RE.GREEN ATLANTIC FOREST REFORESTATION/RESTORATION PROJECT

Document Prepared by **Re.green Participações S.A.**

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1 PROJECT DETAILS

1.1 Summary Description of the Project

The Grouped project aims to implement forest restoration activities throughout the Brazilian Atlantic Forest Biome (hereinafter project zone), mainly in substitution of exotic grasslands formerly used for cattle raising, but also on lands used for annual agriculture (e.g. soy, sugarcane, etc), perennial agriculture of low carbon stocks (coffee, citrus, etc) and/or other non-native ecosystems.

The Atlantic Forest biome is one of the most threatened ecosystems in the world, it is the biome that suffered the highest level of deforestation in Brazil, presenting nowadays a fragmented condition, where only 12% of its original vegetation cover left and most of the remaining forests are small or isolated fragments (Ribeiro et al. 2009). Despite that, due to its remaining level of biodiversity, where many endemic and/or threatened with extinction species can be found and new species of flora and fauna continue to be described (Marques et al. 2021), the Atlantic Forest is considered one of the world biodiversity hotspots (Myers et al. 2000).

The Grouped Project zone comprises 17 States of the Brazilian territory: Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Goiás, Mato Grosso do Sul, Rio de Janeiro, Minas Gerais, Espírito Santo, Bahia, Alagoas, Sergipe, Paraíba, Pernambuco, Rio Grande do Norte, Ceará e Piauí. The project areas are located within climatic and edaphic conditions suitable for plant growth and encompasses regions of high value for biodiversity conservation (Jenkins et al. 2015).

The initial objective is to restore approximately 88,400 hectares of forest cover within the project zone and the subsequent sequestration and storage of carbon in several carbon pools, such as aboveground biomass, belowground biomass, litter, dead wood, and soil organic carbon. Net greenhouse gas removals are estimated in approximately 47,674,010 tCO_2e over 100 years, equivalent to the annual removal of 476,740 tCO_2e. It is expected that the project leads do several benefits that go beyond its mitigation component, such as improving biodiversity and other sustainability aspects, further detailed hereinafter.

The removal of GHG (CO_2) by the project's activities is a consequence of the biological sequestration through plant's photosynthesis, which potential is increased due to the implementation of a continuum of human induced forest restoration activities, ranging from assisted natural regeneration to full planting, including sometimes the use of commercial wood from native tree species, which often help triggering initial restoration process. Special attention will also be devoted to avoiding carbon losses due to accidental or criminal threats, such as fire and illegal logging. Measures include, but are not restricted to, building firebreaks, training, and supporting local fire brigades, satellite monitoring, and continuous site surveillance.

Overall, cattle ranching is the main economic activity practiced within the project zone (Projeto MapBiomas). However, this, and other anthropic activities (annual agriculture and perennial plantations), are also practiced in the project zone, in many cases without proper technical assistance. Pasturelands, for example, are occupied by exotic grasses, in many cases degraded (Projeto MapBiomas) due continuously mowing and burning in the dry season to stimulate the growth of new grasses, promoting erosive process in addition to exclusion of regenerating native plants. In the case of agricultural land-uses, the activities are mainly conducted by heavy machinery and continuous plantation cycles, leading to soil compaction and fertility impoverishment (Bot and Benites, 2005; Cherubin et al. 2016). In the absence of the project, the project areas would remain dominated by land-uses of low-carbon stock and/or continue to be occupied by non-native ecosystems as a consequence of anthropic activities. Thus, no restoration activities would take place and the target lands would remain with reduced concentrations of carbon per hectare, resulting in a small contribution to greenhouse gases (GHG) removals.

The project is expected to generate several positive impacts, e.g.: an increase in habitat availability for biodiversity and the reduction of atmospheric CO2 via ecological restoration. Significant positive social impacts are expected to be generated through the short- and long-term activities of the project. The project will directly provide local employment opportunities during restoration, monitoring, and harvesting phases and indirectly through activities such as seed collection, nursery operations and planting. These activities strengthen the local restoration value chain and support local communities.

The project's first Project Activity Instance (PAI-001) has 365 hectares and is located in the municipality of Eunápolis-Bahia/Brazil. It is expected to generate 197,517 tCO2 over 50 years, equivalent to 3,950 tCO2/ha/year. As part of the Grouped Project dynamics, other project instances will be added within the project zone.

The project's second Project Activity Instance (PAI-002) has 1,200 hectares and is located in the municipality of Eunápolis-Bahia/Brazil. It is expected to generate 682,727 tCO2 over 50 years, equivalent to 13,654 tCO2/ha/year. As part of the Grouped Project dynamics, other project instances will be added within the project zone.

1.2 Sectoral Scope and Project Type

The project corresponds to VCS scope 14 "Agriculture, Forestry and Other Land Use" as an Afforestation, Reforestation and Revegetation (ARR). The project is a grouped project that aims to implement ecological restoration activities on lands (project instances) that are expected to be non-native ecosystems in the absence of the project.

1.3 Project Eligibility

The project is an ARR project, whose PAIs will be developed within the Atlantic Forest Biome. The project activities are eligible under the scope of the VCS Program as the project includes AFOLU activities (project category ARR) which are supported by methodologies approved under the VCS Program. The project areas are eligible according to the criteria and conditions set under the A/R-ACM0003 CDM methodology and the VCS Standard v.4.4[1].

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[1] https://verra.org/programs/verified-carbon-standard/vcs-program-details/#rules-and-requirements

The project activities do not cause any drainage of native ecosystems or degrade hydrological functions to generate carbon credits. All project instances will meet the applicability conditions set out in the methodologies and tools applied to the project. Project areas must have been cleared of native ecosystems more than 10 years prior to the project implementation. As it can be observed in the land-use history analysis of the two project activity instances under implementation (PAI-001 and PAI-002) (Figure 1 and Figure 2), the analysis of the land-use history of the project area by satellite images (Projeto MapBiomas) from different years corroborate that the project areas were cleared of native ecosystems more than 10 years prior to the implementation of the restoration activities by the project proponent.

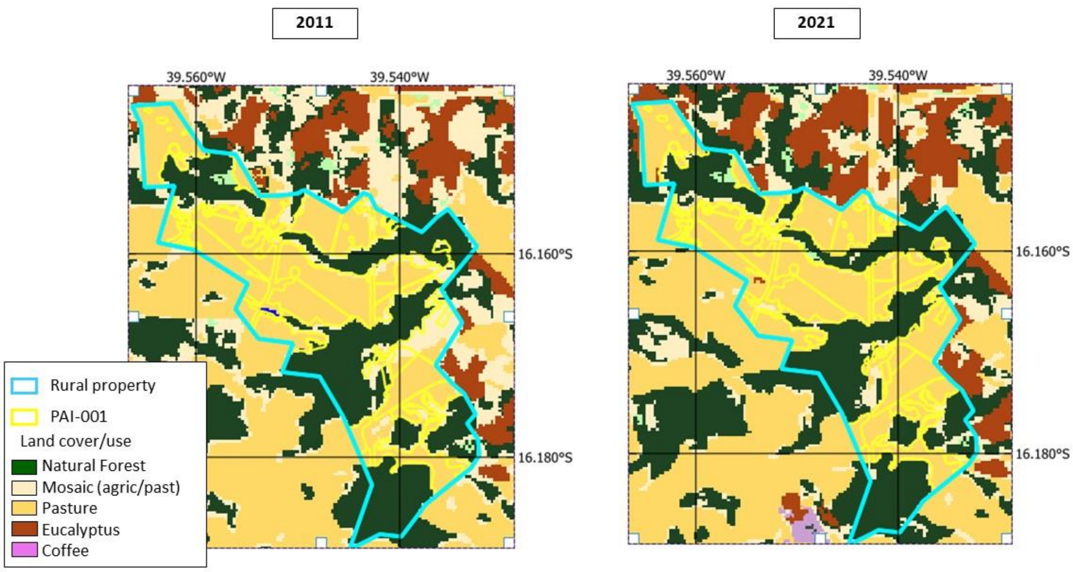

Figure 1. Land-use and cover within the PAI-001 in the years 2011 and 2021 (Projeto MapBiomas).

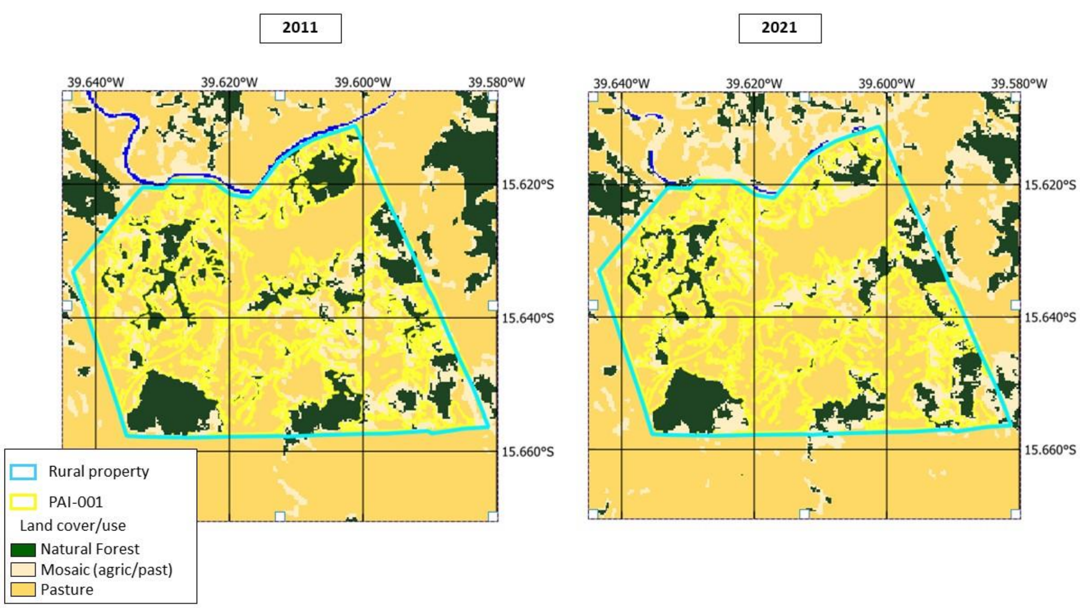

Figure 2. Land-use and cover within the PAI-002 in the years 2011 and 2021 (Projeto MapBiomas).

1.4 Project Design

The project is a grouped project, where different Project Activities Instances (PAIs) will be added over time.

