NaturAll Carbon Program - Conservation Agriculture and Land Management in Brazil

Document Prepared by Neo Green Consultoria Ambiental and NaturAll Carbon Limited

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1 PROJECT DETAILS

1.1 Summary Description of the Project

The Project, “NaturAll Carbon Program - Conservation Agriculture and Land Management in Brazil”, belongs to NaturAll Carbon Limited and is located in Brazil, South America. Its area is situated in 23 states: the Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Mato Grosso, Mato Grosso do Sul, Goiás, Distrito Federal, Espírito Santo, Minas Gerais, Bahia, Sergipe, Alagoas, Pernambuco, Paraíba, Rio Grande do Norte, Ceará, Piauí, Maranhão, Tocantins, Pará, and Rondônia, covering a total area of 414,794,817.70 ha.

The project area also covers four of the six Brazilian biomes: the Caatinga, the Cerrado, the Atlantic Forest, and the Pampa.

The biomes’ biodiversity have great national and global importance. The Cerrado and the Atlantic Forest are considered world hotspots, meaning that they are natural regions whose preservation is a priority worldwide[1].

With flora considered among the richest of the tropical savannas: the Cerrado has a high level of endemism, as of its 10,000 species of plants, 44% are endemic, including almost all grasses. In the Atlantic Forest, the mammals, birds, reptiles, and amphibians total 1,361 species, of which 567 are endemic, representing 2% of all species on the planet, only for these groups of vertebrates. It also has 20,000 species of plants, of which 8,000 are endemic[2].

The Pampa Biome, located in the extreme south of the country, occupies an area of about 176,496 km^2[3] and exhibits an immense cultural heritage associated with biodiversity. There are more than 450 species of grass and 150 species of legumes. The fauna is also very important, with about 500 species of birds and 100 species of terrestrial mammals. Unfortunately, few studies relate to this biome, so these numbers could be much higher[4].

The Caatinga is the only exclusively Brazilian Biome and occupies about 900,000km^2. It has 932 identified plant species, of which, 318 are endemic. The Caatinga's uniqueness results in diverse fauna comprising more than 800 animal species, including 148 species of mammal, 510 birds, 154 reptiles and amphibians, with 240 fish species already having been registered[5].

In this context, protecting Brazilian Biomes and the communities that are part of them is extremely important, as they all face increasing threats which can cause their degradation.

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[1]Conservação Internacional. Hotspots. As Regiões Biologicamente mais Ricas e Ameaçadas do Planeta. Available at: https://www.conservation.org/docs/default-source/brasil/capa_hotspots.pdf

2 Conservação Internacional. Hotspots. As Regiões Biologicamente mais Ricas e Ameaçadas do Planeta. Available at: https://www.conservation.org/docs/default-source/brasil/capa_hotspots.pdf

3IBGE. Biomas. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html

4MMA. Pampa. Available at: https://antigo.mma.gov.br/biomas/pampa.html

5Cerratinga. Caatinga. Available at: https://www.cerratinga.org.br/biomas/caatinga/

In agriculture, studies related to GHG emissions (Greenhouse Gasses) are growing, not only due to the degradation of the biomes and the increase of desertification in sandy soils (mainly in the Northeast and South regions) but also due to the use of management practices that contribute to the increase of these emissions.

In 2020, the Brazilian agricultural sector accounted for approximately 477,670.5 Gg CO_2 equivalent emitted into the atmosphere, representing 28.5% of the country's emissions. The foremost two responsible are the enteric fermentation of cattle (51%) and soil management (31%)[6]. At a global level, it is estimated that agriculture is responsible for 14% of GHG emissions[7].

As mentioned above, inadequate management practices used in agricultural soils and the diet and breeding of ruminant animals are among the main factors contributing to the increase in global GHG emissions and climate change, which consequently impact the local biodiversity and agricultural production itself.

Because of this, it is understood that agriculture is highly dependent on climatic factors, whose changes can affect productivity and crop management, in addition to social, economic, and political factors[8].

With the increase in the temperature threatening the cultivation of plants and animals, the problem of hunger in the most vulnerable parts of the planet could get worse. Underdeveloped countries in Africa and Asia would be the most affected[9].

In Brazil, climate change could reduce the area favorable for cultivating soy, coffee, corn, rice, beans, and cotton, with an estimated loss of R$ 7.4 billion in 2020[10].

As the leading causes of high GHG emissions and agricultural soil degradation have already been identified and are linked to inadequate management practices. But, although there are several studies and research data from all over Brazil, until now, there has been no efficient program to raise awareness and support rural producers in the transition to conservationist soil management on their agricultural property.

The above statement is based on data from the IBGE (Brazilian Institute of Geography and Statistics), responsible for the Agricultural Census[11] in the country, where practices such as plowing, scarification, burning of vegetation, harrowing, high application of correctives and fertilizers, and planting monocultures are still more common in most Brazilian states than soil conservation practices.

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[6] MCTI. Estimativas anuais de emissões de gases de efeito estufa no Brasil. 2020. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/sirene/publicacoes/estimativas-anuais-de-emissoes-gee/arquivos/6a-ed-estimativas-anuais.pdf

[7] IPCC. Impacts, adaptation and vulnerability. Working group II contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change. Technical report. Cambridge University Press, Cambridge, UK/New York, USA. 2014.

[8]Lima, M, A.; Cabral, O, M, R.; Miguez, J, D, G. Mudanças climáticas globais e a agropecuária brasileira. Embrapa Meio Ambiente. Jaguariúna, SP. 2001.

[9] IPCC. Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Report. Available at: http://www.ipcc.ch/ipccreports/ar4-wg2.htm

[10] DECONTO, J. G. (Coord.). Aquecimento global e a nova geografia da produção agrícola no Brasil. Embrapa. Ed. da Unicamp, 2008. 82 p. Available at: https://cetesb.sp.gov.br/proclima/wp-content/uploads/sites/36/2008/05/clima_agricultura_brasil.pdf

[11] IBGE. Censo Agropecuário. Available at: https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/21814-2017-censo-agropecuario.html?=&t=resultados

Because of this, the project aims to encourage rural producers to adopt better management practices on their land, which means conservationist agriculture practices, based on the international initiative "4 per 1000" that aims to demonstrate that agriculture and livestock, and in particular the soils involved in these activities, can play a crucial role in food security and climate change[12].

The “4 per 1000” initiative comes from the definition that the world's soils contain 2 to 3 times more carbon than the atmosphere. If the level of carbon stored by soils in the top 30 to 40 centimeters of the ground was to increase by 0.4% (or 4%) per year, the annual increase in carbon dioxide (CO_2) in the atmosphere would be significantly reduced[13].

Adopting conservation practices in the areas of agricultural and livestock activities, the goal will be to help reduce and remove GHG from the atmosphere, increase Soil Organic Carbon (SOC), avoid soil degradation (physical, chemical, and biological), improving soil fertility and productivity, creating a better resilience to extreme weather events, providing food security and preserving natural resources and their ecosystem services.

The choice of instances inserted in the project will be based on implementing one or more regenerative or conservationist practices from 01/11/2019, which are not common in the region, and there is additionality. The agriculture activities covered in the scope of this project are:

- Reduced tillage/improved residue management;
- Improved water management;
- Improved crop planting and harvesting;
- Improved grazing practices.

The instances will also be chosen based on the crops, which can be: cotton, soybean, corn, wheat, barley, rye, sorghum, sugarcane, sunflower, canola, and pasture.

The project intends to expand over time and reach multiple instances, and a range of agriculture and livestock activities in the four Brazilian Biomes described previously to help drive resilient and sustainable agropastoral systems in these locations.

To estimate the *ex-ante* and the *ex-post* of the GHG reductions and removals by the project application in each instance, the Daycent biogeochemical model will be used together with Remote Sensing techniques as a source of data, conference, and monitoring of the areas.

The choice of this model was due to its wide use and validation in studies related to GHG emissions by agriculture, including descriptions of its performance as possibly being better than the methodology

[12] 4 per 1000. Available at: https://4p1000.org/?lang=en
[13] 4 per 1000. Available at: https://4p1000.org/discover/?lang=en

proposed by the IPCC[14]. It is also the model used by the government of the United States of America (USA) to estimate N_2O emissions from crops and pasture systems for the National Greenhouse Gas Emissions Inventory[15].

Another technology widely used in this project is Remote Sensing, which is used before analyzing the instances included in the project, validating the baselines, and monitoring the activities developed throughout the crediting period.

The Daycent model will also have inputs from an internal NaturAll Carbon geospatial database, compiled from official sources, containing information on soil classification and texture, historical land use and occupation, project boundaries, and other necessary parameters. In addition, historical, real-time, and future climate data will be used from networks of physical and virtual weather stations, such as the National Institute of Meteorology of Brazil and NASA POWER (Prediction Of Worldwide Energy Resources).

The quantification of GHG reductions or removals from conservation practices adopted in the instances inserted in the project area is based on the VM0042 v2.0 Final Draft and all the technologies described in the methodology. We estimate an initial annual GHG removal of approximately 32,200 tons of CO_{2e},.The number of rural properties (instances) participating in the program is also expected to grow over the 5-years validation period, according to the VCS methodology.

1.2 Sector Scope and Project Type

Sectoral Scope: 14. Agriculture, Forestry and Other Land Uses (AFOLU)

AFOLU Project Category: Agricultural Land Management (ALM)

Activity type:

- Reduce tillage/improve residue management;
- Improve water management;
- Improve crop planting and harvesting;
- Improve grazing practices.

1.3 Project Eligibility

[14] DEL GROSSO, S, J.; MOSIER, A,R.; PARTON, W,J.; OJIMA, D,S. DAYCENT model analysis of past and contemporary soil N_2O and net greenhouse gas flux for major crops in the USA. Soil & Tillage Research. V83, p9-24, 2005. Available at: https://www.sciencedirect.com/science/article/pii/S0167198705000358

[15] DEL GROSSO, S, J.; PARTON, W, J.; KEOUGH, C,A.; REYES-FOX, M. Special features of the DayCent modeling package and additional procedures for parameterization, calibration, validation, and applications. Methods of Introducing System Models into Agricultural Research. 2011. Available at: https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/advagricsystmodel2.c5

The project “NaturAll Carbon Program - Conservation Agriculture and Land Management in Brazil” is eligible for the scope of the VCS Program Version 4.3, section 2.1.1., as it fulfills all the criteria in Table 1:

Eligibility criteria	Evidence of fulfillment of eligibility
The project is going to introduce one or more new changes in each instance to its pre-existing agricultural management practices, that: **a.** Improve grazing practices; **b.** Improve water management; **c.** Improve crop planting and harvesting; **d.** Reduce tillage/improve residue management.	A declaration is going to be signed by the owner of the rural property, attesting to their previous practice(s), their gradual adaptations since the beginning of their inclusion in the project, and the adoption of the new conservative practices. This process will be validated and monitored by satellite images using Remote Sensing techniques.
Project activities will be implemented on land that is arable or grazing on the project start date (01/11/2019) and remains arable or grazing throughout the project crediting period. The change of land use, crops, or pastures will not be allowed in the project instances.	A commitment will be signed by the rural property owner, agreeing that no change in land use is to be made during the project's crediting period. During this period, the rural property will be monitored by satellite images to prove that there will be no land use change in any instances.
No instance included in the project shall have deforested areas within 10 years before the entry date of the instance into the project.	An evaluation will be carried out through Remote Sensing, using the MapBiomas database [16] and satellite images 10 years before the entry of each instance into the project. The rural property owner will sign a declaration attesting that there has been no deforestation in the instance intended to be included in the project.
Project activities will not result in a sustained reduction of more than 5% in productivity.	Many existing studies were used, including those validated by official organizations in Brazil, which prove that conservation agriculture practices, in addition to increasing productivity, reduce production costs[17] . The reviewed studies also mentioned that thinking only about increasing productivity without

[16]MapBiomas. Mapas e Dados. Available at: https://mapbiomas.org/

[17]Embrapa. Técnicas conservacionistas garantem produção agrícola em solos arenosos. 2022. Available at: https://www.embrapa.br/en/busca-de-noticias/-/noticia/69608030/tecnicas-conservacionistas-garantem-producao-agricola-em-solos-arenosos

	planning a conservation strategy does not work and gives a rebound effect[18].
The instances added in the project will be analyzed by the risk tool of non -permanence v. 4.0.	This analysis took into account the large area of the project and variations in climate, hydrology, topography, and type of vegetation, among other environmental factors, as well as factors related to the management of each property. Thus, each project instance must be evaluated separately regarding its risk of not remaining in the project.
GHG reductions and removals calculated for the project will be estimated by the VM0042 V2.0 FINAL DRAFT quantification approach 1: measurement and model. The model chosen was the Daycent, which is considered an acceptable model to estimate the flow of GHG based on the implemented edaphic characteristics and agricultural practices, initial soil carbon stocks, and weather conditions.	The DayCent model is validated in scientific studies and can be successfully used to simulate changes in Soil Organic Carbon and waste gas emissions resulting from changes in agricultural management. The model can also support the repetition of the design model simulations, proven by published literature. It was also validated by the detailed procedure of VM0053 (Model calibration and validation guide for methodology for better agricultural land management).
All instances inserted over time into the project will be within the geographic boundaries determined for the project.	Every new instance inserted in the project will present its geodetic coordinates, file in KML format, and a location map within the project to prove that it is eligible.
All additionalities used in the project have characteristics consistent with each instance for the activities developed on site.	There were determined barriers to changes in the project to implement each practice through the scientific literature, agricultural census, government data, independent research data, and reports or assessments compiled by industry associations. Each practice intended to be adopted in the project has been proven not to be a common practice in the project's geographic area (below 20% by weighted average rate).
	The additionality's calculation was determined from the Brazilian Agricultural Census[19], where numerical data was obtained by state (regional) implementation of all practices of

[18]PHALAN, B.; GREEN, R, E.; DICKS, L, V.; DOTTA, G.; FENIUK, C.; LAMB, A.; STRASSBURG, B,B,N.; WILLIANS, D,R.; ZU ERMGASSEN, E,K,H, J.; BALMFORD, A. How can higher-yield farming help to spare nature? Mechanisms to link yield increases with conservation. Science. v 351, p 451-451, 2016. Available at: https://www.science.org/doi/10.1126/science.aad0055

[19] IBGE. Censo Agropecuário 2017. Available at: https://censoagro2017.ibge.gov.br/resultados-censo-agro-2017.html

	conservation agriculture that are intended to be implemented in the instances that will be included in the project. The practices that obtain a value above 20% of use in the state will be recalculated by the weighted average of the set of practices used in the instance or region of the state where the property is located to prove that they are not common practices, which means that there is additionality for this practice or set of practices implemented. If there is no data on the combination of practices, the combined adoption rate of the activity will be calculated by the scalar multiplication of the individual practices, as exemplified in Chapter 7 of VM0042 V2.0 FINAL DRAFT.
	Practices that do not get a value of less than 20% of use in the region will not be considered in the project, even with calculating a weighted average for a set of practices.

Table 1. Project eligibility criteria and evidence of attendance.

1.4 Project Design

☒The project is a grouped project

This is a grouped project and will have multiple project instances. All new instances will be verified according to the applicable guidelines.

1.4.1 Eligibility Criteria

For each instance added to the project, a baseline of the practices used on the property will be made up to 3 years before the start date of the project in the instance, following the standard established in the VM0042 V2.0 FINAL DRAFT. The eligibility criteria will be the same for all instances (Criteria described in the Eligibility item of the project). Therefore, each instance will be evaluated separately for each of the criteria.

1.5 Project Proponent

Organization name	NaturAll Carbon Limited
Contact person	Felipe Granguelli Antoniazi
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1.6 Other Entities Involved in the Project

Organization name	Neo Green Consultoria Ambiental LTDA
Role in the project	Development Project
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Title	CEO
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1.7 Responsibilities

The entities participating in the project and their respective responsibilities are described in the Table below:

Entities	Responsibilities
Neo Green	Project development and advice to the proponent
NaturAll Carbon	Project development, modeling, contact with stakeholders and rural producers and project monitoring

1.8 Ownership

In Brazil, recognized rural properties that require registration in the country's Rural Environmental Registry (CAR) system are divided into four categories [20], which are:

- Public: are those belonging to legal entities governed by internal public law, namely: Union, States, Federal District, Municipalities, Autarchies, and Public Foundations[21];
- Private: are those belonging to individuals or legal entities and managed by them, which cannot be shared with another person, but can be sold or transferred to another owner[22];
- Agrarian Reform Settlements: a set of agricultural units installed by INCRA (National Institute of Colonization and Agrarian Reform) on a rural property. Each of these units, called parcels or lots, is intended for a family of a farmer or rural worker without the economic conditions to acquire a rural property. The beneficiary family must live on and use the lot, with the development of many productive activities[23];
- Territories of traditional peoples and communities: rural properties that belong to indigenous peoples, quilombolas, traditional communities of African origin or terreiros, extractivist, riverside dwellers, caboclos, artisanal fishermen, and Pomeranians, among others[24].

The instances inserted within the project area will only be from private rural properties. These properties are described as a continuous area, whatever its location, which is intended or may be intended for agricultural, livestock, plant extraction, forestry, or agro-industrial exploitation, through private initiative.[25].

In addition to this categorization, there is in Brazilian legislation a law that regulates agrarian reform in the country (Law No. 8.629/1993)[26]) and classifies rural properties by area size, according to the Minimum Installment Fraction (FMP), defined by Law No. 6.746/1979[27]. The classifications defined in the legislation for the size of Brazilian properties are:

- Smallholding: rural property with an area less than the Minimum Installment Fraction;

[20] EMBRAPA. Entenda o Código Florestal – Perguntas e respostas. Available at: https://www.embrapa.br/en/codigo-florestal/entenda-o-codigo-florestal/perguntas-e-respostas

[21] BRASIL. Código Civil. Available at: http://www.planalto.gov.br/ccivil_03/leis/2002/l10406compilada.htm

[22] THE CAPITAL ADVIDOR. Bem privado. Available at: https://comoinvestir.thecap.com.br/bem-privado

[23] Ministério da Agricultura, Pecuária e Abastecimento. Assentamentos. Available at: https://www.gov.br/incra/pt-br/assuntos/reforma-agraria/assentamentos#:~:text=O%20assentamento%20de%20reforma%20agr%C3%A1ria,de%20adquirir%20um%20im%C3%B3vel%20rural.

[24] Secretaria Especial do Desenvolvimento Social. Povos e comunidades tradicionais. Available at: http://mds.gov.br/assuntos/seguranca-alimentar/direito-a-alimentacao/povos-e-comunidades-tradicionais#:~:text=Entre%20os%20PCTs%20do%20Brasil,%2C%20os%20pomeranos%2C%20entre%20outros.

[25] Instituto de Registro Imobiliário do Brasil. Conceiros de imóvel rural: aplicação na certificação do INCRA expedida no emorial descritivo georreferenciado. Available at: https://irib.org.br/obras/3983

[26] BRASIL. Lei nº 8.629 de 9 de fevereiro de 1993. Available at: http://www.planalto.gov.br/ccivil_03/leis/l8629.htm

[27] BRASIL. Lei nº 6.746 de 10 de dezembro de 1979. Available at: http://www.planalto.gov.br/ccivil_03/leis/1970-1979/l6746.htm

- Small property: property with an area between the Minimum Installment Fraction and 4 módulos fiscais (unit of land determined by the federal government for fiscal and other purposes);
- Medium property: rural property with an area greater than 4 and up to 15 módulos fiscais;
- Large property: rural property with an area of more than 15 módulos fiscais.

The módulos fiscais can vary according to each Brazilian municipality and are determined by the predominant type of land use in the municipality, the income obtained from the principal land use, and other uses in the municipality that are not predominant, which are significant depending on the income or used area.

The project intends to include private rural properties regardless of the area and the number of módulos fiscais on the property.

All private rural properties must follow a series of legislation described in Item 1.15 of this document. In this way, all instances included in the project must be aligned with current Brazilian legislation and present the following documentation:

- Proof of ownership of rural property or lease agreement;
- Environmental Property Registry (CAR) – which includes the perimeter, land use, and other information that proves compliance with the legislation.

According to the VCS Program Version 4.3, there must be evidence of ownership of each instance held by the proponent from the respective start date of each instance of the project activity. In this way, NaturAll Carbon will contract with the owner or lessee of the rural property to whom the instance is inserted.

1.8.1 Property

The initial instances are located in the municipality of Cassilândia, in the state of Mato Grosso do Sul. The farm's centroid is at coordinate 19°14'56.17" S 52°20'26.30" W. The property extends over 2,099.63 ha, of which 893.15ha are preserved Cerrado Biome areas. For decades the farm's primary activity has been livestock. Recently, the farmer has been transitioning from livestock to conservation agriculture, with crop and livestock integration elements. New practices make it eligible for this program.

Other proprietary information and evidence will be omitted from this public document for privacy reasons. However, it will be provided to VVB and Verra in the Monitoring and Verification Report.

1.9 Project Start Date

Project start date: 01/11/2019

Farmers participating in the project will start incorporating improved conservation agriculture practices by November 1st, 2019. This will be proven through statements signed by the farmers and confirmed through remote sensing performed by the project proponent.

1.10 Project Crediting Period

The VCS project crediting period is initially 20 years, with the possibility of renewal of up to 100 years. The current crediting period for the project begins on November 1st, 2019, and ends on October31th, 2039. The project longevity is 100 years, as the requirements of the VCS AFOLU Non-Permanence Risk Tool, v4.0.

1.11 Project Scale and Estimated GHG Emission Reductions or Removals

The project's estimated annual GHG emission reductions and removals are:

☒20,000 – 100,000 tCO_2 e/year

In Brazil, the crop year does not follow the calendar year, as farmers start preparing the soil for the growing season in the southern hemisphere during winter. To meet this dynamic, the Brazilian government starts every July 1st of the current year until June of the following year according to the Safra Plan.

The Safra Plan is a federal government program that directs public resources to finance and ensure the activities of the country's small, medium, and large producers. It is one of the main tools to ensure financial security for the different parties involved with agriculture. It is one of the economic activities most subject to risks and sudden changes caused by weather, currency volatility, and international sanctions, among other factors[28].

In the face of this, we will represent the estimated GHG emission reductions and removals (tCO_2 e) in the crop year and not in the calendar year.

This project is a clustered project of atmospheric carbon removal and storage in agricultural soil in the form of soil organic carbon (SOC). Project scales and estimates of GHG removals for all 20 credit years are presented in Table 2, and they are based on conservative estimates of farmer adherence over the project entry window.

The total ex-ante estimate was produced by applying the average annual increase in SOC stock per unit area in the dominant biome of the instances, multiplied by the total area of the incoming instances. The average yearly increase in SOC stock corresponds to 1.61 t CO_2 e/ha.year[29].

[28] Mafra, E. Entenda o que é um Plano Safra. Forbes Agro. 2022. Available at: https://forbes.com.br/forbesagro/2022/06/entenda-o-que-e-um-plano-safra/#:~:text=Criado%20em%202003%20e%20divulgado,e%20grandes%20produtores%20do%20pa%C3%ADs.

[29] Corbeels, M.; Marchão, R, L.; Siqueira Neto, M.; Ferreira, E, G.; Mandari, B, E.; Scopel, E.; Brito, O, R. Evidence of limited carbon sequestration in soils under no-tillage systems in the Cerrado of Brazil. Sci Reports 6, Nature. 2016.

Crop Year	Estimated GHG emissions reductions and removals (tCO_2 e)
2019 - 2020	32,200
2020 - 2021	80,500
2021 - 2022	80,500
2022 - 2023	80,500
2023 - 2024	80,500
2024 - 2025	80,500
2025 - 2026	80,500
2026 - 2027	80,500
2027 - 2028	80,500
2028 - 2029	80,500
2029 - 2030	80,500
2030 - 2031	80,500
2031 - 2032	80,500
2032 - 2033	80,500
2033 - 2034	80,500
2034 - 2035	80,500
2035 - 2036	80,500
2036 - 2037	80,500
2037 - 2038	80,500
2038 - 2039	80,500
Total estimated ERRs	1,561,700
Total number of credit years	20
Average annual ERs	78,085

Table 2. Estimated GHG reductions and removals (tCO_2 e) for the project.

Based on the factors described above, the proponent estimates that the project could generate an average removal of 78,085 tons of CO_2e per year, with the scale of the project being determined according to the VCS Program Version 4.3, section 3.9.1. (Table 3), in this project, less than 300,000 t CO_2 e/year.

Project Scale	
Project	X
Large Project	

Table 3. Project Scale.

1.12 Description of the Project Activity

The project "NaturAll Carbon Program - Conservation Agriculture and Land Management in Brazil" is going to reduce and remove GHG emissions through the adoption of agricultural and conservationist practices in properties that, until included in the project, used inadequate management, which resulted in a series of social, environmental and economic impacts.

Inadequate management in agriculture contributes to a succession of environmental problems, such as contamination and depletion of water resources, deforestation, loss of biodiversity, GHG emissions, and, consequently, an increase in global warming and climate change.

On the ground, the direct impacts caused by inadequate management practices can be described in five types of degradation:

1. Water erosion: loss of surface horizons, terrain deformation, mass movements, and deposition.
2. Wind erosion: loss of surface horizons, terrain deformation, mass movements and deposition.
3. Chemistry: loss of nutrients or organic matter, nutrient imbalance, salinization, acidification, and pollution.
4. Physical: compaction, sealing, scaling, flooding, poor aeration, and excess or lack of water.
5. Biological: reduction of biomass and reduction of biodiversity.

All these impacts mentioned above, can affect the local economy in a short time and, in the medium to long term, the country's economy through the loss of the productive capacity of the soils and higher expenses with irrigation, fertilizers, and pesticides. Productivity loss can also occur due to the lack of adaptation of the cultivars and the animals to climate change.

The traditional land use and management systems, many of which were adapted from techniques established in temperate regions, with local conditions quite different from those in the country, generated a cycle of poverty leveraged by the intense land degradation processes[30].

Taking into account all these impacts, this project is significant for Brazilian agriculture, as conservation agriculture is a way of managing agricultural ecosystems in a way that promotes a sustainable increase in productivity, greater profitability, and food security, while at the same time preserving and strengthening natural resources and the environment[31].

Conservation agriculture is a type of agriculture conducted under the protection of a complex of technologies of a systemic nature, aiming to preserve, maintain and restore or recover the elements of the biosphere or natural resources through the integrated management of soil, water, and biodiversity, being adequately compatible with the use of external inputs. It comprises a set of agricultural practices or precepts that minimize changes in soil structure, composition, and biodiversity[32].

The practices of conservation agriculture that are going to be applied in the instances within the project area (remembering that not all of them will necessarily be used in each instance) are described below:

Level planting: Level planting, also known as contour planting, organizes production using rows with different altitudes according to the terrain. It is recommended for steep terrain, always respecting the region's slopes. Following the contour lines, each planting line works as an obstacle that slows down flash floods in case they form on the land's surface. With a reduction in flash flood volumes, there is more time for water to infiltrate the soil. The contour lines remain perpendicular to the slope and help to conserve the natural ground cover. They consist of lines that join points at the same altitude on a terrain's surface. Therefore, they are also called altimetric curves[33].

Benefits: It reduces flash floods and soil erosion on gentle slopes. This practice can also increase crop yields by retaining soil moisture in arid and semi-arid regions. The results showed that contour cropping reduced the annual flash flood by 10% compared to cropping in line with the slope. Also, cultivation and planting along contour lines compared to cultivation and planting in line with the slope reduced soil and water losses by 49.5 and 32%, respectively[34].

Crop rotation: Crop rotation is defined as the orderly alternation of different crops, in a given period (cycle), in the same area, and the same year's season. The component crops of a crop rotation system must meet as many of the following principles as possible:

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30 MANZATTO, C, V.; FREITAS, P, L.; PERES, J, R, R. Uso agrícola dos solos brasileiros. Embrapa. Rio de Janeiro,2002. Available at: file:///C:/Users/55479/Downloads/uso_agricola_solos_brasileiros.pdf

31 FAO. What is conservation agriculture? Available at: http://www.fao.org/ag/ca/1a.html

32 FAO. What is conservation agriculture? Available at: http://www.fao.org/ag/ca/1a.html

33 FertiSystem. Plantio em nível: conheça os benefícios e saiba pra quando é indicado. Available at: https://www.fertisystem.com.br/m/blog/60d35e095697a756a31a0edc/plantio-em-nivel-conheca-os-beneficios-e-saiba-quando-e-indicado#:~:text=O%20plantio%20em%20n%C3%ADvel%20%C3%A9,sobre%20a%20superf%C3%ADcie%20do%20terreno

34 FARAHANI, S, S.; FARD, F, S.; ASOODAR, M, A. Effects of Contour Farming on Runoff and Soil Erosion Reduction: A Review Study. Elixir Agriculture. 2016. Available at: https://www.researchgate.net/profile/Saeid-Farahani-2/publication/312054716_Effects_of_contour_farming_on_runoff_and_soil_erosion_reduction_A_review_study/links/586d0b9808ae6eb871bcc855/Effects-of-contour-farming-on-runoff-and-soil-erosion-reduction-A-review-study.pdf

- Produce a sufficient amount of aerial part and root phytomass aiming at increasing the soil organic matter (SOM) content and the formation of mulch to control erosion processes, reduce temperature fluctuations and reduce water losses by evaporation;
- Promote favorable soil conditions that reduce the susceptibility of plants to be damaged by pests and diseases and contribute to the formation of a suppressive environment for them;
- Present nutritional requirements and the ability to use different nutrients (legumes and grasses, for example);
- Present susceptibility to different pests and diseases, avoiding species that are hosts to pests and diseases of economic importance for the main crops;
- Allow the diversification of active principles and mechanisms of action such as herbicides, insecticides, and fungicides, aiming to avoid the selection of resistant tolerant species/biotypes;
- Reduce the time when the area remains without live crops, contemplating the inclusion, at some stage, of crops characterized by high phytomass production and deep, aggressive, and abundant root systems, aiming to improve soil quality
- Result in direct income from producing grains, seeds, fodder, or indirect income through positive effects on subsequent crops.

