	unitless
Description	Weight applied to the i^{th} sample point in the reference area
Source of data	Sampling points set.
Value applied	1.91307E-05
Justification of choice of data or description of measurement methods and procedures applied	Parameter calculated from equation A6
Purpose of Data	Used in equation F13

Comments	Since the number of observation is linear in the time and space, the weight is the same for every sample point.

Data / Parameter	W_i (FP-2)
Data unit	unitless
Description	Weight applied to the i^{th} sample point in the reference area
Source of data	Sampling points set.
Value applied	6.87663E-05
Justification of choice of data or description of measurement methods and procedures applied	Parameter calculated from equation A6
Purpose of Data	Used in equation F13
Comments	Since the number of observations is linear in the time and space, the weight is the same for every sample point.

Data / Parameter	X
Data unit	unitless
Description	Covariate values
Source of data	Remote sensing image interpretation
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Used in the equation F20 and F25.
Comments	Covariates were not considered in this project.

Data / Parameter	X_0
Data unit	unitless
Description	Covariate values as of the project start date

Source of data	Participatory Rural Appraisal, public records, Remote sensing image interpretation.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Used in the equation F25.
Comments	Covariates were not considered in this project.

Data / Parameter	X_{SA}
Data unit	unitless
Description	Covariate values as of the arrival of the secondary agents.
Source of data	Participatory Rural Appraisal, public records, Remote sensing image interpretation.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	N/A
Purpose of Data	Used in the equation F2.
Comments	Parameter not used, since is applied in equation to type FP1.

Data / Parameter	X_i
Data unit	Geographic coordinates
Description	Latitude of the i^{th} sample point
Source of data	Sampling points set.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Geographic position of each sample point randomly launched on the Native Cerrado classes, within the reference areas.

Purpose of Data	Used in the equations F11 and A6
Comments	

Data / Parameter	y_i
Data unit	Geographic coordinates
Description	Longitude of the i^{th} sample point
Source of data	Sampling points set.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Geographic position of each sample point randomly launched on the Native Cerrado classes, within the reference areas.
Purpose of Data	Used in the equations F11 and A6
Comments	

5.2 Data and Parameters Monitored

Data / Parameter	w[m]
Data unit	*set*
Description	The set of all burned wood
Source of data	Monitoring records
Description of measurement methods and procedures to be applied	*N/A*
Frequency of monitoring/recording	Every monitoring period
Value monitored	*N/A*
Monitoring equipment	*N/A*
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	N/A

Calculation method	Summation over measurements
Comments	Parameter not used

Data / Parameter	$A_{B\,\Delta\,PAA\,[m]}$
Data unit	ha
Description	Area of avoided conversion
Source of data	PAA and Proxy Area
Description of measurement methods and procedures to be applied	Calculated from Biomass Emission Model, Carbon in PAA and Carbon in Proxy area.
Frequency of monitoring/recording	First monitoring.
Value monitored	8,582.25
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	N/A
Calculation method	From direct application of the equation F52.
Comments	

Data / Parameter	$B_{B[m]}$
Data unit	tonnes
Description	Biomass in burned wood material b
Source of data	Measurements of biomass
Description of measurement methods and procedures to be applied	Scale
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records

Purpose of data	Calculation of project emissions
Calculation method	Summation
Comments	Parameter not used as no biomass was burned as part of project activities

Data / Parameter	$C_{B[m]}$
Data unit	tCO2e / ha
Description	Baseline carbon stocks at the end of the current monitoring period
Source of data	Set of all carbon pools in the proxy area.
Description of measurement methods and procedures to be applied	Average carbon stocks in each carbon pool of the proxy area.
Frequency of monitoring/recording	Every time measured
Value monitored	18.59 (biomass) and 110.8 (soil).
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Used in the equations F20 (biomass), F25 (soil) and F57 (both).
Calculation method	N/A
Comments	Carbon original value to biomass from Third National Communication to UNFCCC is 5.07 tn/ha, however the number was converted to tCO2e / ha.

Data / Parameter	$C_{B\ BGB\ [m]}$
Data unit	tCO2e
Description	Carbon not decayed in BGB at the end of the current monitoring period
Source of data	Proxy area.

Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Used in the equation F16
Calculation method	N/A
Comments	Parameter not applied since the below-ground biomass in proxy area is negligible. Only above-ground biomass has been considered.

Data / Parameter	$C_{B\ SOC}$ [m]
Data unit	tCO2e
Description	Carbon not decayed in SOC at the end of the current monitoring period
Source of data	Proxy area.
Description of measurement methods and procedures to be applied	Calculated from DEM_{soc}
Frequency of monitoring/recording	Every monitoring period
Value monitored	378,002.43
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F16
Calculation method	Direct application of the equation F33.
Comments	The value is the sum of $C_{B\ SOC}$ [m] of each vegetation class.

Data / Parameter	$C_{B\ b}$ [m]

Data unit	$tCO2e$ / ha
Description	Baseline scenario average carbon stock in selected carbon pools from biomass
Source of data	Proxy area.
Description of measurement methods and procedures to be applied	BRASIL. Terceiro Inventário Brasileiro de Emissões e Remoções Antrópicas de Gases de Efeito Estufa: Relatório de Referência—Emissões no Setor Uso da Terra, Mudança do Uso da Terra e Florestas. Brasília, DF: MCTI, 2015. Tabela 37. Pag196
Frequency of monitoring/recording	Every monitoring period
Value monitored	18,59 (aboveground biomass)
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records.
Purpose of data	Used in equation F18.
Calculation method	Approved literature method for calculating carbon stocks of typical crop production in Brazil (soy).
Comments	The value is about the carbon biomass pool that has been defined in this project to be Aboveground biomass only. Belowground biomass has not been considered in the proxy area. Carbon original value to biomass from Third National Communication to UNFCCC is 5.07 tn/ha, however the number was converted to $tCO2e$ / ha.

Data / Parameter	$C_{B\ BM}$ [m]
Data unit	$tCO2e$ / ha
Description	Set of biomass carbon pools at the end of the current monitoring period
Source of data	Proxy area
Description of measurement methods and procedures to be applied	BRASIL. Terceiro Inventário Brasileiro de Emissões e Remoções Antrópicas de Gases de Efeito Estufa: Relatório de Referência—Emissões no Setor Uso da Terra, Mudança do Uso da Terra e Florestas. Brasília, DF: MCTI, 2015. Tabela 37. Pag196
Frequency of monitoring/recording	Every monitoring period

Value monitored	18.59
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Use in the equations F20 and F52.
Calculation method	From equation F18.
Comments	The value is the same from baseline scenario ($C_{B\ b\ [m]}$) because the set of biomass carbon pools considered is the aboveground biomass only. Carbon original value to biomass from Third National Communication to UNFCCC is 5.07 tn/ha, however the number was converted to tCO2e / ha.

Data / Parameter	$C_{B\ SOC}\ ^{[m]}$
Data unit	tCO2e / ha
Description	Soil carbon at the end of the current monitoring period
Source of data	Proxy area.
Description of measurement methods and procedures to be applied	See Section 6.2.3
Frequency of monitoring/recording	Every monitoring period
Value monitored	110.8
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F25.
Calculation method	N/A
Comments	

Data / Parameter	$C_{P}\ ^{[m]}$
Data unit	tCO2e / ha
Description	Project carbon stocks at the end of the current monitoring period.

Source of data	Set of all carbon pools in the project accounting area.
Description of measurement methods and procedures to be applied	Average carbon stocks in each carbon pool of the accounting project area.
Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	145.54 (biomass); 337.40 (soil)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods.
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equations F41 and F57.
Calculation method	Average carbon pools of the vegetation classes.
Comments	The values for the carbon pools (biomass and soil) were obtained for each vegetation class and applied to the BEM (F20) and SEM (F25) according to the area that each one covers, within the PAA. Here, it is presented the average value. Since the current monitoring period is the first monitoring, the value is the same as prior to the first verification event ($C_{P\,[m=0]}$), as approved by methodology VM0009.

Data / Parameter	$C_P^{[m-1]}$
Data unit	tCO2e / ha
Description	Project carbon stocks at the beginning of the prior monitoring period
Source of data	Set of all carbon pools in the project accounting area.
Description of measurement methods and procedures to be applied	Average carbon stocks in each carbon pool of the accounting project area.
Frequency of monitoring/recording	Already monitored
Value monitored	145.54 (biomass); 337.40 (soil)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equations F41 and F57.

Calculation method	Average carbon pools of the four vegetation classes.
Comments	Since the current monitoring period is the first monitoring, the value is the same as prior to the first verification event. See below.

Data / Parameter	$C_{P\ BM}$ [m=0]
Data unit	tCO2e / ha
Description	Project carbon stocks in biomass prior to first verification event.
Source of data	Set of all carbon pools from biomass in the project accounting area.
Description of measurement methods and procedures to be applied	Average carbon stocks from biomass in the project accounting area. AGOT and BGOT were the pools selected as the more suitable to the project. See section 3.3.4. AGOT was obtained by literature (Guimarães, 2020), that can be found here: https://repositorio.bc.ufg.br/tede/bitstream/tede/11223/3/Tese%20-%20Luanna%20Elis%20Guimar%c3%a3es%20-%202020.pdf. BGOT was estimated by applying root-shoot-ratio over AGOT, for each phytophysiognomy..
Frequency of monitoring/recording	Prior first monitoring event
Value monitored	145.54
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F20 and F52.
Calculation method	From equation F17.
Comments	The values for the biomass carbon pools were obtained for each vegetation class and applied on the equations according to the area that each one of them covers, within the PAA. Here, it is presented the average value. Since the current monitoring period is the first monitoring, the value is the same of the biomass carbon stocks at the end of the current monitoring period ($C_{P\ [m]}$), as approved by methodology VM0009.

Data / Parameter	$C_{Pb}[m]$
Data unit	tCO2e/ha
Description	Baseline scenario average carbon stock in selected carbon pools from biomass.
Source of data	Project accounting area.
Description of measurement methods and procedures to be applied	AGOT was obtained by literature (Guimarães, 2020), that can be found here: https://repositorio.bc.ufg.br/tede/bitstream/tede/11223/3/Tese%20-%20Luanna%20Elis%20Guimar%c3%a3es%20-%202020.pdf.
Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	103.81 (AGOT); 41.74 (BGOT)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F17.
Calculation method	AGOT was obtained by allometric equation. BGOT was estimated by applying root-shoot-ratio of 1.58 over AGOT.
Comments	The value is about the carbon biomass pools that has been defined in this project to be Above-ground other tree and Below-ground other tree. The values were used in the equations according to vegetation class (between parenthesis).

Data / Parameter	$C_{Psb}[m]$
Data unit	tCO2e/ha
Description	Average carbon in the set of biomass pools for each project accounting area stratum s
Source of data	Project accounting area
Description of measurement methods and procedures to be applied	See appendix C.

Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	73.77 (SD); 81.59 (SA); 158.44 (FA); 268.35 (CM)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F23
Calculation method	AGOT was obtained by allometric equation. BGOT was estimated by applying root-shoot-ratio over AGOT.
Comments	PAA was stratified into four vegetation class: Forested Savannah (SD), Wooded Savannah (SA), Semi-deciduous Forest (FA), and Deciduous Forest (CM).

Data / Parameter	$C_{P\ SOC}^{[m=0]}$
Data unit	tCO2e/ha
Description	Project carbon stocks from soil at prior to first verification event.
Source of data	Project accounting area
Description of measurement methods and procedures to be applied	Appendix C.
Frequency of monitoring/recording	First monitoring period
Value monitored	337.41
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F25
Calculation method	Average of the four vegetation class SOC values.
Comments	Since the current monitoring period is the first monitoring, the value is the same at the end of the current monitoring period (**$Cp^{[m]}$**), as permitted by methodology VM0009.

Data / Parameter	$E^{[m]}_{\Delta\,GER}$
Data unit	tCO2e
Description	GERs for the current monitoring period
Source of data	Proxy Area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*377,121*
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of GER calculations
Purpose of data	Used in equation F54.
Calculation method	Equation F53
Comments	The value is result of the sum from $E^{[m]}_{GER}$ of the each vegetation classes.

Data / Parameter	$E^{[m]}_{\Delta\,NER}$
Data unit	tCO2e
Description	NERs for current monitoring period
Source of data	Proxy Area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*316,781.6*
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of NER calculations
Purpose of data	Used in equation F56

Calculation method	F.55
Comments	The value is result of the sum from $E^{[m]}_{\Delta\ NER}$ of each vegetation class .