Eligibility Criteria

The eligibility criteria for the Grouped Project are:

a) The proposed areas must be within the Project Zone (Brazilian Atlantic Forest Biome);

b) As required by the VCS Standard v4.4[1] 3.2.4 the project areas shall not be deforested of native ecosystems within the 10-year period prior to the implementation of the activities. In item 3.8 the Standard defines project start date of AFOLU projects as:

> *"The project start date of an AFOLU project is the date on which activities that led to the generation of GHG emission reductions or removals are implemented (e.g., preparing land for seeding, planting, changing agricultural or forestry practices, rewetting, restoring hydrological functions, or implementing management or protection plans)"*

So, each PAI will not be deforested of native ecosystems within the 10-year prior to the project start date considering that the PAI project start date is the date of inclusion in this Grouped Project;

c) Project Activities that increase carbon sequestration and/or reduce GHG emissions include the restoration of forest cover through the planting, sowing or human-assisted natural regeneration of woody vegetation on lands previously occupied by non-native ecosystems;

d) Current land use/cover on the proposed PAIs areas must be non-native ecosystems or land-uses of carbon stocks lower than the carbon stocks estimated for the project activities;

e) The duration of the crediting period for each PAI may start and finish within the Grouped Project crediting period;

f) Be consistent with the additionality criteria adopted for the Grouped Project, as per section 3.5;

g) Usage and application of technology protocols are conducted in a manner similar to that specified in this grouped project.

For the inclusion of new PAIs, these areas shall meet the following criteria:

a) Be located within the selected project zone;

b) Comply with the following eligibility criteria:

   i. All new project activity instance areas to be incorporated into the grouped project must meet the applicability conditions set forth in the methodology applied to the project;

   ii. The new instances shall have characteristics in regard to additionality that are consistent with the requirements of the grouped project;

   iii. Be included in the monitoring report with sufficient information (technical and geographic) to prove compliance with the eligibility criteria;

   iv. Be validated at the time of verification against the eligibility criteria;

v. Have evidence of project ownership, for each project activity instance, held by the project proponent from the respective start date of each project activity instance;
vi. Have a start date that is the same, or later than the grouped project start date.

1.5 Project Proponent

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Contact person	Bernardo Baeta Neves Strassburg
Title	Founder and Co-CEO
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1.6 Other Entities Involved in the Project

There aren't other entities involved in the implementation of the Grouped Project, but the Project Activities Instances may be developed in partnership with other entities, mainly related to the implementation of the restoration activities. During the inclusion of Project Activities Instances the relationship between Re.green and other entities will be provided to the VVB.

Regarding PAI-001 and PAI-002 there aren't other entities involved, except the companies and persons hired to implement the restoration activities.

1.7 Ownership

As Re.green is the project proponent of the Grouped Project "Re.green Atlantic Forest reforestation/restoration project", the project ownership and the rights to manage carbon credits is restricted to Re.green, as defined in the objectives of Re.green by law document.

Re.green will be the account holder on Verra and will manage the inclusion/monitoring of PAIs.

The land tenure document of each PAI will be presented on each verification process, when Re.green controls the ownership. In cases where the PAI is managed by third parties, Re.green will establish specific contracts to ensure that the PAI is in accordance with specific laws that guarantee the land tenure, and follows the eligibility criteria and the monitoring is performed in accordance with the methodologies established in the Grouped Project. In case credits are generated by third parties' PAIs, the ownership of credits will also be established in specific contracts, and where relevant, authorizing custody/operationalization of the same to Re.green.

Re.green has in place a rigorous process for sourcing, analyzing, negotiating and acquiring potential sites. All potential transactions go through extensive due diligence, led by the Chief Operating Officer and Chief Legal Officer and in partnership with highly regarded third party legal firms. The due diligence process includes a thorough review of land titling, legal and financial standing, as well as environmental history. It also includes a detailed analysis of potential conflicts with indigenous and other traditional local communities. All land acquisitions must be submitted and approved by the Board of Directors.

Re.green purchased the farm Ouro Verde (PAI-001) on May 18, 2022 and farm Belo Horizonte (PAI-002) on December 7, 2022. Thus, as provided in the previous items, it acquired all legal rights – including carbon rights - over the properties where the first restoration projects are undergoing. Re.green's rights over these areas are protected by article 5º, XXII (which guarantees property rights) and 170, II (which establishes that private property is one of the guiding principles of economic order) of the Federal Constitution, and articles 1.228 to 1.232 of the Civil Code. Article 1.332 of the Civil Code states that the landowner is entitled to all fruits produced by the land, except when special regulation provides otherwise.

1.8 Project Start Date

The project started on October 4th, 2022, when restoration activities began to be implemented in the first project activity instance, that is, PAI-001.

1.9 Project Crediting Period

The crediting period for the grouped project will be 100 years. The period starts on October 4th, 2022 and ends on October 3th, 2122.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The estimated removals presented below represent the difference in stocks between two consecutive years, based on the result presented in the net change in carbon stocks (Project carbon stocks minus Baseline carbon stocks) presented in section 4.4.

Project Scale	
Project	
Large project	x

Year	Estimated GHG emission reductions or removals (tCO_2e)
Year 2022	0
Year 2023	84115
Year 2024	192252

Year	Estimated GHG emission reductions or removals (tCO_2e)
Year 2025	362171
Year 2026	545528
Year 2027	743861
Year 2028	955587
Year 2029	1178711
Year 2030	1411234
Year 2031	1651253
Year 2032	1897054
Year 2033	1734596
Year 2034	1726438
Year 2035	1595594
Year 2036	1584762
Year 2037	1560341
Year 2038	1524174
Year 2039	1478168
Year 2040	1424202
Year 2041	1036808
Year 2042	894688
Year 2043	1047447
Year 2044	981982
Year 2045	884831
Year 2046	787251
Year 2047	689439
Year 2048	591551
Year 2049	493711
Year 2050	396025
Year 2051	902596
Year 2052	808405
Year 2053	807425
Year 2054	806604
Year 2055	805892
Year 2056	805259
Year 2057	804687
Year 2058	804165
Year 2059	803683
Year 2060	803235

Year	Estimated GHG emission reductions or removals (tCO_2e)
Year 2061	786000
Year 2062	764923
Year 2063	733534
Year 2064	702187
Year 2065	670877
Year 2066	639602
Year 2067	608361
Year 2068	577150
Year 2069	545967
Year 2070	514812
Year 2071	514727
Year 2072	514643
Year 2073	484315
Year 2074	447013
Year 2075	391105
Year 2076	335206
Year 2077	279316
Year 2078	223435
Year 2079	167564
Year 2080	111700
Year 2081	55846
Year 2082	0
Year 2083	0
Year 2084	0
Year 2085	0
Year 2086	0
Year 2087	0
Year 2088	0
Year 2089	0
Year 2090	0
Year 2091	0
Year 2092	0
Year 2093	0
Year 2094	0
Year 2095	0
Year 2096	0

Year	Estimated GHG emission reductions or removals (tCO_2e)
Year 2097	0
Year 2098	0
Year 2099	0
Year 2100	0
Year 2101	0
Year 2102	0
Year 2103	0
Year 2104	0
Year 2105	0
Year 2106	0
Year 2107	0
Year 2108	0
Year 2109	0
Year 2110	0
Year 2111	0
Year 2112	0
Year 2113	0
Year 2114	0
Year 2115	0
Year 2116	0
Year 2117	0
Year 2118	0
Year 2119	0
Year 2120	0
Year 2121	0
Year 2122	0
Total estimated ERs	47,674,010
Total number of crediting years	100
Average annual ERs	476,740

1.11 Description of the Project Activity

The removal of GHG (CO_2) by the project's activities is a consequence of the biological sequestration through plant photosynthesis, where such potential over large portions of lands is enabled due to the implementation of a continuum of forest restoration activities, including measures such as assisted natural regeneration, full planting, and the use of commercial wood species to trigger initial restoration process and provide additional income.

Project activities in the PAIs would not be implemented under the baseline scenario due to barriers related to the lack of access to investments for ecological restoration, challenging ecological conditions, and common practices, as explained in Section 3.5. These barriers prevent land-uses targeting at ecological restoration to increase in the project zone in substitution of non-native ecosystems. Consequently, the climate, social, and biodiversity benefits that result from ecological restoration would not be delivered in the business-as-usual scenario, which is characterized by agricultural activities that include burning and continuous mowing of regenerating native plants (Pereira et al. 2018)

The proposed restoration activities consist of different restoration models that are implemented according to specific site conditions related to the potential for natural regeneration (mainly slope, land use history, and landscape features). Such potential for natural regeneration is determined in the diagnosis phase of the PAIs, which is required to support the definition and stratification of the restoration models.

In this context, Assisting Natural Regeneration is an important method of restoration of native forests because of the lower cost necessary to ensure the site to be restructured, preserving the regional genetic heritage. This method is designed to lands presenting high potential for natural regeneration. The high potential for natural regeneration can be identified by different aspects of the area to be restored, they are: i) high density of regenerating individuals; ii) low-intense land-use history; iii) areas close to forest fragments; and iv) areas embedded in landscapes with high forest cover. These parameters are used to determine the level of resilience of the area, considering both local and regional conditions. It is important to highlight that, in practice, assisting natural regeneration is supported by interventions (other than planting seeds or seedlings) beyond degrading factors elimination, and include activities as the control of exotic or invasive vegetation occurring in the area, ant control, and/or the fertilization of regenerating individuals, if necessary. Without the mentioned activities regenerating individuals would not stablish, consequently, ecological succession would not thrive.

The Intermediated Planting method is designed to lands where there is an intermediate level of resilience. In other words, the method is applied where natural regeneration potential can be assisted but there is the necessity of planting seeds or seedling of native tree species to achieve restoration success. The goal of this method is to the fill the empty spaces not occupied by natural regeneration, which occurs through the introduction of new tree individuals of species of the covering and diversity groups. This method ensures the control of the expansion of aggressive species through the shading promoted by the planted species, providing conditions for natural regeneration to stablish and thrive. Thus, beyond degrading factors elimination, exotic or invasive species control, herbivory control, and fertilization of regenerating individuals, the method includes the intentional introduction of tree species propagules in the area, which makes it necessary to prepare the soil, digging pits, and seedling fertilization. Green manure with exotic species (e.g. *Cajanus cajan, Crotalaria ochroleuca, Crotalaria juncea*) can also be used, but these species spontaneously enter in senescence few months after planting, and are introduced to reduce invasive grass cover and, consequently, the use of herbicide to control grasses.

Finally, the Full Planting method is designed to lands where remaining resilience is very low and there is the necessity of planting seeds or seedling in the entire area. The recommended strategy in these cases is the staggered planting of seedlings or seeds of native tree species, where combinations of species are performed in planting groups, which are planted at different times. Initially, only covering species are planted, but the species from the diversity group are planted posteriorly. Thus, beyond degrading factors elimination, exotic or invasive species control, herbivory control, and fertilization of regenerating individuals, the method includes the intentional introduction of tree species propagules in the area, which makes it necessary to prepare the soil, digging pits, and seedlings fertilization. Green manure with exotic species (e.g. *Cajanus cajan, Crotalaria ochroleuca, Crotalaria juncea*) can also be used, but these species spontaneously enter in senescence few months after planting, and are introduced to reduce invasive grass cover and, consequently, the use of herbicide to control grasses.