Benefits: It contributes to increasing crop productivity and production stability in the face of biotic and abiotic stresses, as well as rationalizing the use of raw materials[35].

Fallow or soil rest: By Law No. 12.727/2012[36], in item XXIV, "fallow is the practice of temporarily interrupting agricultural, livestock or forestry activities or uses, for a maximum of 5 (five) years, to enable the recovery of the use capacity or physical structure of the soil."

Benefits: Leaving soil fallow respects the natural conditions of the land, the particularities of crops, and the place where they are planted. The technique prevents the soil from wearing — since, after planting a crop for a certain period, there is a strategic rest for the plantation, allowing the soil to recover adequately. This attitude allows for the recovery of the site's biostructure, greater rooting depth, and nutrient quality for future planting[37].

Protection and/or conservation of slopes: a practice that uses arboreal or shrub vegetation to protect or conserve a steep slope subject to erosion[38].

Benefits: Prevents erosion and disruption of agricultural soil.

35FRANCHINI, J. C.; COSTA, J. M. da; DEBIASI, H.; TORRES, E. Importância da rotação de culturas para a produção agrícola sustentável no Paraná. Embrapa Soja. 2011. Available at: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/897259/importancia-da-rotacao-de-culturas-para-a-producao-agricola-sustentavel-no-parana

36 BRASIL. Lei nº 12.727 de 14 de outubro de 2012. Available at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12727.htm

37 Pensamento Verde. Pousio e Rotação de Culturas: entenda o que é cada técnica e suas funções para a natureza. Available at: https://www.pensamentoverde.com.br/economia-verde/pousio-e-rotacao-de-culturas-entenda-o-que-e-cada-tecnica-e-suas-funcoes-para-natureza/#:~:text=O%20pousio%20respeita%20as%20condi%C3%A7%C3%B5es,solo%20consiga%20se%20recuperar%20adequadamente.

38IBGE. Dados preliminares do Censo Agropecuário 2017. 2013 . Available at: https://metadados.inde.gov.br/geonetwork/srv/api/records/95b8ee5e-454e-414d-857c-d748aa575514

Restoration of riparian vegetation: This practice involves recovering plant formations around water bodies (rivers, lakes, etc.). The method used for recovery depends on the degree of degradation. It can be total planting, enrichment, natural regeneration, or Agroforestry Systems (AFS)[39].

Benefits: Riparian forests protect water resources and the soil, reducing the silting of rivers and the input of pollutants, creating corridors favorable to the flow of genes between forest remnants, providing food and shelter for fauna, and functioning as a natural barrier against the spread of pests and diseases in crops. In addition, growing forests fix carbon, reducing greenhouse gasses responsible for climate change affecting the planet.[40].

Gully stabilization: The gully is the most advanced stage of erosion. It occurs due to water flow and constant material detachment in the same channel for long periods[41].

Benefits: Stabilization of places that present significant erosion, preventing soil loss by water flow.

Minimum cultivation: Minimal cultivation is an unconventional way of preparing the soil to receive seedlings or seeds of a particular crop. It consists of preparing the soil and planting simultaneously in as few operations as possible. In this way, there is minimal soil disturbance[42].

Benefits: The smallest number of passes by agricultural machinery, turning the soil less, undoing, to a lesser extent, the structure of the same and keeping it covered by the residues of the culture that was previously planted in the area. The area between the planted lines will remain without the passage of machines and implements, which favors the maintenance of the characteristics of the ground, such as, for example, the structure, which is fundamental in favoring the infiltration of water, which will consequently reduce the action of erosive processes. In addition, there will be fuel savings by reducing the number of times agricultural machinery has to enter the area where planting will occur[43].

No-tillage in Straw: This is an agricultural production system in which soil disturbance is avoided, and its surface is always covered with residues (straw) or vegetation. The term "no-till" originates from the concept of planting directly into unplowed soil, and the term "in straw" adds the idea of keeping the soil always protected by residues. The system allows light cultivation, covering scattered seeds, combating weeds, and managing cover vegetation[44].

Benefits: No-tillage in Straw is a cutting-edge agricultural technology that is profitable, sustainable, and protects the environment. The system originated to combat erosion. This effect results from the control of the runoff of rainwater through residues which reduces the speed of the moving water giving more

39 IBGE. Dados preliminares do Censo Agropecuário 2017. 2013 . Available at: https://metadados.inde.gov.br/geonetwork/srv/api/records/95b8ee5e-454e-414d-857c-d748aa575514

40 RICARDO, V, P. Projeto de recuperação das matas ciliares. Monografia. FACEP, Ibitinga. 2008. Available at: https://sigam.ambiente.sp.gov.br/sigam3/Repositorio/378/Documentos/4_2008_Ricardo_Mata_Ciliar.pdf

41 VIANNA, P, C, G.; LIMA, V, R P.; LUNGUINHO, L, L.; TORRES, A, T, G. Estabilização de voçoroca - subproduto ambiental do diagnóstico dos recursos hídricos, o caso do assentamento Dona Antonia, Conde PB. Available at: http://www.geociencias.ufpb.br/leppan/gepat/files/gepat012.pdf

42AmbienteBrasil. Conceitos de Algumas Práticas Conservacionistas. Available at: https://ambientes.ambientebrasil.com.br/agropecuario/conservacao_do_solo/conceitos_de_algumas_praticas_conservacionistas.html

43 AmbienteBrasil. Conceitos de Algumas Práticas Conservacionistas. Available at: https://ambientes.ambientebrasil.com.br/agropecuario/conservacao_do_solo/conceitos_de_algumas_praticas_conservacionistas.html

44 CARDOSO, F, P. Plantio Direto na Palha. CATI. 1998. Available at: https://www.cati.sp.gov.br/portal/produtos-e-servicos/publicacoes/acervo-tecnico/plantio-direto-na-palha#:~:text=O%20QUE%20%C3%89%20O%20PDP,)%20e%2Fou%20de%20vegeta%C3%A7%C3%A3o.

time for its infiltration. The gentle movement of water over undisturbed soil dramatically reduces its erosive action[45]. Other benefits of this practice are:

- Better moisture retention with higher yields in dry years;
- There is no erosion and, therefore, no need for replanting, which implies new soil preparation with a consequent higher consumption of fuel, seeds, and fertilizers. This will lead to a considerable increase in production costs and will not save the farmer from crop failure due to out-of-season planting;
- More time to seed (while in Conventional Planting, it is possible to sow 3 to 6 days after a heavy rain, in No-Till, it is possible to sow 6 to 12 days after a rain);
- Taking advantage of better planting times and planting a larger area in the same period, especially when there are sparse rains [46];
- Increases soil organic matter and carbon;
- Soil becomes more fertile with nutrient recycling;
- Increases biological activity and stability of soil structure;
- Reduces soil compaction;
- It is among the systems that promote the reduction of CO_2 emissions and other Greenhouse Gasses[47].

Crop-livestock Forest Integration (ILPF): is a production strategy that has been growing in Brazil in recent years. It uses different productive, agricultural, livestock and forestry systems within the same area. It can be done by intercropping, in succession, or in rotation so that all activities have mutual benefit[48].

Benefits: Optimizes land use, raises productivity levels in the same area, uses better inputs, diversifies production and generates more income and employment. All this, in an environmentally correct way, with low emission of greenhouse gasses or even with mitigation of these gasses.[49].

All these practices were analyzed for additionality under VM0042 v2.0 Final Draft and the regulations established in the latest version of the VCS Methodology Requirements. Therefore, for all the practices described above, barriers preventing implementing the change to this new practice were identified, and it was demonstrated that adopting the practice or set of practices is not common. The complete description of the additionality of these practices is in section 3.5 (Additionality) of this project.

45 CARDOSO, F, P. Plantio Direto na Palha. CATI. 1998. Available at: https://www.cati.sp.gov.br/portal/produtos-e-servicos/publicacoes/acervo-tecnico/plantio-direto-na-palha#:~:text=O%20QUE%20%C3%89%20O%20PDP,)%20e%2Fou%20de%20vegeta%C3%A7%C3%A3o.

46 WWF. Plantio direto. Available at: https://www.wwf.org.br/natureza_brasileira/reducao_de_impactos2/agricultura/agr_acoes_resultados/agr_solucoes_cases_plantio2/#:~:text=O%20Plantio%20Direto%20%C3%A9%20a,da%20semente%20com%20o%20solo.

47 Boas práticas agronômicas. Plantio direto: prática revolucionária da agricultura brasileira. Available at: https://boaspraticasagronomicas.com.br/boas-praticas/plantio-direto/

48 EMBRAPA. Integração Lavoura-Pecuária-Floresta. Available at: https://www.embrapa.br/tema-integracao-lavoura-pecuaria-floresta-ilpf

49 EMBRAPA. Integração Lavoura-Pecuária-Floresta. Available at: https://www.embrapa.br/tema-integracao-lavoura-pecuaria-floresta-ilpf

For the monitoring and comparison of the dynamics of GHGs in the baselines and after the implementation of the project, to record the reductions and removals of the project, the DayCent biogeochemical model (validated following the methodology of VMD0053 v2.0 Final Draft) was used along with techniques of Remote Sensing. The complete description of the application of the methodology and the tools used are in sections 3 (Methodology) and 4 (Monitoring) of this project.

The project is not registered under any other GHG programs or forms of credit; therefore, for its maintenance, the income from the credits is essential due to the pressures exerted by the baseline activities and the barriers that make it difficult to change to new practices, described in section 3.5 (Additionality). Such activities, in addition to generating credits in the medium to long term, will increase soil productivity and, consequently, profit for the producer, not to mention all the benefits to the environment and ecosystem services that benefit nearby communities.

1.13 Project Location

The project activity and instances will be located exclusively within the national borders of Brazil, in the project area delimited in Figure 1. All project instances will have a clear demarcation of area and location through a database of included instances with a complete set of geodetic coordinates in an acceptable file format such as KML (Keyhole Markup Language).

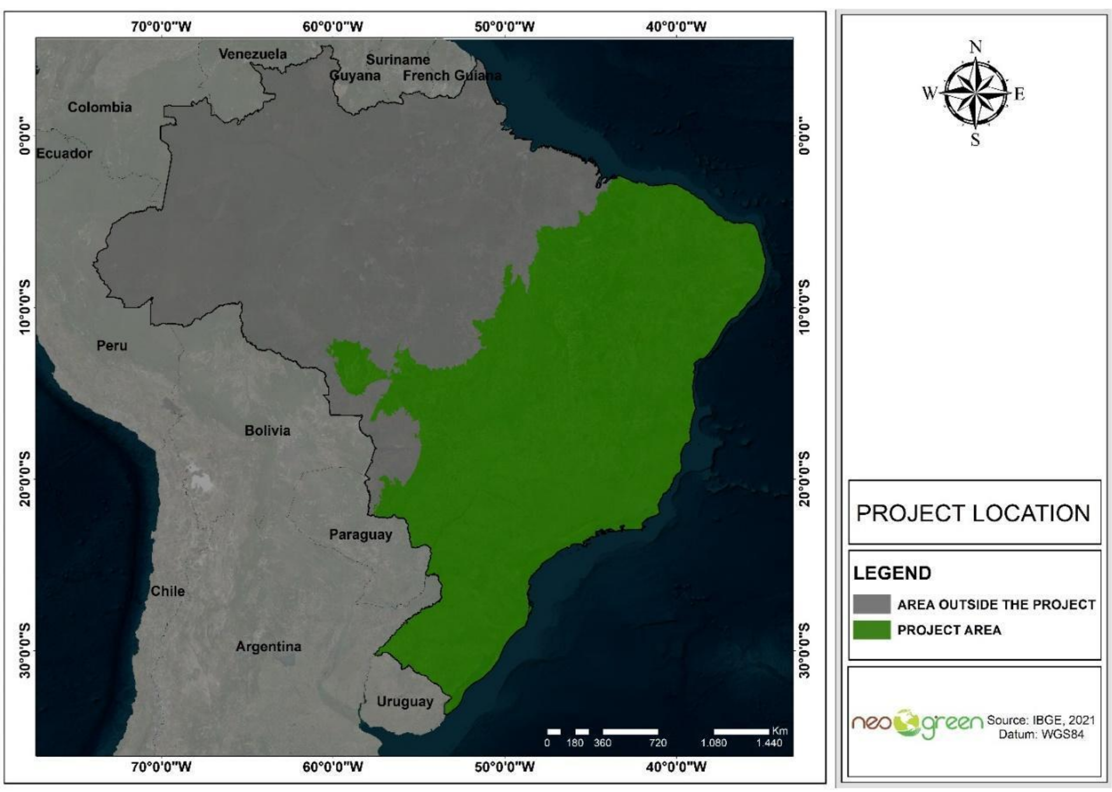

Figure 1. Project area

1.13.1. Initial farm Location

The farm in Cassilândia, state of Mato Grosso do Sul, included in this first stage of validation, is located within the geographic area determined for the project (Figure 1), and its centroid is at coordinate 19°14'56.17" S 52°20'26.30" W. Its boundaries are also available in KML format (Figure 2). The farm is transitioning from cattle grazing as the main commercial activity toward integrating sustainable grain production alongside grazing. The land conversion rate from one activity to another is relatively low, and we expect the economic benefits from carbon credits will accelerate the process.

This farm will be one of many in our program, and others will come. During the validation and verification process, more information about each farm and instance will be presented to Verra and the Validation and Verification Body.

Figure 2. Location of Cassilândia farm.

1.14 Conditions Prior to Project Initiation

The instances that will be included in the project are agricultural or livestock farming properties, which until the implementation of the project, will still apply management practice standards in Brazilian agriculture, coming from intensive agriculture.

Intensive agriculture emerged in the 20th century to supply the growing world food demand, consecutively increasing the need for production.

In this way, from that moment on, Brazilian agriculture developed with the help of machinery, pesticides, inputs, and other technologies. Farmers could increase production and crop profitability, enhancing the result obtained in each square meter of the property[50].

Among the most illustrative indicators of the recent trajectory of Brazilian agriculture are production figures and productivity indices. Between 1975 and 2017, grain production, which was 38 million tons, grew more than six times, reaching 236 million, while the planted area only doubled[51].

Increases in production and productivity were also achieved in livestock. The number of cattle in the country has more than doubled in the last four decades, while the area of pasture has made little progress. In certain regions, there has been even a reduction of land destined for grazing[52].

This needs to expand production in a relatively short period ended up leaving aside essential issues for the continuity of this production in the future and even issues that impact production at present, degrading the primary raw material of agriculture, the soil.

The leading practices of intensive agriculture in Brazil are:

- **Plowing:** the technique of inversion of soil layers to increase the oxidation levels of organic matter. The secondary soil preparation aims to complement the plowing activity, using harrowing implements[53];
- **Subsoiling or scarification:** equipment that works on the surface and sub-surface of the soil to promote the disaggregation of compacted layers to facilitate the penetration of crop roots, water, and air, into the deeper layers of the soil, without incorporating organic matter. Scarification is the practice of loosening densified or compacted layers formed inside the soil caused by heavy machine traffic, animal trampling, and soil preparation operations, using

50 Equipe FieldView. Quais são os principais tipos de agricultura praticados no Brasil? 2021. Available at: https://blog.climatefieldview.com.br/tipos-de-agricultura

51 EMBRAPA. O futuro da agricultura brasileira - Trajetória da agricultura brasileira. Brasília, DF. 2018. Available at: https://www.embrapa.br/visao/trajetoria-da-agricultura-brasileira

52 EMBRAPA. O futuro da agricultura brasileira - Trajetória da agricultura brasileira. Brasília, DF. 2018. Available at: https://www.embrapa.br/visao/trajetoria-da-agricultura-brasileira

53 GeoAgri. Preparo do solo: importância da profundidade correta. Available at: https://geoagri.com.br/blog/7/preparo-do-solo-importancia-da-profundidade-correta

plows and harrows, working at a shallower depth (up to 30 cm). Scarification is also a soil preparation operation in which the inversion of ridges does not occur[54];

- **Controlled burning of vegetation cover on the ground:** a technique used for cleaning and preparing the soil to be used[55];
- **Harrowing:** after plowing, the soil is harrowed. When turning the soil and inverting the soil surface layers, the plow leaves the soil uneven. With harrowing, the clods left by plowing are broken up, so the soil becomes flat.[56];
- **Application of correctives and fertilizers:** agricultural correctives are inputs capable of neutralizing soil acidity and offering secondary nutrients to plants, mainly calcium (Ca) and magnesium (Mg). Along with correctives, fertilizers are vital inputs for use in agriculture and are directly related to increased productivity, as their deficiency or excessive application leads to economic losses[57];
- **Mechanization:** Mechanization focuses on planning and developing activities using machines and implements. Currently, in Brazil, mechanization is essential for improving the daily life of rural producers, and the use of tractors has been increasingly intense. These have been improved over time and are becoming more and more modern[58];
- **Monoculture** is a technique based on growing only one crop type simultaneously in a specific field [59].

These are the leading practices that were also present in the inserted instances before the implementation of the project; however, as each one will have a specificity regarding the practices used, the Baseline Scenario of each instance will be better described in section 3.4 (Baseline Scenario).

1.14.1 Characterization of the Project Area

The project area covers about 420,400,600.794 ha, equivalent to 49.36% of the Brazilian territory, being a large project that covers areas with significant variations in terms of climate, hydrology,

54 SILVA, RP.; FURLANI, C, E, A.; TAVARES, T, O.; VOLTARELLI, M, A. Compactação do solo, escarificação e subsolagem. Jaboticabal, SP. 2015. Available at: https://www.fcav.unesp.br/Home/departamentos/engenhariarural/ROUVERSONPEREIRADASILVA/apostila-compactacao-subsolador-e-escarificador.pdf

55 Nordeste Rural. Queimadas podem provocar redução na fertilidade do solo. 2015. Available at: https://nordesterural.com.br/queimadas-podem-provocar-reducao-na-fertilidade-do-solo/

56 GeoAgri. Preparo do solo: importância da profundidade correta. Available at: https://geoagri.com.br/blog/7/preparo-do-solo-importancia-da-profundidade-correta

57 SENAR. Mecanização: aplicação de corretivos e fertilizantes com distribuidor centrífugo. 2017. Available at: https://www.cnabrasil.org.br/assets/arquivos/182-DISTRIBUIDOR-NOVO.pdf

58 Revista Agropecuária. Mecanização agrícola: Aumento da produtividade e racionalização dos custos! Available at: http://www.revistaagropecuaria.com.br/2019/02/21/mecanizacao-agricola-aumento-da-produtividade-e-racionalizacao-dos-custos/

59 KOGUT, P. Monocultura Agrícola: Vantagens e desvantagens. EOS Data Analytics. 2021. Available at: https://eos.com/pt/blog/monocultura-agricola/

topography, soils, vegetation, and ecosystems. For this reason, it is essential to characterize this region and locate each instance inserted in the project within these variabilities.

These variations were characterized on maps, using official geographic databases of the country.

1.14.1.1 Ecosystem

Brazilian Biomes are not only important as natural resources in the country but also stand out as environments of great natural wealth on the planet[60]. The project area covers four Brazilian biomes, the Caatinga, the Cerrado, the Atlantic Forest, and the Pampa, as shown in Figure 3.

Caatinga: The vegetation characteristic of this biome predominates in the Northeast of Brazil and is inserted in the context of the semi-arid climate. The region's first inhabitants called it this because, in the dry season, most plants lose their leaves, and a clear and whitish appearance of the tree trunks prevails in the landscape. From this comes the name Caatinga (caa: forest and tinga: white), which means "forest or white forest" in Tupi. However, in the rainy season, the landscape changes from whitish to shades of green.[61]. The area covered by the Biome is 844,453 km^2,[62] and all of its limits are within Brazilian territory, which means that its biological heritage is not found in any other region of the world. [63].

60 IBGE. Biomas brasileiros. Available at: https://educa.ibge.gov.br/jovens/conheca-o-brasil/territorio/18307-biomas-brasileiros.html
61 ASSOCIAÇÃO CAATINGA. Bioma Caatinga. Available at: https://www.acaatinga.org.br/sobre-a-caatinga/
62 IBGE. Biomas. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?edicao=16060&t=acesso-ao-produto
63 ASSOCIAÇÃO CAATINGA. Bioma Caatinga. Available at: https://www.acaatinga.org.br/sobre-a-caatinga/

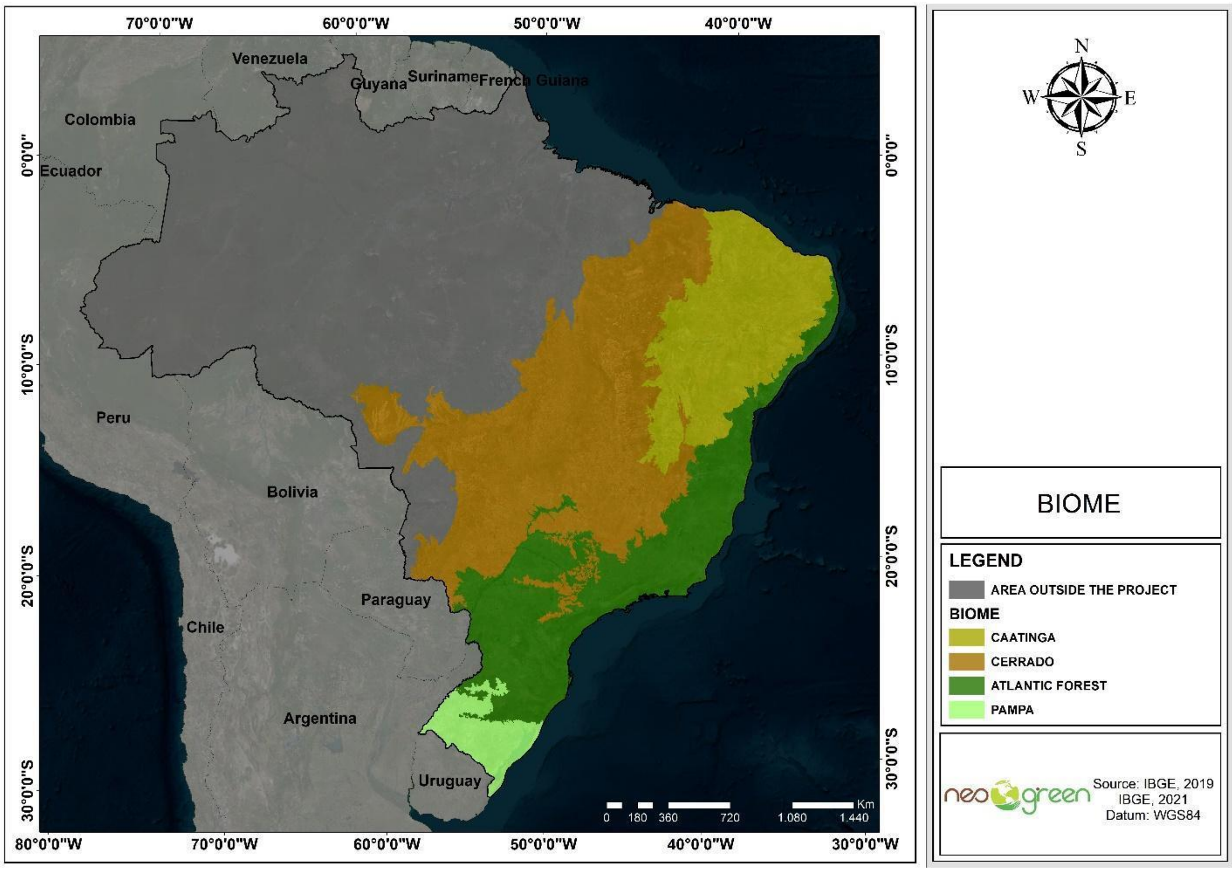

Figure 3. Brazilian biomes present in the project[64]

Despite its importance, the Caatinga biome has been deforested at an accelerated rate, mainly in recent years, mainly due to the consumption of native firewood, illegally and unsustainably exploited, for domestic and industrial purposes, overgrazing and conversion to pastures and agriculture[65].

Cerrado: This is the second largest biome in Brazil, comprising plant formations that include fields, savannas, paths, and forests, primarily determined by variations in topography, soils, and water availability, it is an environment subject to periodic fires and low rainfall[66].It is one of the most biodiverse regions in the world, and it is estimated that it has more than 6 thousand species of trees and 800 species of birds[67]. More than 40% of woody plant species and 50% of bees are believed to be endemic[68].

64 IBGE. Biomas - downloads. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?=&t=downloads

65 MMA. Caatinga. Available at: https://antigo.mma.gov.br/biomas/caatinga.html

66 PEIXOTO, A, L.; LUZ, J, R, P.; BRITO, M, A. Conhecendo a biodiversidade. Editora Vozes, Brasília, 2016. Available at: https://ppbio.inpa.gov.br/sites/default/files/conhecendo_a_biodiversidade_livro.pdf

67 MMA. Cerrado. Available at: https://antigo.mma.gov.br/biomas/cerrado.html

68 ICMBIO. Biodiversidade do Cerrado. Available at: https://www.icmbio.gov.br/cbc/conservacao-da-biodiversidade/biodiversidade.html

In addition to environmental aspects, the Cerrado has great social importance. Many people survive on its natural resources, including indigenous, quilombola, riverine, babassu, floodplain, and quilombola communities that, together, are part of Brazil's historical and cultural heritage and hold a traditional knowledge of its biodiversity. More than 220 species have medicinal uses, and a further 416 can be used to restore degraded soils, as wind barriers, protection against erosion, or create habitat for natural predators of pests. More than ten types of edible fruits are regularly consumed by the local population and sold in urban centers[69].

Atlantic forest: This biome is considered a global hotspot, which means it is one of the richest areas in biodiversity and the most threatened on the planet. It was declared a Biosphere Reserve by Unesco and National Heritage in the Federal Constitution of 1988. Its original composition is a mosaic of vegetation defined as dense, open, and mixed ombrophilous forests; deciduous and semi deciduous seasonal forests; high altitude fields, mangroves, and sandbanks[70].

The Atlantic Forest occupies 1.1 million km² in 17 states of the Brazilian territory, extending over a large part of the country's coast[71]. However, today, about 29% of its original cover remains due to occupation and human activities in the region[72].

The forests and other ecosystems that make up the Atlantic Forest are responsible for the production, regulation, and supply of water; climate regulation and balance; slope protection and disaster mitigation; soil fertility and protection; production of food, wood, fibers, oils, and medicines; in addition to providing scenic landscapes and preserving an immense historical and cultural heritage[73], providing essential ecosystem services to the 145 million Brazilians living in this region[74].

Pampa: This biome is restricted to the state of Rio Grande do Sul, where it occupies an area of 193,836 km²[75]. This corresponds to 69% of the state territory and 2.3% of the Brazilian territory. The natural landscapes of the Pampa are varied, from mountains to plains, from rocky hills to coxilhas. The biome displays an immense cultural heritage associated with biodiversity.

The progressive introduction and expansion of monocultures and pastures with exotic species have led to rapid degradation and de-characterization of the natural landscapes of Pampa. The loss of biodiversity compromises the potential for sustainable development in the region, whether it is the loss of species of forage, food, ornamental and medicinal value, or the compromise of environmental

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69 MMA. Cerrado. Available at: https://antigo.mma.gov.br/biomas/cerrado.html

70 AMDA. Mata Atlântica é hotspot mundial. Available at: https://www.amda.org.br/index.php/comunicacao/informacoes-ambientais/5229-mata-atlantica-e-hotspot-mundial

71 IBGE. Biomas. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?edicao=16060&t=acesso-ao-produto

72 FUNCATE. Fundação de Ciências, Aplicações e Tecnologias Espaciais. Mapa de vegetação nativa na áreas de aplicação da lei nº 11.428/2006 - Lei da Mata Atlântica, ano base 2009. São José dos Campos, SP. 2015.

73 MMA. Mata Atlântica. Available at: https://www.gov.br/mma/pt-br/assuntos/ecossistemas-1/biomas/mata-atlantica#:~:text=As%20florestas%20e%20demais%20ecossistemas,%C3%B3leos%20e%20rem%C3%A9dios%3B%20al%C3%A9m%20de

74 MMA. Mata Atlântica. Available at: https://www.gov.br/mma/pt-br/assuntos/ecossistemas-1/biomas/mata-atlantica

75 IBGE. Biomas. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?edicao=16060&t=acesso-ao-produto

services provided by grassland vegetation, such as soil erosion control and carbon sequestration that mitigates climate change, for example.

Promoting sustainable use of economic activities is essential in ensuring Pampa's conservation. The diversification of rural production, the valorization of livestock with native field management, regional planning, ecological-economic zoning, and respect for ecosystem limits are the ways to ensure the conservation of biodiversity and the economic and social development of this biome[76].