Data / Parameter	$E_B^{[m]}$
Data unit	tCO2e
Description	Cumulative baseline emissions at the end of the current monitoring period
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*415,325.5*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F15
Calculation method	Calculated from F16
Comments	The value is result from sum of $E_B^{[m]}$ of each vegetation class, in current monitoring period.

Data / Parameter	$E_B^{[m-1]}$
Data unit	tCO2e
Description	Cumulative baseline emissions at the beginning of the current monitoring period
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Prior monitoring period

Value monitored	*82,497.2*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F15.
Calculation method	Calculated from F16.
Comments	The value is result from sum of $E_B^{[m-1]}$ of each vegetation class, in the first year of the project.

Data / Parameter	$E^{[m]}_{B\,\Delta}$
Data unit	tCO2e
Description	Change in baseline emissions
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	3*32,828.3*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F16 and F53.
Calculation method	From equation F15.
Comments	The value is result from sum of the parameters of each vegetation classes, in current monitoring period and in the beginning of project. It was calculated by the difference between the baseline emission from biomass in the current monitoring period and the value in the beginning of the project.

Data / Parameter	$E^{[m]}_{B\,\Delta\,BGB}$

Data unit	tCO_2e
Description	Change in baseline emissions from below-ground biomass
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*59,532*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F32
Calculation method	From equation F31
Comments	The value is result from sum of the parameters of each vegetation classes, in current monitoring period and in the beginning of project. It was calculated by the difference between the baseline emission from below-ground biomass in the current monitoring period and the value in the beginning of the project.

Data / Parameter	$E^{[m]}{}_{B\ BGB}$
Data unit	tCO_2e
Description	Cumulative baseline emissions from below-ground biomass at the end of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	75,217.6
Monitoring equipment	Equipment list in Appendix C Monitoring Methods

QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F31.
Calculation method	From equation F30
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m-1]}{}_{B\ BGB}$
Data unit	tCO2e
Description	Cumulative baseline emissions from below-ground biomass at the beginning of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	15,685.7
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F31.
Calculation method	From equation F30
Comments	The value is result from sum of parameter of each vegetation class, in the beginning of project.

Data / Parameter	$E^{[m]}{}_{B\ \Delta\ soc}$
Data unit	tCO2e
Description	Baseline change in emissions from soil carbon
Source of data	Proxy area measurements

Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	435,025
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F16 and F33
Calculation method	Calculated from F26.
Comments	The value is result from sum of the parameters of each vegetation classes, in current monitoring period and in the beginning of project. It was calculated by the difference between the baseline emission from soc in the current monitoring period and the value in the beginning of the project.

Data / Parameter	$E^{[m]}_{B\ soc}$
Data unit	tCO2e
Description	Cumulative baseline emissions from soil carbon at the end of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	544,121.8
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F26.
Calculation method	From equation F25.

Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m-1]}_{B\ soc}$
Data unit	tCO2e
Description	Cumulative baseline emissions from soil carbon at the beginning of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Prior monitoring period
Value monitored	109,096.8
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F16 and F26.
Calculation method	From equation F25.
Comments	The value is result from sum of parameter of each vegetation class, in the beginning of the project.

Data / Parameter	$E^{[m]}_{B\ BM}$
Data unit	tCO2e
Description	Cumulative baseline emissions from biomass at the end of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	249,206.1

Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equations F16 and F30
Calculation method	Calculated for F15
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m]}_{B\,A}$
Data unit	tCO2e
Description	Cumulative emissions allocated to the buffer account at the end of the current monitoring period
Source of data	VCS Non-Permanence Risk Tool
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	60,339
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F55
Calculation method	Direct calculation from 16% on GER's
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m]}_{L}$
Data unit	tCO2e
Description	Cumulative emissions from leakage at the end of the current monitoring period

Source of data	Measurements in the leakage area(s)
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F44
Calculation method	Calculated from F45
Comments	There was no Leakage emission.

Data / Parameter	$E^{[m-1]}_{L}$
Data unit	tCO2e
Description	Cumulative emissions from leakage at the beginning of the current monitoring period
Source of data	Measurements in the leakage area(s)
Description of measurement methods and procedures to be applied	8.3
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	N/A
Purpose of data	Used in the equation F44
Calculation method	Calculated from F45
Comments	There was no Leakage emission.

Data / Parameter	$E^{[m]}_{L\,\Delta}$
Data unit	tCO2e
Description	Change in emissions due to leakage
Source of data	N/A
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F53
Calculation method	Calculated from F44
Comments	There was no Leakage Emission.

Data / Parameter	$E^{[m]}_{L\,ASG}$
Data unit	tCO2e
Description	Cumulative emissions from activity-shifting leakage in grassland areas at the end of the current monitoring period
Source of data	Measurements in the activity-shifting leakage area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records

Purpose of data	Calculation of leakage
Calculation method	Calculated from F47
Comments	There was no Leakage Emission.

Data / Parameter	$E^{[m]}{}_{L\ ME}$
Data unit	tCO2e
Description	Cumulative emissions from market effects leakage at the end of the current monitoring period
Source of data	Measurements in the activity-shifting leakage area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	*N/A*
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F45
Calculation method	From equation F51
Comments	Parameter not used.

Data / Parameter	$E^{[m]}{}_{P\ \Delta}$
Data unit	tCO2e
Description	Change in project emissions
Source of data	Monitoring records for Forest Fire, Burning, logging, wood products, and natural disturbance events
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period

Value monitored	38,204
Monitoring equipment	GIS, Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of project emissions
Calculation method	F.53
Comments	

Data / Parameter	$E^{[m]}{}_{P\ \Delta BRN}$
Data unit	tCO2e
Description	Cumulative project emissions due to burning at the end of the current monitoring period
Source of data	Monitoring plots in the project
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*N/A*
Monitoring equipment	GIS, Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of project emissions
Calculation method	F.41
Comments	Parameter not used, since there is no burning emission in baseline scenario.

Data / Parameter	$E^{[m]}{}_{P\ \Delta LS}$
Data unit	tCO2e

Description	Cumulative project emissions due to livestock grazing at the end of the current monitoring period
Source of data	Monitoring plots in the project
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*N/A*
Monitoring equipment	*N/A*
QA/QC procedures to be applied	*N/A*
Purpose of data	Calculation of project emissions
Calculation method	F.53
Comments	Livestock grazing not included as a project activity

Data / Parameter	$E^{[m]}_{P\ \Delta SF}$
Data unit	tCO2e
Description	Cumulative project emissions due to synthetic fertilizer at the end of the current monitoring period
Source of data	Monitoring plots in the project
Description of measurement methods and procedures to be applied	8.2.2
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of project emissions
Calculation method	F.53
Comments	Synthetic fertilizers not included as part of project activities

Data / Parameter	$E^{[m]}_{U}$
Data unit	tCO2e
Description	Cumulative confidence deduction at the end of the current monitoring period
Source of data	N/A
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	0
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F53.
Calculation method	Calculated from equation F57
Comments	The calculation of the confidence deduction resulted in negative values. In this case, the value is assumed to be zero, according to recommendation of the methodology.

Data / Parameter	$P^{[m]}_{L\ DEG}$
Data unit	proportion (unitless)
Description	Portion of leakage due to degradation at the end of the current monitoring period
Source of data	Monitoring in the leakage area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A

Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of leakage
Calculation method	F.47, F.49
Comments	Parameter not used.

Data / Parameter	P L CON G [m=0]
Data unit	proportion (unitless)
Description	Portion of leakage due to native grasslands prior to the first verification event
Source of data	Monitoring in the leakage area
Description of measurement methods and procedures to be applied	8.3.2.4
Frequency of monitoring/recording	At project start
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Project verification
Purpose of data	Calculation of leakage
Calculation method	F.47, F.49
Comments	Parameter not used.

Data / Parameter	P L CON G [m]
Data unit	proportion (unitless)
Description	Portion of leakage due to native grasslands conversion at the beginning of the current monitoring period
Source of data	Monitoring in the leakage area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.

Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of leakage
Calculation method	F.47, F.49
Comments	Parameter not used.

Data / Parameter	P L CON G [m-1]
Data unit	proportion (unitless)
Description	Portion of leakage due to native grasslands conversion at the end of the current monitoring period
Source of data	Monitoring in the leakage area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of leakage
Calculation method	F.47, F.49
Comments	Parameter not used.

Data / Parameter	t[i-1]
Data unit	days

Description	Time from project start date to beginning of monitoring period i
Source of data	Monitoring records
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	0
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of baseline emissions
Calculation method	Direct count of time
Comments	Time from project start to February, 2 of 2021

Data / Parameter	t[m]
Data unit	days
Description	Time from project start date to end of current monitoring period
Source of data	Monitoring records
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	1,656
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of baseline emissions
Calculation method	Direct count of time
Comments	Time from project start to August, 16 of 2021

Data / Parameter	$t^{[m-1]}$
Data unit	days
Description	Time from project start date to beginning of current monitoring period
Source of data	Monitoring records
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Prior monitoring period
Value applied	0
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Calculation of baseline emissions
Calculation method	Direct count of time
Comments	First monitoring period, therefore the time is start of the project.

Data / Parameter	$U^{[m]}_{B}$
Data unit	tCO2e
Description	Total uncertainty in proxy area carbon stock estimate
Source of data	N/A
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of baseline emissions

Calculation method	B.34
Comments	Not calculated. It is presumed that is insignificant, due to the small carbon stocks in proxy area.

Data / Parameter	$U^{[m]}_{EM}$
Data unit	tCO2e
Description	Total uncertainty in Baseline Emissions Models
Source of data	N/A
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	2,102.98
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of baseline emissions
Calculation method	Equation F14
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$U^{[m]}_{P}$
Data unit	tCO2e
Description	Total uncertainty in project accounting area carbon stock estimate
Source of data	N/A
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	1,204.36

Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of baseline emissions
Calculation method	B.10 and B34
Comments	The value is result from sum of the parameter of each vegetation class, in current monitoring period. It was calculated from uncertainty of biomass and soil (all the pools).

Data / Parameter	**x[m]**
Data unit	varies
Description	Covariate values
Source of data	Participatory Rural Appraisal, analysis of public records, and/or expert interpretation of inventory data or remotely sensed imagery
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of baseline emissions
Calculation method	N/A
Comments	Covariate values can be conservatively excluded

5.3 Monitoring Plan

5.3.1 Monitoring Methods

The objective of the monitoring plan is to quantify the emissions reductions achieved by the project during each monitoring period and consists of three main components: carbon stock measurements, identification of disturbances and landholder report cards. These core monitoring components will be able to help the project technical team to accurately assess the project's effectiveness and VCU generation during each monitoring period. The project employs permanent sample plots (PSP) combined with allometric equations for estimating carbon stocks in the selected pools. Soil carbon is estimated using soil samples collected at PAAs and proxy area. According to section B.1.3 of VM0009, additional plots can be installed in order to decrease uncertainty and reduce confidence deductions. More details of the monitoring plan are laid out in the sections below.

As new project activities instances are included in the Program, the monitoring methods will follow the monitoring plan and frequencies as described below. If any project activities or monitoring activities are to be phased out or incorporated later due to adaptive management, the monitoring and implementation plans for the Avoided Conversion Cerrado project will be updated accordingly. The project's monitoring activities for quantifying its climate benefits are summarized in Table 23 below.

Table 23: Activity Frequency and Methods

Activity	Frequency	Method
Carbon stock measurements	Once every 5 years	Inventory teams measure carbon stocks within project area, proxy area using direct measurement of PSPs, in combination with LIDAR drone imagery where applicable.
Identification of Significant Disturbances	Once every reporting period	Technical team reviews remote sensing products, satellite imagery, and field teams conduct ground- based verification of disturbances if necessary.
Landholder Guidebook Report Card	Annual	Technical team produces a report card each year based on landholder interviews.

5.3.2 Carbon Stock Measurements

The measurement of carbon stocks in the Avoided Conversion Cerrado REDD Program uses a stratified sample based on vegetation classes and three pools: above-ground (or arboreal) and below-ground biomass, and soil organic carbon. During each reporting period, carbon stocks will be measured by the field inventory team using high-definition satellite imagery, drone imagery and/or lidar and field expeditions to sample and observe vegetation cover.

i. Above-ground Other Trees (AGOT)

To estimate the carbon stock in AGOT, primary data collected in the field are used. The project employs permanent plots combined with appropriate allometric equations for each vegetation class found. In each plot, the arboreal individuals will be mapped and enumerated. Diameter measurements will be taken at breast height (DBH) measured at 1.30m from the ground in forest formations and base diameter (DB30), measured at 30cm from the ground in savanna formations, using a tape measure. The height of individual trees will be estimated with the aid of a clinometer. From the collection of this information, the volume of the tree layer will be calculated, and then, allometric equations will be used to estimate carbon stocks.