The selection of the species to be used in the ecological restorations involving planting activities (Intermediate and Full Planting Models) within the project instances is based on the function of the species in the restoration activity. Thus, species were separated into functional planting groups, that is, covering and diversity (Nave 2005, Brancalion et al. 2015). The "Diversity" species are responsible for the greatest contribution to increasing diversity throughout the project, presenting ecological and functional characteristics important for the self-support of the forest and the re-establishment of ecological interactions, including, but not restricted, to endemic, animal-dispersed, rare, and threatened with extinction species. On the other hand, the species considered as "Covering" are those that show, in full sun, fast growth and canopy development, leading to a rapid covering of the soil (shading), which creates conditions suitable for other native species to stablish. This classification will allow the ecological restoration projects to be executed to ensure not only high floristic diversity, but also high functional diversity already in the early stages of the project, enhancing the role of regional biodiversity conservation to be played by the restored areas. To obtain the list of timber species different sources were consulted, such as technical materials and direct consultation with specialists.

The Intermediate and Full Planting models can also be implemented for timber production. The Assisted Natural Regeneration models cannot be subjected to harvesting as no timber species will be planted in these areas and the potential for natural regeneration is high. In these cases, restoration is less expensive and as such there is less dependence on harvesting incomes for abating the restoration costs at the early years of the project. The models including a single harvesting cycle will be subject to only one cutting rotation, since the natural regeneration potential that will express during the harvesting cycle, which will be assisted to stablish in the area, hampers a second rotation without huge impacts on vegetation structure. After the end of the economic exploitation, the areas will be subject to ecological restoration actions. The single-one rotation will be conducted in an extended manner, during the 15th and 30th year after planting.

The proportion of trees harvested in each cutting period will be defined according to the forest inventories conducted over the project lifetime.

It is important to state that a single PAI can be restored by a mix of restoration models, including or not the harvesting component, depending on the diagnosis of the area. Also, among all the PAI expected to be included in the project, the total area designed for models including a single-harvesting cycle that will be posteriorly ecologically restored is inferior to that designed for ecological restoration models from the beginning. Finally, independent of the method used to trigger forest recovery, whether ecological restoration or single-rotation reforestation, the final goal is to achieve forest ecological restoration, ensuring that every area restored by the project reaches high values for ecological indicators of restoration success, in terms of structure, diversity, functioning, and self-perpetuation, required by national and international bodies.

1.12 Project Location

Grouped Project

The Project zone is the Brazilian Atlantic Forest Biome (Figure 3). The Brazilian Atlantic Forest Biome is located within the coordinates: Latitude (4.80°S; 30.18°S); Longitude (55.56°W; 34.69°W). Within this territory, one area is already owned by the project proponent and new eligible project activity instances (PAIs) for implementing the project activities are being selected.

Figure 3. Project zone limited by the Brazilian Atlantic Forest Biome (green polygon) (IBGE, 2019).

Atlantic Forest PAI-001:

The first project activity instance (Atlantic Forest PAI-001) is located within the municipality of Eunápolis, in the Southern region of the State of Bahia/Brazil. The PAI-001 is located within the coordinates: Latitude 16.179°S, 16.144°S; Longitude 39.567°W,39.544°W (Figure 4). The PAI-001 boundary present 365 hectares where project activities will be implemented, including some of the restoration models already mentioned. The pre-project condition of the PAI-001 is mainly pastureland (Figure 5) used for cattle ranching, planted with exotic grasses, and presenting some degrading factors, as erosive process, for example.

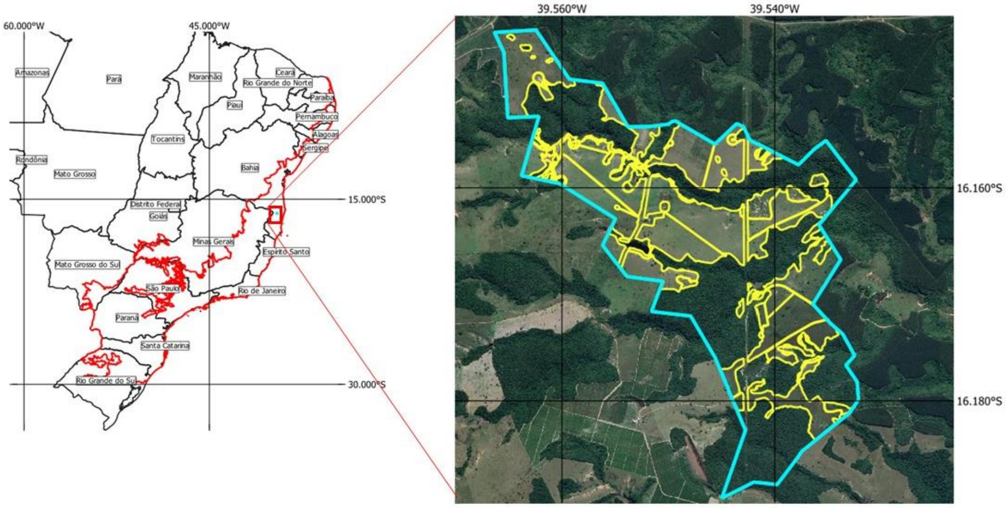

Figure 4. Project zone (red polygon) and PAI-001 boundary (yellow polygons) locations. Project activities (reforestation/restoration) that will be included in the carbon certification will only be implemented within the PAI-001 areas, that is, within the yellow polygons. The blue polygonal represent the whole rural property area that will be managed by the project proponent, including the PAI-001 areas, roads, firebreaks, infrastructure, and preexisting forest fragments.

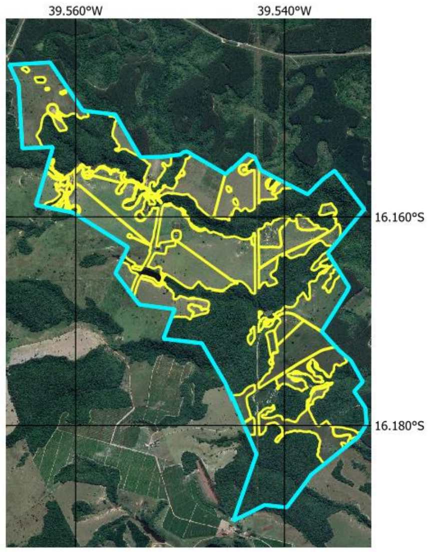

Figure 5. Boundary of PAI-001 (yellow polygons) occupied by pastures.

Atlantic Forest PAI-002 (Farm Belo Horizonte):

The second Project Activity Instance (PAI-002/Farm Belo Horizonte) presents 1,200 hectares of lands under restoration and is located in the Northeast region of Brazil, specifically in the southern portion of the State of Bahia (Figure 6). PAI-002 is a rural property owned by the project proponent, located in the municipality of Potiraguá - Bahia/Brazil. The PAI-002 is located within the coordinates: Latitude 16.610°S, 16.660°S; Longitude 39.645°W, 39.579°W. Project activities will be implemented including some of the restoration models already mentioned. The pre-project condition of the PAI-002 is mainly pastureland (Figure 7) used for cattle ranching, planted with exotic grasses.

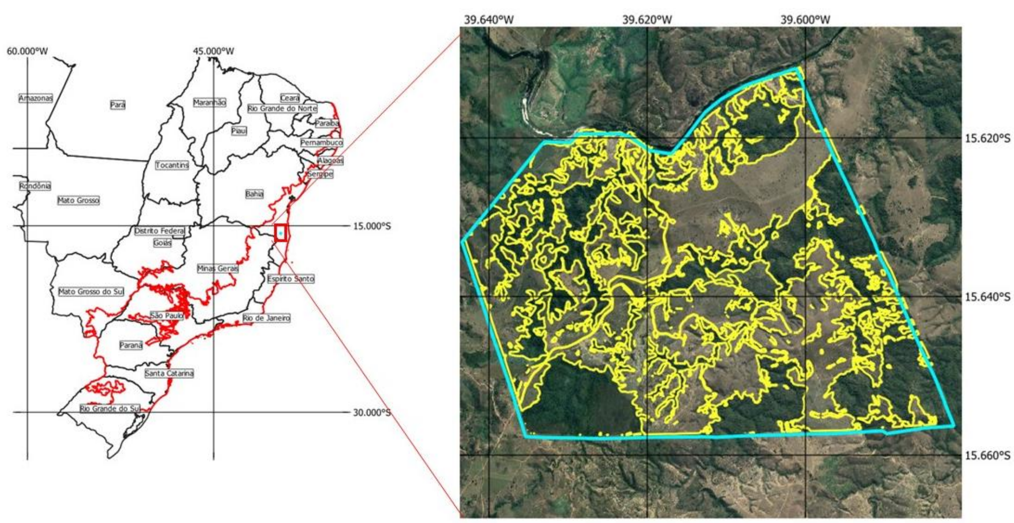

Figure 6. Project zone (red polygon) and PAI-002 boundary (yellow polygons) locations. Project activities (reforestation/restoration) that will be included in the carbon certification will only be implemented within the PAI-002 areas, that is, within the yellow polygons. The blue polygonal

represents the whole rural property area that will be managed by the project proponent, including the PAI-002 areas, roads, firebreaks, infrastructure, and preexisting forest fragments.

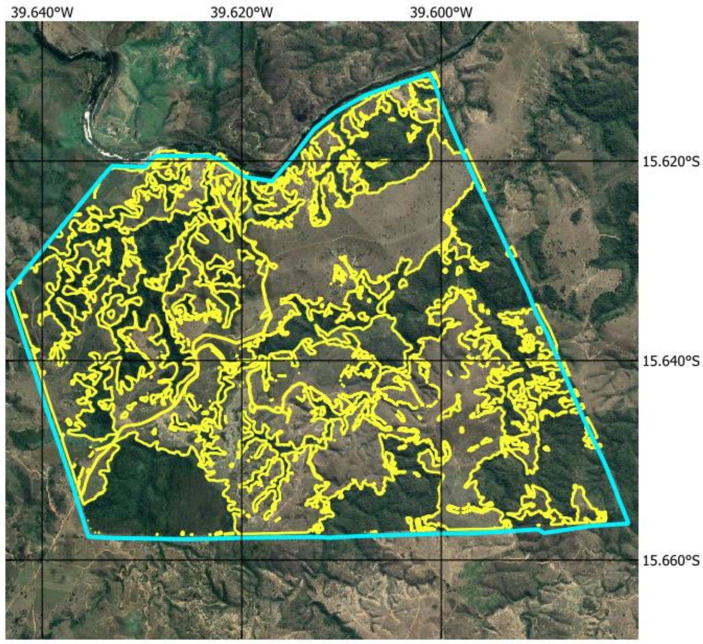

Figure 7. Boundary of PAI-002 (yellow polygons) occupied by pastures

1.13 Conditions Prior to Project Initiation

The project is located in the Brazilian Atlantic Forest. The Atlantic Forest is the second largest plant ecosystem in South America, following the Amazon Forest, being one of the most important biomes in Brazil, as it concentrates about 70% of Brazilian population and 80% of gross domestic production (Marques and Grelle, 2021). The project zone comprises the whole Atlantic Forest biome and an area equal to 1.1 MM km^2, stretching from the Northeastern to the Southern regions of Brazil (Figure 8). This territory is distributed among four of the five Brazilian regions (South, Southeast, Center-West, and Northeast) (Figure 8). Throughout this territory there are 3,429 municipalities.