1.14.1.2 Climate

Brazil is a country with excellent climate diversity. In some places, it is cold, and in others, it is scorching, but generally, the climate is warm in most of the territory[77]. For the climatic classification of the areas within the project, the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the Köppen–Geiger classification system was employed, being the most used in climatology, ecology, and geography[78]. In Figure 4, we have the classes present in the project area and then the description of each class, according to Embrapa (Brazilian Agricultural Research Corporation)[79]:

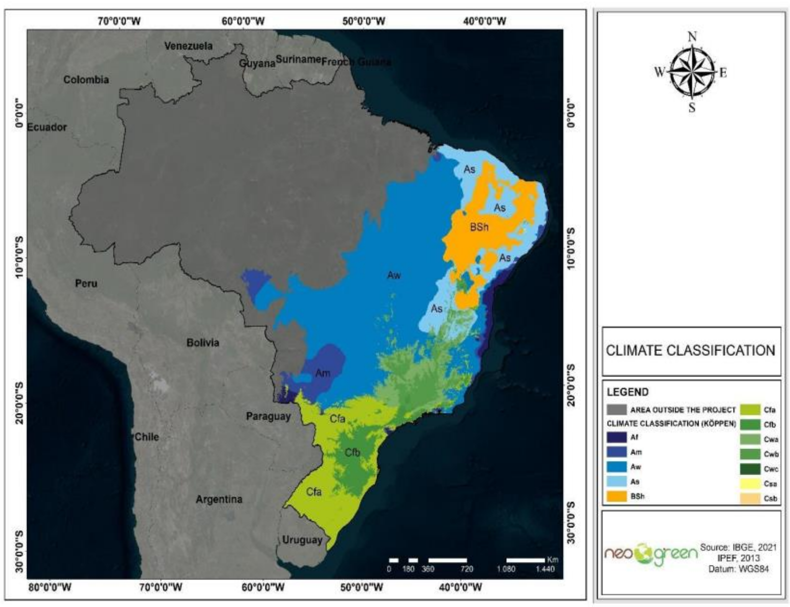

Figure 4. Köppen-Geiger climate classification for the project area[80]

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76 MMA. Pampa. Available at: https://www.gov.br/mma/pt-br/assuntos/ecossistemas-1/biomas/pampa

77 IBGE. Clima> Available at: https://educa.ibge.gov.br/jovens/conheca-o-brasil/territorio/20644-clima.html

78 KOTTEK, M.; GRIESER, J.; BECK,C.; RUDOLF, C.; RUBEL,F. 2006: World Map of the Köppen-Geiger climate classification updated.Meteorol. Z., 15, 259-263. Available at: https://www.schweizerbart.de/papers/metz/detail/15/55034/World_Map_of_the_Koppen_Geiger_climate_classificat?af=crossref

79 Embrapa. Clima. Available at: https://www.cnpf.embrapa.br/pesquisa/efb/clima.htm#:~:text=Af%20%2D%20Clima%20tropical%20%C3%BAmido%20ou,mais%20quente%20superior%20a%2018%C2%BAC.

80 Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.L.M.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v. 22, n. 6, p. 711-728, 2013. Available at:

Af - Humid or super-humid equatorial climate: Climate without a dry season, with the average temperature of the hottest month above 18ºC. The rainfall in the driest month is over 60 mm, with more significant rainfall from March to August, exceeding the annual total of 1,500 mm. In the warmer months (January and February), the temperature is 24 to 25ºC.

Am - Tropical humid or sub-humid climate: It transitions between climate types Af and Aw. It is characterized by an average temperature of the coldest month, always consistently 18ºC, with a short dry season compensated by high precipitation totals.

Aw - Tropical climate, with dry winter: It has a rainy season in the summer, from November to April, and a clear dry season in the winter, from May to October (July is the driest month). The average temperature of the coldest month is above 18ºC. The precipitation is greater than 750 mm per year, reaching 1800 mm.

As - Hot and humid tropical climate, with a dry season in winter: It is characterized by the absence of summer rain and its occurrence in the "winter" (which corresponds to the rainy season and not the winter itself), with annual rainfall around 1,600 mm.

BSh - Hot semi-arid climate: It is characterized by a lack of rainfall and great irregularity in its distribution, low cloud cover, intense insolation, high evaporation rates, and high average temperatures (around 27ºC). The relative humidity of the air is usually low, and the few showers of rain - from 250 mm to 750 mm per year - are concentrated in a short space of time, causing torrential flooding. Even during the rainy season (November to April), its distribution is irregular, failing to occur for a few years and causing droughts. The vegetation characteristic of this type of climate is xerophytic (Caatinga).

Cfa - Humid subtropical climate: Temperatures are above 22ºC in summer, with more than 30 mm of rain in the driest month.

Cfb - Humid maritime temperate climate: Evenly distributed rainfall, without a dry season, and the average temperature of the hottest month does not reach 22ºC. Precipitation from 1,100 to 2,000 mm. Severe and frequent frosts, with an average occurrence of 10 to 25 days annually.

Cwa - Subtropical/altitude tropical climate: Subtropical climate with dry winter (with temperatures below 18ºC) and hot summer (with temperatures above 22ºC).

Cwb - Temperate maritime/altitude tropical climate: Subtropical, high-altitude, with dry winters and mild summers. The average temperature of the hottest month is below 22ºC.

Cwc - Hot summer Mediterranean climate: it has autumn and winter (May to September) with dry and cold conditions, monthly rainfall lower than 50 mm, and an average monthly temperature of 4.5º C in

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http://www.lerf.eco.br/img/publicacoes/Alvares_etal_2014.pdf?_ga=2.197678889.765804623.1656966890-799514261.1656966889

July. The average annual temperature is 9.4º C, and the annual precipitation is approximately 1,300 mm[81].

Csa - Mediterranean temperate climate, hot summers (rain in winter): observed at a specific altitude, between 800 and 1,000 m. Above this altitude range, the climate is classified as Csb (humid subtropical with dry and temperate summers). Precipitation reaches 710 mm per year but is concentrated in autumn, from April to June, and early winter (July), with no more than 100 mm per month. The average annual temperature in the Csa climate in Brazil is 20.9º C with a maximum in January (22.7º C) and a minimum in August (18.1º C)[82].

Csb - Mediterranean temperate climate, mild summers: autumn and winter (May to September) with dry and cold conditions, monthly rainfall lower than 50 mm, and an average monthly temperature of 4.5º C in July. The average annual temperature is 9.4º C, and the annual precipitation is approximately 1,300 mm[83].

1.14.1.3 Hydrography

In Brazil, a large part of water is found in underground aquifers, and another part is in constant flow in the vast network of rivers, streams, streams, and creeks in the territory. So, like any part of the globe, it is all naturally subdivided into several Hydrographic Basins (BH). The relief is responsible for separating the rainwater and determining where it will flow until it reaches the final base level: the ocean – in the Brazilian case, the Atlantic[84].

The BHs that are included in the project area are represented in Figure 5and described below, according to ANA (National Water and Basic Sanitation Agency), a government agency responsible for monitoring critical events, integrated management of water resources, regulation, inspection, basic sanitation and water security in the country[85][86]:

Amazonian: It is the largest BH on the planet and has approximately 3,870,000 km², being a region of outstanding natural and human contrasts, which stands out for its numerous rivers, streams, and lakes. It has an extensive network of rivers with a great abundance of water, the best-known being:

[81] Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.L.M.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v. 22, n. 6, p. 711-728, 2013. Available at: http://www.lerf.eco.br/img/publicacoes/Alvares_etal_2014.pdf?_ga=2.197678889.765804623.1656966890-799514261.1656966889

[82] Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.L.M.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v. 22, n. 6, p. 711-728, 2013. Available at: http://www.lerf.eco.br/img/publicacoes/Alvares_etal_2014.pdf?_ga=2.197678889.765804623.1656966890-799514261.1656966889

83 Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.L.M.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, v. 22, n. 6, p. 711-728, 2013. Available at: http://www.lerf.eco.br/img/publicacoes/Alvares_etal_2014.pdf?_ga=2.197678889.765804623.1656966890-799514261.1656966889

84 IBGE. Bacias e divisões hidrográficas do Brasil / IBGE, Coordenação de Recursos Naturais e Estudos Ambientais. Rio de Janeiro. V. 28. 160 p. 2021. Available at: https://biblioteca.ibge.gov.br/visualizacao/livros/liv101854.pdf

85 ANA. Conjuntura dos Recursos Hídricos do Brasil – Regiões Hidrográficas brasileiras. Brasília, 2015. Available at: http://www.snirh.gov.br/portal/snirh/centrais-de-conteudos/conjuntura-dos-recursos-hidricos/regioeshidrograficas2014.pdf

86 ANA. Regiões hidrográficas. Available at: https://www.gov.br/ana/pt-br/assuntos/gestao-das-aguas/panorama-das-aguas/regioes-hidrograficas

Amazonas, Xingu, Solimões, Madeira, and Negro. The population density is ten times lower than the national average. However, the region concentrates 81% of the country's surface water availability. About 85% of the basin area remains with native vegetation cover.

East Atlantic: This BH has approximately 388,160 Km² and covers four states (Bahia, Minas Gerais, Sergipe, and Espírito Santo). Much of its area is located in the semi-arid region, which has periods of prolonged drought. This basin has the second lowest water availability among the twelve Brazilian hydrographic regions.

West Northeast Atlantic: This BH has an approximate area of 274,300 km² (3% of the national territory). The basin comprises five hydrographic units: Itapecuru, Gurupi, Litoranea MA, Litoranea MA/PA, and Mearim. The main rivers in the region are the Gurupi, Mearim, Itapecuru, and Munim rivers.

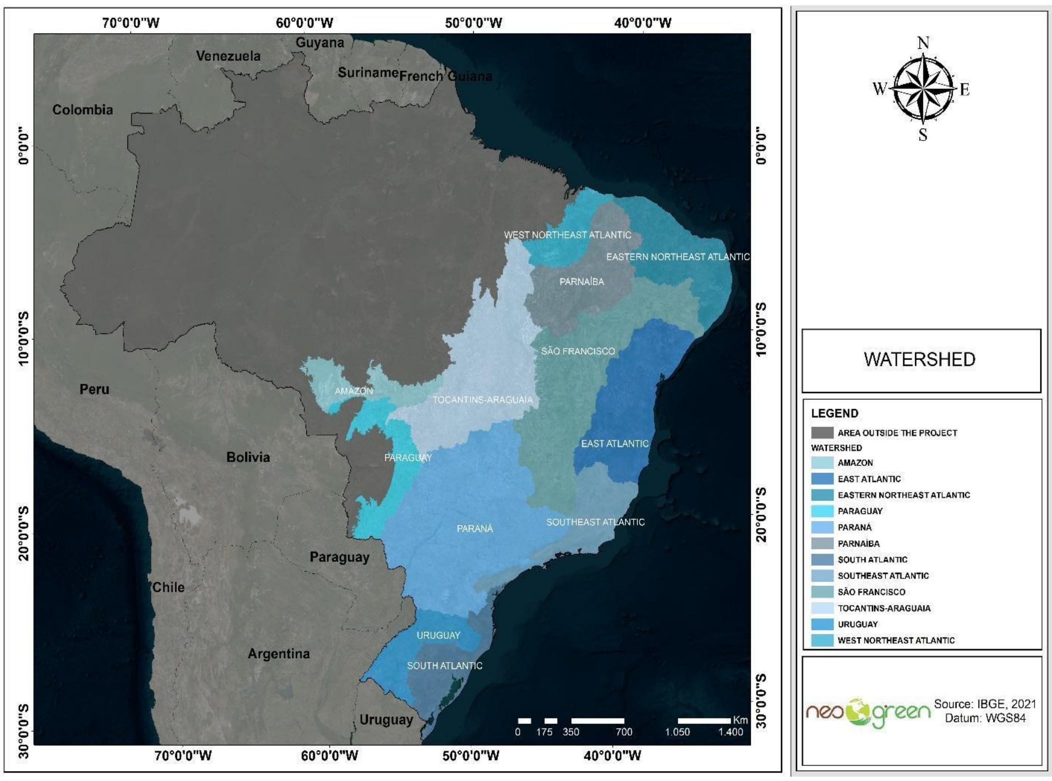

Figure 5. Hydrographic basins in the project area[87]

East Northeast Atlantic: This BH has an area of about 286,800 km² (3.4% of the national territory). The Jaguaribe and Piranhas Açu rivers are home to the main reservoirs in the region. Almost all of its area belongs to the Brazilian Semi-Arid Region, characterized by prolonged dry periods and high temperatures throughout the year. This is the hydrographic region with the lowest water availability in Brazil.

[87] IBGE. Bacias e Divisões Hidrográficas do Brasil – 2021. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/31653-bacias-e-divisoes-hidrograficas-do-brasil.html?=&t=acesso-ao-produto

Southeast Atlantic: This BH drains one of the most significant Brazilian hydrographic regions and has an area of 214,629 km² (2.5% of the country). It is constituted by several small but extensive rivers that form the integrated basins of the rivers Itapemirim, Fluminense, and Paulista, highlighting the rivers Paraíba do Sul, Doce, Ribeira do Iguape, Manhuaçu, Piranga, Pomba, Muriaé, Suaçuí Grande, Santo Antônio and Paraitinga and Fish.

South Atlantic: The BH do Atlântico Sul is of great importance in the country for housing an important population, economic development, and tourist importance. It has an area of 187,552 km² (2.2% of the national territory). Small rivers predominate, which flow directly into the sea. The most significant exceptions are the Itajaí and Capivari rivers in Santa Catarina, which have a greater volume of water. In the Rio Grande do Sul region, large rivers, such as the Taquari-Antas, Jacuí, Vacacaí, and Camaquã, are connected to the lagoon systems of Lagoa Mirim and Patos.

Paraguay: The BH of Paraguay, also called the Upper Paraguay Basin (BAP), has an area of 363,446 km² (4.3% of the national territory). The BAP is divided into two large basins or hydrographic units: the Pantanal (about 36% of the basin) and the Planalto Paraguai. Among its main waterways, there are Paraguay, Taquari, São Lourenço, Cuiabá, Itiquira, Miranda, Aquidauana, Negro, Apa, and Jauru.

Paraná: The BH Paraná occupies 10% of the Brazilian territory (879,873 km²). It is the most populous and most economically developed region in the country. Therefore, it has the highest resource demand, emphasizing industrial use. It is also the region with the largest irrigated area and the most significant use of available hydraulic potential. The main rivers in the region, with a length greater than 500 km, are the Paraná, Grande, Iguaçu, Paranaíba, Tietê, and Paranapanema.

Parnaíba: TheBH Parnaíba occupies 3.9% of the Brazilian territory (333,056 km²). Largely located in the Brazilian semi-arid region, it is characterized by intermittent rainfall, with average annual precipitation well below the national average. The primary use of water in the area is irrigation. The main rivers in the region are the Parnaíba, Canindé, das Balsas, Piauí, Poti, Longá, Itaueira, and Uruçuí Preto rivers. Its waters cross different biomes, such as the Cerrado, in the Upper Parnaíba, the Caatinga, in the Middle and Lower Parnaíba; and the Coastal, in Baixo Parnaíba, making the hydrological characteristics of each of these regions different.

São Francisco: The BH São Francisco has an area of approximately 638,466 km² (7.5% of the national territory). The main rivers in the region are the São Francisco, das Velhas, Grande, Verde Grande, Paracatu, Urucuia, Paramirim, Pajeú, Preto, and Jacaré. This BH encompasses a part of the northeastern semi-arid region, with critical periods of prolonged droughts due to low rainfall and high evapotranspiration. The São Francisco River plays an essential role in this region.

Tocantins-Araguaia: The BH Tocantins-Araguaia is essential in the national context, as it is characterized by the expansion of the agricultural frontier, mainly with grain cultivation and hydro-energy potential. This BH has an area of approximately 920 thousand km² (10.8% of the national territory). It has excellent tourist potential: sport fishing, ecological tourism, river beaches, the largest river island in the world (Ilha do Bananal), the tourist hub of Belém, the Jalapão State Park (TO), and the Chapada dos Veadeiros National Park (GO), recognized for the beautiful waterfalls.

Uruguay: Uruguay's BH is essential to the country due to its agro-industrial activities and hydroelectric potential. Together with the hydrographic regions of Paraná and Paraguay, it forms the great hydrographic region of the La Plata basin. BH Uruguay has, in Brazilian territory, approximately 274,300 km^2 (3% of the national territory).

1.14.1.4 Wetlands

Wetlands are ecosystems at the interface between terrestrial and aquatic environments, continental or coastal, natural or artificial, permanently or periodically flooded or with waterlogged soils. Waters can be fresh, brackish, or salty, with plant and animal communities adapted to their water dynamics[88].

The definition of the wetland concept emerged in the Ramsar Convention. The intergovernmental treaty signed in Iran in 1971 marked the beginning of national and international actions for the conservation and sustainable use of wetlands and their natural resources. Currently, 150 countries are signatories to the treaty, including Brazil[89].

The Ramsar Site title provides wet environments with greater visibility and access to financial benefits related to technical advice for conservation and sustainable use actions. It also prioritizes the implementation of government policies and public recognition by society and the international community[90].

Wetlands are home to various endemic species and periodically terrestrial and deep-water species, contributing substantially to environmental biodiversity. In addition, they play an essential role in the hydrological cycle, expanding the water retention capacity of the region where they are located and promoting the multiple uses of water by human beings[91].

Wetlands will not be included in the project area according to the requirements of VM00042 v2.0 Final Draft. To locate these areas geographically and not have any instances in these areas, the Ramsar[92] database was used, shown in Figure 6.

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88 ICMBio. Dia Mundial das Áreas Úmidas. 2021. Available at: https://www.icmbio.gov.br/cepsul/destaques-e-eventos/670-dia-mundial-das-areas-umidas.html

89 WWF. O que são áreas úmidas? Available at: https://www.wwf.org.br/natureza_brasileira/questoes_ambientais/areas_umidas/#:~:text=As%20%C3%A1reas%20%C3%BAmidas%20s%C3%A3o%20complexos,agricultura%2C%20reservat%C3%B3rios%20de%20hidrel%C3%A9tricas%20etc.

90 ICMBio. Dia Mundial das Áreas Úmidas. 2021. Available at: https://www.icmbio.gov.br/cepsul/destaques-e-eventos/670-dia-mundial-das-areas-umidas.html

91 WWF. O que são áreas úmidas? Available at: https://www.wwf.org.br/natureza_brasileira/questoes_ambientais/areas_umidas/#:~:text=As%20%C3%A1reas%20%C3%BAmidas%20s%C3%A3o%20complexos,agricultura%2C%20reservat%C3%B3rios%20de%20hidrel%C3%A9tricas%20etc.

92 Ramsar. Ramsar Map. Available at: https://rsis.ramsar.org/

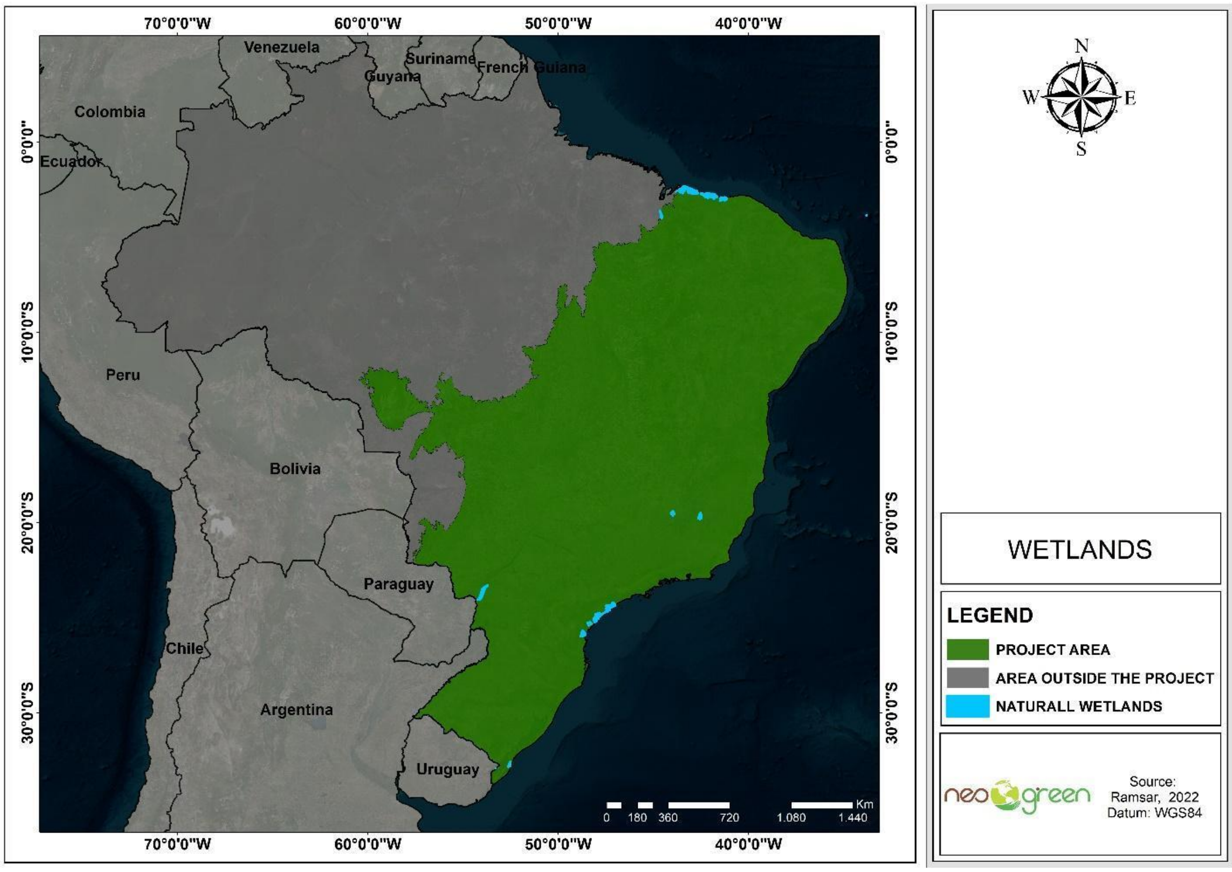

Figure 6. Location of wetlands within the project area.

1.14.1.5 Soils

Brazil has a great variety of soils in its continental extension due to the type of pedoenvironments and soil formation factors. The wide peculiarity observed in pedoenvironments also represents an essential condition for evaluating the potentials and limitations of each soil, conditioning its sustainability according to the uses and management practices applied[93].

In the project area, all 13 types of soils present in the country were identified, represented in Figure 7, and described below, according to the classification of Embrapa (Brazilian Agricultural Research Corporation)[94].

93 Embrapa. Solos Brasileiros. Available at: https://www.embrapa.br/tema-solos-brasileiros/solos-do-brasil
94 SANTOS, H.G. et al. Sistema Brasileiro de Classificação de Solos. 5ª ed. Brasília: EMBRAPA, 2018. 356p.

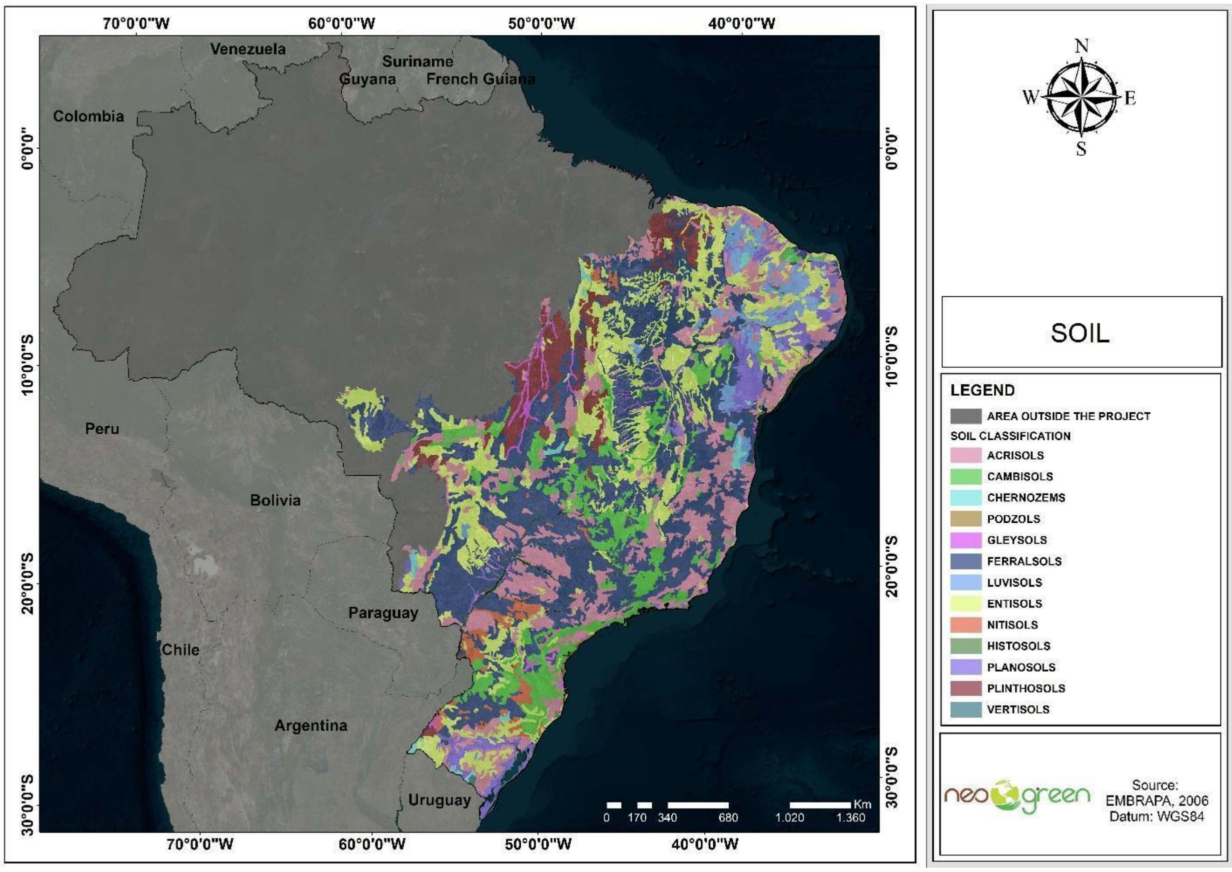

Figure 7. Classification of Brazilian soils present in the project area[95].

Acrisols: These are deep, well-developed soils, with an A horizon (surface) generally sandy on a horizon B (subsurface) clayey, type B textural. These are soils with drainage variation (well to imperfectly drained) and some limitations, mainly concerning natural fertility and water retention in the sandy A horizon. The high susceptibility to erosion must also be taken into account when planning the use of these soils, demanding conservation practices for their sustainable use.

Cambisols: These are soils that present an incipient process of formation. They can range from shallow to profound, with the characteristic presence of saprolite or rock fragments in the incipient B horizon. They are soils that frequently occur in undulating to mountainous reliefs, presenting limitations about erosion, adequate depth, associated stoniness, and fertility.

Chernozems: These are soils with a dark A horizon and high natural fertility called A chernozemic. The higher organic matter levels in the A horizon give the dark color. Although they have high fertility, they

95 Embrapa. Mapa de Solos do Brasil. Available at: http://geoinfo.cnps.embrapa.br/layers/geonode%3Abrasil_solos_5m_20201104

present limitations of mechanization and susceptibility to erosion when they occur in intense undulating relief.

Podzols: are the only soils with an accumulation of organic matter in the B horizon, called spodic B. They are soils that occur in sandy areas and with high rainfall, generally associated with coastal sandbanks. They are very fragile soils due to the sandy texture of horizon A. They present severe limitations for agricultural and urban/industrial use.

Gleysols are shallow to deep soils with the gleization process (iron reduction in flooded environments), resulting in a grayish or black coloration with red and orange spots (mottled). They usually occupy the low plains (várzeas) and can present a sandy or clayey profile. The main limitations are poor drainage (hydromorphism), mechanization, and the high potential for contamination of the water table or aquifer.

Ferralsols are deep and well-developed soils with a high degree of weathering, which is why they are poor in natural fertility. These soils have high agricultural potential. However, they require fertility correction with the application of fertilizers and agricultural lime. The physical properties are very good for plant development, as they are clayey soils with a high degree of aggregation (structuring), increased water retention, good density, and drainage. They also demand conservation practices to avoid the erosive process.

Luvisols are shallow to deep soils that present a textural gradient between horizons A and B. These soils differ from Argisols because they offer high base saturation associated with increased activity clay, that is, greater natural fertility due to expansive clays such as vermiculite or smectites. They are more clayey and less deep when compared to Ultisols. They also demand conservation practices for their sustainable use.

Entisols: These are generally shallow soils, in the cases of Litholic Neosols and Regolithic Neosols, or deep soils such as Quartzarenic Neosols and Fluvic Neosols. They are poorly developed soils with severe limitations for agricultural or urban/industrial use, mainly due to their small depth, stoniness, sandy texture, and frequent occurrence in undulating to mountainous reliefs. Its use must be supported by technical knowledge and adequate planning.

Nitisols: These are deep, well-developed, generally well-drained, clayey, and red soils characterized by a robust structure associated with expressive waxiness. These soils are very similar to Latosols and sometimes to Ultisols. They have high agricultural potential and demand fertility correction and erosion control practices.