Step-by-step procedure established for collecting biomass data:

1. Plot delimitation
2. Metal frame in the center
3. Counting and numbering of arboreal individuals (diameter > 5cm)
5. Diameter measurement: DAP (1.30m) for forest formations / DB30 (0.30m) savanna formations - with diametric tape
6. Height measurement of arboreal individuals - with a clinometer
7. Transcription of field spreadsheets to an excel document, properly stored in the Project cloud
8. Verification of values by a third individual for certification of outlier values
9. Data is saved and backed-up in ERA and ECCON's Project cloud

ii. Below-ground Other Trees (BGOT)

Obtaining data on underground biomass is onerous, from field collection to subsequent analysis of the material collected in the laboratory, requiring more field sampling time and a large number of financial resources. Therefore, the belowground biomass will be estimated through the results obtained for tree biomass (described above), applying a root-to-shoot ratio specific for each vegetation type.

iii. Soil Organic Carbon (SOC)

To measure the soil organic carbon stock, considered the major pool in the cerrado biome, intentional samples will be used in the proxy areas and samples combined with biomass plots in the accounting areas, to compare the carbon stock of the two areas.

In this method, three variables are needed to estimate the soil carbon content: bulk density, organic carbon content and soil depth. The samples will be collected by digging until 40 cm of soil at the stipulated points, and the samples will be sent to a specialized laboratory for analysis of the main components.

Step-by-step procedure established for collecting soil data (Adapted from FAO Guidebook):

1. Use a GPS device with a minimum precision of 4 meters to record the sampling point of the plot in the field
2. Clean the sample site of live plants, plant debris and surface rocks.
3. With the ground cleared, insert the auger at 20cm or 40cm for sample collection
4. Remove the sample and place it in a sterile plastic bag
5. Identify the plastic bag with the date (day, month and year), the parcel number and the georeferencing of each sample
6. Write down the same information in the field book
7. Keep the samples in a dry and ventilated place until all collections are completed
8. At the end of the collections, send the properly identified samples to the laboratory
9. Register the field book information in an excel file in the shared folder in the Project Cloud
10. Upon receipt of the analyses, save the identified results (by date and sample) in the shared folder in the Project cloud

The stratification was applied to improve the accuracy of the data. The strata are defined according to the vegetation classes present in the project's accounting area. The permanent sample plot measurements reflect changes due to natural processes such as growth and mortality, and changes due to human activities, such as management, harvest and degradation. It is noteworthy that temporary (additional) plots may be randomly inserted for biomass and soil estimates in case the permanent plots suffer any kind of injury or disturbance. Plots are marked permanent with standard metal fencing that is hammered into the ground. An error of 15% in the sampling and a confidence interval of 95% were assumed for the calculation of sample sufficiency.

The inventory, containing information on DBH, height and volume for all 80 plots, stratified into 4 vegetation types, it was used to calculate the biomass, our variable of interest, of all sampled individuals, from the application of the allometric equations presented in Guimarães (2020). For this purpose, the carbon stock of ABG at a given point in time was estimated using the stratified random sampling method as set forth in section 8.1.1 of the A/R methodological tool: Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities tool, where each vegetation class represents a stratum. The average carbon stock in the biomass within the strata was estimated as follows:

$$C_{TREE} = \frac{44}{12} \times CF_{TREE} \times B_{TREE}$$ Equation (12)

$$B_{TREE} = A \times b_{TREE}$$ Equation (13)

$$b_{TREE} = \sum_{i=1}^{M} w_i \times b_{TREE,i}$$ Equation (14)

Where:

C_{TREE}	=	Carbon stock in trees in the tree biomass estimation strata; t CO_2e
CF_{TREE}	=	Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$. A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value.
B_{TREE}	=	Tree biomass in the tree biomass estimation strata; t d.m.
A	=	Sum of areas of the tree biomass estimation strata; ha
b_{TREE}	=	Mean tree biomass per hectare in the tree biomass estimation strata; t d.m. ha^{-1}
w_i	=	Ratio of the area of stratum i to the sum of areas of tree biomass estimation strata (i.e. $w_i = A_i/A$); dimensionless
$b_{TREE,i}$	=	Mean tree biomass per hectare in stratum i; t d.m. ha^{-1}

The average tree biomass per hectare in a stratum was estimated using equation 16 of that tool:

$$b_{TREE,i} = \frac{\sum_{p=1}^{n_i} b_{TREE,p,i}}{n_i}$$ Equation (16)

Where:

$b_{TREE,i}$	=	Mean tree biomass per hectare in stratum i; t d.m. ha^{-1}
$b_{TREE,p,i}$	=	Tree biomass per hectare in plot p of stratum i; t d.m. ha^{-1}
n_i	=	Number of sample plots in stratum i.

Tree biomass per hectare on a fixed area plot was estimated using a combination of allometric equations (See section 6.2.2 Biomass Plot Measurement) based on tree sizes and consolidated biomass expansion factors for the vegetation classes considered in this project, as applied in Brazil's Fourth National Communication to the United Nations Framework Convention on Climate Change, section 2.6 LAND USE, LAND USE CHANGE AND FORESTS SECTOR.[70]

[70] Pages 112-116. BRASIL. USO DA TERRA, MUDANÇA DO USO DA TERRA E FLORESTAS.[versão de consulta pública] 2020. Brasília, DF: Ministério da Ciência, Tecnologia e Inovação. 291p., 2020.

The variance of carbon stock of the ABGs within each stratum was estimated by applying the procedure given in Equation B.8 of Appendix B of Methodology VM0009:

$$\hat{\sigma}_k^2 = \frac{\sum_{j\in\mathcal{P}_k}\left(y_{j,k}\right)^2 - \left(\sum_{j\in\mathcal{P}_k} y_{j,k}\right)^2/\#(\mathcal{P}_k)}{\#(\mathcal{P}_k) - 1} \qquad \text{[B.8]}$$

Variables	$\hat{\sigma}_k^2$ = estimated variance in stratum k $y_{j,k}$= a quantity estimated for or measured on plot j in stratum k $\mathcal{P}_k$ = set of all plots in stratum k
Section References	B.1.4
Comments	The equation is used to estimate the within-stratum variance of the variable y for stratum k.

To access the total standard error associated with estimating the carbon stock of the ABG within the PAA, equation B.10 was employed:

$$\text{U} = \sqrt{\sum_{k\in\mathcal{S}}\left[\frac{A_k^2\hat{\sigma}_k^2}{\#(\mathcal{P}_k)}\left(\frac{N_{P,k} - \#(\mathcal{P}_k)}{N_{P,k}}\right)\right]} \qquad \text{[B.10]}$$

Variables	U = estimated standard error of the total for the selected carbon pool $\hat{\sigma}_k^2$ = estimated variance in stratum k A_k = area of stratum k $N_{P,k}$ = total number of possible plots in stratum k $\mathcal{P}_k$ = set of all plots in stratum k $\mathcal{S}$ = set of all strata in the area

The sampling intensity of 80 plots achieved an error of ± 14.95%, for a 95% confidence interval of probability (Table 23). All calculations were balanced by the statistical rigor of good forest inventory practices with respect to the carbon stock estimation methods indicated by the methodology in use (VM0009, Version 3.0, Sectoral Scope 14).

Table 24 Estimated carbon stock in above ground tree biomass, standard errors and sample size for each stratum in the PAA.

Strata	Average Carbon Stock Value (tCO_2e ha^{-1})	Standard Error (tCO_2e ha^{-1})	Sample Size*
CM	195.87	11.98	20
FA	132.04	8.02	20
SA	26.84	1.64	20
SD	60.46	3.92	20

* The sample size achieved a standard error of the mean within a 95% confidence interval.

Figure 73: Sampling points for biomass and soil data collection at PAI. Source: Guimarães (2020)

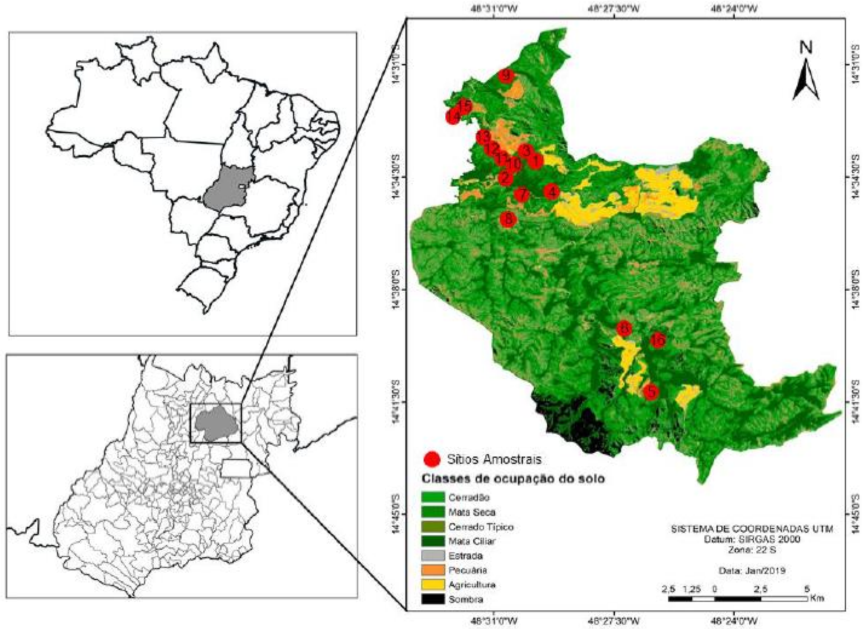


Figure 74. Sampling design exemplifying a sampling unit and transect form containing five parcels each. On the left, sampling unit allocated in dry forest, and on the right in a wooded savanna area

The list of allometric equations used to calculate aboveground biomass from field measurements of dendrometric variables, as well as the sources, are in the table below

Table 25: List of alometric equations for each vegetation type

Vegetation type	Equation	R^2 ajust.	Syx (Kg)	Syx (%)	Source
Sa	y = [(409,0469739 * v0.97545) * 1,17]/106	0,92	3,73	73,6	Roitman et al., 2018
Sd	y = exp[-12,2999911901 + 2,6961223975 · ln(dap) + 0,8094354054 · ln(h)]	0,94	127,03	49,83	Scolforo et al., 2008
Fa	y = exp[-10,439791707 + 2,1182873001 · ln(dap) + 0,8339834928 · ln (h)]	0,97	98,09	46,26	Scolforo et al., 2008
Cm	y = exp[-10,5940 + 1,6027· ln(dap) + 1,5879 · ln(h)]	0,88	98,23	49,37	Scolforo et al., 2008

y = aboveground tree biomass (Mg), dap = diameter at breast height (m), h = height (m), v = cylindrical volume (dm3).

Observing the requirements of section 9.3.3, the allometric equations used in this project are justified for the following reasons:

- For each selected allometric equation, the proportion of the total carbon stocks predicted by the equation has been calculated, and the biomass total (from BEF) is low of tree biomass used in this project Biomass expansion factors (BEF) for different compartments of necromass and herbaceous-shrubby strata were calculated based on direct physical measurements in field. The vegetation that had the highest contribution of the non-tree component to the total aboveground biomass was Sa (18%), followed by Sd (13%), Fa (6%) and Cm (4%). The comparison of the total biomass, from the BEF, and the biomass only of the tree component (tree aboveground biomass), calculated based on the allometric equations, are in the next table.

Table 26: Total biomass values, considering the calculation with BEF, and the tree biomass values calculated from allometric equation (adapted from Guimarães (2020))

Vegetation type	Total Biomass (tn)	Tree Biomass(tn)	Ratio (Tree/Total)
Sa	112,440.10	91,707.3	0.82
Sd	315,826.58	273,773.5	0.87
Fa	375,426.90	352,812.1	0.94
Cm	647,423.68	619,258.2	0.96

- The selected allometric equation was employed for the first time to estimate carbon stocks in the project area between 2017 and 2019, which corresponds to the first monitoring period.
- Since the equations have been fit within the Cerrado domain in plant typologies identical to those that are part of the project area, validations as suggested in sections 9.3.3.1 or 9.3.3.2. are not required. The elaboration of the equations prioritized the criteria based on the destructive sampling, its adjustment [number of sampled trees (n), its amplitude and diametric distribution],

adjustment statistics [adjusted coefficient of determination (R^2adjust) and error pattern], graphical analysis of errors and geographic proximity to the study area (Guimarães, 2020).