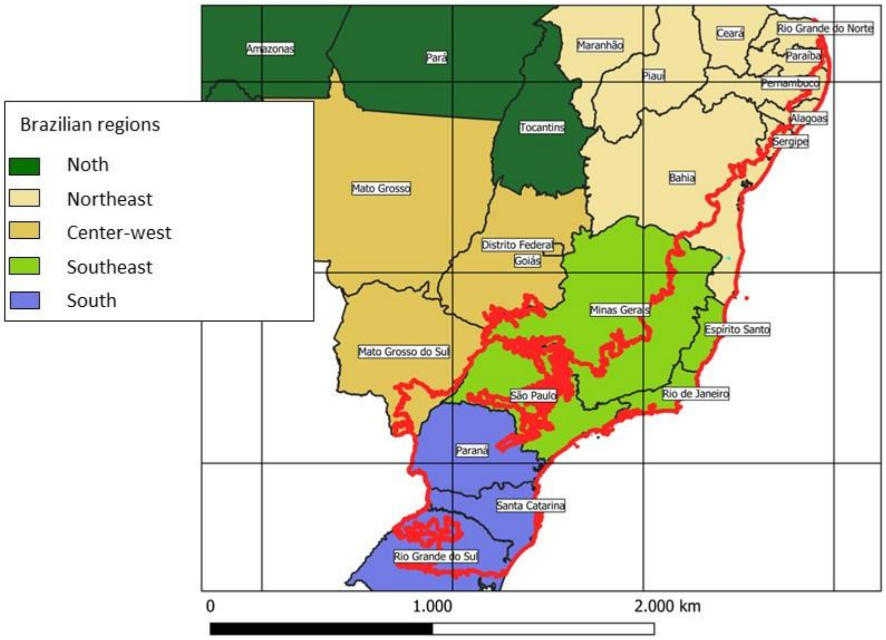

Figure 8. Geopolitical subdivisions (regions and states) of the project zone (red polygon).

The pre-project land use within the eligible lands is non-native ecosystems (See section 1.12). Overall, cattle ranching is the main economic activity practiced within the project zone, but other anthropic activities (annual agriculture and perennial plantations) are also practiced in the project zone (Projeto MapBiomas). Among pasturelands, they are occupied by exotic grasses that are in many cases continuously mowed and burned in the dry season to stimulate the growth of new grasses and to exclude any regenerating native plants[2] (Dutra et al. 2004; Pereira et al. 2018; dos Santos et al. 2019; Singh and Huang, 2022). This practice is widespread within the project zone also because lands with regenerating patches present low value. For decades, the extensive cattle raising activities have led pastures to erosive processes and a significant reduction in soil quality (decreased organic matter, decreased fertility, and soil compaction), where degraded pastures can easily be observed (Projeto MapBiomas) (Figure 9). The main factors that led to such depletion of the quality of the pastures and soils were:

- Cattle grazing: grazing cattle ingest green fodder, which contain nutrients extracted from the soil that are exported from the land by meat production;
- Lack of fertilization: Nutrient inputs are required to replenish the nutrients extracted from the soil by grazing cattle and exported form the area, which is not a common practice in the pre-project conditions;
- Fire: Illegal fires are used to stimulate grass regeneration, in depletion of natural regeneration, seed bank, soil organic matter, soil microbiology, and soil fertility.

[2] www.revistaagropecuaria.com.br/2011/06/21/controle-de-plantas-daninhas-em-pastagens/

- Soil compaction: intense and continuous cattle trampling compact soils and decrease soil protection by existing vegetation. Such compaction also decreases soil infiltration and together with the direct exposition of the soil surface to rainfall, runoff erosion and fertility losses can be observed;

Regarding agricultural land-uses, the activities are mostly practiced with the use of heavy machinery and repeated planting cycles, leading to soil compaction and fertility impoverishment.

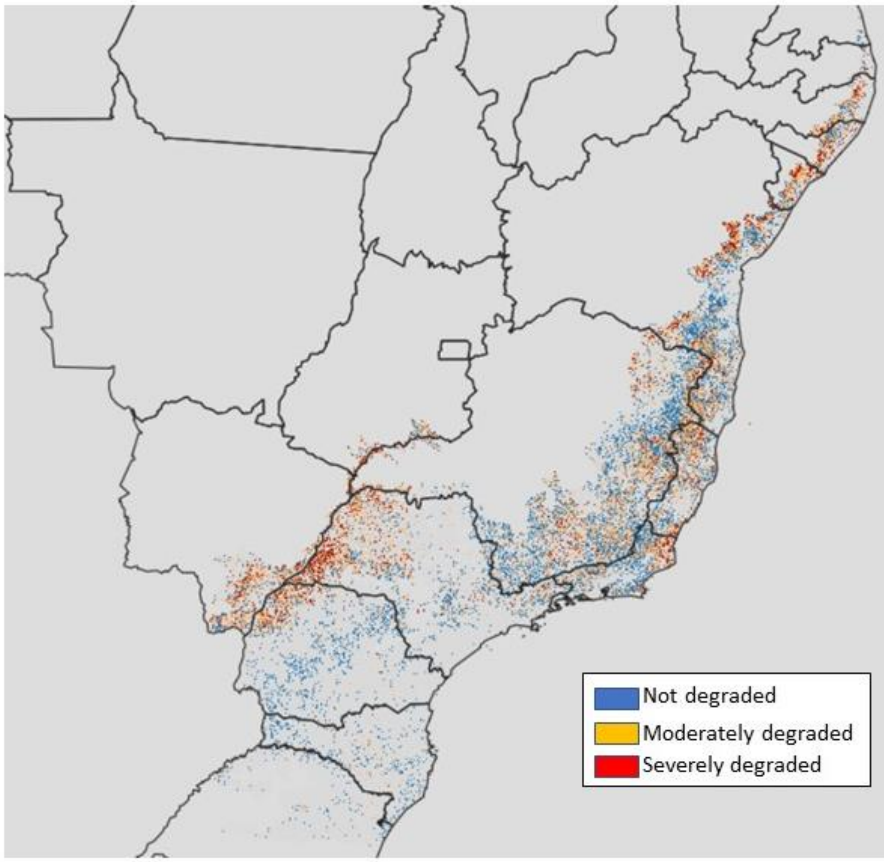

Figure 9. Quality of pastures within the Atlantic Forest Biome (Projeto MapBiomas).

TOPOGRAPHY

The Project Zone presents several geological and topographic conditions. It is distributed over four geomorphological domains: Phanerozoic Basins and Sedimentary Covers; Neoproterozoic Mobile Belts; Neoproterozoic Cratons; and Quaternary Sedimentary Deposits (Figure 10). Elevation within the project zone ranges from 0 m to 1846 m above sea level (Figure 10). The slope ranges from plain to steeped, where lands categorized as plain and light undulated are concentrated in coastal zones of the Northern region and in the countryside of the Southeastern region of the project zone. Undulated and heavy undulated are predominant in the Central-North and in the coastal zones in the Southern region of the expansion zone (Figure 11).

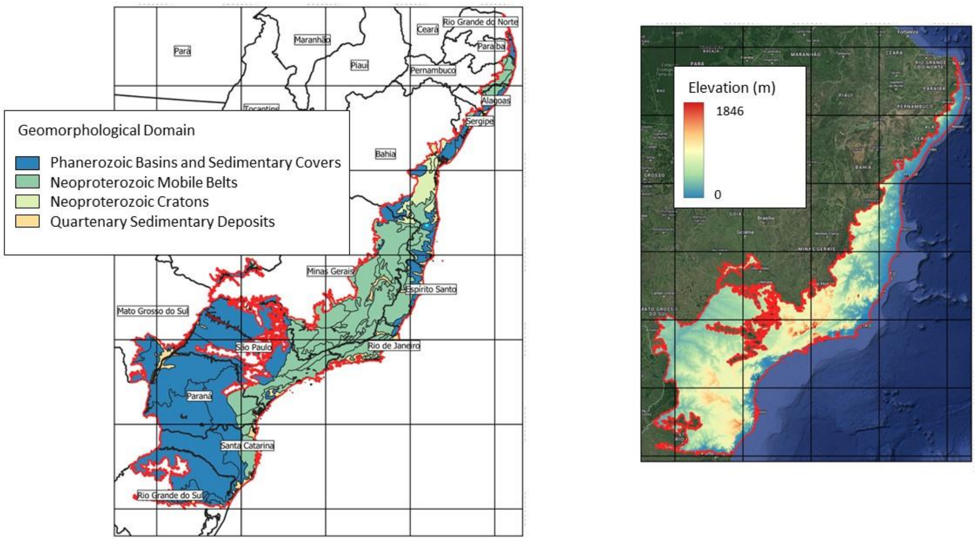

Figure 10. Geomorphological domains [3] and elevation[4] throughout the Project Zone.

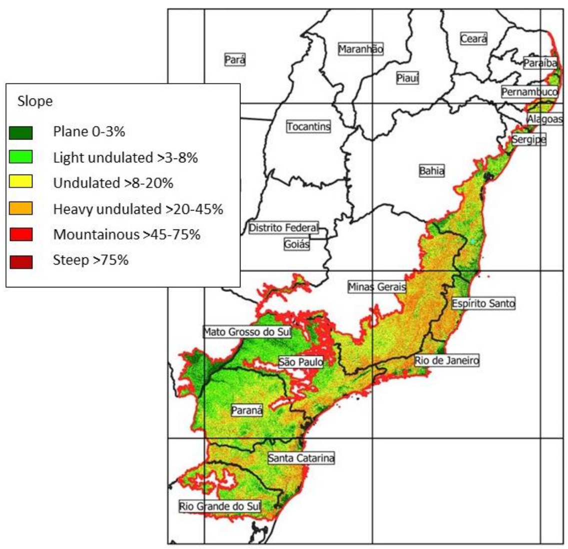

Figure 11. Slope classes of the terrain throughout the Grouped Project Zone[5].

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[3] https://www.ibge.gov.br/geociencias/informacoes-ambientais/geologia/15824-hidrogeologia.html?=&t=downloads. Accessed: 07 Nov 2022

[4] TOPODATA - Banco de Dados Geomorfométricos do Brasil (www.drs.inpe.br/topodata). Accessed: 16 Nov 2022

[5] http://www.cprm.gov.br/publique/Gestao-Territorial/Gestao-Territorial/Mapa-de-Declividade-em-Percentual-do-Relevo-Brasileiro-3497.html. Accessed: 07 Nov 2022

SOIL

The main soil occurring within the Project Zone are: Latosol, Argisol, and Cambisol (Figure 12). According to IPCC and the World Reference Base for Soil Resources, Latosols (Ferralsol) and Argisols (Acrisols) present low activity clay content, while Cambisol present high activity clay content[6].