Histosols: This is the only class of organic soil; in the other classes, there is a predominance of mineral particles. Organosols are soils formed by the occurrence of an organic layer called the Histic horizon. These infrequent soils occur in areas that are not very significant in territorial terms but with high environmental value. These are fragile soils that have essential ecosystem functions. When subjected to agricultural use, they are destroyed in a few years; therefore, they must be maintained as an environmental preservation area.

Planosols: These are poorly drained soils with a high textural gradient between horizons A and B. They generally occur in flat areas (floodplains) associated with Gleissolos and Fluvic Neosols. These are soils with high potential for irrigated rice cultivation in southern Brazil. They generally have low natural fertility on the A horizon, characterized as sandy.

Plinthosols: These are generally deep soils with plinthites or petroplinthites in the profile. Plinthites and petroplinthites are concentrated iron nodules that limit root penetration and water retention in the horizons where they occur. In this case, Plintosols present limitations to agricultural production and, therefore, need to be identified to plan their use correctly.

Vertisols: These are shallow to deep soils and dark in color due to the homogeneous presence of organic matter and expansive clays of the 2:1 type. These are soils with high natural fertility, except phosphorus, which physically presents management limitations. Expansive clays make the soil very hard when dry and very plastic and sticky when wet. These are soils used for extensive livestock farming on native fields or irrigated rice cultivation.

1.14.1.6 Relief

The Brazilian relief consists mainly of plateaus, plains, and depressions96. The types of relief in the project area are represented in Figure 8 and described below, according to the IBGE (Brazilian Institute of Geography and Statistics) classification97.

Plain: These are sets of flat or gently undulating landforms, generally positioned at low altitudes, and in which sedimentation processes surpass those of erosion.

Spur: Sets of flat-topped landforms, elaborated in sedimentary rocks, generally limited by scarps. They have relatively low altitudes.

Cliff: Sets of flat-top landforms, built on sedimentary rocks, generally limited by scarps, sets of flat-top landforms, built on sedimentary rocks, typically determined by scarps. They are located at higher altitudes.

Depression: These are sets of flat or wavy relief located below the level of the neighboring regions, formed by rocks of different classes.

Highlands: These are flat or wavy relief, formed by different classes of rock, constituting intermediate surfaces or steps between areas of higher relief and topographically lower sites.

Plateaus: These are sets of flat or dissected relief, of high altitude, limited, at

least on one side, by lower surfaces, where erosion processes surpass those of sedimentation.

96 IBGE. Relevo do Brasil. Available at: https://educa.ibge.gov.br/jovens/conheca-o-brasil/territorio/18306-relevo-do-brasil.html
97IBGE. Manual técnico de geomorfologia. 2º ed. Rio de Janeiro, 2009. Available at: https://biblioteca.ibge.gov.br/visualizacao/livros/liv66620.pdf

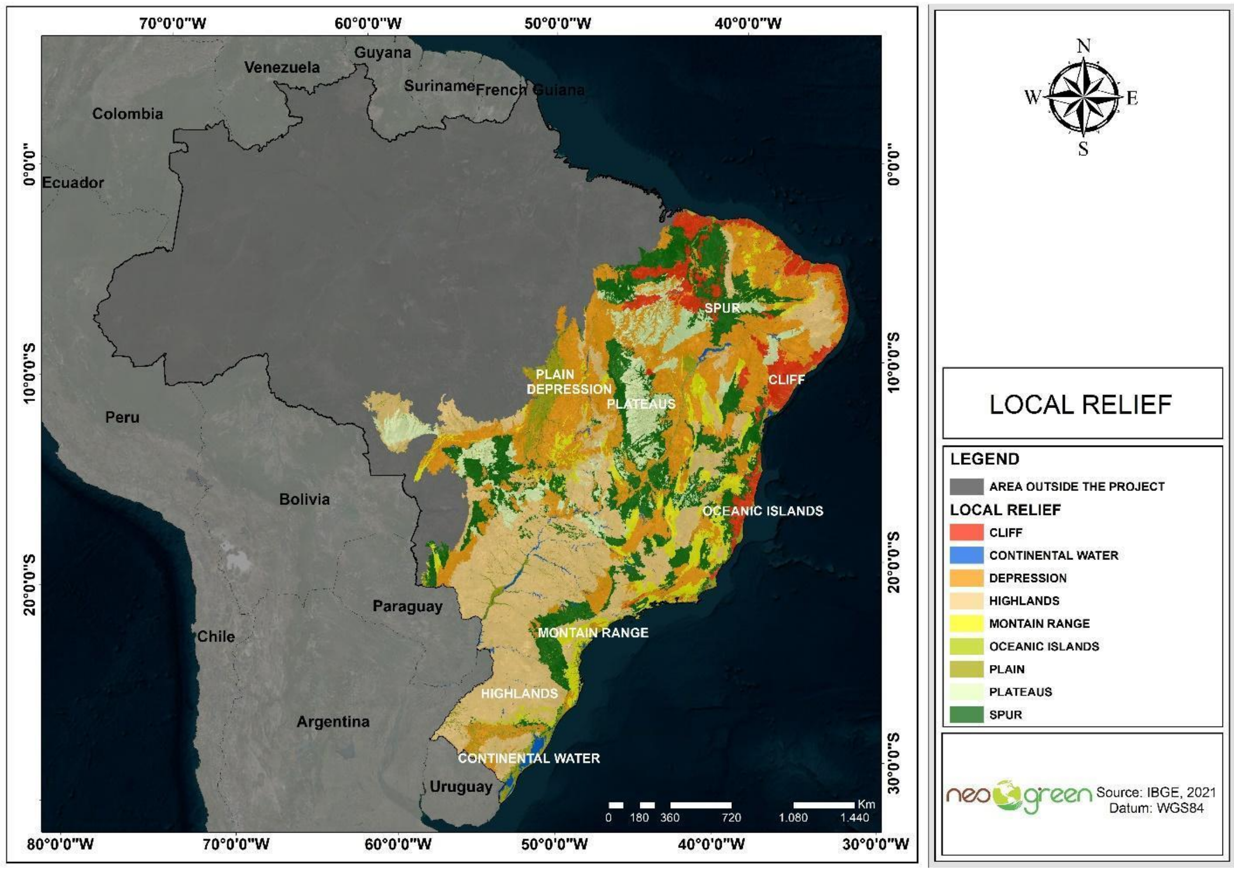

Figure 8. Relief classification in the project area[98].

Mountain range: These constitute rugged reliefs, formed by different rocks, crests, and ridges forming steep edges of plateaus.

Continental waters: Continental waters are bodies of water that are on dry land and are integrated by two large ecosystems: Lentic, formed by calm waters, such as lakes, swamps, dams, and mangroves, among others, and Lotic, formed by water currents, such as streams and rivers. Lentic ecosystems are distinguished from lotic ecosystems by the force of the current, the exchange between land and water, and the amount of oxygen in the water[99].

98 IBGE. Unidades de relevo 1:5.000.000/2006. Available at: https://www.ibge.gov.br/geociencias/informacoes-ambientais/geomorfologia/15827-unidades-de-relevo.html?=&t=downloads

99 Águas de Santarém. Águas continentais. Available at: https://aguasdesantarem.pt/site-jovem/canal-educativo/a-agua-como-meio/aguas-continentais/#:~:text=As%20%C3%A1guas%20continentais%20s%C3%A3o%20corpos,tais%20como%20c%C3%B3rregos%20e%20rios.

Oceanic islands: Five islands and archipelagos on the ocean floor are part of the national territory: São Pedro and São Paulo, Fernando de Noronha and Rocas atoll, all in the equatorial region; Trindade island and Martin Vaz archipelago in the tropical region[100].

As a result of the size of the project area, the environmental conditions vary greatly, so for each instance added, a brief description of the place will be made.

1.14.2 Current and Historical Land Use

Agriculture and the Brazilian economy have gone through a series of cycles, often centered on a single product, the export monoculture. Even after industrialization, the country's economy never stopped being linked to agriculture or plant and mineral extraction.

Initially, in the colonial period, the extraction of Pau-Brasil wood in the region of the Atlantic Forest biome was the main product removed from Brazilian lands. With time the use of the land was converted to the plantation of sugar cane on a large scale, in the Northeast region of the country. At the height of sugar production, tobacco cultivation began in the same area. With the increase in population, subsistence cultivars such as cassava and corn were also developed, together with livestock, further into the country’s interior and growing increasingly in the south since the coastal part of the Northeast was dedicated to sugar.

In the 19th century, with the Industrial Revolution and the development of the textile industry, cotton had significant growth in the world economy; in Brazil, its cultivation was developed in the Northeast and descended to the Southeast of the country.

At the end of the 19th century and the beginning of the 20th century, coffee cultivation began to emerge, becoming the main economic activity in Brazil, spreading through several regions, reaching the Midwest, but being cultivated mainly in the Southeast.

In the same period as coffee, with the development of the automotive industry, there was a growing demand for rubber, and extraction from rubber trees was concentrated in the Amazon basin.

At the end of the 20th century and the middle of the 21st century, soybean plantations began to rise, becoming the main agribusiness crop in Brazil and being mainly responsible for the geographical change in agricultural production in the country. The first tests were carried out in Bahia, but they soon expanded to the Southeast and South and then to the Midwest. Another soya milestone in the country was the expansion of soya in the Cerrado biome.

In conjunction with the geographic shift caused by soybean cultivation, corn followed the same trend, produced between soybean crops. Another important fact was the increase in meat production (cattle, poultry, swine) linked to the large production of grains in all regions[101].

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100 ALMEIDA, F, F, M. Ilhas oceânicas brasileiras e suas relações com a tectônica atlântica. Terra e didática. v 02. p 003. UNICAMP, São Paulo. 2006. Available at: https://www.ige.unicamp.br/terraedidatica/v2/pdf-v2/t_didatica_2006_v02n01_p003-018_almeida.pdf

[101] MIRANDA, R,A. Breve história da agropecuária brasileira. Embrapa, 2020. Available at: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1122598/breve-historia-da-agropecuaria-brasileira

Figure 9 represents Brazil's regions to understand better the geographic regions mentioned above in the text.

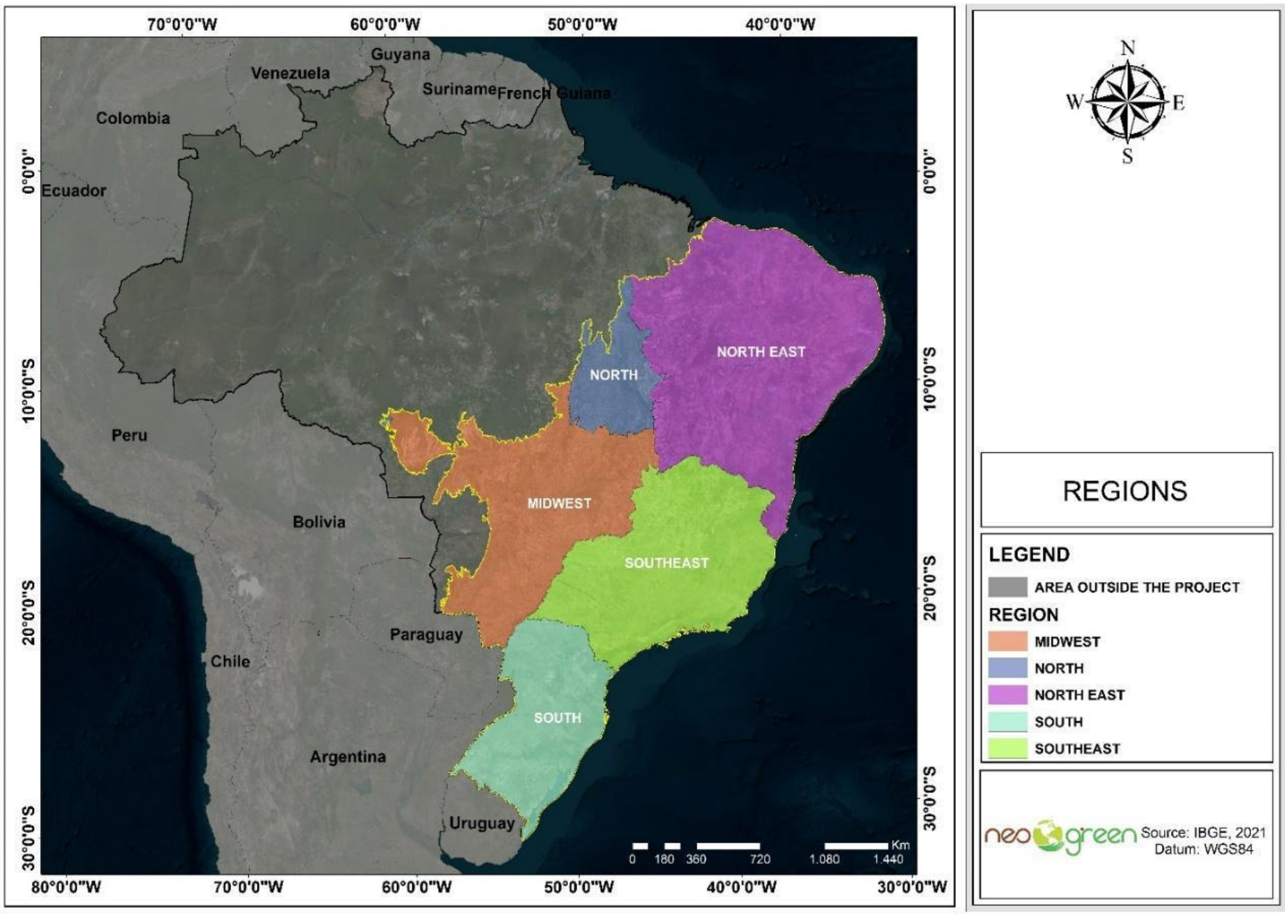

Figure 9. Geographic regions of Brazil, with emphasis on areas within the project.

In the project area, the current land use for the distribution of agriculture and livestock is represented in Figure 10:

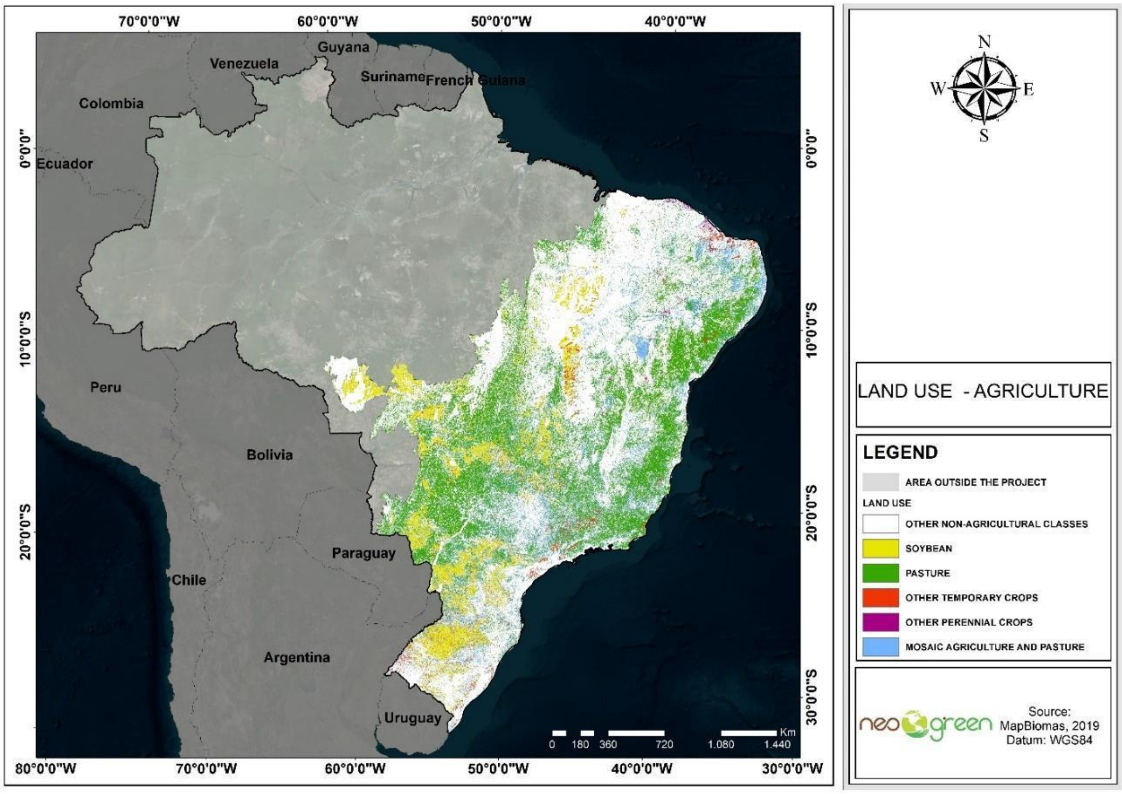

Figure 10. Distribution of agriculture and pasture classes within the geographical area of the project.

1.14.3 Deforestation History

Has the land been cleared of native ecosystems within 10 years of the project start date?

☐Yes ☒No

Project instances cannot have deforested their areas within 10 years of the project start date, following the guidelines of the VM0042 v2.0 Final Draft methodology.

For this multi-temporal analysis of the project area and verification of the absence of deforestation in each instance, data obtained by Remote Sensing will be used.

At first, the land use classifications available on the MapBiomas website will be used. The data provided by the MapBiomas software is based on Landsat satellite collections and a pixel-by-pixel classification of Brazil'[102]. Classifications have been made available since 1985, enabling the temporal analysis of all instances to be included in the project.

The methodology used by MapBiomas is validated and available on the project website[103].

[102] MapBiomas. Visão geral da metodologia. Available at: https://mapbiomas.org/visao-geral-da-metodologia
[103] MapBiomas. Download dos ATBDS com método detalhado. Available at: https://mapbiomas.org/download-dos-atbds

For the validation of this classification, satellite images (Landsat, Sentinel, and other passive sensors) will also be analyzed for the 10 years before the entry of each instance in the project.

As an example of the annual land use classifications provided by MapBiomas, Figures Figure 11 and Figure 12 for the years 2009 and 2019 consecutively are shown below.

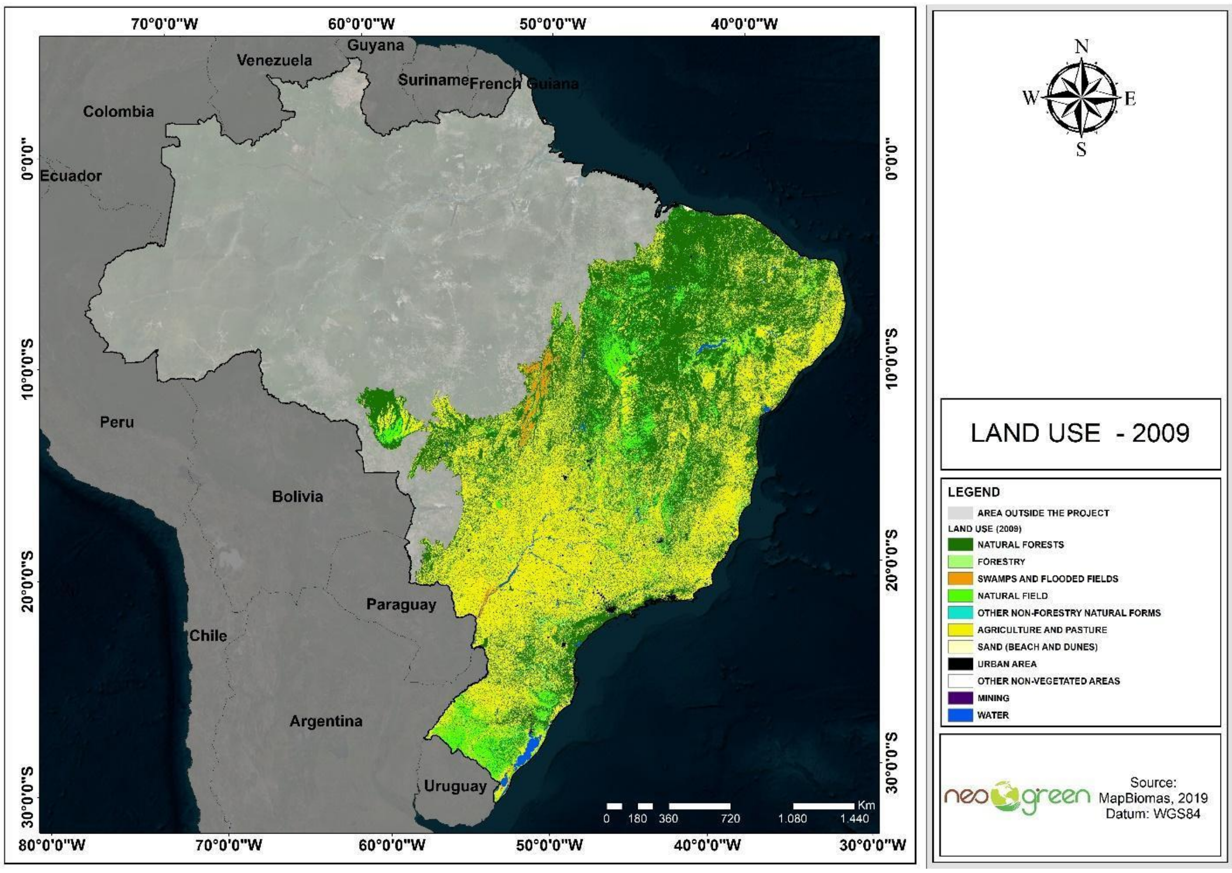

Figure 11. Land Use Classification provided by MapBiomas for the year 2009[104]

[104] MapBiomas. Classificação do Uso da terra para o ano de 2009. Available at: https://storage.googleapis.com/mapbiomas-public/brasil/collection-6/lclu/coverage/brasil_coverage_2009.tif

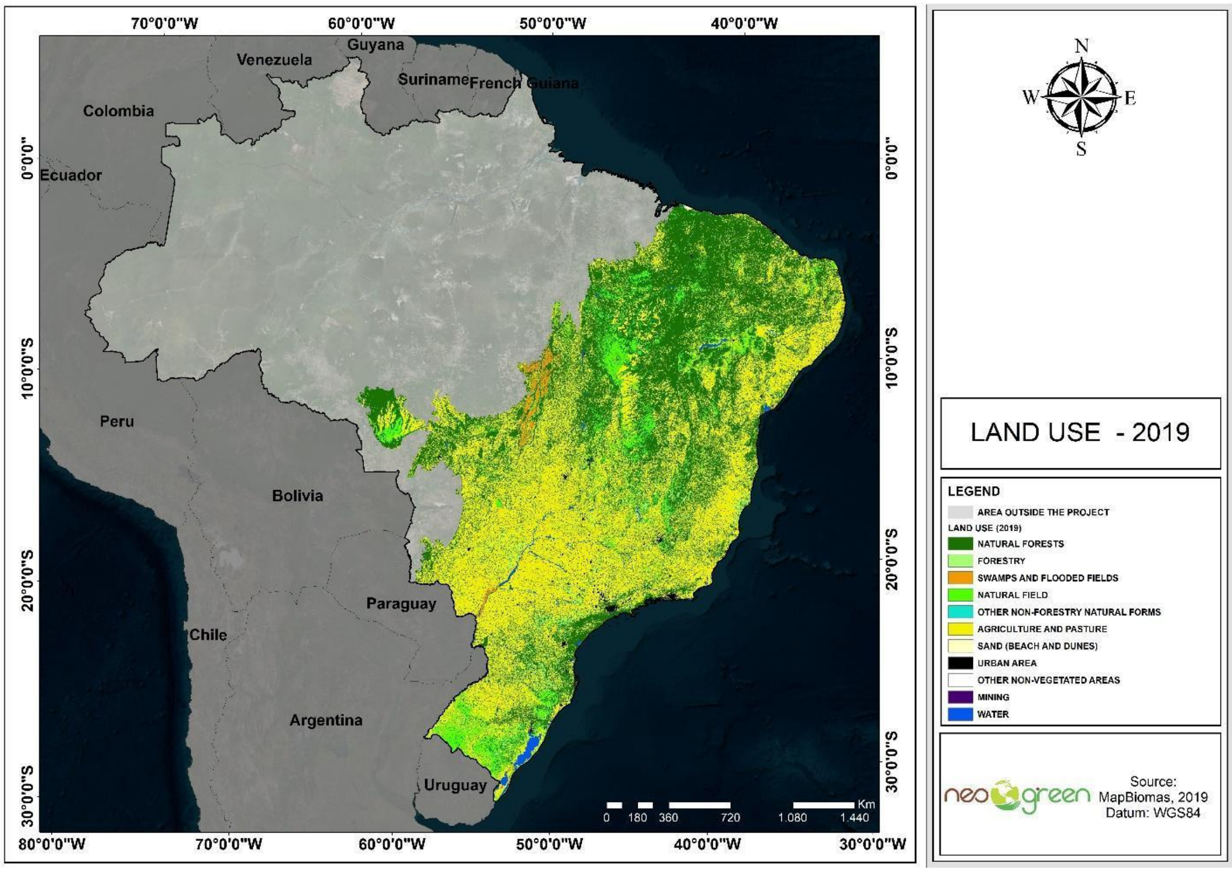

Figure 12. Land Use Classification provided by MapBiomas for the year 2019.

1.15 Compliance with Laws, Statutes, and Other Regulatory Frameworks

The following is a list of laws and other documents that deal with the preservation of the environment in Brazil and other laws related to the project's scope, demonstrating that the project complies with the country's legislation.

1.15.1 Law 6.938/81 - National Environmental Policy

Provides for the National Environmental Policy, its purposes and mechanisms of formulation and application, and other measures [105].

Conformity: The project complies with the National Environmental Policy described in the Law; it also aims to preserve, improve and restore the environmental quality that is conducive to life to ensure, in the country, conditions for the development of socio-economic and national security interests and the protection of the dignity of human life.

[105] BRASIL. Lei nº 6.938, de 31 de agosto de 1981. Available at: http://www.planalto.gov.br/ccivil_03/leis/l6938.htm

1.15.2 Law 7.802/89 - Pesticide Law

Provides for research, experimentation, production, packaging and labeling, transport, storage, marketing, commercial advertising, use, import, export, the final destination of waste and packaging, registration, classification, control, inspection, and inspection of pesticides, their components and similar, and other measures[106].

Conformity: The properties (instances) included in the project comply with the Pesticides Law, following all the guidelines for the controlled use of pesticides and, in this way, ensuring the protection of health and the environment, preventing the indiscriminate use and incorrect disposal of waste.

1.15.3 Law 8.171/91 - Agricultural Policy

Provides for the agricultural policy[107].

Conformity: The project complies with the Agricultural Policy of Brazil, following the precepts of agricultural planning, protection of the environment and conservation of natural resources, defense of agriculture, irrigation and drainage, agricultural mechanization, and others provided for by law.

1.15.4 Law 9.433/97 - National Policy on Water Resources

Establishes the National Water Resources Policy, creates the National Water Resources Management System, regulates item XIX of art. 21 of the Federal Constitution, and amends art. 1 of Law No. 8,001, of March 13rd, 1990, which modified Law No. 7,990, of December 28th, 1989[108].

Conformity: The National Water Resources Policy is based on the principle that water is a limited natural resource that has economic value and that its management must rely on the participation of users and communities. One of the policy's objectives is to ensure that current and future generations will have water available to appropriate standards according to use. Soil conservation is necessary to maintain this natural resource for the instances included within the project, mainly because it has agriculture as a source of income.

1.15.5 Law 12.651/12 - New Brazilian Forest Code

Provides for the protection of native vegetation; amends Laws No. 6,938, of August 31st, 1981, No. 9,393, of December 19th, 1996, and No. 11,428, of December 22nd, 2006; revokes Laws No. 4,771, of September 15th, 1965, and No. 7,754, of April 14th, 1989, and Provisional Measure No. 2,166-67, of August 24th, 2001; and takes other measures[109].

106 BRASIL. Lei nº 7.802, de 11 de julho de 1989. Available at: http://www.planalto.gov.br/ccivil_03/leis/l7802.htm
107 BRASIL. Lei nº 8.171, de 17 de janeiro de 1991. Available at: http://www.planalto.gov.br/ccivil_03/leis/l8171.htm
108 BRASIL. Lei nº 9.433, de 8 de janeiro de 1997. Available at: http://www.planalto.gov.br/ccivil_03/leis/l9433.htm
109 BRASIL. Lei nº 12.651, de 25 de maio de 2012. Available at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm#:~:text=12.,os%20casos%20previstos%20no%20art.

Conformity: Before registering the project in the VCS, the regularity of the areas that make up the project were verified. All are duly registered under a registration number with a competent body, in addition to being recorded in the Rural Environmental Registry (CAR).

1.15.6 Law No. 12.187/09 - National Policy on Climate Change

Establishes the National Policy on Climate Change - PNMC and takes other measures[110].

Conformity: The current project contributes to mitigating climate change through conservationist agriculture practices and aims to use the financial mechanism, which means the generation of carbon credits from the project.

1.15.7 Law No. 10.803/03 - Determination of penalties to the crime of condition analogous to that of slave

Amends art. 149 of Decree-Law No. 2,848, of December 7th, 1940 - Penal Code, to establish penalties for the crime typified therein. It indicated the cases in which a condition analogous to slavery is configured[111].

Conformity: This project will only cover rural properties that prove they do not have employees in a situation similar to that of slave labor.

1.15.8 Law No. 14.119 - National Policy for Payment for Environmental Services

Establishes the National Policy for Payment for Environmental Services; and amends Laws No. 8,212, of July 24th, 1991, 8,629, of February 25th, 1993, and 6,015, of December 31st, 1973, to adapt them to the new policy[112].