- The equations are suitable for the project area, since they were taken from specialized scientific literature, where technical criteria for direct and indirect measurement of dendrometric variables were observed, within the required statistical rigor. In addition, the studied regions represent the project area, from a regional, climatic variables and vegetation typologies point of view, and they were taken within the limits of the Cerrado, therefore, within of the geographic boundary. Allometric equation for Sa was fit based on destructive method and data from the field measurements of diameter and height by using regression techniques (Roitman et al, 2018). The study was divided in a series of steps: a) evaluating regression techniques and variables to identify the individual-tree AGB model with the strongest fit; b) using the selected model to estimate and determine biomass variation of Wooded Savannah (Sa) in the Cerrado; and c) it was developed models to estimate plot AGB density based on plot basal area data. The equations for Sd, Fa and Cm are part of a joint project between the government of Minas Gerais State, State Forest Institute (IEF) and the Federal University of Lavras (UFLA) called "Mapping and inventory of native flora and reforestation in Minas Gerais", where there was an extensive field survey for forest inventory, and tree density and volume samples, from destructive approach over 539 trees, to fit allometric equations by vegetation type and sub-region (Scolforo et al, 2008).

Regarding the soil and seeking to optimize the sampling effort, soil collections will be carried out aligned with the biomass plots in the PAA.Considering the sampling design and intensity applied by Guimaraes (2020), sample sufficiency was verified for the sample size of 80 plots, considering the guidelines indicated insection 4.3.3.5.4 of the GPG-LULUCF (IPCC, 2006), as well as section B.1.4. in Appendix B. of methodology VM009.

To estimate the total soil carbon stock, the corrected bulk density was calculated for each plot using equation [B.27].

$$\rho_{soil,j,k} = \frac{m_{soil,j,k} - m_{rf,j,k}}{v_{soil,j,k} - v_{rf,j,k}}$$ [B.27]	
Variables	$\rho_{soil,j,k}$ = bulk density of fine portion of soil sample in plot j in stratum k $m_{soil,j,k}$ = dry mass of soil sample take from plot j in stratum k. $m_{rf,j,k}$ = dry mass of rock fraction of soil sample in plot j in stratum k $v_{soil,j,k}$ = total volume of soil sample in plot j in stratum k $v_{rf,j,k}$ = volume of coarse fragments (> 2mm) in soil sample taken in plot j in stratum k

Subsequently, the soil carbon stock per unit area, for plot j in stratum k, was determined using equation [B.28].

$$SOC_{j,k} = \frac{44}{12} \times 10 \times p_{CF\,soil,j,k} \times \rho_{soil,j,k} \times d_{j,k} \times (1 - \frac{v_{rf,j,k}}{v_{soil,j,k}})$$ [B.28]	
Variables	$SOC_{j,k}$ = soil carbon stock in plot j stratum k $\rho_{soil,j,k}$ = bulk density of fine portion of soil sample in plot j in stratum k $p_{CF\,soil,j,k}$ = carbon fraction of soil sample in plot j in stratum k $d_{j,k}$ = depth of soil sample in plot j in stratum k $v_{soil,j,k}$ = total volume of soil sample in plot j in stratum k $v_{rf,j,k}$ = volume rock fragments (> 2mm) in soil sample taken in plot j in stratum k

The average soil carbon stock was estimated from equation [B.9].

$$z = \frac{1}{\sum_{k \in \mathcal{S}} A_k} \sum_{k \in \mathcal{S}} \frac{A_k}{n_k} \sum_{j \in \mathcal{P}_k} y_{j,k}$$ [B.9]	
Variables	z = the estimated average in the sampled area, for carbon this is c and for degredation this is $p_{L\,DEG}$ A_k = the area of stratum k n_k = number of plots in stratum k $y_{j,k}$= a quantity estimated for or measured on plot j in stratum k $\mathcal{P}_k$ = set of all plots in stratum k $\mathcal{S}$ = set of all strata

We then proceeded to check the variance estimated within each stratum by equation [B.8].

$$\hat{\sigma}_k^2 = \frac{\sum_{j \in \mathcal{P}_k} (y_{j,k})^2 - \left(\sum_{j \in \mathcal{P}_k} y_{j,k}\right)^2 / \#(\mathcal{P}_k)}{\#(\mathcal{P}_k) - 1}$$ [B.8]	
Variables	$\hat{\sigma}_k^2$ = estimated variance in stratum k $y_{j,k}$= a quantity estimated for or measured on plot j in stratum k $\mathcal{P}_k$ = set of all plots in stratum k
Section References	B.1.4
Comments	The equation is used to estimate the within-stratum variance of the variable y for stratum k.

And finally, the estimation of the standard error of the total soil carbon stock as equation [B.10], excluding the finite population correction factor.

$$U = \sqrt{\sum_{k \in \mathcal{S}} \left[\frac{A_k^2 \hat{\sigma}_k^2}{\#(\mathcal{P}_k)} \left(\frac{N_{P,k} - \#(\mathcal{P}_k)}{N_{P,k}} \right) \right]} \quad \text{[B.10]}$$

Variables	U = estimated standard error of the total for the selected carbon pool $\hat{\sigma}_k^2$ = estimated variance in stratum k A_k = area of stratum k $N_{P,k}$ = total number of possible plots in stratum k $\mathcal{P}_k$ = set of all plots in stratum k $\mathcal{S}$ = set of all strata in the area

Observing the statistical rigor in compliance for the applied methodology, the sampling intensity of 80 plots achieved a standard error around the overall mean of the SOC for a confidence interval of 95% probability, see Table below.

Table 27 Soil carbon stocks, calculated standard error and sample size for each stratum in the PAA.

Strata	Carbon Stock (tCO2e/ha)	Standard Error (tCO_2e/ha) *	Sample Size
CM	435.7	43.49	20
FA	349.4	13.49	20
SA	272.93	21.10	20
SD	291.6	25.04	20

* The sample size achieved a standard error of the mean within a 95% confidence interval

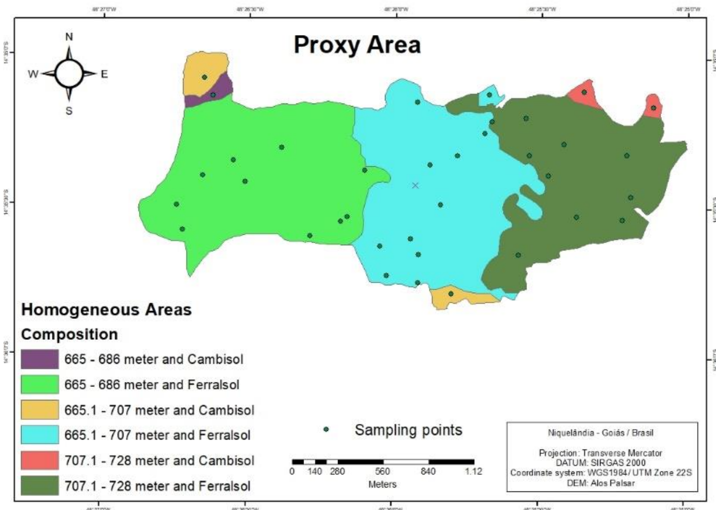
In the proxy area, for the spatialization and definition of the sample size, the standard recommendations of FAO and VM0009 were used.

As suggested by the cited references, the constant homogeneous areas within the proxy area were identified. To identify these homogeneous areas, the altitude and soil levels present in the area were superimposed. VM0009 and FAO still recommend overlapping climate unit, biome and vegetation, but given the scale of the study, these conditions are all uniform (no variation).

The hypsometric amplitude of the proxy area is 63 m (maximum altitude of 728 m and minimum of 665). The categorization was done in three topographic units, these being from 665 to 686 m, 686.1 to 707m and 707.1 to 728m. Within these units, according to the overlapping of the maps present in the proxy area (Cambisols and Ferralsolos), coincident plots with the same soil and altimetric class were verified.

Finally, a total of six homogeneous areas are concluded, three of which occupy most of the proxy area for which 10 points were determined for sample collection and three small points for which 1 point for sample collection was designated for each, totalizing 36 sample points, as shown in the figure below.

Figure 75. Sample points for soil collection in the proxy area.



The SOC monitoring frequency has been a hotspot in recent decades, with a large number of publications on the subject in high-impact indexed journals. In this sense, Paul (2007)[71] suggests that when thinking about a monitoring plan, one should be aware of environmental variables and, mainly, temperature variations governed by climatic seasons. This concern is not valid for our case, since according to the Köppen climate classification, the area is located in a monsoon climate (Aw), so that there are no considerable variations in temperature throughout the hydrological year, only the passage between a dry season and a rainy season.

In this sense, document VM0009 categorically suggests (on pages 59, 177 and 179) that the SOC sampling limit interval is up to 5 years, an interval that does not abruptly differ from that proposed by the authors cited by FAO (2019)[72], in which it would have an interval of three 3 years according to Donovan (2013)[73] and an interval between 6 and 10 years according to Smith (2004)[74].

According to the scenario predicted by Paul (2007), in which the degree of humification of organic matter would be directly linked to temperature and humidity (since the use and management will not change), we conclude that the maximum interval stipulated by VM0009 is applicable to the scenario of the area under

[71] Paul, E.A. 2007. Soil Microbiology, Ecology and Biochemistry. Third edition. Academic Press. 535 pp. Accessed at: https://www.sciencedirect.com/science/article/pii/B9780080475141500056

[72] FAO. 2019. Measuring and modelling soil carbon stocks and stock changes in livestock production systems: Guidelines for assessment (Version 1). Livestock Environmental Assessment and Performance (LEAP) Partnership. Rome, FAO. 170 pp. Licence: CC BY-NC-SA 3.0 IGO.. Accessed at: https://www.fao.org/3/ca2934en/CA2934EN.pdf

[73] Donovan, P. 2013. Measuring soil carbon change: A flexible, pratical, local method [onlin]. [07 January 2019] https://soilcarboncoalition.org/files/MeasuringSoilCarbonChange.pdf

[74] Smith, P. 2004. How long before a change in soil organic carbon can be detected. Global Change Biology, 10: 1878-1883. Accessed at:https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2004.00854.x#:~:text=With%20a%20doubling%20(100%25%20increase,5%20years%20(Table%202).

monitoring of this project. Therefore, the monitoring of changes in SOC stocks in the proxy area will initially be carried out every 5 years.

5.3.3 Monitoring Team Organizational Structure

ERA and ECCON are the organizations responsible for monitoring, coordinating monitoring activities and processes for the initial PAI. The teams responsible for carrying out monitoring activities and the roles within each team are as follows:

Technical Team

- Technical Manager – responsible for overseeing technical work to methodological and standard requirements, conducting quality control checks.
- Technical Analyst – responsible for conducting technical analyses related to remote sensing and project/baseline emissions calculations.

Field Team:

- Field Coordinator – responsible for training team members, conducting quality control checks, data recording and transcription, and conducting ground-truthing of any identified areas with disturbances.
- Forest Engineers and/or Biologists – responsible for taking carbon stock measurements in the field based on the guidebook in Appendix C Monitoring Methods, and support Technical manager in data collection and transcription.

5.3.4 Measures and Oversight for Quality Control, Accuracy and Data Archiving Procedures

A standard operating procedure (SOP) has been developed for maintaining quality control, accuracy and defining data archiving procedures. This SOP can be found in the supporting project folder. The technical team is responsible for carrying out all quality control measures on remote sensing, carbon stock estimates, and GHG quantification. ECCON is responsible for carrying out all quality control checks of field data collected at the initial PAI and for ensuring that the data collected is done in keeping with the guidelines set for by the IFN in Appendix C Monitoring Methods. If a systemic deviation is found in the measurement and re- measurement of the parameter, the deviation is to be investigated and resolved. When updating data stored electronically, the file should be versioned.

The field teams and the technical teams minimize error by working to check the identification of tree species and diameter measurements, and to review the data collected and inputted. If drones are used to measure carbon stock, all images will be stored electronically and backed-up.

To reduce and eliminate transcriptional error, a subset of spreadsheets is proofed by re- reading the field notebooks and comparing it to the data that has been entered. Checks are also made for any values or variables that are outliers against the recorded data, and corrected if deemed to be transcription errors. All publicly available satellite data used in monitoring, validation, verification and certification will be archived and made available to auditors.

5.3.4.1 Monitoring Conversion and Leakage

To ensure consistency and quality results, the Monitoring Team uses the MapBiomas database and platform to detect conversion events as well as perform the necessary imagery processing, interpretation, and change detection procedures. As described in Section 3.4.6 MapBiomas is a credible platform that strictly adheres to best practices and good practice guidelines as well as methodological requirements. All data sources and analytical procedures will be documented and archived.