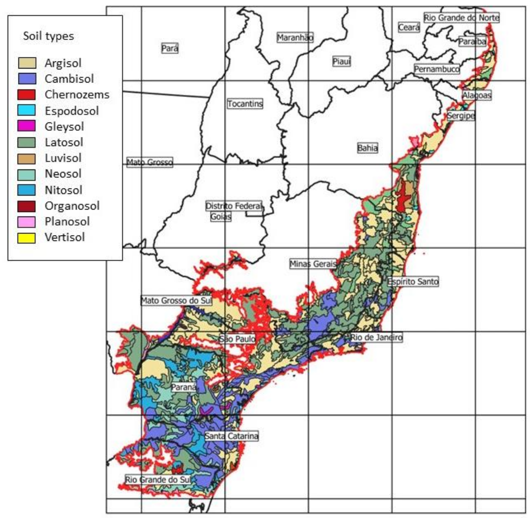

Figure 12. Soil types occurring in the project zone (red polygon) (dos Santos et al. 2011)

CLIMATE

Throughout the project zone, average annual temperatures are mainly concentrated in the range from 15°C to 24°C (Figure 13). The average annual precipitation is concentrated in the range from 1000-1900 mm/year (Figure 13). The territory is embedded within the tropical and humid subtropical zones, dominated by four climates (Aw, Cfa, Cfb, and Cwb, according to Köppen) (Alvares et al. 2013) (Figure 14).

[6] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf. Accessed: 16 Nov 2022

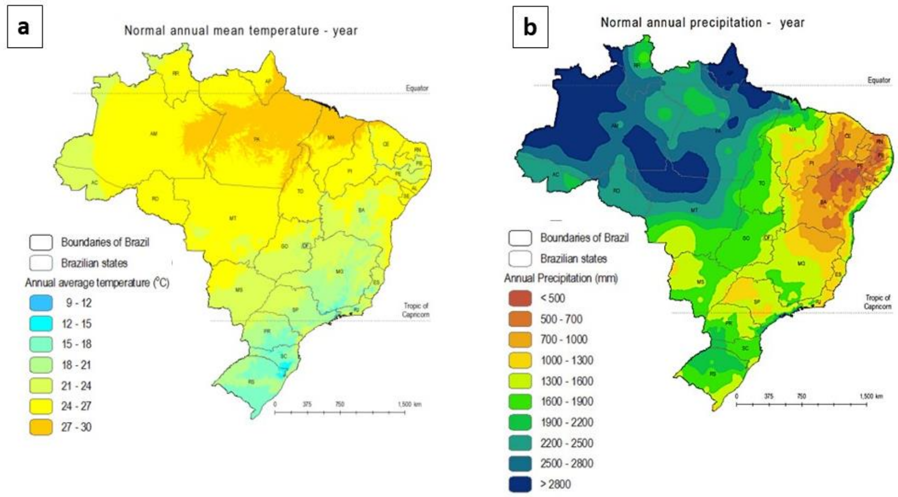

Figure 13. Average annual precipitation and temperature in Brazil[7].

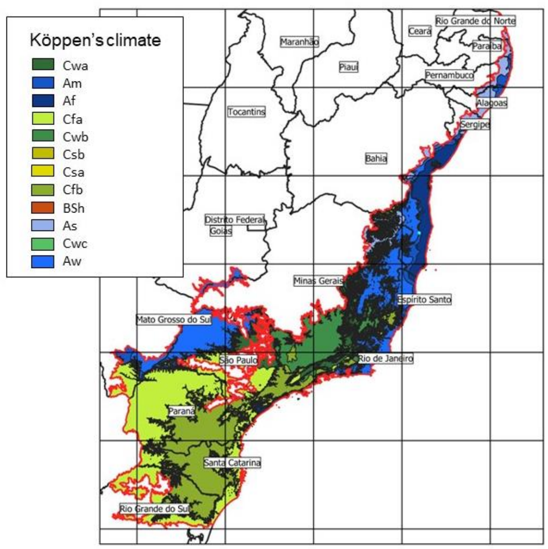

Figure 14. Climate categories encompassing the project zone (red polygon) (Alvares et al. 2013).

HYDROGRAPHY

Within the Project Zone there are seven hydrographic regions (Eastern Atlantic, Northeastern Atlantic, Southeastern Atlantic, Southern Atlantic, Paraná, São Francisco, and Uruguay) (Figure 15). There are three main aquifers in the Project Zone: Fraturado Centro-Sul, Fraturado Semiárido, Bauru-Caiuá, and

[7] https://www2.ipef.br/geodatabase/mapas.asp. Accessed: 07 Nov 2022.

Serra Geral (Figure 16). The region presents a large hydrographic network, where important rivers occur in the territory, as Tietê, Piracicaba, Grande, Jequitinhonha, São Francisco, Paraná, and others.

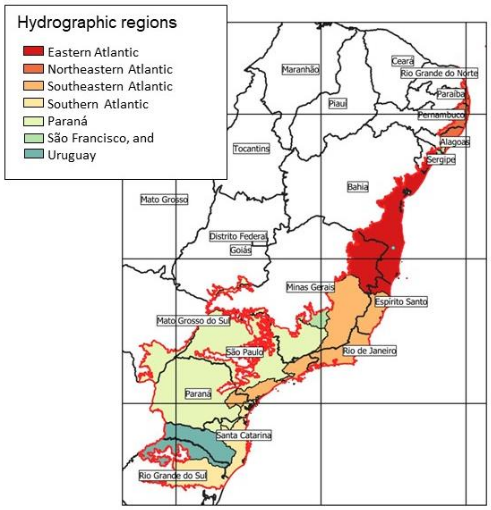

Figure 15. Hydrographic regions of the Project Zone (red polygon)[8] .

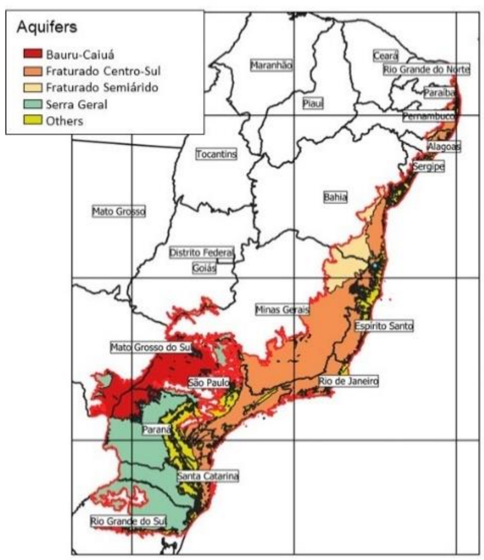

Figure 16. Aquifers of the Project Zone (red polygon)[9] .

[8] https://metadados.snirh.gov.br/geonetwork/srv/api/records/fb87343a-cc52-4a36-b6c5-1fe05f4fe98c/attachments/mapa_das_divisoes_hidrograficas_do_brasil_2021.pdf. Accessed: 07 Nov 2022.

[9] https://metadados.snirh.gov.br/geonetwork/srv/por/catalog.search#/metadata/3ec60e4f-85ea-4ba7-a90c-734b57594f90. Accessed: 07 Nov 2022.

TYPES OF VEGETATION

The Project Zone is embedded in the Atlantic Forest biome (Figure 17), one of the most threatened ecosystems in the world, where only 12-28% of its original cover is now occupied by native forests and 7.2 Mha of degraded riparian lands require forest restoration activities (Ribeiro et al. 2009; Rezende et al. 2018). The main forest formations occurring within the region are the Dense Ombrophilous Forest, Open Ombrophilous Forest, and Seasonal Semideciduous Forest, which are highly biodiverse native forests, but other vegetation types can also be observed in the territory, as Seasonal Deciduous Forests, Pioneer formations, Savannas, contact zones, and others (Figure 17). Within the Project Zone, the predominant land-cover is by far pastures constituted by exotic grasses (Figure 18) used for cattle raising, commonly practiced at low productive rates and degraded soils. Agriculture is also important for the region, being mainly represented by soy plantations.

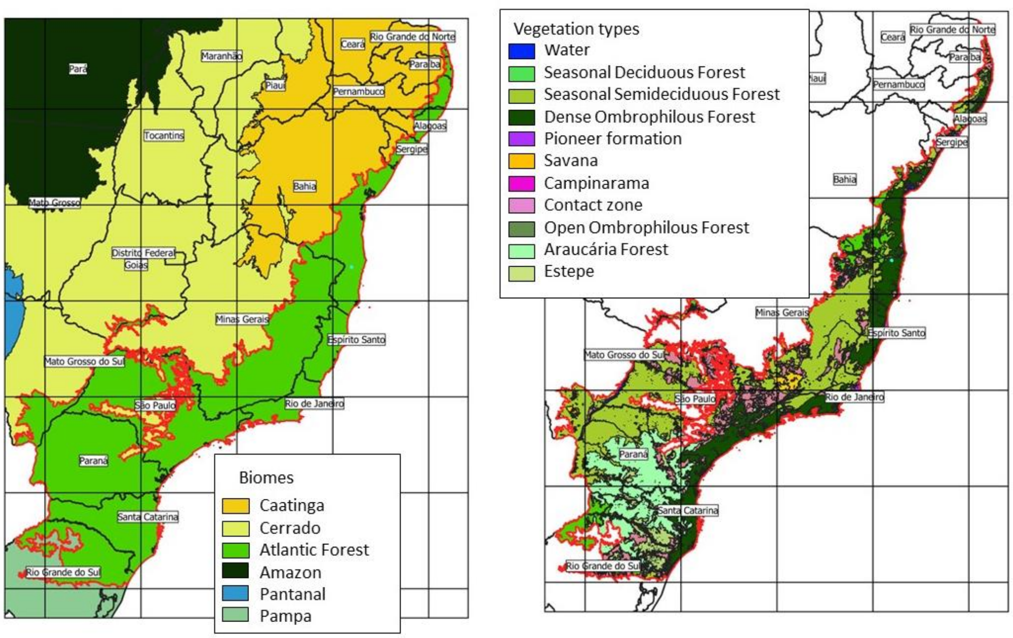

Figure 17. Original vegetation of the project region (red polygon)[10,11].

[10] https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html?edicao=25799&t=acesso-ao-produto. Accessed: 07 Nov 2022.

[11] https://www.ibge.gov.br/geociencias/informacoes-ambientais/pedologia/24252-macrocaracterizacao-dos-recursos-naturais-do-brasil.html?edicao=24253&t=downloads Accessed: 07 Nov 2022.