Conformity: This project is in accordance with the objectives of the National Policy for Payment for Environmental Services, which describes in its guidelines the orientation towards payment for environmental services to maintain, recover or improve ecosystem services at the national level, stimulate soil conservation, avoid loss of native vegetation, fragmentation of habitats, desertification and other processes of degradation of native ecosystems, contribute to the regularization of the climate and reduction of emissions, stimulate the elaboration and execution of voluntary private projects of provision and payment for environmental services, recognize individual or collective initiatives that favor the maintenance, recovery or improvement of ecosystem services, through monetary or non-monetary retribution, provision of services or another form of reward, encourage the creation of a market for environmental services and foster sustainable development.

110 BRASIL. Lei nº 12.187, de 29 de dezembro de 2009. Available at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm

111 BRASIL. Lei nº 10.803, de 11 de dezembro de 2003. Available at: http://www.planalto.gov.br/ccivil_03/leis/2003/l10.803.htm

112 BRASIL. Lei nº 14.119, de 13 de janeiro de 2021. Available at: http://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/L14119.htm

1.14.9 Law No. 4.504/1964 - Earth Statute

Provides for the Land Statute and makes other provisions[113]. Law created to implement Agrarian Reform and promote Agricultural Policy.

Conformity: The rural properties that are going to compose the instances of the project are in accordance with the Land Statute, which describes that the property thoroughly performs its social function when: it favors the well-being of the owners and employees who work on it, as well as their families, maintain satisfactory levels of productivity, ensure the conservation of natural resources, observe the legal provisions that regulate honest working relationships between those who own and cultivate them.

1.14.10 Law No. 8.629 - Agrarian Reform

Provides for regulating constitutional provisions related to agrarian reform, provided in Chapter III, Title VII, of the Federal Constitution[114].

Conformity: The instances included in the project are in accordance with the Law that regulates Agrarian Reform in the country, as they are productive properties and fulfilling their social role. A productive property is one that, economically and rationally exploited, simultaneously achieves levels of land use and efficiency in use, according to indices set by the competent federal agency.

1.14.11 Law No. 6.746 - Tax Modules

Amends the provisions of articles 49 and 50 of Law No. 4,504, November 30th, 1964 (Land Statute), and other provisions[115].

Conformity: all instances belonging to the project comply with the legislation regarding the division of land into Fiscal Modules, according to the municipality where they are located.

1.16 Participation under Other GHG Programs

1.16.1 Projects registered (or seeking registration) in other GHG program(s)

The project or any of its project components do not participate in other programs that may generate carbon credits in the soil.

1.16.2 Projects rejected by other GHG programs

This project has never been submitted to any other GHG program. Therefore, it has never been rejected.

113 BRASIL. Lei nº 4.504 de 30 de novembro de 1964. Available at: http://www.planalto.gov.br/ccivil_03/leis/l4504.htm
114 BRASIL. Lei nº 8.629 de 25 de fevereiro de 1993. Available at: http://www.planalto.gov.br/ccivil_03/leis/l8629.htm
115 BRASIL. Lei nº 6.746 de 10 de dezembro de 1979. Available at: http://www.planalto.gov.br/ccivil_03/leis/1970-1979/l6746.htm

1.17 Other Forms of Credit

1.17.1 Emissions Trading Programs and Other Linked Limits

Does the project reduce GHG emissions from activities included in an emissions trading program or any other mechanism that includes GHG permit trading?

☐Yes ☒No

1.17.2 Other Forms of Environmental Credit

Has the project sought or received another form of GHG-related credit, including renewable energy certificates?

☐Yes ☒No

1.18 Sustainable Development Contributions

The Ministry of Planning, Development, and Management, through the Institute of Applied Economic Research (IPEA), adapted the goals of 2030 Agenda of the UN Sustainable Development Goals to the Brazilian reality[116]. The project “NaturAll Carbon Program –Conservation Agriculture and Land Management in Brazil” contributes to the following UN Sustainable Development Goals (SDGs):

- SDG 2: Zero Hunger and Sustainable Agriculture: End hunger, achieve food security, improve nutrition and promote sustainable agriculture;
- SDG 6: Drinking water and sanitation: Ensure the availability and sustainable management of safe drinking water and sanitation for all;
- SDG 8: Decent Work and Economic Growth: Promoting sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all;
- SDG 12: Responsible consumption and production: Ensuring sustainable production and consumption patterns;
- SDG 13: Action Against Global Climate Change: Take urgent action to combat climate change and its impacts;
- SDG 15: Terrestrial Life: Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt the loss of biodiversity; and
- SDG 17: Partnerships and means of implementation: Strengthen means of implementation and revitalize the global partnership for sustainable development.

116 IPEA. Objetivos de Desenvolvimento Sustentável. 2019. Available at: https://www.ipea.gov.br/ods/

These objectives will be met by applying conservation practices in the instances included in the project.

1.18.1 SDG 2: Zero Hunger and Sustainable Agriculture: ending hunger, achieving food safety and improving nutrition, and promoting sustainable agriculture

The project will contribute to goal 2.3, aiming to increase agricultural productivity using conservationist agriculture practices, which will also contribute socio-economically to the region where each participating instance is, providing access to other productive resources.

For goal 2.4, there will be a significant contribution, as conservation management is a sustainable food production system. The project will implement resilient agricultural practices that increase productivity and production, help maintain ecosystems, strengthen capacity adaptation to climate change, extreme weather conditions, droughts, floods, and other disasters, and progressively improve the quality of the land and soil[117].

1.18.2 SDG 6: Drinking water and sanitation: Ensuring the availability and sustainable management of safe drinking water and sanitation for all

The project will contribute to goal 6.3 by 2030 to improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally. The contribution will keep the riparian forests intact to create a safe distance from crops/pasture and chemicals applied in these places that can cause water pollution and promote conservation agriculture, which over time, by promoting a more resilient soil, will reduce the application of polluting substances in the instances.

1.18.3 SDG 8: Decent Work and Economic Growth: Promoting sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all

The project will contribute to goal 8.2, reaching higher levels of productivity in agriculture and livestock through conservation management in the areas, which will also bring technological modernization, innovation, and better control of the regions.

Target 8.4 is also related to the project, as it strives to decouple economic growth from environmental degradation. And also to goals 8.7 and 8.8, committing to include instances that do not have workers in conditions analogous to slavery.

1.18.4 SDG 12: Strengthen the means of implementation and revitalize the global partnership for sustainable development

[117] IPEA. Objetivo de Desenvolvimento Sustentável – ODS 2: Fome Zero e Agricultura Sustentável. Available at: https://www.ipea.gov.br/ods/ods2.html

The project is going to contribute to achieving, by 2030, the sustainable management and efficient use of natural resources (SDG 12.2), the environmentally sound management of chemicals and all waste, throughout their entire life cycle, by the agreed international frameworks, and significantly reduce their release to air, water, and soil, to minimize their adverse impacts on human health and the environment (SDG 12.4), and support developing countries to strengthen their scientific and technological capacities to change towards more sustainable patterns of production and consumption (SDG 12. a).

1.18.5 SDG 13: Action Against Global Climate Change: Take urgent action to combat climate change and its impacts

The project commits to taking urgent measures to combat climate change and its impacts, meeting target 13.1, increasing resilience and adaptive capacity to risks and consequences resulting from climate change and natural disasters, and anticipating risks at each instance included in the project through the Non-Permanence Risk Tool and applying conservation practices that increase soil resilience, fertility, and productivity.

For goal 13.2, the project is integrated with the National Policy on Climate Change (PNMC) regulated by Law No. 12,187/2009[118], committing to reducing anthropogenic GHG emissions, making economic and social development compatible with the protection of the climate system, and strengthening anthropogenic GHG removals.

1.18.6 SDG 15: Terrestrial Life: Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt the loss of biodiversity

The project is committed to combating desertification, halting and reversing land degradation and biodiversity loss, meeting goal 15.3, combating desertification, and restoring degraded land and soil. This objective is going to be achieved through the application of conservation practices in the instances included in the project.

1.18.7 SDG 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development

The project is committed to developing environmentally friendly technologies in Brazil, meeting goal 17.7, and promoting the development, transfer, dissemination, and diffusion of environmentally friendly technologies to developing countries under favorable conditions, including concessional and preferential conditions, as mutually agreed. This objective will be achieved by applying conservation practices in the instances included in the project, as mutually agreed with the owners of the rural properties.

[118] BRASIL. Lei nº 12.187, de 29 de dezembro de 2009. Available at: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2009/lei/l12187.htm

1.19 Additional Information Relevant to the Project

1.19.1 Leakage Management

The VCS Program defines leakage as net changes in GHG emissions outside the project boundaries. NaturAll Carbon promotes the implementation and intensification of conservationist and regenerative agricultural practices in areas that usually continue to play their productive role. Additionally, the implemented practices are expected to increase agricultural production in the regions, minimizing the leakage of activities outside the project boundaries.

To address the leakage problem, the project is designed not to allow any carbon flows outside its borders to be accounted for in generating carbon credits. In the specific case of livestock activities, the project will only allow the application of manure generated and/or previously used within the property.

Also, to monitor potential leaks, productivity data will be cross-referenced with SOC addition data to verify if the latter is not being increased to the detriment of the former.

1.19.2 Commercially Sensitive Information

There is no commercially confidential information in this project description document. Supporting documents that include commercially confidential information that will not be made publicly available include: agreements, contracts with buyers and service providers, and documents related to project finances used in the risk assessment, including bank statements.

1.19.3 Other Information

More information can be requested on demand.

2 SAFEGUARDS

2.1 No Net Harm

It is not expected that the project will have a negative environmental or socio-economic impact on NaturAll Carbon's partners and society. As the NCP focuses on encouraging conservation and regenerative agriculture, the benefits go beyond GHG removal and reduction, as demonstrated earlier in this document. The increase in the income generated by trading the resulting carbon credits serves as an important incentive mechanism for maintaining positive socio-environmental practices. Joining the project will mean for many rural producers an increase in the use of digital agriculture tools, which in turn has the potential to make agriculture more productive, consistent, and efficient. This will bring critical benefits to farmers and society in general[119].

[119] Project Breakthrough. Digital Agriculture. Available at: http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/

2.2 Local Stakeholder Consultation

Farmers and ranchers who participate in the project “NaturAll Carbon Program – Conservation Agriculture and Land Management in Brazil” through sustainable management voluntarily agree to commit to the improved practices suggested by the current project through a contract between the NaturAll Carbon and the owner of agricultural land and/or pasture. All legislation cited in the project must also be complied with equally by the participating property.

As the project is going to take place in private areas and, as mentioned before, will not have any negative environmental or socio-economic impact, interviews with interested parties will not be necessary since the interested parties are the rural producers of the project, who are already going to be in direct contact with NaturAll Carbon. Therefore, there will be no impact on local communities.

2.3 Environmental Impact

As stated earlier, this project does not generate any negative environmental or socioeconomic impact. Its focus is to encourage conservation agriculture, sequestering carbon in agricultural soils and pastures through sustainable management.

The only impact that communities and the owners of the instances will have over the project period will be positive impacts on local ecosystem resources.

2.4 Public Comments

The public comment period will start from the day of submission of this project, for a period of 30 days.

2.5 AFOLU-Specific Safeguards

As mentioned in Section 2.2, the project will not have a negative impact on local communities. Therefore, there is no need to contact the community.

Section 3.17.10 of the VCS Standard v.4.3 states that if project activities do not impact local stakeholders, projects are not required to assess and identify risks, communicate and consult with local stakeholders during the project's life or develop grievance redress procedures to resolve disputes with them.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

VM0042 “Methodology for improved agricultural land management” Version 2.0 Final Draft of December 21, 2021 - Sectoral Scope 14 and its applicable tools. Additional Tools:

- VCS Standard, v.4.3 – June 22, 2022
- VCS Program definitions, v. 4.2 - June 22, 2022
- *VCS Program guide, v. 4.2 - June 22, 2022*
- Registration and issuance process, v4.2 - June 22, 2022
- Non-Permanence Risk Tool AFOLU, v4.0 – September 19, 2019
- Model calibration, validation, and uncertainty guidance for the methodology for improved agricultural land management - VMD0053 v2.0 Final Draft–December 22, 2021

3.2 Applicability of Methodology

All applicability conditions described in methodology VM0042 v2.0 Final Draft will be met by the project, as already described in Section 1.3 (Project eligibility).

Briefly, for monitoring and comparing the dynamics of GHGs in the baselines and after project implementation, to record project reductions and/or removals, the DayCent biogeochemical model will be used (validated following the methodology of VMD0053 v2.0 Final Draft) in combination with Remote Sensing techniques. The Daycent model is a "process-based biogeochemical model", a "daily time-step" version of the publicly available CENTURY model, which simulates C and N fluxes between the atmosphere, soil and vegetation. It is made up of submodels that include, among others, plant production and allocation of net primary production (NPP – Net Primary Production), decomposition of soil organic matter and plant biomass, N emission from processes of nitrification and denitrification and methane oxidation in unsaturated soils.[120].

The Daycent inputs are:

- Daily maximum/minimum temperature and precipitation;
- Soil texture classes;
- Coverage and land use data;
- Crop specific data is also needed to obtain C and N fluxes at regional and national levels.

In view of the inputs, to run the Daycent model it is necessary to inform the "cultivation/planting schedules" and which crop is present in a given period. In this way, the project proponent's approach will be to receive this cultivation data through documented statements by the owner of each instance and cross them with the data obtained by Remote Sensing, to check the information and also to fill in any data missing or of poor quality.

[120] DEL GROSSO, S, J.; OJIMA, D, S.; PARTON, W, J.; STEHFEST, E.; HEISTEMANN, M.; DEANGELO, B.; ROSE, S. Global scale DAYCENT model analysis of greenhouse gas emissions and mitigation strategies for cropped soils. Global and Planetary Change. Ed 67. 2009. Available from: https://doi.org/10.1016/j.gloplacha.2008.12.006

The main sources of Remote Sensing data will be from the Landsat Programs (NASA/USGS) and Sentinel[121] (ESA). In the absence of data on the analysis dates, low quality or high cloud cover, other public or commercial satellite constellations may be used, always making the origin of the data clear.

The data coming from the satellites will be analyzed using the composition of RGB spectral bands (true color) and other compositions that facilitate the analysis of agricultural areas and vegetation. The different spectral compositions help bring out elements in the image that the human eye cannot see in an RGB (true color) composition.

For the composition of the bands, the raw data of Remote Sensing are submitted to processing to reduce the noise in the image. The result is a so-called false-color image, which can highlight healthy vegetation, clouds, soil moisture, hot spots, and other features. Using mathematical algorithms specially designed for this purpose, highlighted elements can also be measured to provide quantitative data.[122].

The satellite images will also be processed to derive useful indices for the checking task, such as the Normalized Difference Tillage Index (NDTI), Enhanced Vegetation Index (EVI) and the Normalized Difference Vegetation Index (NDVI). An index is basically a ratio of values in different satellite bands to measure how high or low the reflectance of a given element is[123].

In addition to satellite data, the model will also rely on inputs originating from an internal NaturAll Carbon geospatial database, compiled from official sources, containing soil classification and texture information[124], historical land use and occupation[125], project boundaries[126] and other necessary parameters.In addition, historical, real-time and future climate data will be used from networks of meteorological stations (eg: National Institute of Meteorology of Brazil[127]), virtual weather stations

[121]USGS. GloVis. Available from: https://glovis.usgs.gov/app?_ga=2.41328676.782605249.1660833157-1457164687.1657799837

[122]EOS Data Analytics. Imagem de satélite e combinações de banda espectral. Available from: https://eos.com/pt/make-an-analysis/

[123]EOS Data Analytics. Imagem de satélite e combinações de banda espectral. Available from: https://eos.com/pt/make-an-analysis/

[124]EMBRAPA SOLOS. Mapa de solos do Brasil. 2020. Available from: http://geoinfo.cnps.embrapa.br/layers/geonode%3Abrasil_solos_5m_20201104

[125]MAPBIOMAS. Coleções MapBiomas. 2020. Available from: https://mapbiomas.org/colecoes-mapbiomas-1?cama_set_language=pt-BR

[126]IBGE. Malhas territoriais. 2021. Disponível: https://www.ibge.gov.br/geociencias/organizacao-do-territorio/malhas-territoriais.html

[127]INMET. Banco de dados meteorológicos INMET. Available from: https://bdmep.inmet.gov.br/

(NASA Power[128]) and other commercial output from regional and global climate models (GFS-NOAA[129], ECMWF[130]), or any other source of consistent data that may replace those described.

The project is not registered in any other soil carbon sequestration GHG program or credit forms, therefore, for its maintenance, the income from the credits is essential, due to the pressures exerted by the baseline activities described in section 3.5 (Additionality). Such activities compete with the preservation of native forest in terms of profitability from land use and extractivism.

It is also worth mentioning that the project activity does not occur in natural wetlands, any instance in these places being excluded from the project. The analysis of wetlands within or close to the areas included in the project will be carried out using the geographic database provided by Ramsar[131].

3.3 Project Boundary

The project instances are all inserted in the spatial boundary of the project, determined in Section 1.11 (Property) and the properties included in the project are cotton, soybean, corn, wheat, sorghum, sugar cane, sunflower, canola, rice and pasture (livestock).

Table 4 shows selected and non-selected carbon sources for the baseline and project scenario and their respective GHG sources.

Source		Gas	Included?	Justification/Explanation
Baseline	Woody biomass above and below ground	CO_2	No	Areas with reforestation will not be included in the scope of the project, so there is no need to account for woody biomass.
	Underground woody biomass	CO_2	No	Areas with reforestation will not be included in the scope of the project, so there is no need to account for woody biomass.

[128] NASA POWER. The Power project. Available from: https://power.larc.nasa.gov/

[129] National Centers for Environmental Information – National Oceanic and Atmospheric Administration. Global Forecast System. Available from: https://www.ncei.noaa.gov/products/weather-climate-models/global-forecast

[130] ECMWF. Forecast charts and data. Available from: https://www.ecmwf.int/en/forecasts

[131]Ramsar. Ramsar Map. Available from: https://rsis.ramsar.org/

Source		Gas	Included?	Justification/Explanation
	Soil methanogenesis	CH_4	No	Methane emissions resulting from baseline and design scenarios will not be included. The Daycent model has the ability to quantify soil methanogenesis, however, the model calculates methanogenesis for flooded areas, which will not be the case in this project. There are small emissions in non-flooded soils that do not exceed 5%, in which case it will be considered as minimis, with no need to calculate this source.
	Enteric fermentation	CH_4	Yes	CH_4 emissions resulting from enteric fermentation will be included in activities where livestock are present.
	Manure deposition	CH_4	Yes	CH_4 emissions resulting from enteric fermentation will be included in activities where livestock are present.
		N_2O		
	Use of nitrogen fertilizers	N_2O	No	The project scenario conservatively does not foresee a decrease in the application of nitrogen fertilizers.
	Use of nitrogen-fixing species	N_2O	Yes	Some nitrogen-fixing species are planted as cover crops and/or intercrops in the project scenario, so that N2O emissions from nitrogen-fixing species.
	Biomass burning	N_2O	No	In the project scenario, the burning of biomass is not foreseen.
		CO_2		

Source		Gas	Included?	Justification/Explanation
	SOC	CO_2	Yes	The adoption of project activities would have an overall net impact on the SOC group. Will be quantified as stock changes in the SOC pool.
	Fossil Fuels	CO_2	No	In the project scenario, the burning of fossil fuel is not foreseen because it is considered minimis.

Table 4. Selected carbon pools for baseline and project scenario.

3.4 Baseline Scenario

The project's baseline scenario was determined by applying a historical hindsight period. The schedule of activities will cover at least 3 years before the start of the project and will be applied in the baseline scenario, starting from t = 1. The emission changes and/or GHG reductions in the baseline scenario are modeled using the Quantification Approach 1 for SOC and Approach 1 or 3 for Nitrous Oxide. Further detailing of the modeling and equations used for the estimates of emission change and/or GHG reductions is presented in Section 4 Quantification of GHG Removals and Reductions.

3.4.1. Schedule of activities

The schedule of activities with a historical retrospective of at least three years of each instance will be done together with the property owner. Evidence of the validity of the schedules presented for each instance will be presented through Remote Sensing.

Remote Sensing data and other information in addition to the data collected from the owners of the instances, for evidence of the activity schedule of the baseline scenario of agricultural activities, for the calibration of the Daycent model, quantification of GHG emissions and/or reductions and monitoring of instances, will be obtained from the following sources:

- Embrapa Soils - Brazilian soil classification data[132 and 133];
- USGS, EarthExplorer - Landsat images updated every 16 days for monitoring instances and historical retrospective of activities developed in instances[134];

[132] EMBRAPA. Classificação de solos. Available from: https://www.embrapa.br/solos/sibcs/classificacao-de-solos/

[133] EMBRAPA. Mapa de classificação dos solos brasileiros. Available from: http://geoinfo.cnps.embrapa.br/layers/geonode%3Abrasil_solos_5m_20201104

- USGS; GloVis - Landsat images updated every 16 days for monitoring instances and historical retrospective of activities developed in instances[135];

- EOS Data Analytics - Landsat, Sentinel and CBERS satellite images for consultation, download and analysis of online band and index combinations, for monitoring instances and historical retrospective of activities developed in instances[136];

- MapBiomas - Classification of land use for multitemporal analysis (Classification from 1985 to 2020) - Historical retrospective of activities developed in the instances[137];

- INMET - Meteorological Database of Brazil - Input for the Daycent model[138];

- NASA POWER - Meteorological Database - Input for the Daycent model[139];

- National Centers for Environmental Information – National Oceanic and Atmospheric Administration. Global Forecast System - Weather Database - Input for Daycent model[140];

- ECMWF (Forecast Charts and data) - Meteorological database - Input for the Daycent model[141];

- IBGE - Agricultural Production - Input for the Daycent model and data for monitoring instance productivity (Agricultural Production in Brazil - IBGE)[142];

- CONAB (National Supply Company) - Agricultural information -Input for the Daycent model and data for monitoring the productivity of the instances[143].

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[134]USGS. Earth Explorer. Available from: https://earthexplorer.usgs.gov/

[135]USGS. Glovis. Available from: https://glovis.usgs.gov/app?_ga=2.41328676.782605249.1660833157-1457164687.1657799837

[136]EOS Data Analytics. Available from: https://eos.com/pt/make-an-analysis/

[137]MapBiomas. Coleção de mapas. Available from: https://mapbiomas.org/colecoes-mapbiomas-1?cama_set_language=pt-BR

[138]INMET. Banco de Dados Meteorológico. Available from: https://bdmep.inmet.gov.br/

[139] NASA POWER. The Power Project. Available from: https://power.larc.nasa.gov/

[140] National Centers for Environmental Information. Global Forecast. Available from: https://www.ncei.noaa.gov/products/weather-climate-models/global-forecast

[141] ECMWF. Forecast Charts and data. Available from: https://www.ecmwf.int/en/forecasts

[142]IBGE. Produção Agropecuária. Available from: https://www.ibge.gov.br/explica/producao-agropecuaria/?adlt=strict&toWww=1&redig=E5922C8232004BC2B3C2B2C6D5F51E4C

[143]CONAB. Informações Agropecuárias. Available from: https://www.conab.gov.br/info-agro?adlt=strict&toWww=1&redig=B762DF83B0054675872C475687A5812D

If this information is not available, farmers, agencies and companies responsible for rural extension services in the region will be consulted, prioritizing direct contact with specialists (agronomists) to obtain reliable information. The project will be limited to locations where baseline scenario information is available. In addition to all this validated data from official sources, random and representative soil samples will be collected from areas within the project, for calibration of the Daycent model for quantifying GHG emissions and/or reductions and monitoring instances.

As collections will be made in each instance, the number of samples will be determined according to the stratification by type of soil that exists in the place.

The methodology chosen for the collection of soil samples and analysis is better described in the organized soil document, further details are omitted from this public file as it is a NaturAll Carbon methodology.

3.4.2. Soil sampling

Samples will be collected in each instance, for the calculation of sample sufficiency, sampling methodology and collection analysis. The following documents were used as a basis:

- Soil Organic Carbon MRV Sourcebook for Agricultural Landscapes[144];
- Soil Sampling and Methods of Analysis[145];
- VCS – Module VMD0018 v1.0: Methods to determine stratification[146];
- VCS – Module VMD0021 v1.0: Estimation of stocks in the soil carbon pool[147].

As mentioned in the previous Section (3.4.1 Schedule of activities), further information on the methodology for soil collection is omitted from this public file as it is a proprietary methodology by NaturAll Carbon.

[144] World Bank. Soil Organic Carbon MRV Sourcebook for Agricultural Landscapes. Washington, DC. 2021. Available from: https://openknowledge.worldbank.org/handle/10986/35923

[145] Carter, M, R.; Gregorich, E, G. Soil Sampling and Methods of Analysis. 2ed. 2007. Available from: https://www.taylorfrancis.com/books/mono/10.1201/9781420005271/soil-sampling-methods-analysis-gregorich-carter?adlt=strict&toWww=1&redig=6BB72E5A9E7E4849910B00593B540BA6

[146] The Earth Partners LLC. VCS Module VMD0018 – Methods to determine stratification. v1.0. 2012. Available from: https://verra.org/methodology/vmd0018-methods-to-determine-stratification-v1-0/

[147] The Earth Partners LLC. VCS Module VMD0021 – Estimation of stocks in the soil carbono pool. v1.0. 2012. Available from: https://verra.org/methodology/vmd0021-estimation-of-stocks-in-the-soil-carbon-pool-v1-0/

3.5 Additionality

3.5.1. Barriers to the implementation of conservationist agricultural practices

Sustainable development in agriculture is an increasingly frequent concern within Brazilian agribusiness production chains. However, the issue surrounding sustainability is still a central issue in the debate on agriculture and the environment.[148].

According to the text referenced above and various information found during the construction of this project, it is understood that, despite not being a completely unknown topic in Brazil, including many studies and information disseminated by official bodies, many producers are still unaware of the benefits of these practices.

In general, the fact that the adoption of these practices still remains limited may be due, in part, to personal, socioeconomic, cultural characteristics, as well as the lack of knowledge about these practices or technical information, attachment to the traditions of previous generations, learning difficulties, the characteristics of the technology itself, the fear of economic losses or even the cost of adopting such practices[149].

Extensionists and technicians from the agricultural sector are well aware of the difficulties in convincing farmers to adopt soil conservation techniques, especially among traditional farmers or those from less favored regions and with greater limitations in terms of soil, climate and access to technology.[150].

Considering that economic viability is the guiding principle for farmers and the fact that sustainability based on conservationist practices is essential for maintaining sustainable agricultural production, there is thus an impasse. Pondering the need for survival of rural establishments based on profit and return on invested capital, it would be simplistic to think that these practices could be developed only from the awareness of farmers[151].

It is worth mentioning again that there are already some studies that claim that there is an increase in productivity in rural establishments that adopt these practices and also citing the whole environmental issue and soil conservation. However, there are also studies citing lower spending on inputs by adopters of these practices, as in the case of the 2006 Agricultural Census, carried out by the Brazilian government, which mentions that adopters of conservationist practices spend an average of BRL

[148] Telles, T, S.; Vieira Filho, J, E, R.; Righeto, A, J.; Ribeiro, M, R. Desenvolvimento da agricultura de baixo carbono no Brasil. IPEA. 2021. Available from: http://repositorio.ipea.gov.br/bitstream/11058/10531/1/td_2638.pdf

[149] Wreford, A., Ignaciuk, A., & Gruère, G. (2017). Overcoming barriers to the adoption of climate-friendly practices in agriculture (OECD Food, Agriculture and Fisheries Papers, No. 101). Paris: OECD Publishing. Available from: http://dx.doi.org/10.1787/97767de8-en

[150]Freitas, P, L.; Manzatto, C, V. Uso agrícola dos Solos brasileiros - Cenários Sobre a Adoção de PráticasConservacionistas Baseadas no PlantioDireto e Seus Reflexos na ProduçãoAgrícola e na Expansão do Uso da Terra. Embrapa. Rio de Janeiro, RJ. 2002.

[151]Fortini, R, M.; Braga, M, J. Freitas, C, O. Impactos das práticas agrícolas conservacionistas na produtividade

3,955.00 on inputs, and those who do not adopt spend BRL 11,656.00, that is, non-adopters spend 2.9 times more than adopters.[152and153]

Therefore, it is understood that what is missing for the development of conservationist agriculture in Brazil is proof through the practice of financial results for rural producers and the propagation of these results, since issues of soil and environment conservation have been widespread for many years and despite being issues of great importance, it is not what attracts a producer to adopt these practices.

In this way, the Project "NaturAll Carbon Program - Intensification of Carbon Sequestration in Agricultural Soils and Pastures through Sustainable Management in Brazil", aims to encourage the adoption of conservationist techniques in Brazilian properties, through the quantification made by the Daycent biogeochemical model, to monitor the productivity values of the producers and thus demonstrate and prove the increase in production, thus attracting more properties to the project and increasing the adoption of these techniques in Brazil.

3.5.2. Proof of additionality in project instances

Additionality calculations were based on data from the 2017 Agricultural Census[154] (Most updated census at the moment). The Census provides the number of agricultural establishments interviewed by state and the soil management practices used in each one, so it was possible to estimate the percentage of agricultural establishments that use each practice and whether they have additionality for that region (state).