Accuracy of the MapBiomas classification, will be assessed by comparing the classification with ground-truthing as well as drone imagery. Any data collected from ground-truth points will be recorded (including GPS coordinates, identified land-use class, and supporting photographic evidence) and archived. All high-resolution drone imagery used to assess classification accuracy will also be archived.

Ground-truthing and drone monitoring will also occur in PAA polygons classified as high-risk areas, for example in between the roads and other properties with agriculture areas, where the width of the strip is approximately 60 meters.

All data sources and processing, classification and change detection procedures will be documented and stored in a dedicated long-term electronic archive.

Information related to monitoring conversion in the archive will include:

• Forest / non-forest maps;

• Documentation of software type and procedures applied (including all pre-processing steps and corrections, spectral bands used in final classifications, and classification methodologies and algorithms applied), if applicable; and

• Data used in accuracy assessment - ground-truth points (including GPS coordinates, identified land-use class, and supporting photographic evidence) and/or sample points of high-resolution imagery.

In the initial PAI, the Landholder CBA is constantly patrolling the PAAs, and the area counts with security guards in the perimeters. In addition, the road access entrances to the farm are blocked with gates, fences and personnel. Furthermore, supporting entity ECCON will make yearly visits to the PAA, as well as utilize drone technology *in situ*.

5.3.4.2 Monitoring Fire Disturbances

Fire disturbances will be identified through:

- Brazil's National Space Agency (INPE) Fire Monitoring Program, using the open data portal https://queimadas.dgi.inpe.br/queimadas/dados-abertos/;
- Satellite imagery; and
- Landholder interviews and registered in the Landholder Report Card.

5.3.4.3 Forest Carbon Stocks and Degradation

The following steps will be taken to control for errors in field sampling and data analysis:

1. Trained field crews will carry out all field data collection and adhere to standard operating procedures developed by field team. Field crew leaders will be responsible for ensuring that field protocols are followed to ensure accurate and consistent measurements. To ensure accurate measurements, the height of diameter at breast height (1.3 m) will be periodically re-assessed by personnel during the inventory.
2. Field measurement data will be recorded on standard field data sheets and entered into an excel database for data management and quality control. Potential errors in data entry (anomalous values) will be verified or corrected consulting the original data sheets or personnel involved in measurement. Original data sheets will be permanently archived in a dedicated long-term electronic archive. The electronic database will also archive GIS coverages detailing forest and strata boundaries and plot locations.

Personnel involved in the revising of the baseline will have detailed knowledge in regards to spatial modeling and land use change and deep familiarity with REDD methodologies. Remote sensing data used will include officially published dataset, or classified imagery, which meets accuracy assessment requirements as laid out in the methodology.

All measurement and monitoring equipment requiring calibration will be calibrated according to the equipment's specifications and/or relevant national or international standards.

5.3.4.4 Data Archiving

Data archived will be maintained through at least two years beyond the end of the project crediting period. All project records are secure and retrievable. This includes project documents saved on the desktop of the Technical Manager and stored in ERA's and ECCON's database. An identical version of the project documents are remotely saved on an external hard drive. Furthermore, many project documents (e.g., VCS Project Description, Monitoring Reports, Project Implementation Reports, Validation and Verification Reports, etc.) are publicly available and stored on the Standards' website. 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.

5.3.5 Revision of the Baseline

The baseline will be revised every 10 years from the project start date. Revising the baseline will include reviewing the datasets used to define the historic baseline conversion for a new reference period.

6 ACHIEVED GHG EMISSION REDUCTIONS AND REMOVALS

6.1 Data and Parameters Monitored

The data monitored in the current period [m=1] were also used in the ex-ante calculation for the baseline estimates. According to the methodology, In the case where project validation and the first verification event fall on the same date, then [m=0] parameters will be equal to [m=1] parameters. The following table summarizes the parameters that have been effectively monitored during the monitoring period. of project emission and leakage emission.

Data / Parameter	$C_{B}^{[m1]}$
Data unit	tCO_2e / ha
Description	Baseline carbon stocks at the end of the current monitoring period
Source of data	Set of all carbon pools in the proxy area.
Description of measurement methods and procedures to be applied	Average carbon stocks in each carbon pool of the proxy area.
Frequency of monitoring/recording	Every time measured
Value monitored	18.59 (biomass) and 110.8 (soil).
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	Used in the equations F20 (biomass), F25 (soil) and F57 (both).
Calculation method	N/A
Comments	Carbon original value to biomass from Third National Communication to UNFCCC is 5.07 tn/ha, however the number was converted to tCO_2e / ha.

Data / Parameter	$C_{B\ SOC}^{[m1]}$

Data unit	$tCO2e$
Description	Carbon not decayed in SOC at the end of the current monitoring period
Source of data	Proxy area.
Description of measurement methods and procedures to be applied	Calculated from DEM $_{soc}$
Frequency of monitoring/recording	Every monitoring period
Value monitored	378,002.43
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F16
Calculation method	Direct application of the equation F33.
Comments	The value is the sum of $C_{B\ SOC}$ [m] of each vegetation class.

Data / Parameter	$C_{B\ SOC}$ [m1]
Data unit	$tCO2e$ / ha
Description	Soil carbon at the end of the current monitoring period
Source of data	Proxy area.
Description of measurement methods and procedures to be applied	See Section 6.2.3
Frequency of monitoring/recording	Every monitoring period
Value monitored	110.8
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F25.
Calculation method	N/A
Comments	

Data / Parameter	$C_{P\,[m]}$
Data unit	tCO2e / ha
Description	Project carbon stocks at the end of the current monitoring period.
Source of data	Set of all carbon pools in the project accounting area.
Description of measurement methods and procedures to be applied	Average carbon stocks in each carbon pool of the accounting project area.
Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	145.54 (biomass); 337.40 (soil)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods.
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equations F41 and F57.
Calculation method	Average carbon pools of the vegetation classes.
Comments	The values for the carbon pools (biomass and soil) were obtained for each vegetation class and applied to the BEM (F20) and SEM (F25) according to the area that each one covers, within the PAA. Here, it is presented the average value. Since the current monitoring period is the first monitoring, the value is the same as prior to the first verification event ($C_{P\,[m=0]}$), as approved by methodology VM0009.

Data / Parameter	$C_{P\,b\,[m1]}$
Data unit	tCO2e/ha
Description	Baseline scenario average carbon stock in selected carbon pools from biomass.
Source of data	Project accounting area.
Description of measurement methods and procedures to be applied	AGOT was obtained by literature (Guimarães, 2020), that can be found here: https://repositorio.bc.ufg.br/tede/bitstream/tede/11223/3/Tese%20-%20Luanna%20Elis%20Guimar%c3%a3es%20-%202020.pdf.

Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	103.81 (AGOT); 41.74 (BGOT)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F17.
Calculation method	AGOT was obtained by allometric equation. BGOT was estimated by applying root-shoot-ratio of 1.58 over AGOT.
Comments	The value is about the carbon biomass pools that has been defined in this project to be Above-ground other tree and Below-ground other tree. The values were used in the equations according to vegetation class (between parenthesis).

Data / Parameter	$C_{P\,s\,b}$ [m1]
Data unit	tCO2e/ha
Description	Average carbon in the set of biomass pools for each project accounting area stratum s
Source of data	Project accounting area
Description of measurement methods and procedures to be applied	See appendix C.
Frequency of monitoring/recording	Every time measured (≤5 years)
Value monitored	73.77 (SD); 81.59 (SA); 158.44 (FA); 268.35 (CM)
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F23
Calculation method	AGOT was obtained by allometric equation. BGOT was estimated by applying root-shoot-ratio over AGOT.

Comments	PAA was stratified into four vegetation class: Forested Savannah (SD), Wooded Savannah (SA), Semi-deciduous Forest (FA), and Deciduous Forest (CM).

Data / Parameter	$E^{[m1]}_{\Delta\ GER}$
Data unit	tCO2e
Description	GERs for the current monitoring period
Source of data	Proxy Area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*377,121*
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of GER calculations
Purpose of data	Used in equation F54.
Calculation method	Equation F53
Comments	The value is result of the sum from $E^{[m]}_{GER}$ of the each vegetation classes.

Data / Parameter	$E^{[m1]}_{\Delta\ NER}$
Data unit	tCO2e
Description	NERs for current monitoring period
Source of data	Proxy Area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*316,781.6*

Monitoring equipment	N/A
QA/QC procedures to be applied	Review of NER calculations
Purpose of data	Used in equation F56
Calculation method	F.55
Comments	The value is result of the sum from $E^{[m]}_{\Delta\ NER}$ of each vegetation class .

Data / Parameter	$E_B^{[m1]}$
Data unit	tCO2e
Description	Cumulative baseline emissions at the end of the current monitoring period
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*415,325.5*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F15
Calculation method	Calculated from F16
Comments	The value is result from sum of $E_B^{[m]}$ of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m1]}_{B\ \Delta}$
Data unit	tCO2e
Description	Change in baseline emissions
Source of data	Proxy area measurements

Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*332,828.3*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F16 and F53.
Calculation method	From equation F15.
Comments	The value is result from sum of the parameters of each vegetation classes, in current monitoring period and in the beginning of project. It was calculated by the difference between the baseline emission from biomass in the current monitoring period and the value in the beginning of the project.

Data / Parameter	$E^{[m1]}_{B\,\Delta\,BGB}$
Data unit	tCO2e
Description	Change in baseline emissions from below-ground biomass
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	*59,532*
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F32
Calculation method	From equation F31

Comments	The value is result from sum of the parameters of each vegetation classes, in current monitoring period and in the beginning of project. It was calculated by the difference between the baseline emission from below-ground biomass in the current monitoring period and the value in the beginning of the project.

Data / Parameter	$E^{[m1]}{}_{B\ BGB}$
Data unit	tCO2e
Description	Cumulative baseline emissions from below-ground biomass at the end of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	75,217.6
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F31.
Calculation method	From equation F30
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m1]}{}_{B\ \Delta\ soc}$
Data unit	tCO2e
Description	Baseline change in emissions from soil carbon
Source of data	Proxy area measurements
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.

Frequency of monitoring/recording	Every monitoring period
Value monitored	435,025
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F16 and F33
Calculation method	Calculated from F26.
Comments	The value is result from sum of the parameters of each vegetation classes, in current monitoring period and in the beginning of project. It was calculated by the difference between the baseline emission from soc in the current monitoring period and the value in the beginning of the project.

Data / Parameter	$E^{[m1]}_{B\ soc}$
Data unit	tCO2e
Description	Cumulative baseline emissions from soil carbon at the end of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	544,121.8
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F26.
Calculation method	From equation F25.
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m1]}_{B\ BM}$
Data unit	tCO2e
Description	Cumulative baseline emissions from biomass at the end of the current monitoring period
Source of data	Measurements in the proxy area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	249,206.1
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equations F16 and F30
Calculation method	Calculated for F15
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m1]}_{B\ A}$
Data unit	tCO2e
Description	Cumulative emissions allocated to the buffer account at the end of the current monitoring period
Source of data	VCS Non-Permanence Risk Tool
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	60,339
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F55
Calculation method	Direct calculation from 16% on GER's
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	$E^{[m1]}_{L}$
Data unit	tCO2e
Description	Cumulative emissions from leakage at the end of the current monitoring period
Source of data	Measurements in the leakage area(s)
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records

Purpose of data	Used in the equation F44
Calculation method	Calculated from F45
Comments	There was no Leakage emission.

Data / Parameter	$E^{[m1]}_{L\ \Delta}$
Data unit	tCO2e
Description	Change in emissions due to leakage
Source of data	N/A
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in the equation F53
Calculation method	Calculated from F44
Comments	There was no Leakage Emission.

Data / Parameter	$E^{[m1]}_{L\ ASG}$
Data unit	tCO2e
Description	Cumulative emissions from activity-shifting leakage in grassland areas at the end of the current monitoring period
Source of data	Measurements in the activity-shifting leakage area
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.

Frequency of monitoring/recording	Every monitoring period
Value monitored	N/A
Monitoring equipment	Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of leakage
Calculation method	Calculated from F47
Comments	There was no Leakage Emission.