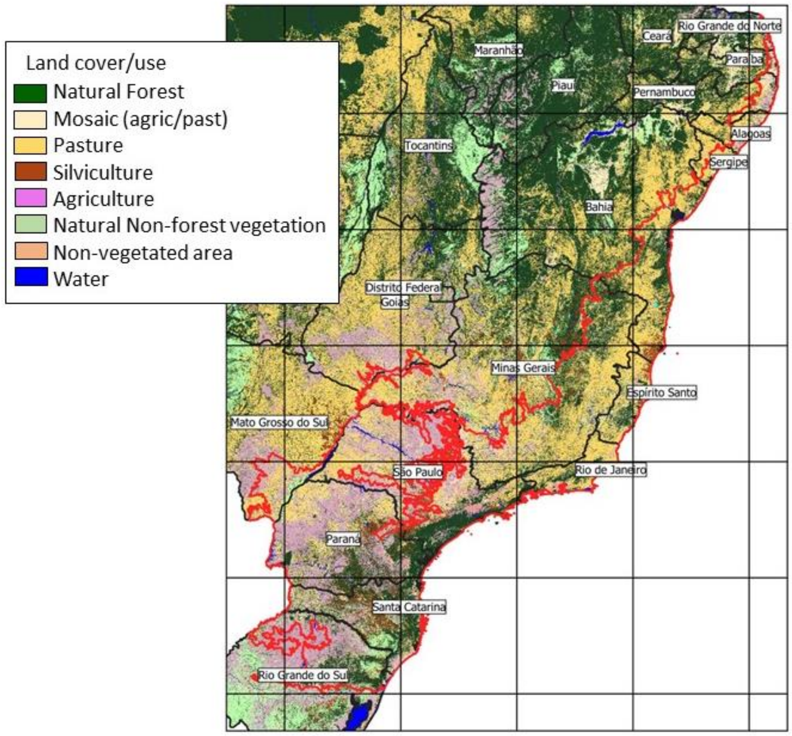

Figure 18. Land-cover and land-use types within Project Zone (red polygon) (Projeto MapBiomas**).**

Atlantic Forest PAI-001 (Farm Ouro Verde):

The first Project Activity Instance (PAI-001/Farm Ouro Verde), presents 365 hectares of lands under restoration and is located in the Northeast region of Brazil, specifically in the Southern portion of the State of Bahia (Figure 19). PAI-001 is a rural property owned by the project proponent, located in the municipality of Eunápolis - Bahia/Brazil. This region was the first to be colonized by Europeans since the year 1500 a.C., which has led to extensive appropriation of natural resources and devastation of primary and high-diverse forest ecosystems. The economic behavior of the municipality of Eunápolis (municipality of the PAI-001) is characterized by its agricultural vocations, where the main productive activity is cattle farming. Monocultural plantations as *Eucalyptus*, coffee, and cocoa can also be observed, but in a much lesser extent. Since the end of the 19th century, deforestation associated with the planting of pastures, has taken place, generating several environmental problems. Because cattle raising has been practiced without soil conservation practices, many locations present erosive processes and silting of rivers. Particularly, PAI-001 is occupied by pastures (Figure 20) and is located in the Northeastern portion of the Project Zone, within the microregion of Porto Seguro (Figure 21).

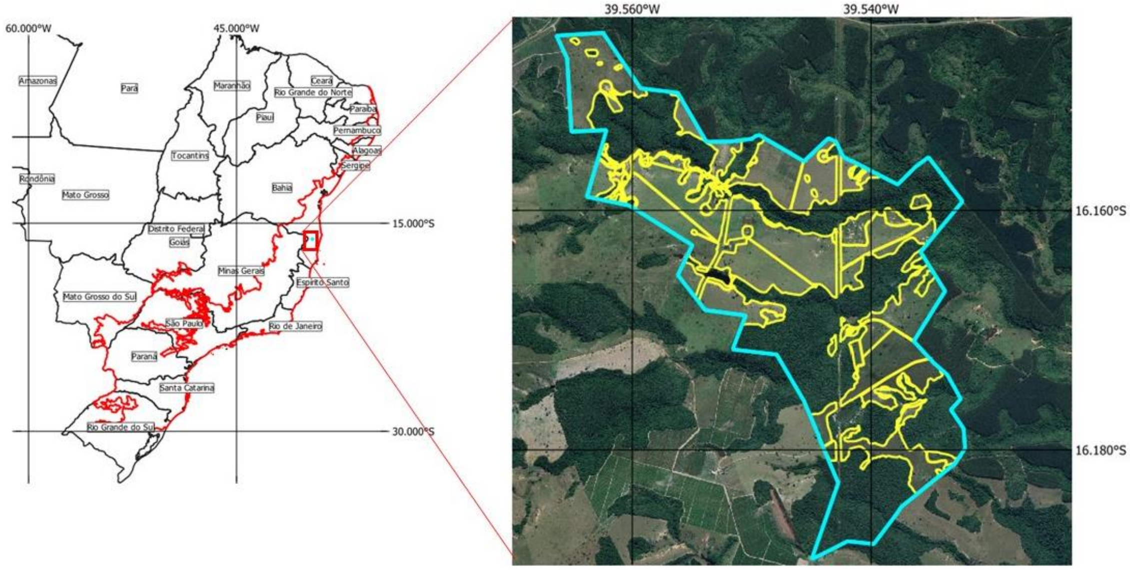

Figure 19. Project zone (red polygon) and PAI-001 locations (yellow polygons). Project activities (reforestation/restoration) that will be included in the carbon certification will only be implemented within the pastures within PAI-001. The blue polygonal represent the whole rural property perimeter that is under management of Re.green, including roads, firebreaks, infrastructure, and preexisting forest fragments.

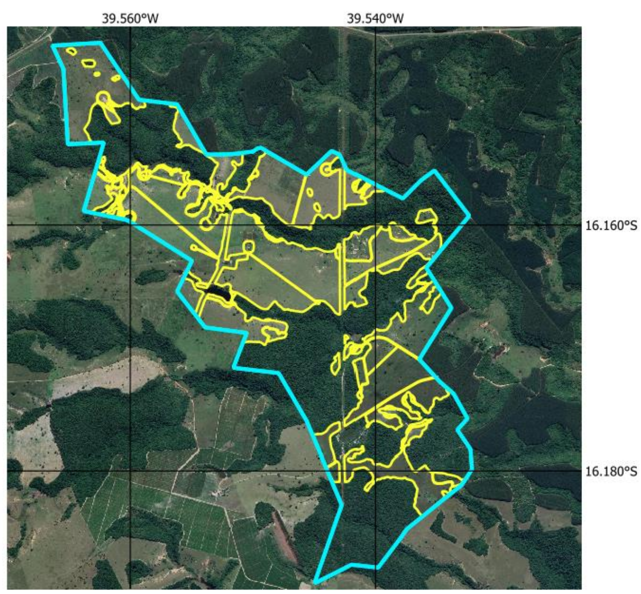

Figure 20. PAI-001 (yellow polygons) occupied by pastures.

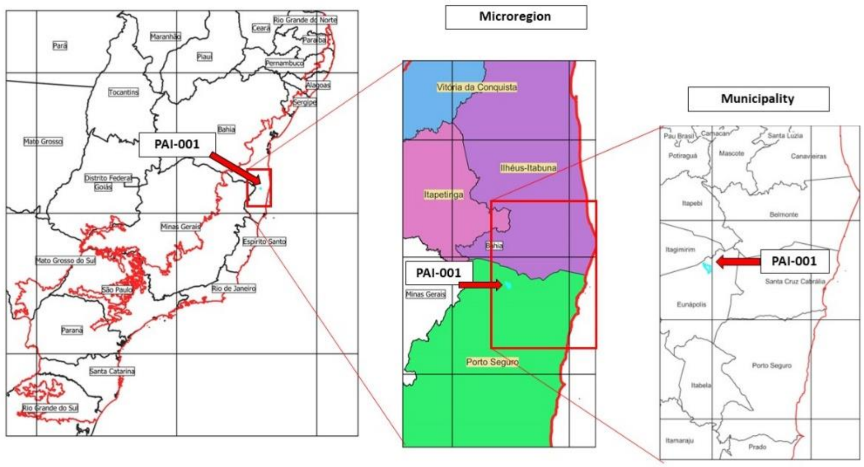

Figure 21. Geopolitical subdivisions of the project zone (red polygon) and the Farm Ouro Verde (PAI-001 area) region.

<u>TOPOGRAPHY</u>

The geomorphological domain of the encompassing PAI–001 consist of Phanerozoic Basins and Sedimentary Covers (Figure 22). The relief is mainly light undulated (slope >3%-8%) and undulated (slope >8%-20%) (Figure 23). Elevation within PAI-001 ranges from 149 m to 249 m above sea level (Figure 22).

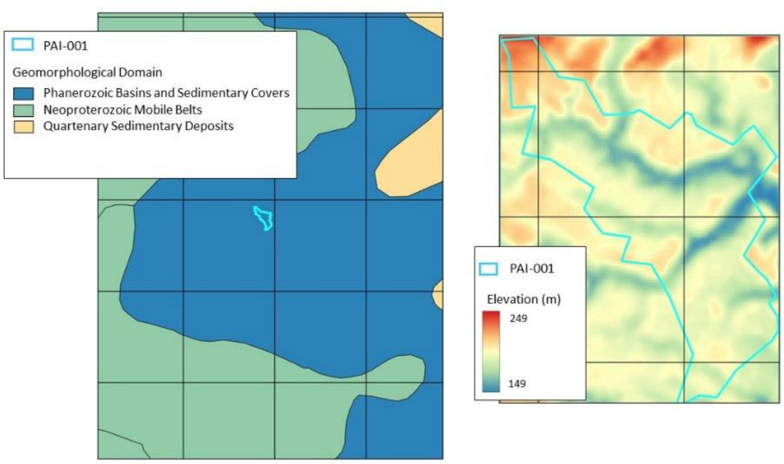

Figure 22. Geomorphological domains[3] and elevation[4] of the Farm Ouro Verde (including PAI-001 area) region.

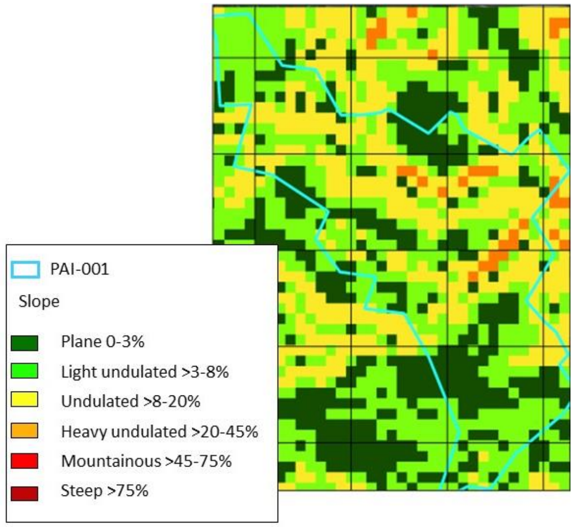

Figure 23. Slope classes of the terrain throughout the region of the Farm Ouro Verde (including PAI-001 area)[5].