For the choice of source and development of the calculations, the requirements of VM0042 v2.0 Final Draft were followed, which describes that "Evidence must be provided in the form of publicly available information contained in: 1. Agricultural census or other government data; 2. Peer-reviewed scientific research; 3. Independent research data; 4. Reports or assessments compiled by industry associations".

The values calculated to determine the Adoption Rate (AR) of conservationist practices by state used for this project will be presented in the document called Regional Common Practices and updated with each new Agricultural Census made available by IBGE.

Using AR, in cases of instances that will adopt these practices in states where the value is above 20% (common practice), the weighted average rate of adoption will be calculated, as guided by VM0042 v2.0 Final Draft, to assess whether conservation practices are really common in the areas of agriculture and livestock establishments in that region. The equations for calculating the weighted average adoption rate are as follows:

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[152] IBGE – Instituto Brasileiro de Geografia e Estatística. Censo Agropecuário 2006: Brasil, Grandes Regiões e Unidades da Federação. Rio de Janeiro, p. 1-777, 2009.

[153] Fortini, R, M. Adoção de Práticas Agrícolas Conservacionistas e Eficiência Produtiva na Agricultura Brasileira. UFV, Viçosa, Minas Gerais. 2018.

[154] IBGE. Censo Agropecuário – 2017. Available from: https://sidra.ibge.gov.br/Table/6845#/n1/all/n3/all/v/all/p/all/c829/46302/c12568/all/c12564/41145/c12771/45951/c218/46502/c800/41147/l/v,p+c829+c12568+c12564,t+c12771+c218+c800/resultado

$$AR = ((EA_{ai} \times PA_{ai}) + (EA_{a2} \times PA_{a2}) + \cdots + (EA_{an} \times PA_{an});$$

$$PA_{a1} = \frac{Area_{a1}}{Area_{a1} + Area_{a2} + \cdots + Area_{an}} \quad (1)$$

$$PA_{a2} = \frac{Area_{a1}}{Area_{a1} + Area_{a2} + \cdots + Area_{an}} \quad (2)$$

$$PA_{an} = \frac{Area_{a1}}{Area_{a1} + Area_{a2} + \cdots + Area_{an}} \quad (3)$$

Where:

AR = weighted average adoption rate in region; %
EA_{a1} = existing adoption rate of largest (i.e., size of land area) most common proposed project activity in region; %
EA_{a2} = existing adoption rate of second largest most common proposed project activity in region; %
EA_{an} = existing adoption rate of the n largest most common proposed project activity in region; %
PA_{a1} = ratio of proposed project-level adoption of Activity a1 relative to proposed project-level adoption of Activity a1 + Activitya2 + ... + Activityan in region; unitless
PA_{a2} = ratio of proposed project-level adoption of Activity a2 relative to proposed project-level adoption of Activity a1 + Activitya2 + ... + Activityan in region; unitless
PA_{an} = ratio of proposed project-level adoption of Activity an relative to proposed project-level adoption of Activity a1 + Activitya2 + ... + Activityan in region; unitless
$Area_{a1}$ = area of proposed project-level adoption of Activity a1 in region; hectares or acres
$Area_{a2}$ = area of proposed project-level adoption of Activity a2 in region; hectares or acres
$Area_{an}$ = area of proposed project-level adoption of Activity an in region; hectares or acres
n = project activity category

The weighted average will be calculated by combining two or more conservation agriculture practices used in that region, all based on evidence.

3.5.3. *Additionality in the instances of the Cassilândia, MS farm*

The first farm included in the project is located in Cassilândia, state of Mato Grosso do Sul, already described in 1.13.1. Historically, the farm's primary commercial production is cattle for the beef industry. However, many regional cultural and economic factors led to a production system that slowly degraded the land. Recently the farmer started to convert the degraded grassland into a sustainable no-till, crop rotation, and integrated grazing system for grain (soybean and corn) and beef production.

According to data compiled from IBGE (the Brazilian official statistics bureau), the farm is located in a region where those new practices are non-common. Also, those practices are eligible for our program; thus, additionality is present.

3.6 Methodology Deviations

There were no methodology deviations in this project.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Emission Reductions and Removals

The project's emissions and/or reductions will be quantified using Quantification Approach 1 and Approach 3, as previously mentioned, and follows the instructions of VM0042 v2.0 (Section 8.2.1).

The model selected for the quantifications was the DayCent. This model simulates fluxes of C and N between the atmosphere, vegetation and soil[155][156] and is widely used in studies to simulate ecosystem responses to changes in climate and agricultural management practices in crops, grassland, forest and savannah ecosystems[157].

DayCent simulates nutrient decomposition and mineralization of plant litter and soil organic matter, plant growth and senescence, and water fluxes and soil temperature. C and nutrient fluxes are controlled by the amount of C in the various pools, the C/N and lignin in the pool ratios, soil

[155] Del Grosso, S.J., Parton, W.J., Mosier, A.R., Hartman, M.D., Keough, C.A., Peterson, G.A., Ojima, D.S., Schimel, D.S., 2001b. Efeitos simulados do uso da terra, textura do solo e precipitação nas emissões de gases N usando DAYCENT. In: R.F. Follett, R.F., Hatfield, J.L. (Eds.), Nitrogen in the Environment: Sources, Problems, and Management. Elsevier Science Publishers, Países Baixos, pp. 413-431.

[156] Parton, W.J., Ojima, D.S., Cole, C.V., Schimel, D.S., 1994. Um modelo geral para a dinâmica da matéria orgânica do solo: sensibilidade à química do lixo, textura e manejo. In: R.B. Bryant, R.B., Arnoldm, R.W. (Eds.), Modelagem Quantitativa dos Processos de Formação do Solo. Soil Sci. Soc. Am., Madison, WI, pp. 147-167.

[157] Necpálová, M.; Anex, R, P.; Fienen, M, N.; Del Grosso, S, J.; Castellano, M, J.; Sawyer, J, E.;Iqbal, J.; Pantoja, J, L.; Barker, D, W. Understanding the DayCent model: Calibration, sensitivity, and identifiability through inverse modeling,Environmental Modelling & Software. v.66. 2015. p. 110-130. Available from: https://doi.org/10.1016/j.envsoft.2014.12.011.

water/temperature factors, and soil physical properties related to texture. Soil Organic Matter (SOC) is divided into three pools based on decomposition rates[158].

Therefore, the model allows accurate simulations of the dynamics of each Instance inserted in the project, relying on inputs originating from an internal NaturAll Carbon geospatial database, compiled from official sources, containing information on soil classification and texture, use and historical occupation of the land, project boundaries and other necessary parameters. In addition, historical, real-time and future climate data will be used from networks of physical and virtual meteorological stations, such as the National Institute of Meteorology of Brazil and NASA POWER (Prediction of Worldwide Energy Resources).

Other input information and model application in Instances is better described in 3.2.

4.1.1 Baseline Scenario and Project Scenario

The project's net reductions and removals are the result of a function $f(\mu)$ which considers Baseline Scenario and Project Scenario emissions. As a significant part of the equations presented in this chapter are common for both scenarios, we will denote $\mu = bsl$ for the Baseline Scenario and $\mu = wp$ for Project Scenario.

$$\mu = \begin{cases} bsl, & Baseline\ Scenario \\ wp, & Project\ Scenario \end{cases} \tag{4}$$

4.2 Calculation of Verified Carbon Units

The calculation of the Verified Carbon Units (VCU) is formed by the sum of the net GHG reductions (Ered,n,t) with the net GHG removals (Erem,n,t) and subtracted by the buffer credits that will be deposited in the AFOLU pooled buffer account, as described by equation 87 presented in Section 8.7 of VM0042 v2.0 Final Draft.

$$VCU_t = E_{red,n,t} + E_{rem,n,t} - Buffer_t \tag{5}$$

Where:

VCU_t = Number of VCU in year t; t CO2e
$E_{red,n,t}$ = Estimated net GHG emissions reductions in year; t CO2e
$E_{rem,n,t}$ = Estimated net GHG emissions removals in year t; t CO2e
$Buffer_t$ = Number of buffer credits to be contributed to the AFOLU pooled buffer account in year t; t CO2e

4.2.1 Net Emissions Reduction and Removals

[158]Parton, W.J., Ojima, D.S., Cole, C.V., Schimel, D.S. Um modelo geral para a dinâmica da matéria orgânica do solo:sensibilidade à química, textura e gestão do lixo. In: Modelagem quantitativa dos Processos de Formação do Solo.SSSA, Spec. Madison, WI, p. 147 - 167. 1994.

Net GHG emission reductions are quantified as:

$$\boldsymbol{E_{red,n,t}} = \left(\left(\boldsymbol{A_0} \times \frac{\boldsymbol{E_{red,g,t}}}{\boldsymbol{ERR_{g,t}}}\right) \times \boldsymbol{E_{red,g,t}} - \left(\boldsymbol{LE_t} \times \frac{\boldsymbol{E_{red,g,t}}}{\boldsymbol{ERR_{g,t}}}\right)\right) \times \left(\boldsymbol{1} - \left(\boldsymbol{UNC_t} \times \frac{\boldsymbol{E_{red,g,t}}}{\boldsymbol{ERR_{g,t}}}\right)\right) \tag{6}$$

Where:

$E_{red,n,t}$ = Estimated net GHG emission reductions in year t; t CO2e

A_0 = Individual instance area; unit area

$E_{red,g,t}$ = Estimated gross GHG emission reductions in year t; t CO2e per unit area

$ERR_{g,t}$= Estimated gross GHG emission reductions and removals in year t; t CO2e per unit area

LE_t = Leakage in year t, equal to zero; t CO2e

UNC_t = Uncertainty deduction in year t; fraction between 0 and 1

Net GHG emission removals are quantified as:

$$\boldsymbol{E_{rem,n,t}} = \left(\left(\boldsymbol{A_0} \times \frac{\boldsymbol{E_{rem,g,t}}}{\boldsymbol{ERR_{g,t}}}\right) \times \boldsymbol{E_{rem,g,t}} - \left(\boldsymbol{LE_t} \times \frac{\boldsymbol{E_{rem,g,t}}}{\boldsymbol{ERR_{g,t}}}\right)\right) \times \left(\boldsymbol{1} - \left(\boldsymbol{UNC_t} \times \frac{\boldsymbol{E_{rem,g,t}}}{\boldsymbol{ERR_{g,t}}}\right)\right) \tag{7}$$

Where:

$E_{rem,n,t}$ = Estimated net GHG emission removals in year t; t CO2e

A_0 = Individual instance area; unit area

$E_{rem,g,t}$ = Estimated gross GHG emission removals in year t; t CO2e per unit area

$ERR_{g,t}$= Estimated gross GHG emission reductions and removals in year t; t; t CO2e per unit area

LE_t = Leakage in year t, equal to zero; t CO2e

UNC_t = Uncertainty deduction in year t; fraction between 0 and 1

4.2.2 Gross Emissions Reductions and Removals

Gross GHG emission reductions and removals are quantified as:

$$ERR_{g,t} = E_{red,g,t} + E_{rem,g,t} \tag{8}$$

Where:

$\mathrm{ERR}_{g,t}$ = Estimated gross GHG emission reductions and removals in year *t*; t CO_{2e} per unit area

$\mathrm{E}_{red,g,t}$ = Estimated gross GHG emission reductions in year *t*; t CO_{2e} per unit area

$\mathrm{E}_{rem,g,t}$ = Estimated gross GHG emission removals in year *t*; t CO_{2e} per unit area

$E_{red,g,t}$ (equation 9) and $E_{rem,g,t}$ (equation 10) are calculated as follows:

$$E_{red,g,t} = \overline{\Delta CO2\_ff_t} + \overline{\Delta CH4\_ent_t} + \overline{\Delta CH4\_md_t} + \overline{\Delta CH4\_bb_t} + \overline{\Delta CH4\_soil_t} + \overline{\Delta N2O\_soil_t} + \overline{\Delta N2O\_bb_t} \quad (9)$$

Where:

$E_{red,g,t}$= Estimated gross GHG emissions reductions in year t; t CO_{2e} per unit area

$\overline{\Delta CO2\_ff_t}$= Areal average carbon dioxide emissions reductions from fossil fuel combustion in year t; t CO_{2e} per unit area

$\overline{\Delta CH4\_ent_t}$= Areal average methane emission reductions from livestock enteric fermentation in year t; t CO_{2e} per unit area

$\overline{\Delta CH4\_md_t}$= Areal average methane emission reductions from manure deposition in year t; t CO_{2e} per unit area

$\overline{\Delta CH4\_bb_t}$= Areal average methane emission reductions from avoided or reduced burning biomass in year t; t CO_{2e} per unit area

$\overline{\Delta CH4\_soil_t}$= Areal average methane emission reductions from increasing uptake into the soil in year t; t CO_{2e} per unit area

$\overline{\Delta N2O\_soil_t}$= Areal average nitrous oxide emission reductions from nitrification/ denitrification in year t; t CO_{2e} per unit area

$\overline{\Delta N2O\_bb_t}$= Areal average nitrous oxide emission from avoided or reduced burning biomass in year t; t CO_{2e} per unit area

$$E_{rem,g,t} = \overline{\Delta CO2\_soil_t} + \overline{\Delta C_{TREE,t}} + \overline{\Delta C_{SHRUB,t}} \quad (10)$$

Where:

$E_{rem,g,t}$ = Estimated gross GHG emissions removals in year t; t CO_{2e} per unit area

$\overline{\Delta CO2\_soil_t}$= Areal average carbon dioxide emission removals from increasing the soil organic carbon pool in year t; t CO_{2e} per unit area

$\overline{\Delta C_{TREE,t}}$= Areal average carbon dioxide emission removals from increasing tree biomass in year t; t CO_{2e} per unit area

$\overline{\Delta C_{SHRUB,t}}$= Areal average carbon dioxide emission removals from increasing shrub biomass in year t; t CO_{2e} per unit area

4.2.3 Carbon dioxide reductions and removals

Emissions reductions from fossil fuel combustion ($\Delta CO2\_ff_t$):

Emissions reductions from reducing fossil fuel combustion are not included in the project boundary, so this term in Equation 9 will be considered null.

Emissions removals from increasing tree biomass ($\Delta CTREE_t$) and from increasing shrub biomass ($\Delta CSHRUB_t$):

The project does not include activities that aim to increase the biomass of trees and shrubs as a carbon reservoir, therefore both terms of Equation 10 will be considered null.

Carbon dioxide emission removals from increasing the soil organic carbon pool ($\Delta CO2\_soil_t$):

The main objective of this project is to remove atmospheric carbon dioxide and store it in agricultural soils through the dissemination and application of conservationist and regenerative agricultural management practices. The term $\overline{\Delta CO2\_soil_t}$ of Equation 10 is numerically equal to the result of Equation 11 below:

$$\Delta CO2\_soil_{i,t} = \left(SOC_{wp,i,t} - SOC_{wp,i,t-1}\right) - \left(SOC_{bsl,i,t} - SOC_{bsl,i,t-1}\right) \qquad (11)$$

Where:

$\Delta CO2\_soil_{i,t}$ = Carbon dioxide emission removals by enhancing the soil organic carbon pool for sample unit *i* in year *t*; t CO_{2e} per unit area

$SOC_{wp,i,t}$ = Carbon stocks in the soil organic carbon pool in the project scenario for sample field *i* in year *t*; t CO_{2e} per unit area

$SOC_{wp,i,t-1}$ = Carbon stocks in the soil organic carbon pool in the project scenario for sample field *i* in year *t-1*; t CO_{2e} per unit area

$SOC_{bsl,i,t}$ = Carbon stocks in the soil organic carbon pool in the baseline scenario for sample field *i* in year *t*; t CO_{2e} per unit area

$SOC_{bsl,i,t-1}$ = Carbon stocks in the soil organic carbon pool in the baseline scenario for sample field *i* in year *t-1*; t CO_{2e} per unit area

Determining $SOC_{\mu,i,t}$ using Approach 1:

The CO_2 removals from the baseline scenario and the project scenario will be quantified using Quantification Approach 1, as previously mentioned, and follow the instructions of VM0042 v2.0 Final Draft (Section 8.2.1).

The model selected for the quantifications was the Daycent. This model simulates fluxes of C and N between the atmosphere, vegetation and soil and is widely used in studies to simulate ecosystem responses to changes in climate and agricultural management practices in crops, ecosystems of grasslands, forests and savannas[159].

Daycent simulates nutrient decomposition and mineralization of plant litter and soil organic matter, plant growth and senescence, and water fluxes and soil temperature. C and nutrient fluxes are controlled by the amount of C in the various pools, the C/N and lignin in the pool ratios, soil water/temperature factors, and soil physical properties related to texture. Soil Organic Matter (SOC) is divided into three pools based on decomposition rates[160].

Therefore, the model allows accurate simulations of the dynamics of each instance inserted in the project, relying on inputs originating from an internal NaturAll Carbon geospatial database, compiled from official sources, containing information on soil classification and texture, use and historical occupation of the land, project boundaries and other necessary parameters. In addition, historical, real-time and future climate data will be used from networks of physical and virtual meteorological stations, such as the National Institute of Meteorology of Brazil and NASA POWER (Prediction of Worldwide Energy Resources).

Further information on the inputs and the application of the model to the instances is better described in Section 3.2 Applicability of the Methodology.

Soil Organic Carbon (SOC) stocks will be calculated using Quantification Approach 1, by the Daycent biogeochemical model, as already mentioned in the other Sections of this project. The Daycent model is represented by the function $f(SOC_{\mu,i,t-1})$ shown in Equation 12 below:

$$SOC_{\mu,i,t} = f(SOC_{\mu,i,t-1}) \qquad (12)$$

Where:

$SOC_{\mu,i,t}$= Estimated carbon stocks in the soil organic carbon pool in the scenario μ for sample unit *i* at the end of period *t-1*; t CO_{2e} per unit area

$f(SOC_{\mu,i,t-1})$ = Modeled soil organic carbon stocks in the scenario μ for sample unit *i* at the end of period *t-1*; t CO_{2e} per unit area

The cultivation and practice history of each instance (baseline schedule in 3.4.1) will be collected for at least three years before the start of the project and will be fed into the NaturAll Carbon database for modeling using DayCent. The calculation of the baseline will be dynamic.

[159] Necpálová, M.; Anex, R, P.; Fienen, M, N.; Del Grosso, S, J.; Castellano, M, J.; Sawyer, J, E.;Iqbal, J.; Pantoja, J, L.; Barker, D, W. Understanding the DayCent model: Calibration, sensitivity, and identifiability through inverse modeling,Environmental Modelling & Software. v.66. 2015. p. 110-130. Available from: https://doi.org/10.1016/j.envsoft.2014.12.011.

[160]Parton, W.J., Ojima, D.S., Cole, C.V., Schimel, D.S. Um modelo geral para a dinâmica da matéria orgânica do solo:sensibilidade à química, textura e gestão do lixo. In: Modelagem quantitativa dos Processos de Formação do Solo.SSSA, Spec. Madison, WI, p. 147 - 167. 1994.

As the biogeochemical model is constantly being improved by the academic community, more information about its functioning and improvements will be added to the Monitoring Reports and Model Validation Reports prepared during the project's monitoring period.

4.2.4 Methane reductions and removals

Methane emissions from the Soil Organic Carbon Pool ($\Delta CH4\_soil_t$):

According to Pisante et al (2020)[161], the primary sinks of methane are the oxidation of the gas to carbon dioxide on the troposphere and oxidation by mathanotrophic bacteria in the aerobic zone of methanogenic soils and in upland soils. The author goes on to state that soils can act as a net source or sink for CH4 depending on the oxidative state of the matrix, hence land use and management practices directly affect methane release to the atmosphere. He goes on to say that in long-term no-till, the potential oxidation of CH4 is considerably higher, from 2 to 11 times more than conventional tillage and minimum tillage.

Considering that the project will not involve instances in wetlands and will promote practices that reduce or stop the physical disruption of the soil, methane from methanogenesis in the soil will not be considered, since emissions increase are less than 5% throughout the project. In Section 3.3.6 of VCS Methodology Requirements v4.1 it is stated that specific carbon pools and GHG sources, including carbon pools and GHG sources that cause project and leakage emissions, may be considered *de minimis* and need not be accounted for, because if together the decrease in carbon stocks (in carbon pools) or the increase in GHG emissions (from GHG sources) are omitted, it is equivalent to less than 5% of the total GHG benefit generated by the project.

Methane emissions from livestock enteric fermentation ($\Delta CH4\_ent_t$):

Methane emission reductions from livestock enteric fermentation are quantified as shown on equation 13 below:

$$\Delta CH4\_\mathrm{ent}_{i,t} = CH4\_ent_{bsl,\mathrm{i,t}} - CH4\_ent_{wp,i,t} \tag{13}$$

Where:

$\Delta \mathrm{CH4\_ent}_{\mu,\mathrm{i,t}}$ = Methane emission reductions from livestock enteric fermentation for sample unit i in year t; t CO_{2e} per unit area

$\mathrm{CH4\_ent}_{\mathrm{bsl,i,t}}$ = Methane emissions from livestock enteric fermentation in the baseline scenario for sample unit i in year t; t CO_{2e} per unit area

$\mathrm{CH4\_ent}_{\mathrm{wp,i,t}}$ = Methane emissions from livestock enteric fermentation in the project scenario for sample unit i in year t; t CO_{2e} per unit area

[161] M. Pisante, F. Stagnari, Marco Acutis, M. Bindi, L. Brilli, et al.. Conservation agriculture and climatechange. Conservation agriculture, Springer International, 2015, 978-3-319-11619-8. 10.1007/978-3-319-11620-4_22.hal-02796321.

Enteric fermentation will be calculated using Equation 7 of Quantification Approach 3 (Section 8.2.7 of VM0042 v2.0 Final Draft), described below:

$$CH4\_ent_{\mu,i,t} = \frac{\left(\frac{GWP_{CH4} \times \sum_{l=1}^{L} P_{\mu,l,i,t} \times Days_{\mu,l,i,t} \times EF_{ent,l}}{1000 \times 365}\right)}{A_i} \quad (14)$$

Where:

$CH4\_ent_{\mu,i,t}$ = Methane emissions from livestock enteric fermentation in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

$P_{\mu,l,i,t}$ = Population of grazing livestock in the μ scenario of type l in sample unit i in year t; head

$Days_{\mu,l,i,t}$ = Average grazing days per head in the μ scenario for each livestock type l in sample unit i in year t; days

$EF_{ent,l}$ = Enteric emission factor for livestock type l; kg CH_4 per (head*year)

GWP_{CH4} = Global warming potential for CH_4

A_i = Area of sample unit i; unit area

l = Type of livestock

i = Sample unit

365 days per year

1000 Kg per tonne

Methane emissions from manure deposition $\Delta CH4\_md_t$:

Methane emission reductions from manure deposition are quantified as shown on equation 15 below:

$$\Delta CH4\_md_{i,t} = CH4\_md_{bsl,i,t} - CH4\_md_{wp,i,t} \quad (15)$$

Where:

$\Delta CH4\_md_{i,t}$ = Methane emission reductions from manure deposition for sample unit i in year t; t CO_{2e} per unit area

$CH4\_md_{bsl,i,t}$ = Methane emissions from manure deposition in the baseline scenario for sample unit i in year t; t CO_{2e} per unit area

$CH4\_md_{wp,i,t}$ = Methane emissions from manure deposition in the project scenario for sample unit i in year t; t CO_{2e} per unit area

Emissions from manure deposition will be calculated using Equations 16 and 17 of Quantification Approach 3, described below:

$$CH4\_md_{\mu,i,t} = \frac{GWP_{CH4} \times \sum_{l=1}^{L} (P_{\mu,l,i,t} \times VS_{\mu,l,i,t} \times Days_{\mu,l,i,t} \times EF_{CH4,md,l})}{10^6 \times A_i} \quad (16)$$

Where:

$CH4\_md_{\mu,i,t}$= Methane emissions from livestock enteric fermentation in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

GWP_{CH4} = Global warming potential for CH_4

$P_{\mu,l,i,t}$ = Population of grazing livestock in the μ scenario of type l in sample unit i in year t; head

$VS_{\mu,l,i,t}$ = Average volatile solids excretion per head for livestock type l in sample unit i in year t; kg volatile solids per (head*day)

$Days_{\mu,l,i,t}$ = Average grazing days per head in the μ scenario for each livestock type l in sample unit i in year t; days

$EF_{CH4,md,l}$ = Emission factor for methane emissions from manure deposition for livestock type l; g CH_4 per Kg volatile solids

A_i = Area of sample unit i; unit area

l = Type of livestock

i = Sample unit

10^6grams per tonne

$$VS_{l,i,t} = VS_{rate,l} \times \frac{W_{\mu,l,i,t}}{1000} \quad (17)$$

Where:

$VS_{\mu,l,i,t}$ = Average volatile solids excretion per head for livestock type l in sample unit i in year t; kg volatile solids per (head*day)

$VS_{rate,l}$ = Default volatile solids excretion rate for livestock type l; kg volatile solids per (1000 kg animal mass * day)

$W_{\mu,l,i,t}$ = Average weight in the μ scenario of livestock type l for sample unit i in year t; kg animal mass per head

l = Type of livestock

i = Sample unit

1000 Kg per 1000 kg

Methane emission reductions from avoided or reduced burning biomass ($\Delta CH4\_md_t$):

The project does not have activities that contemplate avoided or reduced burning biomass and, therefore, these emissions will not be monitored.

4.2.5 Nitrous oxide reductions and removals

Nitrous oxide emission reductions from nitrification/denitrification ($\Delta N2O\_soil_t$):

Nitrous oxide emission reductions from nitrification/denitrification are quantified as shown at equation 18 below:

$$\Delta \mathrm{N2O}\_soil_{i,t} = \mathrm{N2O}\_soil_{bsl,i,t} - \mathrm{N2O}\_soil_{wp,i,t} \quad (18)$$

Where:

$\Delta \mathrm{N2O}\_soil_{i,t}$ = Nitrous oxide emission reductions from nitrification/denitrification for sample unit *i* in year *t*; t CO_{2e} per unit area

$\mathrm{N2O}\_soil_{bsl,i,t}$ = Nitrous oxide emissions from nitrogen inputs to soils in the baseline scenario for sample unit *i* in year *t*; t CO_{2e} per unit area

$\mathrm{N2O}\_soil_{wp,i,t}$ = Nitrous oxide emissions from nitrogen inputs to soils in the project scenario for sample unit *i* in year *t*; t CO_{2e} per unit area

In cases where there is calibration and validation of the Daycent biogeochemical model for N_2O fluxes, quantification approach 1 (equation 19) will be applied. In cases where there is not, the quantification approach 3 (equation 20) will be applied.

$$\mathrm{N2O}\_soil_{\mu,i,t} = GWP_{N2O} \times fN2Osoil_{\mu,i,t} \quad (19)$$

Where:

$\mathrm{N2O\_soil}_{\mu,i,t}$ = Direct and indirect nitrous oxide emissions due to nitrogen inputs to soils in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

$\mathrm{fN2Osoil}_{\mu,i,t}$ = Modeled nitrous oxide emissions from soil (summed across the reporting period for sample uniti i) ; t N_2O per unit area

$\mathrm{GWP}_{\mathrm{N2O}}$ = Global warming potential for N_2O

i = Sample unit

$$\mathrm{N2O}\_soil_{\mu,i,t} = N2Ofert_{\mu,i,t} + N2Omd_{\mu,i,t} + N2ONfix_{\mu,i,t} \quad (20)$$

Where:

$\mathrm{N2O\_soil}_{\mu,i,t}$ = Direct and indirect nitrous oxide emissions due to nitrogen inputs to soils in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

$N2Ofert_{\mu,i,t}$ = Nitrous oxide emissions due to fertilizer use in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

$N2Omd_{\mu,i,t}$ = Nitrous oxide emissions due to manure deposition in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

$N2ONfix_{\mu,i,t}$ = Nitrous oxide emissions due to the use of N-fixing species in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

i = Sample unit

Emission reductions related to the application of nitrogenous fertilizers will not be monitored in the project, therefore the term $N2Ofert_{\mu,i,t}$ will be considered null.