Data / Parameter	$E^{[m1]}{}_{P\,\Delta}$
Data unit	tCO2e
Description	Change in project emissions
Source of data	Monitoring records for Forest Fire, Burning, logging, wood products, and natural disturbance events
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	38,204
Monitoring equipment	GIS, Equipment list in Appendix C Monitoring Methods
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of project emissions
Calculation method	F.53
Comments	

Data / Parameter	$E^{[m1]}{}_{U}$

Data unit	tCO2e
Description	Cumulative confidence deduction at the end of the current monitoring period
Source of data	N/A
Description of measurement methods and procedures to be applied	Section 8 of Methodology VM0009.
Frequency of monitoring/recording	Every monitoring period
Value monitored	0
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Used in equation F53.
Calculation method	Calculated from equation F57
Comments	The calculation of the confidence deduction resulted in negative values. In this case, the value is assumed to be zero, according to recommendation of the methodology.

Data / Parameter	t[m1]
Data unit	days
Description	Time from project start date to end of current monitoring period
Source of data	Monitoring records
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	1,656
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A

Purpose of data	Calculation of baseline emissions
Calculation method	Direct count of time
Comments	Time from project start to August, 16 of 2021

Data / Parameter	U[m1]$_{EM}$
Data unit	tCO2e
Description	Total uncertainty in Baseline Emissions Models
Source of data	N/A
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period
Value monitored	2,102.98
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of baseline emissions
Calculation method	Equation F14
Comments	The value is result from sum of parameter of each vegetation class, in current monitoring period.

Data / Parameter	U[m1]$_{P}$
Data unit	tCO2e
Description	Total uncertainty in project accounting area carbon stock estimate
Source of data	N/A
Description of measurement methods and procedures to be applied	N/A
Frequency of monitoring/recording	Every monitoring period

Value monitored	1,204.36
Monitoring equipment	N/A
QA/QC procedures to be applied	Review of monitoring records
Purpose of data	Calculation of baseline emissions
Calculation method	B.10 and B34
Comments	The value is result from sum of the parameter of each vegetation class, in current monitoring period. It was calculated from uncertainty of biomass and soil (all the pools).

6.2 Baseline Emissions

Baseline emissions are calculated using the GHG Emissions Model_PAI1_FP2_GP2_FINAL workbook, see Appendix H. The value of t_{PAI} is 0, as the primary agent would have begun commercial agriculture in the PAI on the project start date of February 2nd 2017. Current baseline emissions $E_{B\,\Delta}^{[m]}$ are calculated 415,325 tCO2e during this first monitoring period.

Baseline Emissions Cumulative					
Period	GP2	FP2			Total
	Sa (wooded savannah)	Sd (forested savannah)	Fa (seasonal alluvial semideciduos forest)	Cm (montane seasonal deciduos forest)	
2/2/2017 to 12/31/2017	20,725	24,157	20,848	16,767	82,497
2/2/2017 to 12/31/2018	42,702	52,746	45,240	36,301	176,988
2/2/2017 to 12/31/2019	63,397	81,880	70,097	56,207	271,581
2/2/2017 to 12/31/2020	83,108	110,985	94,928	76,092	365,112
2/2/2017 to 08/16/2021	93,386	126,100	108,584	87,256	415,325

Cumulative baseline emissions as of the end of the first monitoring period for each selected pool are included in the Table below. The equations and calculations for these emissions are taken from the VM0009 Methodology and were included in Section 4.1 Baseline Emissions.

Table 28: Cumulative baseline emissions for selected pools

Emissions Pool	VM0009 Parameter	Total Emissions in First Monitoring Period (tCO_2e)
Biomass Emissions Model	$E_{B\,BM}^{[m]}$	249,206

Carbon not Decayed – BGB	$C_{B\ BGB}^{[m]}$	0
Soil Emissions Model	$E_{B\ SOC}^{[m]}$	544,122
Carbon not Decayed - Soil	$C_{B\ SOC}^{[m]}$	378,002
Cumulative Baseline Emissions	$E_{B}^{[m]}$	415,325

Cumulative baseline emissions are calculated using equation F.16 of the methodology:

$$E_B^{[m]} = E_{B\ BM}^{[m]} + E_{B\ SOC}^{[m]} - C_{B\ BGB}^{[m]} - C_{B\ SOC}^{[m]}$$

Please see GHG Emissions Model_PAI1 for calculations of emissions reported in the Table above.

There are four vegetation class strata for the initial PAI, Wooded Grassland (Sa), Forested Grassland (Sd), Alluvial Semi-Deciduous Seasonal Forest (Fa), Seasonal Forest (Cm). The respective carbon stocks are provided in the Table below. The following sections describe the methods used to calculate carbon stocks from each vegetation class identified in the initial PAI.

Table 29: Results from the biomass plots to calculate carbon stock for each vegetation class strata

Fitofisionomia	Densidade (ind./ha)	Área basal (m^2/ha)	Biomassa Mg ha^{-1} (±IC)	Carbono Mg ha^{-1} (±IC)
Sa	630	7,38	15,57 (5,14)	7,32 (2,42)
Sd	1525	14,50	35,09 (11,99)	16,49 (5,63)
Fa	1095	15,18	76,62 (25,60)	36,01 (12,03)
Cm	1415	16,70	113,67 (28,92)	53,42 (13,59)

Legenda: ±IC = intervalo de confiança; S_a = savana arborizada; S_d = savana florestada; F_a = floresta estacional semidecidual aluvial; C_m = floresta estacional semidecidual montana.

Legend 1: Sa = Wooded Grassland Sd = Forested Grassland Fa = Alluvial Semi-Deciduous Seasonal Forest Cm = Seasonal Forest

6.2.1 Carbon Stock Measurement

Eighty biomass plots were measured once during the monitoring period to calculate carbon stocks of the 4 identified vegetation classes. Since the project start date, the PAAs were monitored using satellite images to verify the vegetation cover and identify conversion events using the IBGE national database. In 2021, the field team validated the vegetation classes according to the IBGE vegetation class mapping classification.

During the current monitoring period, the PAI was monitored using remote sensing to verify each year the preservation of vegetation cover in the PAAs. The sources analyzed in remote sensing include images from the Landsat 8 satellite, with a spatial resolution of 30m, and from the CBERS 4A satellite, with a spatial resolution of 2 meters. In addition, data collected in loco by the LVC property management team was used.

In July 2021, a technical field visit was carried out by specialized professionals from the ECCON team. The field trip occured from July 15th to 27th 2021 in Niquelândia, Goiás, at the properties Fazenda Engenho and Fazenda Serra Negra, to visually validate the vegetation classes observed through satellite imagery. The field team recorded and identified species, notes, aerial photographs (drone) and ground level photographs (Appendix I), to validate the vegetation classes.

Fazenda Engenho has 10,172.7 ha of native vegetation included as the project's accounting area. A recent study developed in the site presented carbon stock estimates from data collected between 2017 and 2020 on aboveground biomass (Guimarães, 2020). Such study is a result of a partnership signed between the Federal University of Goiás (UFG) and CBA and this research contributed to the national forest inventory (or Inventário Florestal Nacional "IFN" in Portuguese) database on the Cerrado biome. In this context, considering that the study is in accordance with the VM0009 methodology, it was used as primary data to calculate carbon stock data of the four native vegetation classes identified. The study identified the biomass present at four vegetation classes throughout the Engenho's PAA: wooded savannah, forested savannah, seasonal alluvial semideciduous forest and montane seasonal deciduous forest. The PAA of the Fazenda Serra Negra has 1,336.48 ha. On this property, the field team validated the presence of three vegetation classes: wooded savannah, forested savannah and montane seasonal deciduous forest, see Table below.

Table 30. Occurrence of vegetation classes for each property monitored.

		Vegetation Classes	Engenho	Serra Negra
ABBREVIATIONS	Sa	Wooded savannah or Savana arborizada (SA) in portuguese	X	X
	Sd	Forested savana or savana florestada (SD) in portuguese	X	X
	Fa	Seasonal alluvial semideciduous forest or floresta estacional semidecidual aluvial (FA) in portuguese	X	
	Cm	Montane seasonal deciduous forest or floresta estacional decidual montana (CM) in portuguese	X	X

6.2.2 Biomass Plot Measurement

To measure the carbon stock, tree biomass was quantified through a stratified sample, using the indirect (non-destructive) method. In this context, 80 plots were sampled, 20 plots in each type of physiognomy found, representing 0.2 ha per vegetation class. Each sampling unit contains 5 plots of 10 x 10m and 50m apart. For each plot, the arboreal individuals were numbered and taxonomically identified to the most specific level possible. Data were obtained on the height of each individual and the diameter at breast height (DBH) measured at 1.30m in forest formations and base diameter (DB30) measured at 0.30m in savanna formations (Guimarães, 2020). The biomass of the arboreal component was estimated by applying the equations for each studied vegetation class, as explained previously.

For the other strata, such as non-arboreal and below ground, expansion factors and equations indicated by VM0009 were used, as the root-to-shoot ratio for the below ground strata. Biomass to carbon conversion factors were used based on specific literature and default values from the fourth national communication on climate change (BRASIL, 2020). Since then, carbon estimates were made for the area (ha) referring to the different classes of native vegetation.

Figure 76. Map showing the biomass plot locations at the Engenho property

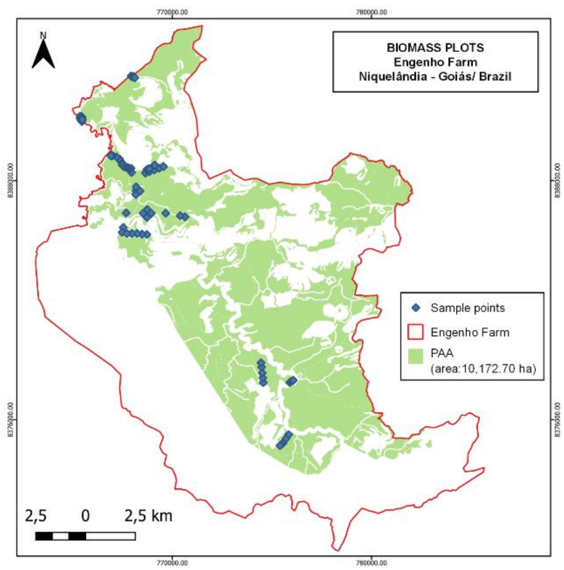


Figure 77: Example of the biomass sampling method used by Guimarães. 5 biomass parcels distributed along an aluvial forest transect at the Engenho property

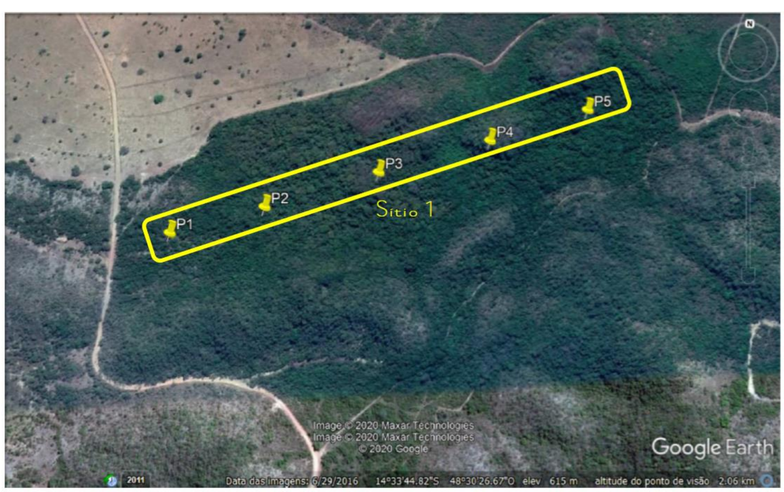


Table 31: Allometric equations used to estimate biomass for each vegetation class strata sampled

Fitofisionomia	Equação	R^2 ajust.	Syx (Kg)	Syx (%)	Fonte
(Sa)	$y = [(409{,}0469739 * v^{0.97545}) * 1{,}17]/10^6$	0,92*	3,73	73,60	Roitman et al., 2018
(Sd)	$y = \exp[-12{,}2999911901 + 2{,}6961223975 \cdot \ln(dap) + 0{,}8094354054 \cdot \ln(h)]$	0,94	127,03	49,83	Scolforo et al., 2008
(Fa)	$y = \exp[-10{,}439791707 + 2{,}1182873001 \cdot \ln(dap) + 0{,}8339834928 \cdot \ln(h)]$	0,97	98,09	46,26	Scolforo et al., 2008
(Cm)	$y = \exp[-10{,}5940 + 1{,}6027 \cdot \ln(dap) + 1{,}5879 \cdot \ln(h)]$	0,88	98,23	49,37	Scolforo et al., 2008

Legend 2: Sa = Wooded Grassland Sd = Forested Grassland Fa = Alluvial Semi-Deciduous Seasonal Forest Cm = Seasonal Forest

6.2.3 Soil Carbon Measurement

To measure the soil organic carbon stock, soil samples from the project's proxy and accounting areas were analyzed, seeking to obtain a representative sample of the different types of soil present in these areas.