<u>SOIL</u>

The soil occurring within the PAI-001 is the Red-Yellow Dystrophic Latosol (Figure 24). This type of soil occurs in well-drained environments, being very deep and uniform in characteristics of color, texture and structure. As a consequence of the high depth and porosity, this soil presents adequate conditions for good root development in depth. According to IPCC and the World Reference Base for Soil Resources, Latosols (Ferralsol) present low activity clay content[12].

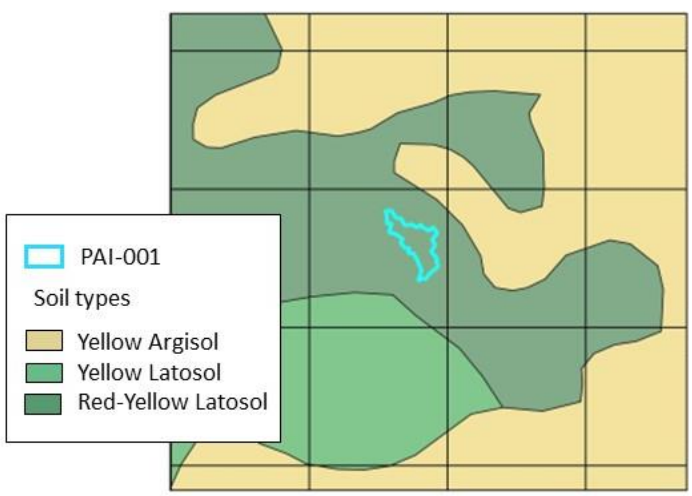

Figure 24. Soil types occurring in the Farm Ouro Verde (PAI-001 area)region (Santos et al. 2011).

[12] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf. Accessed: 16 Nov 2022

CLIMATE

The municipality of Eunápolis/BA, where PAI-001 is embedded, presents mean annual temperature ranging from 21°C to 24°C, where 25.5 °C is the average temperature of the warmer month of the year (February) and 20.9°C is the average temperature of the coldest month (July)[13]. The annual precipitation is 1000-1300 mm/year. August is the driest month of the year where precipitation averages 46 mm, while November is the wettest month averaging 142 mm. The territory of the PAI-001 is in the intersection of two climate domains, the tropical monsoon climate (Aw) and the tropical climate without dry season (Am), according to Köppen (Figure 25) (Alvares et al. 2013). Despite that, the precipitation presents a seasonal pattern with a dry season between June and September, and a rainy season between November and March.

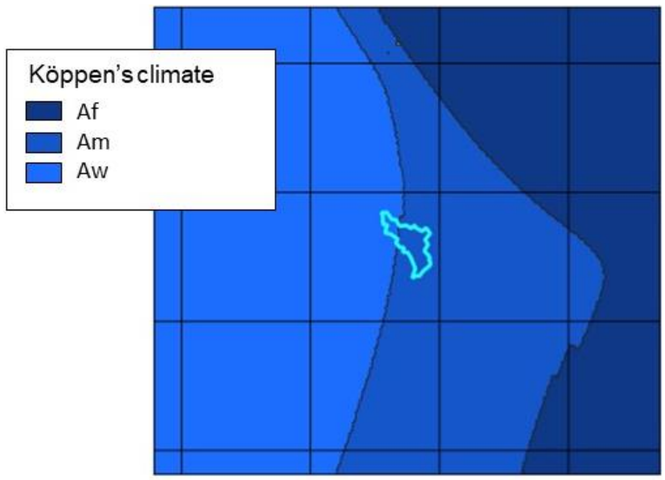

Figure 25. Climate categories encompassing the Farm Ouro Verde (including PAI-001 area) (light-blue polygon).

HYDROGRAPHY

The Project Instance PAI-001 is located within the aquifers "Fraturado Centro-Sul" and "Barreiras", particularly within the hydrographic region of the "Eastern Atlantic"[14] and the subbasin of the rivers São Mateus and Itanhaém (Figure 26). The rivers occurring in the PAI-001 are tributaries of the Rio João de Tiba and Córrego do Buri, (Figure 27).

[13] https://pt.climate-data.org/america-do-sul/brasil/bahia/eunapolis-43478/. Accessed: 16 Nov 2022

[14] https://metadados.snirh.gov.br/geonetwork/srv/por/catalog.search#/metadata/43539328-3a83-4bf2-9cea-2b47513f4b07. Accessed: 16 Nov 2022

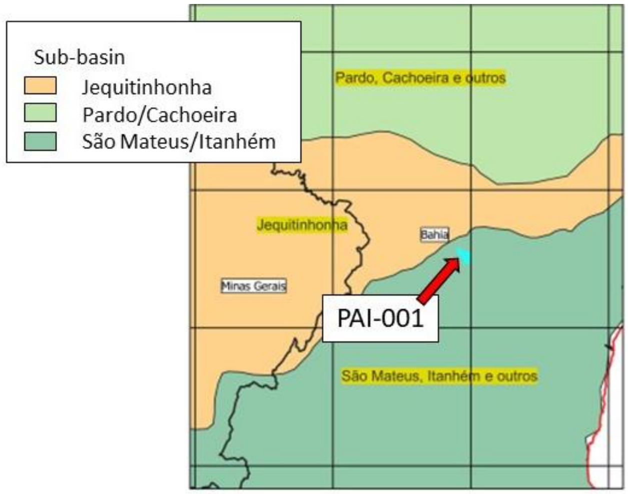

Figure 26. Hydrographic sub-basins occurring in the Farm Ouro Verde (PAI-001 area)region[8].

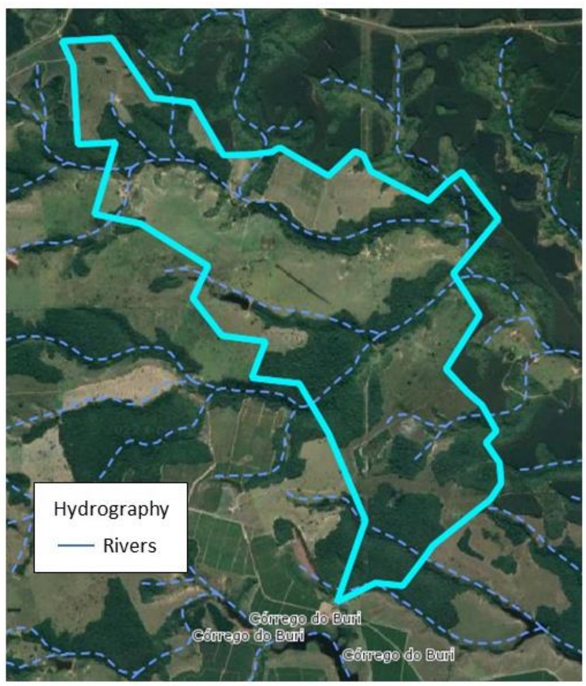

Figure 27. Hydrographic network within the Farm Ouro Verde (including PAI-001 area).

<u>TYPES OF VEGETATION</u>

The municipality of Eunápolis is embedded within the original distribution of the Dense Ombrophilous Forests (Figure 28), but the territory is currently dominated by pasture lands, where cattle raising is practiced at low productivity rates and without best soil conservation practices. This is the case of PAI-001, which is mainly occupied by pastures (exotic grasses) (Figure 29).

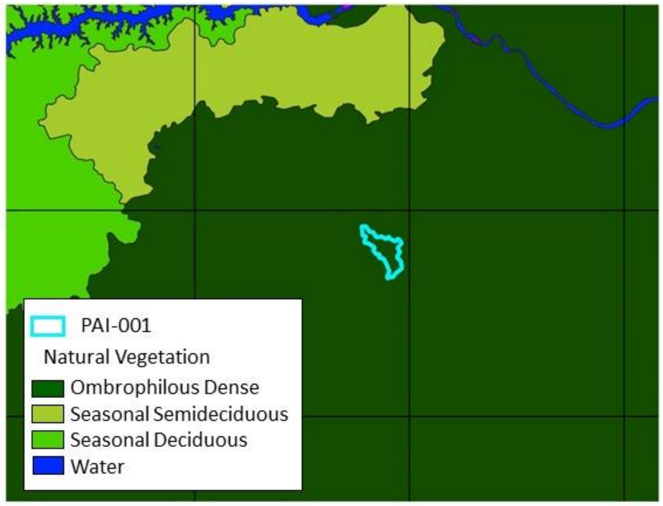

Figure 28. Original vegetation within the region of the Farm Ouro Verde (including PAI-001 area)[11].

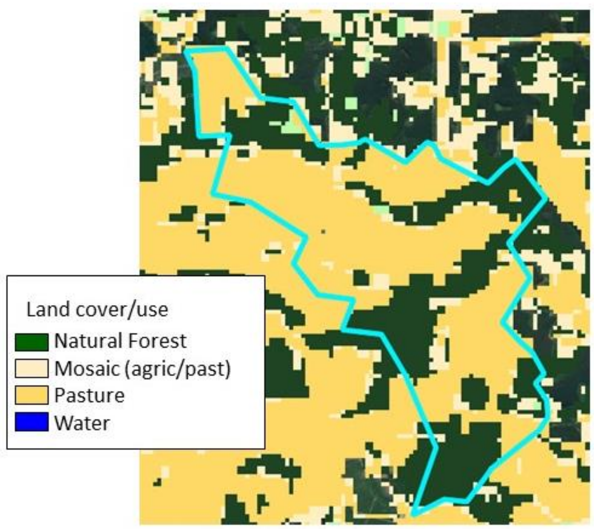

Figure 29. Land-cover and land-use types within Farm Ouro Verde (including PAI-001 area) in 2021 (Projeto MapBiomas).

Atlantic Forest PAI-002 (Farm Belo Horizonte):

The second Project Activity Instance (PAI-002/Farm Belo Horizonte) presents 1,200 hectares of lands under restoration and is located in the Northeast region of Brazil, specifically in the southern portion of the State of Bahia (Figure 30). PAI-002 is a rural property owned by the project proponent, located in the municipality of Potiraguá - Bahia/Brazil. As PAI-001, this region was the first to be colonized by Europeans since the year 1500 a.C., and experienced the same appropriation of natural resources and devastation of primary and high-diverse forest ecosystems. The economic behavior of the municipality of Potiraguá (municipality of the PAI-002) is characterized by its agricultural vocations, where the main productive activity is cattle farming. Since the end of the 19th century, deforestation associated with the planting of pastures, has taken place. Because cattle raising has been practiced without soil conservation practices, many locations present erosive processes and silting of rivers. Particularly, PAI-002 is occupied by pastures (Figure 31) and located in the Northeastern portion of the Project Zone, within the microregion of Itapetininga/Bahia (Figure 32).