Nitrous oxide emission reductions due to manure deposition ($\Delta N2O\_md_{\mu,i,t}$):

Emission reductions related to manure deposition ($N2Omd_{\mu,i,t}$) will be calculated according to equations 21 below:

$$N2Omd_{\mu,i,t} = N2Omd_{\mu,direct,i,t} + N2Omd_{\mu,indirect,i,t} \quad (21)$$

Where:

$N2Omd_{\mu,i,t}$ = Nitrous oxide emissions due to manure deposition in the μ scenario for sample unit unit i in year t; t CO2e per unit area

$N2Omd_{\mu,direct,i,t}$ =Direct nitrous oxide emissions due to manure deposition in the μ scenario for sample unit i in year t; t CO2e per unit area

$N2Omd_{\mu,indirect,i,t}$ = Indirect nitrous oxide emissions due to manure deposition in the μ scenario for sample unit i in year t; t CO2e per unit area

Direct nitrous oxide emissions due to manure deposition in the μ scenario are quantified using equation 22 and equation 23.

$$N2Omd_{\mu,direct,i,t} = \left(\sum_{l=1}^{L} F_{\mu,manure,l,i,t} \times EF_{N2O,md,l} \times \left(\frac{44}{28}\right) \times GWP_{N2O}\right)/A_i \quad (22)$$

Where:

$N2Omd_{\mu,direct,i,t}$ = Direct nitrous oxide emissions due to manure deposition in the μ scenario for sample unit i in year t; t CO2e per unit area

$F_{\mu,manure,l,i,t}$ = Amount of nitrogen in manure and urine deposited on soils by livestock type l in sample unit i in year t; t N

$EF_{N2O,md,l}$ = Emission factor for nitrous oxide from manure and urine deposited on soils by livestock type l; kg N_2O-N/kg N input

(44/28)Ratio of molecular weight of N_2O to molecular weight of N applied to convert N_2O-N emissions to N_2O emissions

GWP_{N2O} = Global warming potential for N_2O

A_i = Area of sample unit i; unit area

l = Type of livestock

i = Sample unit

$$F_{\mu,manure,l,i,t} = 1000 \times \left[(P_{\mu,l,i,t} \times Nex_l) \times MS_{\mu,l,i,t} \right] \quad (23)$$

Where:

$F_{\mu,manure,l,i,t}$ = Amount of nitrogen in manure and urine deposited on soils by livestock type l in sample unit i in year t; t N

$P_{\mu,l,i,t}$ = Population of livestock type l for sample unit i in year t; head

Nex_l= Average annual nitrogen excretion per head of livestock type l; kg N/head/year

$MS_{\mu,l,i,t}$= Fraction of total annual N excretion for each livestock type l for sample unit i in year t that is deposited on the project area; %

l = Type of livestock

i = Sample unit

Indirect nitrous oxide emissions due to manure deposition in the μ scenario are quantified under Quantification Approach 3 using equation24, equation 25 and equation 26.

$$N2Omd_{\mu,indirect,i,t} = \left(N2Omd_{\mu,volat,i,t} + N2Omd_{\mu,leach,i,t} \right) / A_i \quad (24)$$

Where:

$N2Omd_{\mu,indirect,i,t}$ = Indirect nitrous oxide emissions due to manure deposition in the μ scenario for sample unit i in year t; t CO_{2e} per unit area

$N2Omd_{\mu,volat,i,t}$ = Indirect nitrous oxide emissions produced from atmospheric deposition of N volatilized due to manure deposition for sample unit i in year t; t CO_{2e}

$N2Omd_{\mu,leach,i,t}$ = Indirect nitrous oxide emissions produced from leaching and runoff of N, in regions where leaching and runoff occurs, as a result of manure deposition for sample unit i in year t. Equal to 0 where annual precipitation is less than potential evapotranspiration, unless irrigation is employed; t CO_{2e}

A_i = Area of sample unit i; unit area

$$N2Omd_{\mu,volat,i,t} = F_{\mu,manure,l,i,t} \times Frac_{GASM} \times EF_{Nvolat} \times \left(\frac{44}{28}\right) \times GWP_{N2O} \qquad (25)$$

Where:

$\mathrm{N2Omd}_{\mu,\mathrm{volat,i,t}}$ = Indirect nitrous oxide emissions produced from atmospheric deposition of N volatilized due to manure deposition for sample unit i in year t; t CO_{2e}

$\mathrm{F}_{\mu,\mathrm{manure,l,i,t}}$= Amount of nitrogen in manure and urine deposited on soils by livestock type l in sample unit i in year t; t N

$\mathrm{Frac}_{\mathrm{GASM}}$= Fraction of all organic N added to soils and N in manure and urine deposited on soils that volatilizes as NH_3 and NO_x; dimensionless

$\mathrm{EF}_{\mathrm{Nvolat}}$= Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces; t N_2O-N /(t NH_3-N + NO_x-N volatilized

$\mathrm{GWP}_{\mathrm{N2O}}$ = Global warming potential for N_2O

$$N2Omd_{\mu,leach,i,t} = F_{\mu,manure,l,i,t} \times Frac_{LEACH} \times EF_{Nleach} \times \left(\frac{44}{28}\right) \times GWP_{N2O} \qquad (26)$$

Where:

$\mathrm{N2Omd}_{\mu,\mathrm{leach,i,t}}$ = Indirect nitrous oxide emissions produced from leaching and runoff of N, in regions where leaching and runoff occurs, as a result of manure deposition for sample unit i in year t. Equal to 0 where annual precipitation is less than potential evapotranspiration, unless irrigation is employed; t CO_{2e}

$\mathrm{Frac}_{\mathrm{LEACH}}$= Fraction of all organic N added to soils and N in manure and urine deposited on soils that is lost through leaching and runoff, in regions where leaching and runoff occurs; dimensionless. For wet climates[162] or in dry climate regions where irrigation (other than drip irrigation) is used, a value of 0.24 is applied. For dry climates, a value of zero is applied.

$\mathrm{EF}_{\mathrm{Nleach}}$= Emission factor for nitrous oxide emissions from leaching and runoff; t N_2O-N / t N leached and runoff

$\mathrm{GWP}_{\mathrm{N2O}}$ = Global warming potential for N_2O

Nitrous Oxide Emissions from Biomass Burning:

[162] Wet climates occur in temperate and boreal zones where the ratio of annual precipitation : potential evapotranspiration > 1, and tropical zones where annual precipitation > 1000 mm. Dry climates occur in temperate and oreal zones where the ratio of annual precipitation : potential evapotranspiration < 1, and tropical zones where annual precipitation < 1000 mm.

The project does not have activities that contemplate avoided or reduced burning biomass and, therefore, these emissions will not be monitored.

4.3 Baseline Emissions

VM0042 V2.0 FINAL DRAFT uses a dynamic baseline approach, where the GHG ERRs are calculated from the application of monitored variables in a baseline scenario of historical practices of the instance. The equations presented above, when applicable, will be represented by the variable μ equal to bsl, in order to highlight the monitoring in the baseline scenario and ensure the application of correct data inputs and outputs.

The Table 5 (Table 6 of item 8.2 from VM0042 v2.0 Final Draft) shows the guidance on biophysical model inputs for the baseline scenario.

Model Input Category	Timing	Approach
Soil organic carbon stock content and bulk density to calculate SOC stocks (initial)	Determined *ex ante*	Directly measured via conventional analytical laboratory methods, e.g., dry combustion, at t=0 or (back-) modeled to t =0 from measurements collected within +/-5 years of t =0, or determined for t=0 via emerging technologies (e.g., INS, LIBS, MIR and Vis-NIR) with known uncertainty following the criteria in Appendix 4 of the VM0042 V2.0 FINAL DRAFT.
Soil properties (other than bulk density and soil organic carbon)	Determined *ex ante*	Directly measured or determined from published soil maps, with known uncertainty. Estimates from direct measurements must satisfy the following: ● Derived from representative (unbiased) sampling ● Accuracy of measurements is ensured through adherence to best practices.
Climate variables (e.g., precipitation, temperature)	Continuously monitored *ex ante*	Measured for each model-specific meteorological input variable at its required temporal frequency (e.g., daily) model prediction interval. Measurements are taken at the closest continuously monitored weather station, not exceeding 50 km from the sample field, or from a synthetic weather station (e.g., PRISM).

Table 5. Guidance on biophysical model inputs for the baseline scenario.

4.3.1 Soil Organic Carbon

Soil Organic Carbon (SOC) will be calculated using Quantification Approach 1, by the DayCent biogeochemical model, as already mentioned in the other Sections of this project. The equation used for this calculation is Equation 2, described in Section 8.2.1 of VM0042 v2.0 Final Draft. The equation used is the following:

$$SOC_{bsl,i,t} = fSOC_{bsl,i,t} \tag{27}$$

Where:

$SOC_{bsl,i,t}$= Carbon stocks in the soil organic carbon pool in the baseline scenario for sample unit i at the end of period t; tCO 2 e/unit area;

$fSOC_{bsl,i,t}$= Modeled soil organic carbon stocks in the baseline scenario for sample unit i at the end of period t ; tCO 2 e/unit area;

i= Sample unit.

The cultivation and practice history of each Instance (baseline schedule in 3.4) will be collected for at least three years before the start of the project and will be fed into the NaturAll Carbon database for modeling using DayCent, the calculation of baseline will be dynamic.

4.3.2 Methane

Methane from methanogenesis in the soil will not be considered, as emissions are less than 5% throughout the project. In Section 3.3.6 of VCS Methodology Requirements v4.1 it is stated that specific carbon pools and GHG sources, including carbon pools and GHG sources that cause project and leakage emissions, may be considered de minimis and need not be accounted for, because if together the decrease in carbon stocks (in carbon pools) or the increase in GHG emissions (from GHG sources) are omitted, it is equivalent to less than 5% of the total GHG benefit generated by the project.

In the cases of enteric fermentation and manure deposition, both will consider the methane resulting from the process in the Project Instances.

Enteric fermentation will be calculated using Equation 6 of Quantification Approach 3 (Section 8.2.6 of VM0042 v2.0 Final Draft), described below:

$$CH4ent_{bsl,i,t} = \frac{\left(\frac{GWP_{CH4} \times \sum_{l=1}^{L} P_{bsl,l,i,t} \times Days_{bsl,l,i,t} \times EF_{ent,l}}{1000 \times 365}\right)}{A_i} \quad (28)$$

Where:

$CH4ent_{bsl,i,t}$= Methane emissions from livestock enteric fermentation in the baseline scenario for sample unit i in year t; tCO2e/unit área;

$P_{bsl,l,i,t}$= Population of grazing livestock in the baseline scenario of type l in sample unit i in year t;head;

$Days_{bsl,l,i,t}$= Average grazing days per head in the baseline scenario for each livestock type l in sample unit i in year t; days;

$EF_{ent,l}$ = Enteric emission factor for livestock type l; kg CH4/(head * year);

GWP_{CH4}= Global warming potential for CH4;

Ai = Area of sample unit i; unit area

l = Type of livestock

i =Sample unit

*365 days per year

*1000kg per tonne

Fermentation manure deposition will be calculated by Equations 29 and 30 of Quantification Approach 3 (Section 8.2.6 of VM0042 v2.0 Final Draft), described below:

$$CH4_{md_{bsl,i,t}} = \frac{GWP_{CH4} \times \sum_{l=1}^{L}(P_{bsl,l,i,t} \times VS_{l,i,t} \times Days_{bsl,l,i,t} \times EF_{CH4,md,l})}{10^6 \times A_i} \quad (29)$$

Where:

$CH4\_md_{bsl,i,t}$ = Baseline CH 4 emissions from manure deposition in the baseline scenario for sample unit i in year t ; t CO 2 e/unit area;

GWP_{CH4} = Global warming potential for CH4;

$P_{bsl\ l,i,,t}$ = Population of grazing livestock in the baseline scenario of type l for sample unit i in year t ; head;

$VS_{l,i,t}$ = Average volatile solids excretion per head for livestock type l in sample unit i in year t ; kg volatile solids/(head * Days bsl l,i,t Average grazing days per head in the baseline scenario for each livestock type l in sample unit i in year t; days;x

$EF_{CH4,md,l}$ = Emission factor for methane emissions from manure deposit i on for livestock type l ; g kg volatile solids;

A_i =Area of sample unit i ; unit area;

l = Type of livestock

i = Sample unit

* 10^6 Grams per tonne

$$VS_{l,i,t} = VS_{rate,l} \times \frac{W_{bsl,l,i,t}}{1000} \quad (30)$$

Where:

$VS_{l,i,t}$ = Annual volatile soli ds excretion of livestock type l for sample unit i in year t ; kg volatile solids/(head * day;

$VS_{rate,l}$ = Default volatile solids excretion rate for livestock type l ; kg volatile solids/(1000 kg animal mass * day;

$W_{bsl,l,i,t}$ = Average weight in the baseline scenario of livestock type l for sample unit i in year t ; kg animal mass/head;

l = Type of livestock

i = Sample unit

*1000 Kg per 1000 kg

4.3.3 Nitrous oxide

It is expected that some Instances that will be part of the project adopted N fertilization in their baseline, and as a project activity they will decrease fertilization with reduced N. Estimates of ex ante NO_2 emissions from fertilizer application do not differ between baseline and project activity. Even with the possible decrease in the use of fertilizers as an agricultural management practice during the project, these differences will be difficult to predict, as they are not practices intended by the owners of the Instances so far.

Adopting a more conservative analysis of Nitrous Oxide in the soil, the project assumes that there will be no changes.

4.4 Project Emissions

Project emissions will be calculated both by Approach 3 equations from VM0042 v2.0 Final Draft (already described in previous sections) and by Approach 1 applying the Daycent biogeochemical model. Similar to what is proposed for baseline emissions, when applicable, the equations will be represented by the variable μ equal to wp and will be periodically used to calculate project emissions.

Most of the data used as input for the Daycent model during monitoring will be obtained by Remote Sensing and declaration of activities of the Instance owners. The description of all data sources and input references are further described in 3.4.1 of this document. Further, as per Section 8.4.2 of the VM0042 V2.0 FINAL DRAFT, if livestock are included in the baseline, the minimum value allowed for the project is equal to the average value from the historical baseline period. In Table 6, bellow, is shown the guidance on collection of model inputs for the project scenario where required by the model.

Model Input Category	Timing	Approach
Soil organic carbon and bulk density	Determined at project start (re-measured every 5 years or less)	Directly measured via conventional analytical laboratory methods, e.g., dry combustion, or estimated via emerging technologies (INS, LIBS, MIR and Vis- NIR) with known uncertainty following the criteria in Appendix 4 of the VM0042 V2.0 FINAL DRAFT, every 5 years or less. Back modeling to instance start date can be used on applicable cases.
Soil properties (other than bulk density and soil organic carbon)	Determined *ex ante*	Measured or determined from published soil maps with known uncertainty. Estimates from direct measurements must: ● Derived from representative (unbiased) sampling; ● Accuracy of measurements is ensured through adherence to best practices (to be determined by the project proponent and outlined in the monitoring plan)
Climate variables (e.g., precipitation, temperature)	Continuously monitored *ex post*	Measured for each model-specific meteorological input variable at its required temporal frequency (e.g., daily) model prediction interval. Measurements are taken at the closest continuously monitored weather station, not exceeding 50 km from the sample field, or from a synthetic weather station (e.g., PRISM)
Agricultural management activities (as identified following procedures in VMD0053 "Model Calibration and Validation Guidance for the Methodology for Improved Agricultural Land Management", referencing categories of practices outlined in applicability condition 1)	Monitored *ex post*	Required model inputs related to agricultural management practices will be monitored and recorded for each project year, *t*. Information on agricultural management practices will be monitored via consultation with, and substantiated with a signed attestation from, the farmer or landowner of the sample unit. Any quantitative information (e.g., discrete or continuous numeric variables) on agricultural management practices must be supported by one or more forms of documented evidence pertaining to the selected sample field and relevant monitoring period (e.g., management logs, receipts or invoices, farm equipment specifications).Units for quantitative information will be based on model input requirements.

Table 6. Guidance on collection of model inputs for the project scenario where required by the model.

4.5 Buffer

The Verified Carbon Standard directs that part of the emissions reductions and removals (ERRs) needs to be contributed to an AFOLU pooled buffer account. The share ($Buffer_t$) of the ERRs is determined by applying the latest version of the VCS AFOLU Non-Permanence Risk Tool. That share can vary along the project duration according to individual internal and external permanence risks and proposed mitigation action plans. Due to the project's spatial diversity, the VCS AFOLU Non-Permanence Risk Toll will be assessed at the instance scale.

4.6 Leakage

In the areas of the Instances inserted in the project, it is expected that the implemented practices increase the agricultural production of the areas, minimizing the leakage of activities outside the project boundaries. A better description of the monitoring of leakages is in 1.17.1 of this document.

The project aims to monitor potential leaks, crossing productivity data with SOC addition data to verify that the latter isn't increasing to the detriment of the former. VM0042 V2.0 FINAL DRAFT presents three relevant equations to quantify leaks that may occasionally occur in an instantiation, which are presented below.

New Application of Manure Organic Amendments from Outside the Project Area

On VM0042 V2.0 FINAL DRAFT, section 8.4.1 shows the procedures and situations where a new application of organic manure amendments from outside the project area needs to be accounted for and considered as leakage, using Equation 31 below:

$$LE_t = \sum_l \left(M\_manure_{ins,l,t} \times CC_{ins,l,t} \times 0.12 \times \frac{44}{12} \right) \qquad (31)$$

Where:

LE_t Leakage in year t; t CO_{2e}

$M\_manure_{ins,l,t}$ Mass of manure applied as fertilizer on the instance area from livestock type l in year t; tonnes

$CC_{ins,l,t}$ Carbon content of manure applied as fertilizer on the instance area from livestock type l in year t; fraction

0.12 Fraction of manure carbon expected to remain in the soils on the instance area by the end of the project term; fraction

$\frac{44}{12}$ Conversion from carbon to carbon dioxide equivalent; t C/t CO_{2e}

Leakage from Livestock Displacement

According to VM0042 V2.0 FINAL DRAFT, if livestock displacement occurs, the CH_4 and N_2O emissions associated with livestock must continue to be counted in the project scenario to account for potential emissions leakage. This is to avoid crediting emission reductions from livestock displacement (i.e., lowering of CH_4 and N_2O emissions within the project area relative to the baseline, by reducing the number of livestock within the project boundary). The number of livestock in the project scenario must not be lower than the number of livestock in the historical baseline period.

Leakage from Productivity Declines

Market leakage is likely to be negligible because the land in the project scenario remains in agricultural production. Further, producers are unlikely to implement and maintain management practices that result in productivity declines, since their livelihoods depend on crop harvests as a source of income. Nevertheless, to ensure leakage is not occurring, the VM0042 V2.0 FINAL DRAFT at is 8.4.3 section provides the guidance to check some leakage has occurred from productivity decline, to be completed every 10 years. The equation 32 and the equation 33 bellow are part of the proposed guidance.

$$\Delta P = \left(\frac{P_{wp,p} - P_{bsl,p}}{P_{bsl,p}}\right) \times 100 \qquad (32)$$

Where:

ΔP	Change in productivity; percent
$P_{wp,p}$	Average productivity for product p during the project period; productivity per hectare
$P_{bsl,p}$	Average productivity for product p during the historical baseline period; productivity per hectare
p	Crop/livestock product

$$\Delta PR = \left(\frac{P_{wp,p}}{RP_{wp,p}} - \frac{P_{bsl,p}}{RP_{wp,p}}\right) \times 100 \qquad (33)$$

Where:

ΔPR	Change in productivity ratio per hectare
$P_{wp,p}$	Average productivity for product p during the project period
$P_{bsl,p}$	Average productivity for product p during the historical baseline period
$RP_{wp,p}$	Average regional productivity for product p during the same years as the project period
$RP_{bsl,p}$	Average regional productivity product p during the same years as the historical baseline period
p	Crop/livestock product

4.7 Ex Ante Net GHG Emission Reductions and Removals

To calculate the *ex ante* net reductions and removals of GHG emissions a projection of enrolled farm areas in the project was used and the average yearly soil organic carbon stock change for Cerrado (our target biome for the coming years) according to the scientific literature[163] and a conservative estimation (19%) from the AFOLU Non-Permanence Risk Tool. The *ex ante* estimate of VCUs is shown at Table 7 below.

Crop Year	Gross soil organic carbon removals (tCO2e)	Leakage Deduction	Buffer Deduction	Ex ante estimate of VCUs
2019 - 2020	32,200	0	6,118	26,082
2020 - 2021	80,500	0	15,295	65,205
2021 - 2022	80,500	0	15,295	65,205
2022 - 2023	80,500	0	15,295	65,205
2023 - 2024	80,500	0	15,295	65,205
2024 - 2025	80,500	0	15,295	65,205
2025 - 2026	80,500	0	15,295	65,205
2026 - 2027	80,500	0	15,295	65,205
2027 - 2028	80,500	0	15,295	65,205
2028 - 2029	80,500	0	15,295	65,205
2029 - 2030	80,500	0	15,295	65,205
2030 - 2031	80,500	0	15,295	65,205
2031 - 2032	80,500	0	15,295	65,205
2032 - 2033	80,500	0	15,295	65,205
2033 - 2034	80,500	0	15,295	65,205
2034 - 2035	80,500	0	15,295	65,205
2035 - 2036	80,500	0	15,295	65,205
2036 - 2037	80,500	0	15,295	65,205
2037 - 2038	80,500	0	15,295	65,205
2038 - 2039	80,500	0	15,295	65,205
Total estimated VCUs			1,264,977	
Total number of crediting years			20	
Average annual VCUs			63,249	

Table 7. Yearly Ex Ante VCUs

[163] Corbeels, M.; Marchão, R, L.; Siqueira Neto, M.; Ferreira, E, G.; Mandari, B, E.; Scopel, E.; Brito, O, R. Evidence of limited carbon sequestration in soils under no-tillage systems in the Cerrado of Brazil. Sci Reports 6, Nature. 2016.

5 MONITORING

5.1 Data and Parameters Available at Validation or that will be monitored

TablesTable 8 to Table 31, below, summarize the data and parameters that will be available at validation.

Data/Parameter	AR
Data unit	Percent
Description	Weighted average adoption rate
Source of data	Data will be retrieved from the most recent Brazilian agricultural census published by IBGE (Instituto Brasileiro de Geografia e Estatistística). Other data sources can be used, following the instructions described in VM0042 V2.0 FINAL DRAFT.
Value applied	To not be considered common, practice must be less than or equal to 20%. Local values for common practice assessment will be available in the latest version of Regional Common Practices document, Table 1.
Justification of choice of data or description of measurement methods and procedures applied	See Section 7 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Common practice assessment
Comments	Determining common practice rates from publicly available data often requires deriving information from multiple sources. The Regional Common Practices document is built using the best available data and conservative calculations.

Table 8. AR parameter.

Data/Parameter	$Area_{an}$
Data unit	Hectares
Description	Area of proposed project-level adoption of each activity
Source of data	Data will be retrieved from the most recent Brazilian agricultural census published by IBGE (Instituto Brasileiro de Geografia e Estatistística). Other data sources can be used, following the instructions described in VM0042 V2.0 FINAL DRAFT.
Value applied	The proposed project-level adoption of $Activity_{an}$
Justification of choice of data or description of measurement methods and procedures applied	See Section 7 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Common practice assessment
Comments	Determining common practice rates from publicly available data often requires deriving information from multiple sources. The Regional Common Practices document is built using the best available data and conservative calculations.

Table 9. $Area_{an}$parameter.

Data/Parameter	EA_{an}
Data unit	Percent
Description	Adoption rate of the n largest most common proposed project activity in the region
Source of data	Data will be retrieved from the most recent Brazilian agricultural census published by IBGE (Instituto Brasileiro de Geografia e Estatistística). Other data sources can be used, following the instructions described in VM0042 V2.0 FINAL DRAFT.
Value applied	Conditional on data source
Justification of choice of data or description of measurement methods and procedures applied	See source of data above and Section7 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Common practice assessment
Comments	Determining common practice rates from publicly available data often requires deriving information from multiple sources. The Regional Common Practices document is built using the best available data and conservative calculations.

Table 10. EA_{an}parameter.

Data/Parameter	A_0
Data unit	Hectares
Description	Individual instance area
Source of data	GIS and Shape files from instance created during the farmer on boarding process.
Value applied	Conditional on data source
Justification of choice of data or description of measurement methods and procedures applied	See source of data above and Section7 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 11. A_0parameter.

Data/Parameter	GWP_{CH4}
Data unit	$tCO2e/t\ CH_4$
Description	Global warming potential for CH_4
Source of data	IPCC Fifth Assessment Report
Value applied	28
Justification of choice of data or description of measurement methods and procedures applied	See source of data above. VCS Standard v4.3, Section 3.14.4requires that CH_4 must be converted using the 100-year global warming potential derived from the IPCC Fifth Assessment Report for GHG emission reductions occurring on or after 1 January 2021.
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 12. GWP_{CH4}parameter.

Data/Parameter	$EF_{ent,l}$
Data unit	kg CH_4/(head*year)
Description	Enteric emission factor for livestock type *l*
Source of data	Peer-reviewed published data may be used. For example, suitable values may be selected from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4Chapter 10 Table 10.10 and Table 10.11
Value applied	The emission factor is selected based on livestock type
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 13. $EF_{ent,l}$parameter.

Data/Parameter	$VS_{rate,l}$
Data unit	Kg volatile solids/(1000kg animal mass*day)
Description	Default volatile solids excretion rate for livestock type *l*
Source of data	Peer-reviewed published data may be used. For example, suitable values may be selected from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4Chapter 10 Table 10.10 and Table 10.13a
Value applied	The volatile solids excretion rate is determined based on livestock type. Where agricultural systems are differentiated into low and high productivity systems in Table 10.13a in Chapter 10ofthe 2019 Refinement to the 2006IPCC Guidelines for National Greenhouse Gas Inventories Volume4,the mean values selected.
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of base line and project emissions
Comments	None

Table 14. $VS_{rate,l}$parameter.

Data/Parameter	GWP_{N2O}
Data unit	t CO_2e/t N_2O
Description	Global warming potential for N_2O
Source of data	IPCC Fifth Assessment Report Volume 4, Chapter 11, Table 11.1
Value applied	265
Justification of choice of data or description of measurement methods and procedures applied	See source of data above. VCS Standard v4.3 section 3.14.4 requires that N_2O must be converted using the 100-year global warming potential derived from the IPCC Fifth Assessment Report for GHG emission reductions occurring on or after 1 January 2021.
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 15. GWP_{N2O}parameter.

Data/Parameter	*$Frac_{GASM}$*
Data unit	Dimensionless
Description	Fraction of all organic N added to soils and N in manure and urine deposited on soils that volatilizes as NH_3 and NO_x
Source of data	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume4, Chapter11,Table11.3
Value applied	0.21
Justification of choice of data or description of measurement methods and procedures applied	See source of data above
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 16. $Frac_{GASF}$parameter.

Data/Parameter	*EF_{Nvolat}*
Data unit	tN_2O-N/(tNH_3-N+NOx-N volatilized)
Description	Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces
Source of data	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume4, Chapter11,Table11.3
Value applied	0.01
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 17. EF_{Nvolat} parameter.

Data/Parameter	*$EF_{N2O,md,l}$*
Data unit	kgN2O-N/kgN input
Description	Emission factor for nitrous oxide from manure and urine deposited on soils by livestock type l
Source of data	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 11, Table 11.1
Value applied	The emission factor for nitrous oxide from manure and urine deposited on soils is determined based on livestock type. For cattle, poultry, and pigs $EF_{N2O,md,l}$ = 0.004 kg N2O-N/kg N input. For sheep and other animals $EF_{N2O,md,l}$=0.003 kg N2O-N/kg N input.
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 18. $EF_{N2O,md,l}$ parameter.

Data/Parameter	Nex_l
Data unit	Kg N deposited/(t livestock mass*day)
Description	Nitrogen excretion of livestock type*l*
Source of data	Peer-reviewed published data may be used. For example, suitable values may be selected from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4,Chapter 10,Table 10.19
Value applied	The nitrogen excretion rate is determined based on livestock type. Where agricultural systems are differentiated into low and high productivity systems in Table 10.19, in Chapter 10 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4,the mean value is selected.
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 19. Nex_l parameter.

Data/Parameter	$MS_{bsl,l,i,t}$
Data unit	Fraction of N deposited
Description	Fraction of nitrogen excretion of livestock type *l* that is deposited on the project area
Source of data	Data may be sourced according to the guidance inBox1 of VM0042 V2.0 FINAL DRAFT
Value applied	The fraction of nitrogen deposited on the project area is determined based on the amount of time spent grazing on the project area during year *t* for each livestock type. In the absence of data available according to Box 1 of VM0042 V2.0 FINAL DRAFT (or to conservatively reduce the effort of project development), a value of 1 may be applied with no additional support. This would conservatively assume that the livestock deposited 100% of their excreted N on the project area for the entirety of year *t*.
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 20.$MS_{bsl,l,i,t}$ parameter.

Data/Parameter	$N_{content,g}$
Data unit	tN/tdm
Description	Fraction of N in dry matter for N-fixing species *g*
Source of data	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 11,Table11.2
Value applied	The fraction of N in dry matter is determined based on the N-fixing species type.
Justification of choice of data or description of measurement methods and procedures applied	See source of data above of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline and project emissions
Comments	None

Table 21.$N_{content,g}$ parameter.

Data/Parameter	$P_{bsl,l,i,t}$
Data unit	Head
Description	Population of grazing livestock in the baseline scenario of type*l*in sample unit i in year t
Source of data	Information provided by farmers during instance enrollment
Value applied	Variable, to be determined.
Justification of choice of data or description of measurement methods and procedures applied	The size of grazing population will be informed by the farmer on enrollment.
Purpose of Data	Calculation of baseline emissions
Comments	None

Table 22. $P_{bsl,l,i,t}$ parameter.

Data/Parameter	$Days_{bsl,l,i,t}$
Data unit	Days
Description	Average grazing days per head in the baseline scenario inside sample unit*i* for each livestock type*l*in year *t*
Sourceof data	Information provided by farmers during instance enrollment
Value applied	Variable, to be determined.
Justification of choice of data or description of measurement methods and procedures applied	The average grazing days in baseline scenario will be informed by the farmer on enrollment.
Purpose of Data	Calculation of baseline emissions
Comments	None

Table 23.$Days_{bsl,l,i,t}$ parameter.

Data/Parameter	$MB_{g,bsl,i,t}$
Data unit	tdm
Description	Annual dry matter, including g above ground and below ground, of N-fixing species *g* returned to soils for sample unit *i* at time *t*
Source of data	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Value applied	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Justification of choice of data or description of measurement methods and procedures applied	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Calculation of baseline emissions
Comments	Mass of residues burned is a function of the amount of above ground biomass, the removal of above ground biomass, and whether or not remaining residues are burned.