To estimate the soil carbon content, three main components were analyzed: bulk density, organic carbon content and soil depth. This first monitoring period had 80 plots in the PAI and 06 in the proxy area (Figure 7), seeking to compare the organic carbon averages obtained in the two areas.

Both samples were carried out by research projects developed by specialist professors at UFG, with support from FAPEG. Professor Renata Momoli, leader of the Soil Quality project in the karst regions, was responsible for the six proxy area soil samples, in the Engenho property, while Professor Fábio Venturoli, responsible for the Cerrado Allometry project developed his research using eighty sample plots in the project's accounting area as per the Figure below.

Figure 78. Map showing the soil organic carbon plot locations at the PAI and proxy areas.

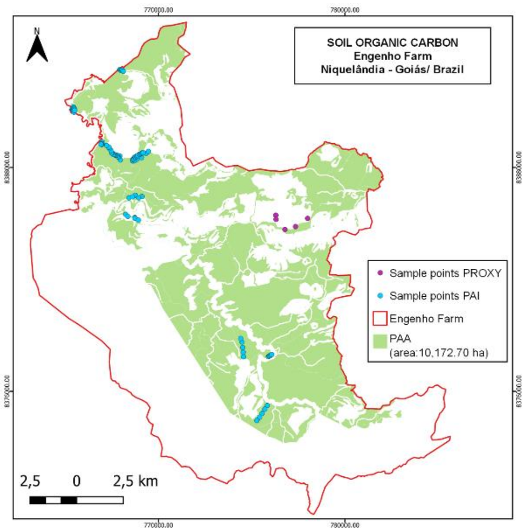


Table 32: Soil Sampling Pilot Inventory[75]

Leading Researcher	Project	Laboratory	Locality	Analisis method	Source	Comments
PhD. Renata Momoli	"Qualidade dos Solos das regiões cársticas"	LASSOLO	Municipality of Goiânia, state of Goiás, Brazil	Embrapa Soil Analysis Method	Manual de métodos de análise de solo	Laboratório de Análise de Substrato e Solo, da Escola de Agronomia da Universidade Federal de Goiás (UFG)
PhD. Fábio Venturoli	"Alometria no Cerrado"	SAFRAR	Municipally of Uberlândia, state of Minas Gerais, Brazil			Contratado pelo Serviço Florestal Brasileiro por meio de licitação para padronizar os dados do Inventário Florestal Nacional.

[75] Embrapa. 2017. The manual can be accessed at: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1085209/manual-de-metodos-de-analise-de-solo

6.2.4 Validation of Vegetation Class Strata

At the end of the initial monitoring period, the field team validated the vegetation class distribution defined by the Guimareas research from 2018. The analyzed points were georeferenced and are displayed in the Figures below.

Figure 79. Map showing the sample points locations to validate de vegetation classes in Engenho property.

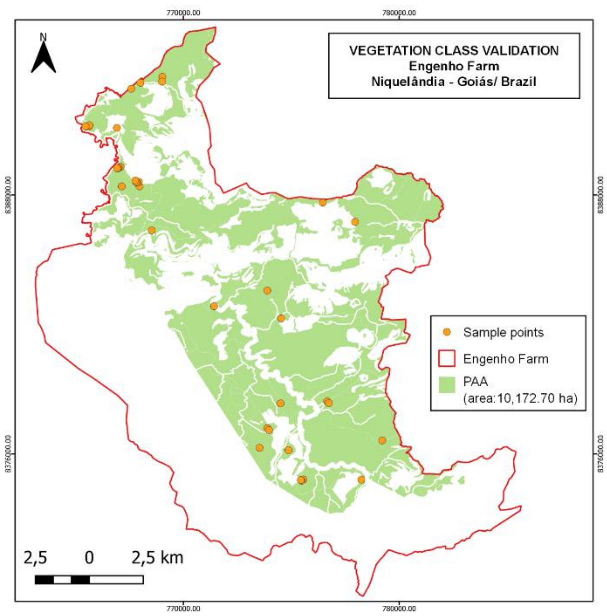
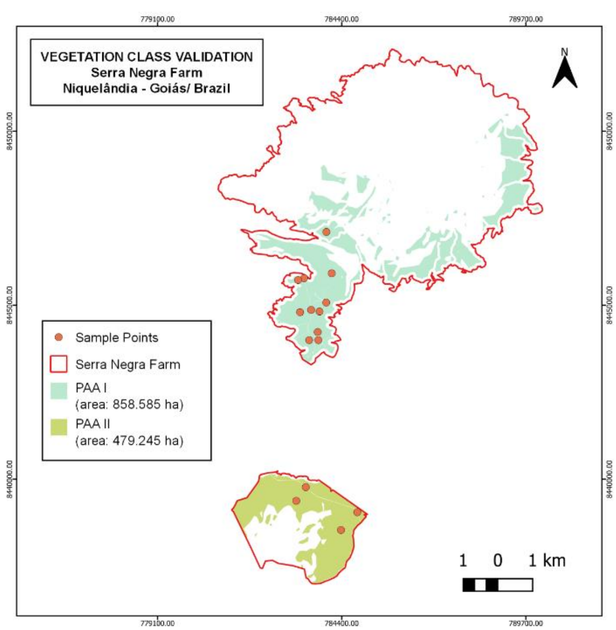


Figure 80. Map showing the sample points locations to validate de vegetation classes in Serra Negra property.



For each sample point the following qualitative data was collected in order to validate the vegetation class and characterize the level of preservation:

i) **approximate height and canopy coverage.** the height of predominant individuals from the highest stratum at each sampling point was measured using a digital tape measure, with a view to identifying the height of the canopy. Canopy cover was classified as continuous (dense cover, with greater proximity between individual trees) or discontinuous (exposed soil sections, greater distance between individual trees);
ii) **stratification level:** vegetation stratification was verified at each point visited, through visual data related to topographic characteristics, forest types, distance, volume and height;
iii) **vegetation regenerants**: in order to analyze the natural processes of vegetation, the density and diversity of regenerating native plants, including regrowths, was verified. Other factors that collaborate to verify the degree of regenerants in a given landscape were low frequency of invasive species and poorly compacted soil;
iv) **litter level**: the volume and thickness of the litter were verified, together with observations on the type of surface soil (sandy, stony, etc.) present at the site;
v) **main flora species found:** the most abundant species that characterize the vegetation type were recorded for each point sampled (APPENDIX II);
vi) **disturbances:** annotation and record of any signs of disturbances, anthropogenic or natural (fires, invasions, hunting evidence, irregular conversion areas, etc.).

Our field analysis enabled the refinement of the vegetation types present in the PAI, detecting the presence of four phytophysiognomies of the cerrado biome, validating the information available in the literature for the area (Guimarães, 2020). The main species recorded in the monitoring and their occurrence in each vegetation class are in appendix II. Below is a detailed description of each vegetation class found in the project's PAAs, based on information collected in the field, using IBGE classification and terminology and correlating relevant information present in the description of Ribeiro & Walter, as described in Section 3.2 and Guimarães (2020).

i) **Wooded savannah or Savana arborizada (SA) in portuguese**: also known as cerrado sensu stricto, encompasses landscapes (subtypes) such as typical, dense, thin and rocky cerrado. The main characteristic of the vegetation of this typology is the presence of a low and tortuous arboreal layer (20 – 50%), shrubby and herbaceous distributed over the area and with stony or sandy soil, with medium to low level of litter (Figure 1 – Appendix I).
ii) **Forested savannah or savana florestada (SD) in portuguese**: corresponds to the cerradão which is characterized as a forest formation with xenomorphic aspects and continuous crowns (8 to 15m) and canopy closure of 20 to 50%, on average, with species corresponding to those of the typical cerrado and of dry forests (Figure 2 – Appendix I).
iii) **Seasonal alluvial semideciduous forest or floresta estacional semidecidual aluvial (FA) in portuguese**: widely called riparian forest, this typology presents leaf semideciduous due to the seasonal climate and permeates river channels and other water courses (Figure 3 – Appendix I).
iv) **Montane seasonal deciduous forest or floresta estacional decidual montana (CM) in portuguese**: known as dry forest, it is characterized by forest formations with different levels of deciduousness.

This typology is recognized by its decay during the dry season. It usually occupies rocky areas of limestone origin, rich in nutrients and has no association with watercourses. The average height of the tree stratum varies from 15 to 20m and reaches 70 to 95% of coverage in the rainy season, with a large discrepancy in the dry season landscapes. It occurs in disjoint areas of the cerrado and, as it is of the "montana" type, it is usually associated with high altimetric parameters (Figure 4 – Appendix I).

6.3 Project Emissions

The VM0009 Methodology captures carbon emissions by measuring changes in carbon stocks over time. During the first monitoring period, there were 7 conversion events at the Engenho property, that affected carbon stocks. 169 hectares of native vegetation were converted for agricultural purposes. Total project emissions for the first monitoring period were calculated to be 38,204 tCO2e.

Project emissions were calculated by applying the following equations using the data presented in the following table

Project emissions = {area converted * ABG factor} + {area converted * BGB factor} + {area converted * (soil carbon – proxy carbon) * soil decay factor}

Table 33: Data to Calculate Project Emissions

Year	Area Converted & Veg. Class	Total Emissions
2017	3.47 hectares of Sa	756
2018	34.7 hectares of Sd 37.6 hectares of Sa	15,998
2019	0.2 hectares of Fa 3.3 hectares of Cm	1,848
2019	89 hectares of Sa	19,407
2020	0.9 hectares of Sa	196

In 2019 and 2020, there were fire disturbances; however, carbon stocks were not affected because of the resilient and regenerative capacity of the Cerrado biome. As described in the Project Description section 4.2.2, research shows that 95% of fire combustion in the Cerrado come from grasses, leaves and dead branches, and not from the trees and shrubs, therefore carbon stocks included in the project boundary are not significantly affected. See Appendix F for maps and evidence showing that carbon stocks regenerate in less than a year.

6.4 Leakage

6.4.1 Activity-Shifting Leakage

The Macedo farm was defined as the activity-shifting leakage area because it is a neighboring private property owned by CBA. The leakage areas were established based on the same selection criteria as the project accounting areas, meaning that the leakage polygons were establish based on agricultural aptitude. Activity-shifting leakage emissions were estimated by the following steps:

1. Calculate the Macedo farm baseline conversion rate for agriculture by looking at the historical average over the past 10 years.
2. Identify the conversion events during the first monitoring period.
3. If the conversion is higher than the normal, than it is assumed that activity-shifting leakage has occurred.
4. Calculate activity shifting leakage emissions based on the conversion above the baseline rate, and multiply by the relevant carbon stock of the identified vegetation class(es).

No planned conversion events were detected through a spatial analysis using the MapBiomas temporal analysis from 2017-2021, (see Appendix F GIS Maps) therefore, cumulative emissions from activity-shifting leakage for this monitoring period is 0 tCO2e.

6.4.2 Market Leakage

Market leakage occurs when the project may significantly change the supply of agricultural commodities such as soy and livestock. If conservation activities impact commodity markets resulting from a loss in supply, it is assumed that market leakage will occur to meet the demand.

As per the VCS Global Commodity Leakage Module: Production Approach, if the project proponent can demonstrate that the loss of commodities is less than 5% of the market, then no market leakage has occurred because the loss in commodities is so small compared to the size of the market. The following calculations were done to prove that the loss in commodities is less than 5% of the Cerrado market size:

Step 1: Amount of Production Subject to Leakage

Total project accounting area = 11,509 hectares

Baseline commodities yields = 3,400 kg/hectare (average soy productivity in Niquelandia[76])

Total amount of foregone production subject to leakage = 39M kg (39k tonnes) of soy

Step 2: Agriculture Production in Cerrado

[76] IBGE. Acessed at: https://cidades.ibge.gov.br/brasil/go/niquelandia/pesquisa/14/10193?tipo=grafico&indicador=10372

Based on data from CONAB, the total area under soy production in the Cerrado is 17 million hectares[77]. Assuming the average productivity in the Cerrado is, conservatively, 3,200 kilos per hectare, the total production is:

$$17{,}000{,}000\ ha \times 3{,}200\ \frac{kg}{ha} \times \frac{0.0001t}{1kg} = 54M\ t\ of\ soy$$

Step 3: Calculate Leakage Emissions

The foregone production subject to leakage represents less than 5% of the soy market in the Cerrado biome, calculated by dividing the amount of production subject to leakage, 39k tonnes by the total amount of soy production in the Cerrado, 54M tonnes.