Table 24. $MB_{g,bsl,i,t}$ parameter.

Data/Parameter	$P_{\mathrm{bsl},p}$
Data unit	Productivity (e.g.,kg) per hectare
Description	Average productivity for product p during the historical baseline period
Source of data	Information on productivity/yields will be provided by the farmer during instance enrollment
Value applied	Variable, to be determined.
Justification of choice of data or description of measurement methods and procedures applied	See Box 1 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Determination of baseline productivity for future market leakage analysis
Comments	None

Table 25. $P_{\mathrm{bsl},p}$ parameter.

Data/Parameter	$RP_{bsl,p}$
Data unit	Productivity (e.g. kg) per hectare
Description	Average regional productivity for product p during the same years as the baseline period
Source of data	Secondary evidence sources of regional productivity (e.g., peer-reviewed science, industry associations, international databases, government databases)
Justification of choice of data or description of measurement methods and procedures applied	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Purpose of Data	Determination of baseline productivity ratio for future market leakage analysis
Comments	None

Table 26. $RP_{bsl,p}$ parameter

Data/Parameter:	$W_{bsl,l,i,t}$
Data unit:	kg animal mass/head
Description:	Average weight in the baseline scenario of livestock type *l* for sample unit *i* in year *t*
Source of data:	Peer-reviewed published data or expert judgement may be used
Justification of choice of data or description of measurement methods and procedures applied	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Purpose of data:	Calculation of baseline emissions
Comments:	None

Table 27. $W_{bsl,l,i,t}$parameter.

Data/Parameter:	$Frac_{LEACH}$
Data unit:	Dimensionless
Description:	Fraction of N added (synthetic or organic) to soils and N in manure and urine deposited on soils that is lost through leaching and runoff, in regions where leaching and runoff occurs
Source of data:	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 11, Table 11.3
Value applied	For wet climates or in dry climate regions where irrigation (other than drip irrigation) is used, a value of 0.24 is applied. For dry climates, a value of zero is applied.
Description of measurement methods and procedures to be applied:	See source of data above
Purpose of data:	Calculation of baseline and project emissions
Comments:	Wet climates occur in temperate and boreal zones where the ratio of annual precipitation: potential evapotranspiration > 1, and tropical zones where annual precipitation > 1000 mm. Dry climates occur in temperate and boreal zones where the ratio of annual precipitation: potential evapotranspiration < 1, and tropical zones where annual precipitation < 1000 mm.

Table 28. $Frac_{LEACH}$ parameter.

Data/Parameter:	EF_{Nleach}
Data unit:	t N2O-N / t N leached and runoff
Description:	Emission factor for nitrous oxide emissions from leaching and runoff
Source of data:	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 11, Table 11.3
Value applied	0.011
Description of measurement methods and procedures to be applied:	See source of data above
Purpose of data:	Calculation of baseline and project emissions
Comments:	None

Table 29. EF_{Nleach} parameter.

Data/Parameter:	$EF_{Ndirect}$
Data unit:	t N2O-N/t N applied
Description:	Emission factor for direct nitrous oxide emissions from N additions from synthetic fertilizers, organic amendments and crop residues
Source of data:	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 11, Table 11.1
Value applied	A value of 0.01 is applied for N additions from synthetic fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as a result of loss of SOC. Disaggregated values may be used as follow: • A value of 0.016 is applied for inputs of synthetic fertilizer and fertilizer mixtures that include both synthetic and organic forms of N. in wet climates • A value of 0.006 is applied for other N input as organic amendments, animal manures, N in crop residues and mineralized N from SOC decomposition in wet climates • A value of 0.005 is applied to all N inputs in dry climates A value of 0.004 is applied for flooded rice fields. Disaggregated values may be used as follow: • A value of 0.006 is applied for continuous flooding. • A value of 0.005 is applied for single and multiple drainage A value of 0.004 is applied for manure from cattle (dairy, non-dairy and buffalo), poultry and pigs. Disaggregated values maybe used as follow: • A value of 0.006 is applied for wet climates • A value of 0.002 is applied for dry climates. A value of 0.003 is applied for manure from sheep and ‘‘other animals’’. When specific emission factors are available, a Tier 2 approach may be applied following the guidance in Chapter 11 Section11.2.2.1 - Choice of Method and the good practice guidance in Chapter 2 Section 2.2.4 - Emission factors and direct measurement of emissions (IPCC, 2019). depending on, e.g., SOC content, soil texture, drainage, soil pH, N application rate per fertilizer type; fertilizer type, liquid or solid form of organic fertilizer; irrigation and type of crop with differences between legumes, non-leguminous arable crops, and grass.
Description of measurement methods and procedures to be applied:	See source of data above
Purpose of data:	Calculation of baseline and project emissions
Comments:	Emission factor applicable to N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as result of loss of soil carbon. Wet climates occur in temperate and boreal zones where the ratio of annual precipitation: potential evapotranspiration > 1, and tropical zones where annual precipitation > 1000 mm. Dry climates occur in temperate and boreal zones where the ratio of annual precipitation: potential evapotranspiration < 1, and tropical zones where annual precipitation < 1000 mm. ‘Other animals’ include goats, horses, mules, donkeys, camels, reindeer, and camelids.

Table 30. $EF_{Ndirect}$ parameter.

Data/Parameter:	$EF_{CH4,md,l}$
Data unit:	g CH_4/(kg volatile solids)
Description:	Emission factor for methane emissions from manure deposition for livestock type *l*
Source of data:	Peer-reviewed published data may be used. For example, suitable values may be selected from the2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 10, Table 11.14 and Table 10.15
Value applied	The emission factor is determined based on livestock type. Excluding livestock types listed in Table 10.15 in Chapter 10, Volume 4 (IPCC, 2019), a value of 0.6 is applied for all animals in both low and high productivity pasture, range, and paddock systems per Table 10.14 of the same chapter.
Description of measurement methods and procedures to be applied:	See source of data above
Purpose of data:	Calculation of baseline and project emissions
Comments:	None

Table 31. $EF_{CH4,md,l}$ parameter.

5.2 Data and Parameters Monitored

Tables Table 32 to Table 53, below, summarize the data and parameters that will be monitored during the project

crediting period.

Data/Parameter:	AR
Data unit:	Percent
Description:	Weighted average adoption rate
Source of data:	Calculated for the project across the group or all activity instances
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Annual
QA/QC procedures to be applied:	See Section7 of VM0042 V2.0 FINAL DRAFT
Purpose of data:	Common practice assessment
Calculation method:	See Section7 of VM0042 V2.0 FINAL DRAFT
Comments:	None

Table 32. AR parameter.

Data/Parameter:	$Area_{an}$
Data unit:	hectares
Description:	Area of proposed project-level adoption of each activity
Source of data:	Farm records and project activity commitments
Description of measurement methods and procedures to be applied:	The area is estimated prior to verification
Frequency of monitoring/recording:	Annual
QA/QC procedures to be applied:	Delineation of the sample unit area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS data sets used must be geo-registered referencing corner points, clear landmarks or other intersection points.
Purpose of data:	Common practice assessment
Calculation method:	Not applicable(measured)
Comments:	None

Table 33. $Area_{an}$ parameter.

Data/Parameter:	EA_{an}
Data unit:	Percent
Description:	Adoption rate of the largest most common proposed project activity in the region
Source of data:	Publicly available information contained in agricultural census or other government (e.g. survey) data, peer-reviewed scientific literature, independent research data, or reports/assessments compiled by industry associations. If all of the above sources are unavailable, signed and dated attestation statement from a qualified independent local expert.
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Annual
QA/QC procedures to be applied:	SeeSection7 of VM0042 V2.0 FINAL DRAFT
Purpose of data:	Common practice assessment
Calculation method:	Not applicable
Comments:	None

Table 34. EA_{an} parameter.

Data/Parameter:	A_i
Data unit:	Hectare
Description:	Area of sample unit *i*
Source of data:	Determined in project area
Description of measurement methods and procedures to be applied:	The sample unit area is measured prior to verification
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	Delineation of the sample unit area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS datasets used must be geo-registered referencing corner points, clear landmarks or other intersection points.
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	Not applicable
Comments:	None

Table 35. A_i parameter.

Data/Parameter:	*i*
Data unit:	Dimensionless
Description:	Sample unit; defined area that is selected for measurement and monitoring, such as a field
Source of data:	Determined in project area
Description of measurement methods and procedures to be applied:	The sample unit is determined prior to verification
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	Delineation of the sample unit area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS datasets used must be geo-registered referencing corner points, clear landmarks or other intersection points.
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	Not applicable
Comments:	None

Table 36. i parameter.

Data/Parameter:	*l*
Data unit:	Dimensionless
Description:	Type of livestock
Source of data:	Determined in sample unit *i* from farm livestock activities information
Description of measurement methods and procedures to be applied:	Farm records or farmer attestation that will be sourced according to Box 1 of VM0042 V2.0 FINAL DRAFT. Livestock type is determined prior to verification.
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	Not applicable
Comments:	None

Table 37. *l* parameter.

Data/Parameter:	g
Data unit:	Dimensionless
Description:	Type of N-fixing species
Source of data:	Determined in sample unit *i*
Description of measurement methods and procedures to be applied:	Farm records or farmer attestation that will be sourced according to Box 1 of VM0042 V2.0 FINAL DRAFT. N-fixing species type is determined prior to verification.
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT.
Purpose of data:	Calculation of baseline and project emissions
Calculation method:	Not applicable
Comments:	None

Table 38. g parameter.

Data/Parameter:	$f(SOC_{\mu,i,t})$
Data unit:	t CO_{2e}per hectare
Description:	Modeled soil organic carbon stocks pool in the baseline scenario (μ=bsl) or project scenario (μ=wp) for sample unit *i* at time *t*
Source of data:	Modeled in the project area
Value applied:	Variable
Description of measurement methods and procedures to be applied:	Daycent biogeochemical model from Colorado State University will be used to quantify Soil Organic Carbon stock changes over time during the project period, according to Approach 1. The model will be periodically calibrated and validated following VM0042 V2.0 FINAL DRAFT and VMD0053 V2.0 FINAL DRAFT rules.

	Daycent's inputs are: • Daily maximum/minimum temperature and precipitation; • Soil texture classes; • Land cover and soil use data; • Crop-specific data is also needed to obtain C and N fluxes at regional and national levels. In view of the inputs, to run the Daycent model it is necessary to inform the “cultivation/planting schedules” and which crop is present in a given period. In this way, the project proponent's approach will be to receive this cultivation data through statements documented by the owner of each instance and cross them with the data obtained by Remote Sensing, to check the information and also to fill in any data which is missing or has a low quality. The set of Daycent input variables to be monitored are specific to the validated model, so a detailed description of the monitored variables and other parameters is included in Model Validation Report. See Box 1 of VM0042 V2.0 FINAL DRAFT for sources of data and description of measurement methods and procedures to be applied to obtain values for model input variables.
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	Standard QA/QC procedures for soil inventory including field data collection and data management must be applied. Use or adaptation of QA/QCs available from published handbooks, such as those published by FAO and available on the FAO Soils Portal, or from the IPCC GPG LULUCF 2003 is recommended.
Purpose of data:	Calculation of baseline emissions
Calculation method:	Not applicable
Comments:	The soil organic carbon stocks at time *t*=0 are calculated based on directly measured soil organic carbon content and bulk density at *t*=0 or (back-) modeled to *t*=0 from measurements via conventional analytical laboratory methods, e.g., dry combustion, collected performed within +/-5 years of *t*=0, or determined for *t*=0 via VERRA’s approved emerging technologies (INS, LIBS, MIR and Vis-NIR) with known uncertainty following the criteria in Appendix 4 of VM0042 V2.0 FINAL DRAFT: Guidance on potential emerging technologies to measure SOC stocks, and must be used in both the baseline and with- project scenario for the length of the project.

Table 39. $f(SOC_{\mu,i,t})$ parameter.

Data/Parameter:	$fN2Osoil_{\mu,i,t}$
Dataunit:	t N2O per hectare
Description:	Modeled nitrous oxide emissions from soil in the baseline scenario (μ=bsl) or project scenario (μ=wp) for sample unit *i* at time *t*
Source of data:	Modeled in the project area
Value applied:	Variable
Description of measurement methods and procedures to be applied:	When applicable, Daycent biogeochemical model from Colorado State University will be used to quantify nitrous oxide emissions from soil during the project period. The model will be periodically calibrated and validated following VM0042 V2.0 FINAL DRAFT and VMD0053 V2.0 FINAL DRAFT rules. Daycent's inputs are: • Daily maximum/minimum temperature and precipitation; • Soil texture classes; • Land cover and soil use data; • Crop-specific data is also needed to obtain C and N fluxes at regional and national levels. In view of the inputs, to run the Daycent model it is necessary to inform the “cultivation/planting schedules” and which crop is present in a given period. In this way, the project proponent's approach will be to receive this cultivation data through statements documented by the owner of each instance and cross them with the data obtained by Remote Sensing, to check the information and also to fill in any data which is missing or has a low quality. The set of Daycent input variables to be monitored are specific to the validated model, so a detailed description of the monitored variables and other parameters is included in Model Validation Report. See Box 1 of VM0042 V2.0 FINAL DRAFT for sources of data and description of measurement methods and procedures to be applied to obtain values for model input variables.
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	Standard QA/QC procedures for soil inventory including field data collection and data management must be applied. Use or adaptation of QA/QCs available from published handbooks, such as those published by FAO and available on the FAO Soils Portal, or from the IPCC GPG LULUCF 2003 is recommended.
Purpose of data:	Calculation of baseline emissions
Calculation method:	Not applicable
Comments:	When applicable, Approach 1 will be used to calculate nitrous oxide emissions from soil, otherwise Approach 3 will be applied.

Table 40. $fN2Osoil_{\mu,i,t}$parameter.

Data/Parameter	$P_{wp,l,i,t}$
Data unit	Head
Description	Population of grazing livestock in the project scenario of type*l*in sample unit i in year t
Source of data	Information of instance activities provided by farmers during project execution.
Value applied	Variable, to be determined.
Justification of choice of data or description of measurement methods and procedures applied	The size of grazing population will be informed by the farmer based on instance activities records.
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT.
Purpose of Data	Calculation of project emissions
Comments	None

Table 41. $P_{wp,l,i,t}$ parameter.

Data/Parameter	$Days_{wp,l,i,t}$
Data unit	Days
Description	Average grazing days per head in the project scenario inside sample unit *i* for each livestock type*l* in year *t*
Source of data	Information of instance activities provided by farmers during project execution.
Value applied	Variable, to be determined.
Justification of choice of data or description of measurement methods and procedures applied	The average grazing days will be informed by the farmer based on instance activities records.
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT.
Purpose of Data	Calculation of project emissions
Comments	None

Table 42.$Days_{wp,l,i,t}$ parameter.

Data/Parameter	$MB_{g,wp,i,t}$
Data unit	tdm
Description	Annual dry matter, including above ground and below ground, of N-fixing species *g* returned to soils for sample unit *i* at time *t*
Source of data	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Value applied	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Justification of choice of data or description of measurement methods and procedures applied	SeeBox1 of VM0042 V2.0 FINAL DRAFT
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT.
Purpose of Data	Calculation of project emissions
Comments	Mass of residues burned is a function of the amount of above ground biomass, the removal of above ground biomass, and whether or not remaining residues are burned.

Table 43. $MB_{g,wp,i,t}$ parameter.

Data/Parameter:	$W_{wp,l,i,t}$
Data unit:	kg animal mass/head
Description:	Average weight in the project scenario of livestock type *l* for sample unit *i* in year *t*
Source of data:	Peer-reviewed published data or expert judgement may be used
Description of measurement methods and procedures to be applied:	See source above of VM0042 V2.0 FINAL DRAFT
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	The project proponent must justify why the values selected for these parameters results in emission reductions that are conservative
Purpose of data:	Calculation of project emissions
Calculation method:	Not applicable
Comments:	None

Table 44. $W_{wp,l,i,t}$ parameter.

Data/Parameter:	*LE,t*
Data unit:	tCO2e
Description:	Leakage in year t;
Source of data:	Not applicable
Description of measurement methods and procedures to be applied:	Leakage is equal to zero per the applicability conditions and Section 8.4 of VM0042 V2.0 FINAL DRAFT
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	The project proponent must justify why the values selected for these parameters results in emission reductions that are conservative
Purpose of data:	Calculation of project emissions
Calculation method:	Not applicable
Comments:	None

Table 45. LE,t parameter.

Data/Parameter:	$M\_manure_{ins,l,t}$
Data unit:	tonnes
Description:	Project manure applied as fertilizer on the project area from livestock type *l* in year *t*
Source of data:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Description of measurement methods and procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	The project proponent must justify why the values selected for these parameters results in emission reductions that are conservative
Purpose of data:	Calculation of project emissions
Calculation method:	Not applicable
Comments:	None

Table 46. $M\_manure_{ins,l,t}$ parameter.

Data/Parameter:	$CC_{ins,l,t}$
Data unit:	fraction
Description:	Carbon content of manure applied as fertilizer on the project area from livestock type *l* in year *t*
Source of data:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Description of measurement methods and procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	The project proponent must justify why the values selected for these parameters results in emission reductions that are conservative
Purpose of data:	Calculation of project emissions from leakage
Calculation method:	Not applicable
Comments:	None

Table 47. $CC_{ins,l,t}$ parameter.

Data/Parameter:	ΔP
Data unit:	Percent
Description:	Change in productivity
Equations:	Equation 29 of VM0042 V2.0 FINAL DRAFT
Source of data:	Calculated (not applicable)
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Every 10 years
QA/QC procedures to be applied:	Not applicable
Purpose of data:	Determination of change in crop/livestock productivity for leakage analysis
Calculation method:	See Section 8.4.2 of VM0042 V2.0 FINAL DRAFT
Comments:	None

Table 48. ΔP parameter.

Data/Parameter:	$P_{wp,p}$
Data unit:	Productivity (e.g., kg) per hectare
Description:	Average productivity for product p during the project period
Source of data:	Farm productivity (e.g., yield) records
Description of measurement methods and procedures to be applied:	Measured using locally available technologies (e.g., mobile weighing devices, commercial scales, storage volume measurements, fixed scales, weigh scale tickets, etc.)
Frequency of monitoring/recording:	Each growing season
QA/QC procedures to be applied:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Purpose of data:	Determination of project productivity for market leakage analysis
Calculation method:	Not applicable (measured)
Comments:	None

Table 49. $P_{wp,p}$ parameter.

Data/Parameter:	*p*
Data unit:	Categorical variable
Description:	Crop/livestock product
Source of data:	See Box 1 of VM0042 V2.0 FINAL DRAFT
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Each growing season
QA/QC procedures to be applied:	Not applicable
Purpose of data:	Identification of crop/livestock product for market leakage analysis
Calculation method:	Not applicable (measured)
Comments:	None

Table 50. p parameter.

Data/Parameter:	ΔPR
Data unit:	Percent
Description:	Change in productivity ratio
Equations:	Equation 30 of VM0042 V2.0 FINAL DRAFT
Source of data:	Calculated (not applicable)
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Every 10 years
QA/QC procedures to be applied:	Not applicable
Purpose of data:	Determination of change in crop/livestock productivity for leakage analysis
Calculation method:	See Section 8.4.2 of VM0042 V2.0 FINAL DRAFT
Comments:	None

Table 51. ΔPR parameter.

Data/Parameter:	$RP_{wp,p}$
Data unit:	Unitless
Description:	Average regional productivity for product p during the same years as the project period
Source of data:	Regional productivity data from government (e.g., IBGE, CONAB, others), industry, published, academic or international organization e.g., FAO) sources.
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Every 10 years
QA/QC procedures to be applied:	Not applicable
Purpose of data:	Determination of project productivity ratio for market leakage analysis
Calculation method:	Not applicable
Comments:	None

Table 52. $RP_{wp,p}$ parameter.

Data/Parameter:	*Buffer$_t$*
Data unit:	tCO_{2e}
Description:	Number of buffer credits to be contributed to the AFOLU pooled buffer account in year *t*
Source of data:	The number of buffer credits to be contributed to the AFOLU pooled buffer account must be determined by applying the latest version of the VCS AFOLU Non-Permanence Risk Tool
Description of measurement methods and procedures to be applied:	Not applicable
Frequency of monitoring/recording:	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
QA/QC procedures to be applied:	The number of buffer credits to be contributed to the AFOLU pooled buffer account must be determined by applying the latest version of the VCS AFOLU Non-Permanence Risk Tool
Purpose of data:	Calculation of project emissions
Calculation method:	The number of buffer credits to be contributed to the AFOLU pooled buffer account must be determined by applying the latest version of the VCS AFOLU Non-Permanence Risk Tool
Comments:	Due to the project's spatial diversity, the VCS AFOLU Non-Permanence Risk Toll will be assessed at the instance scale.

Table 53. *Buffer$_t$*parameter.

5.3 Monitoring Plan

The NaturAll Carbon Program – Conservation Agriculture and Land Management in Brazil is a project that uses technology to scale the MRV process of ERRs on partner farms. The primary GHG to be monitored is carbon (on Soil Organic Carbon fluxes), where we will apply Approach 1. Monitoring will be done individually for each instance. The farmer must have at least one instance listed in the project. In the following items, we will address the main steps of the monitoring process.

5.3.1. Instance initial characterization

5.3.1.1. Determining instance boundaries

An instance is the largest homogeneous area unit inserted in the project. This homogeneity considers the soil, crop functional groups, practices categories, historical land use, and the project start date. In the project, instances will be determined using local and remote data. Instances may be merged and split as long as they carry the history associated with them.

The instances will receive a random and unique identification code. In addition, their boundaries will be registered in a vector data storage format that stores the location, shape, and attributes (e.g., ESRI Shapefile, KML, and others).

5.3.1.2. Soil sampling

Initial soil samples will be collected to determine the physicochemical characteristics of the instance and the initial carbon stock, both for future verification and to apply back-modeling in the Daycent model in situations where it was not possible to determine the SOC at the Project start date. Due to the constant evolution of technology, VM0042, and soil sciences, the area stratification, the collection points, and the sample collection and analysis procedures are described in a support document, which will be updated as Verra and its community approve new approaches.

5.3.1.3. Baseline determination

The instance baseline scenario will be determined using official and unofficial property records, farmer statements, and remote sensing data. In situations with missing data, information from common practices in the region where the instance is inserted will be used.

5.3.1.4. Eligibility

To be eligible for the project, an instance must adhere to the Verified Carbon Standard, VM0042, this PD, and the contractual conditions between NaturAll Carbon and the land owner.

5.3.2. Cropping and grazing practices monitoring

5.3.2.1. Farmer's logbook

To remain in the project, the farmer has a contractual commitment to periodically report the interventions and actions carried out in instances, both ordinary and extraordinary. This information will be registered through a set of forms and questionnaires prepared by NaturAll Carbon and delivered to the farmer. Initially, they will combine physical documents (paper) and online platform forms (e.g., Google Forms). Still, as NaturAll Carbon evolves in building its proprietary online platform, it will be migrated to the new format. In situations where there is no internet connection or any other digital collection of the logbook is not feasible, NaturAll Carbon will provide physical documents to record the logs and ensure the integrity and security of the transport of the farmer's papers to the processing office.

5.3.2.2. Remote Sensing Data

Remote sensing data will be used to monitor the actions the farmer is applying to the instances, both to confirm compliance with the commitments assumed when participating in the program and to correct missing data situations. The temporal analysis of satellite images is crucial to strengthen the integrity of the information provided by farmers in the logbook. Information on planting dates, harvesting, crop cycle, and no-till, among others, will be compared with information provided by the farmer. The use of indexes calculated by different algebraic combinations of spectral bands will be fundamental for the task. Machine learning techniques may be applied during the project's duration in classification and monitoring tasks, always with VVB approval in the respective Monitoring Report.

5.3.3. Soil Organic Carbon quantification

The Daycent modeling process follows the flow as shown in Figure 13.

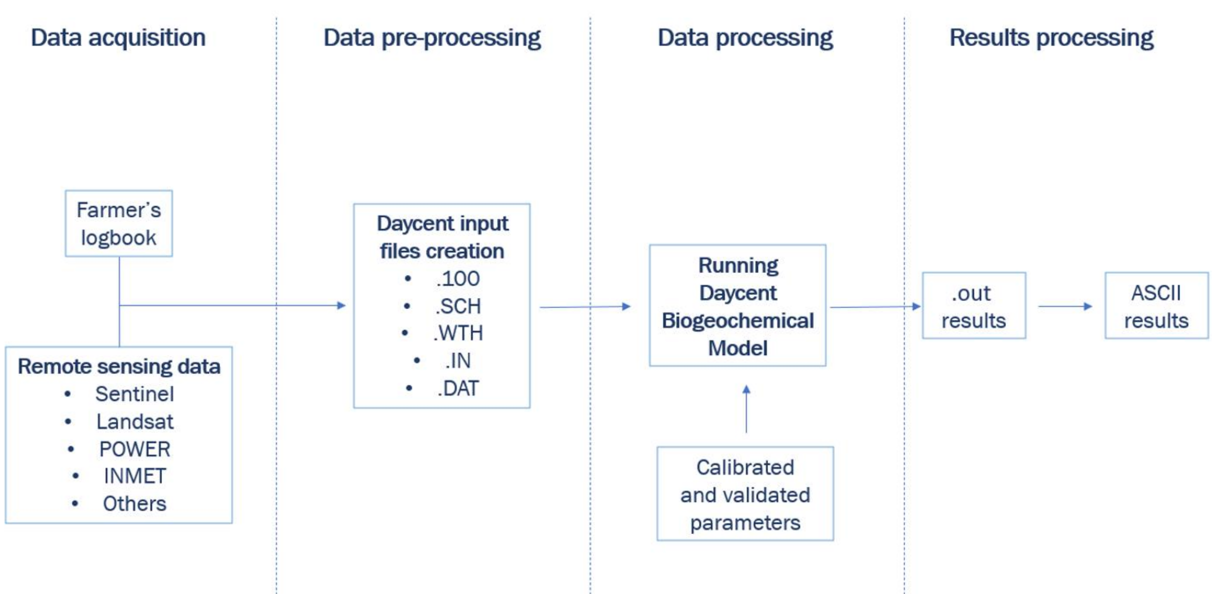

Figure 13 - Daycent modeling process

5.3.3.1. Data acquiring

Data for SOC quantification will be acquired from multiple sources, including, but not only from European Space Agency's Sentinel mission, the US National Oceanic and Atmospheric Administration's Landsat mission, the National Aeronautics and Space Administration's project Prediction of Worldwide Energy Resources (POWER), Brazilian Instituto Nacional de Meteorologia (INMET), among others. The data will follow the characteristics described in the parameter tables in this section of the document and the characteristics described in the Model Validation Report.

5.3.3.2. Data pre-processing

The data of each instance will be pre-processed to ensure that they are temporally continuous, that there are no inconsistencies, and that they are in accordance with this Project Design. These data will be compiled into .100, .SCH, .WTH, .IN, .DAT, and other files to serve as input for the Daycent biogeochemical model. All files that served as model input will be saved in digital format for later replication of calculations, if necessary.

5.3.3.3. Data processing

In addition to the calibrated and validated parameters according to the Model Validation Report, the pre-processed data of the instances will be used to perform the SOC stock changes calculations by the Daycent biogeochemical model in the software version informed in the Model Validation Report.

5.3.3.4. Results processing

Daycent calculations' output is a .out binary file (not human-readable). This file will also be processed to export the results in a .lis ASCII (human-readable) format to other files. This data will be compiled to present SOC stocks at the beginning and the end of the monitored period.

5.3.3.5. Use of Daycent for other ERRs calculations

Within this project's scope, the Daycent biogeochemical model can be applied to calculate the ERRs of nitrous oxides only when the model is calibrated and validated for this purpose. Therefore, calculating the ERRs for this gas will be similar to that presented for the SOC.

5.3.4. Emissions Reductions and Removals calculations

The Emissions Reductions and Removals (ERRs) calculations will be made for each instance to accurately reflect the number of Verified Carbon Units (VCUs) in the baseline, physical and cropping, and grazing practices context in which it is embedded. The equations for calculating ERRs and VCUs are described in Section 4 of this document. The Monitoring Report to be presented periodically in the process of verifying the ERRs will tell, for each instance, the value of VCUs and measured Buffer credits. The total number of VCUs to be issued and the buffer deposit over the period will be the sum of all instances.

5.3.5. Evidence storage and integrity

All the evidence used in the monitoring process will be digitally stored for the entire crediting period. If it's a paper document, it will be digitized and held for at least Monitoring Report approval. All digital data will be securely stored in a cloud server and physical media. An SHA-256 hash algorithm will be applied to the digital monitoring data to ensure data integrity. The SHA-256 (secure hash algorithm) is an algorithm that takes an input of any length and uses it to create a 256-bit fixed-length hash value. The “256” refers to the hash digest length. SHA-256 it's a NIST's (National Institute of Standards and Technology) recommended and officially approved standard algorithm.

5.3.6. QA/QC

Quality Assurance and Quality Control of the modeling process will be conducted by our Biogeochemical Modeling Specialist and supervised by its direct hierarchical superior. Our current strategy is to compare the model results with academic literature value ranges and trigger an investigation if any significant deviation is found. Then, internal, external, or both experts can investigate the issue to find and resolve the possible root causes.