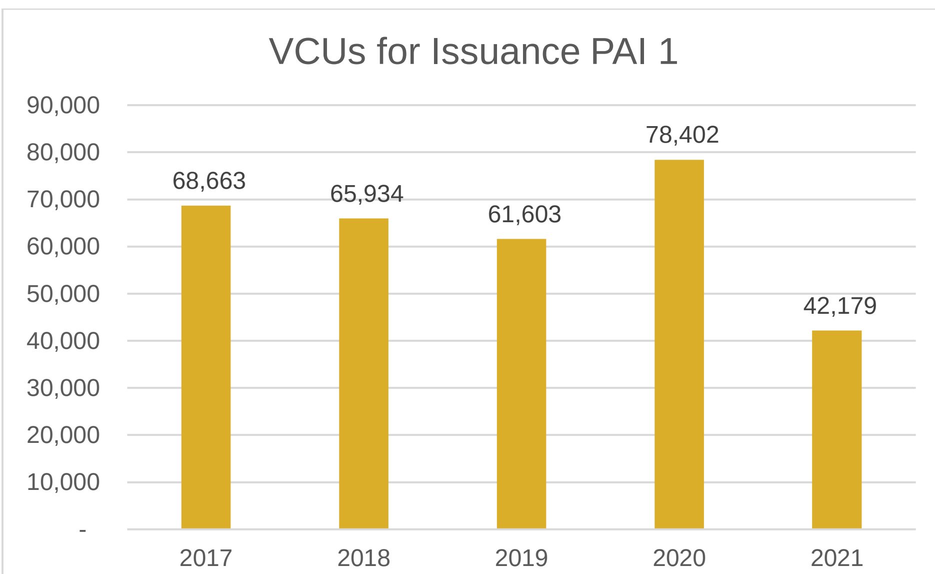
$$39{,}000\ t \div 54{,}000{,}000\ t = 0.07\%$$

As such, market leakage emissions are assumed to be 0 tCO2e.

6.5 Net GHG Emission Reductions and Removals

The following table shows the net emission reductions calculated for the initial project activity instance for the first monitoring period. The calculation confidence deductions resulted in negative value. Therefore, the default of zero was applied, according to the methodology recommended. The NERs include the buffer and therefore are equivalent to the VCUs eligible for issuance.

Figure 81: VCUs for Issuance from Initial PAI



[77] ABIOVE. 2018. Análise geoespacial da dinâmica da soja no bioma Cerrado: 2014 a 2017. Accessed at: https://abiove.org.br/wp-content/uploads/2019/02/12022019-125848-12.02.2019_analise_geoespacial_da_dinamica_da_soja_no_bioma_cerrado_2014_a_2017_v02.pdf

The confidence deduction ($U_U^{[m]}$) is calculated to be zero for this monitoring period as per the calculations found in the GHG Emissions Model_PAI1_FP2_GP2_FINAL workbook.

The Net Emissions Reductions for the current monitoring period are 316,782 tCO_2e and calculated using the following equation:

$$E_{\Delta\, NER}^{[m]} = E_{\Delta\, GER}^{[m]} - E_{BA}^{[m]}$$

Per the VM0009 Methodology, Net Emissions Reductions (NERs) are calculated by subtracting the buffer account allocation from the GERs.

The buffer account allocation was determined by following the requirements of VCS Standard v4.0. The document "Non-Permanence Risk Report for LVC PAI" provides further details on how the risk rating of 16% was determined.

The buffer account allocation is calculated per the following equation:

$$E_{BA}^{[m]} = E_{\Delta\, GER}^{[m]} - RR_{PAI}^{[m]}$$

The parameter $RR_{PAI}^{[m]}$ is the buffer pool for the current monitoring period, which totals 60,339 tCO_2e.

The current monitoring period extends from February 2nd 2017 to August 16nd 2021. Calculated NERs for these years are provided in the table below.

Table 34: Initial PAI Summary Table

Year	Baseline emissions (tCO_2e)	Project emissions (tCO_2e)	Leakage emissions (tCO_2e)	Net GHG emission reductions (tCO_2e)	Buffer pool allocation	VCUs eligible for issuance
2017	82,497	756	0	81,742	13,079	68,663
2018	94,491	15,998	0	78,493	12,559	65,934
2019	94,592	21,255	0	73,337	11,734	61,603
2020	93,532	196	0	93,336	14,934	78,402
2021	50,213	0	0	50,213	8,034	42,179
Total	415,325	38,204	0	377,121	60,339	316,782

APPENDIX I: VALIDATION OF VEGETATION CLASSES

Figure 1. Wooded savannah or Savana arborizada (SA) in portuguese – "cerrado stricto sensu"

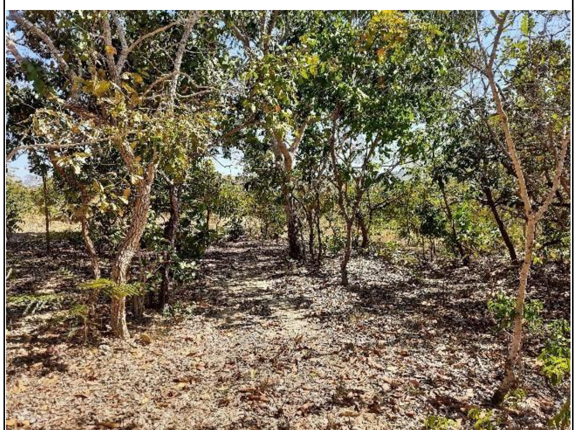
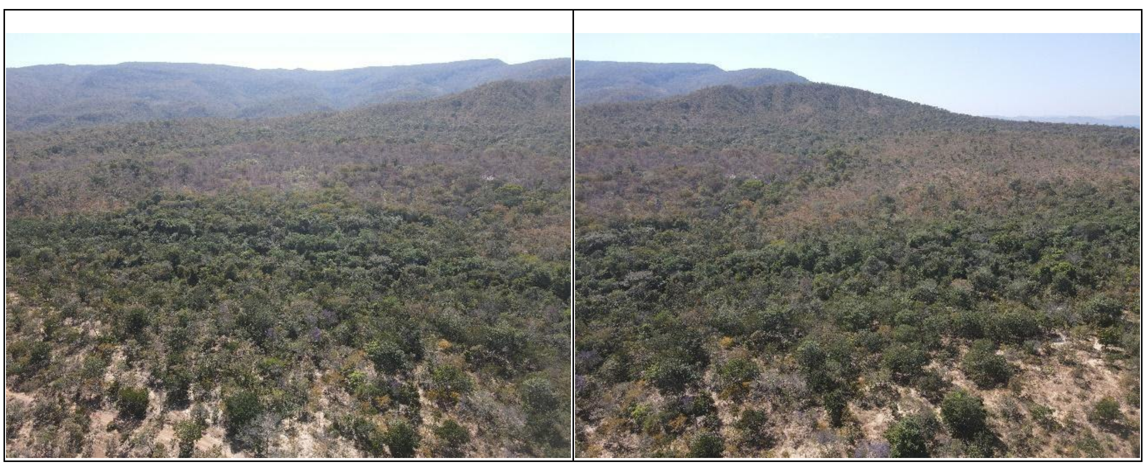
	
	
	

Figure 2. Forested savana or savana florestada (SD) in portuguese – “cerradão”



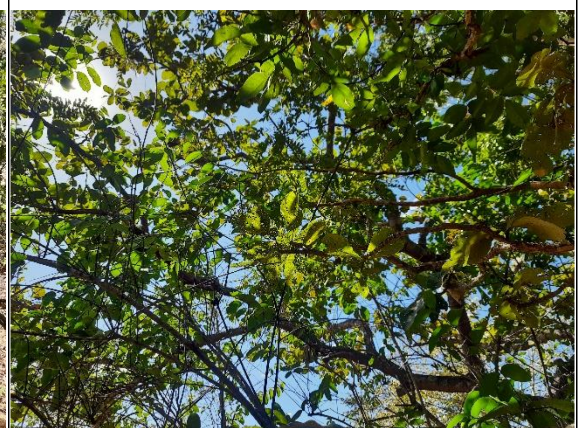
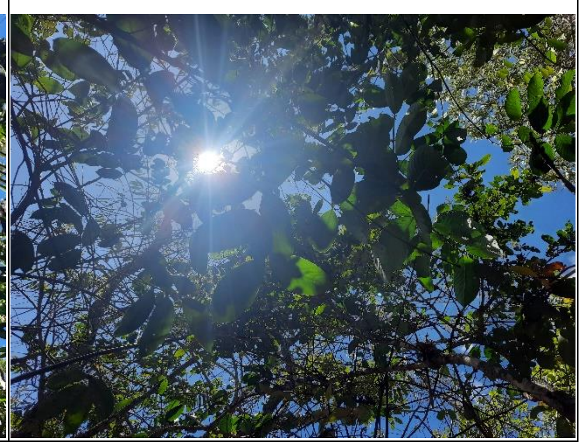
	
	
	

Figure 3. Seasonal alluvial semideciduous forest or floresta estacional semidecidual aluvial (FA) in portuguese – “mata ciliar”

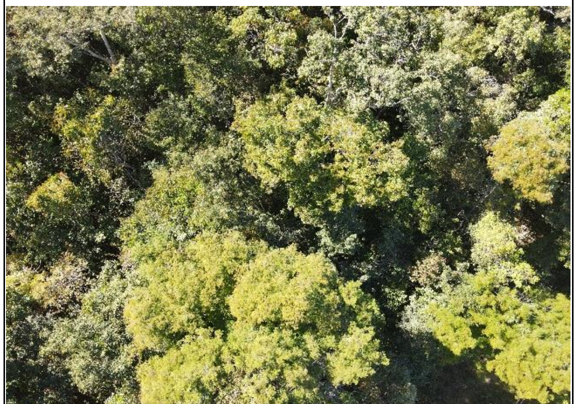
	
	
	
	

Figure 4. Montane seasonal deciduous forest or floresta estacional decidual montana (CM) in portuguese – "mata seca"











APPENDIX II: MAIN FLORA SPECIES

Tabela 1. Main flora species registered in the monitoring

Nome popular	Nome científico	SA	SD	FA	CM
Açoita cavalo	*Luehea candicans*				
Amargoso	*Vatairea macrocarpa*				
Angico-branco	*Anadenanthera colubrina*				
Araçá	*Psidium myrsinites*				
Aroeira	*Myracrodruon urundeuva*				
Bálsamo	*Myroxylon peruiferum*				
Baru	*Dipteryx alata*				
Cajuzinho	*Anacardium occidentale*				
Canela de ema	*Vellozia squamata*				
Carvoeiro	*Tachigali vulgaris*				
Casco-d'anta	*Aspidosperma nobile*				
Catulé	*Syagrus comosa*				
Cerveja-de-pobre	*Agonandra brasiliensis*				
Cocô de bode	*Hirtella glandulosa*				
Copaíba	*Copaifera langsdorffii*				
Curriola	*Pouteria ramiflora*				
Gonçalo	*Astronium fraxinifolium*				
Guatambu-do-cerrado	*Aspidosperma tomentosum*				
Ipê-tabaco	*Zeyhera tuberculata*				
Jatobá-do-campo	*Hymenaea stigonocarpa*				
Lixeira	*Curatella americana*				
Louro-branco	*Cordia glabrata*				
Macaúba	*Acrocomia aculeata*				
Mamoninha	*Mabea fistulifera*				
Moreira	*Maclura tinctoria*				
Murici	*Byrsonima* sp.				

Murici macho	*Heteropterys byrsonimifolia*				
Mutambo	*Guazuma ulmifolia*				
Negramina	*Siparuna guianensis*				
Pau-doce	*Vochysia rufa*				
Pau-jangada	*Apeiba tibourbou*				
Pau-terra	*Qualea parviflora*				
Pequi	*Caryocar brasiliense*				
Pimeta de macaco	*Xylopia aromatica*				
Pixirica	*Clidemia hirta*				
Poleiro-de-jacu	*Celtis iguanaea*				
Pororoca	*Myrsine gardneriana*				
Sucupira-branca	*Pterodon emarginatus*				
Sucupira-preta	*Bowdichia virgilioides*				
Tamboril	*Enterolobium contortisiliquum*				
Umburuçu	*Pseudobombax* sp.				
Unha-de-boi	*Diospyros sericea*				

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