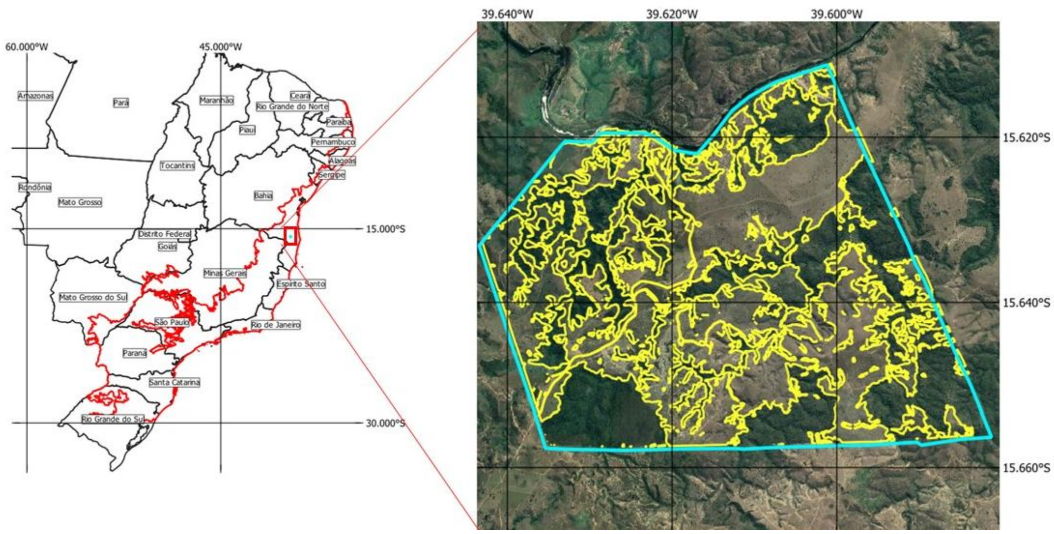

Figure 30. Project zone (red polygon) and PAI-002 (yellow polygons) locations. Project activities (reforestation/restoration) that will be included in the carbon certification will only be implemented within the pastures within PAI-002. The blue polygonal represent the whole rural property perimeter that is under management of Re.green, including roads, firebreaks, infrastructure, and preexisting forest fragments.

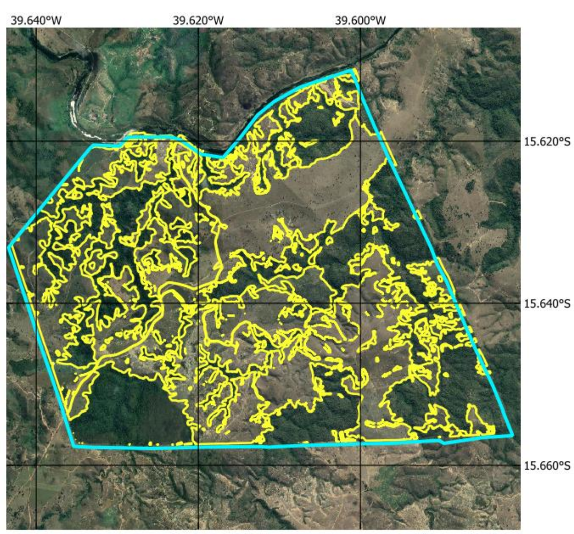

Figure 31. PAI-002 occupied by pastures.

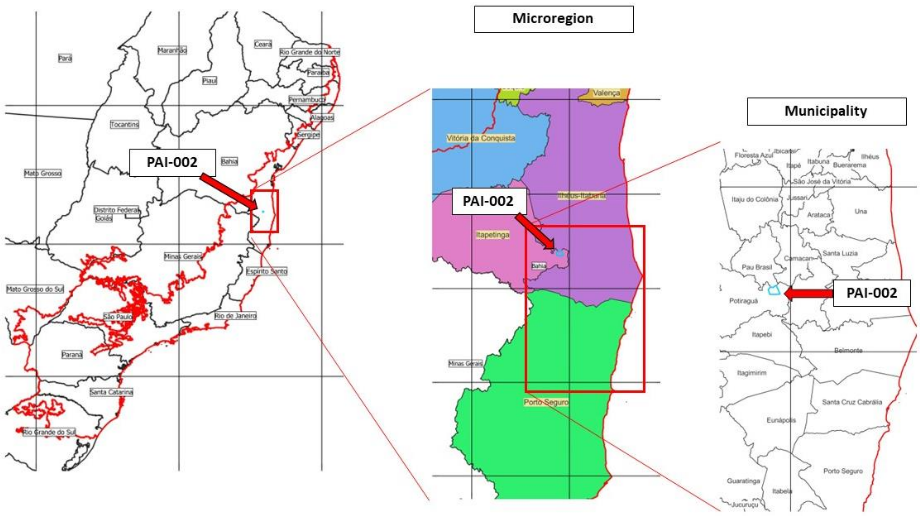

Figure 32. Geopolitical subdivisions of the project zone (red polygon) and the Farm Belo Horizonte (including PAI-002 area) region.

<u>TOPOGRAPHY</u>

The geomorphological domain of the encompassing PAI–002 consists of Phanerozoic Basins and Neoproterozoic Mobile Belts (Figure 33). The relief is mainly light undulated (slope >3%-8%) and undulated (slope >8%-20%) (Figure 34). Elevation within PAI-002 ranges from 58 m to 317 m above sea level (Figure 33).

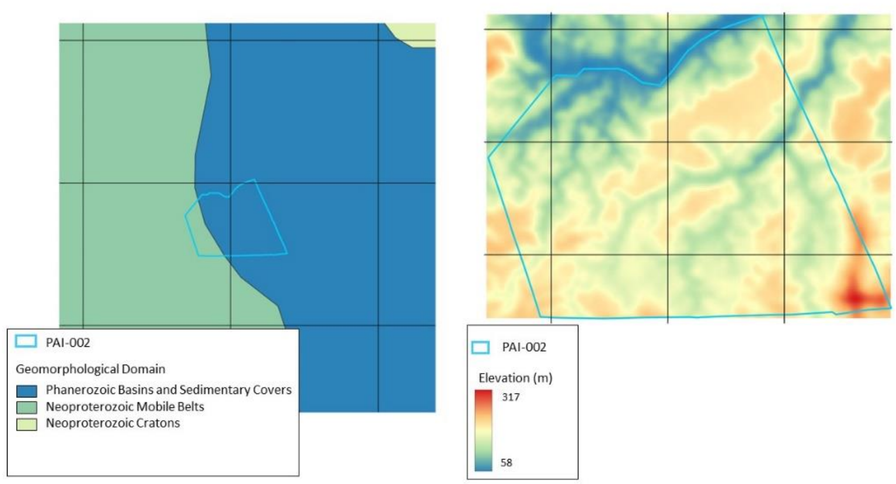

Figure 33. Geomorphological domains[3] and elevation[4] of the Farm Belo Horizonte (including PAI-002 area) region.

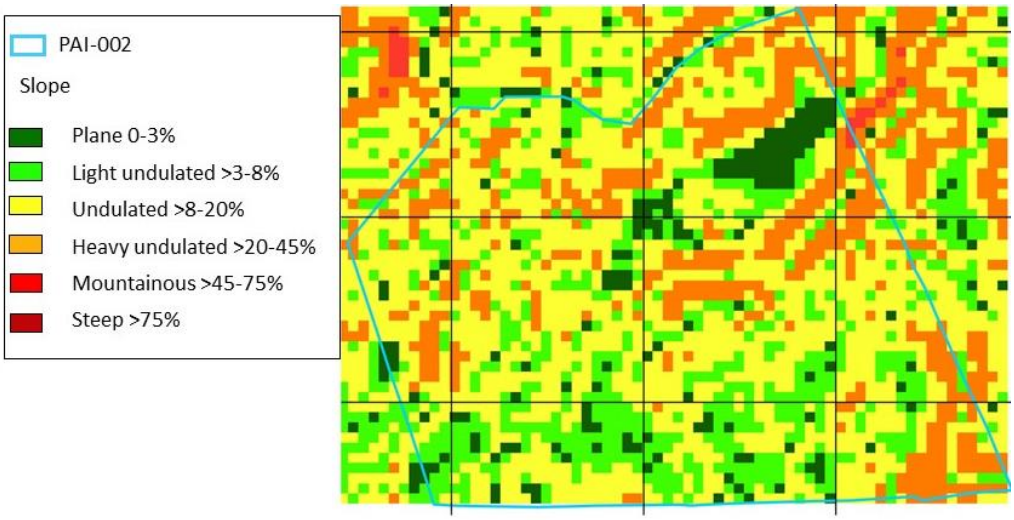

Figure 34. Slope classes of the terrain throughout the region of the Farm Belo Horizonte (including PAI-002 area)[5].

SOIL

The soils occurring within the PAI-002 is the Red-Yellow Dystrophic Argisol and Luvisol Chromic (Figure 35). The first one presents a clay accumulation horizon, with yellowish-red colours due to the presence of a mixture of the iron oxides hematite and goethite. The second one is a very strong colored soil, red or yellow, which presents the eutrophic character (high base saturation in the subsurface horizons) that favors rooting at depth. According to IPCC and the World Reference Base for Soil Resources, Argisols (Acrisols) present low activity clay content, while Luvisols present high clay activity[12].

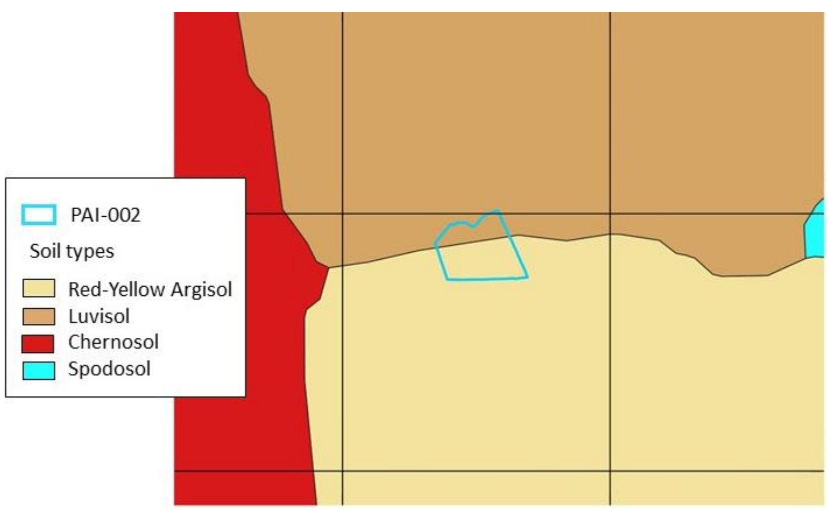

Figure 35. Soil types occurring in the Farm Belo Horizonte (including PAI-002 area)region (Santos et al. 2011).

CLIMATE

The municipality of Potiraguá/BA, where PAI-002 is embedded, presents mean annual temperature of 23.6 °C, where 25.6°C is the average temperature of the warmer month of the year (February) and 20.9°C is the average temperature of the coldest month (July)[15]. The annual precipitation is 863 mm/year. August is the driest month of the year where precipitation averages 38 mm, while November is the wettest month averaging 122 mm. The territory of the PAI-002 is within the domain of the tropical monsoon climate (Aw), according to Köppen (Figure 36) (Alvares et al. 2013). Despite that, the precipitation presents a seasonal pattern with a dry season between July and September, and a rainy season between October and March.

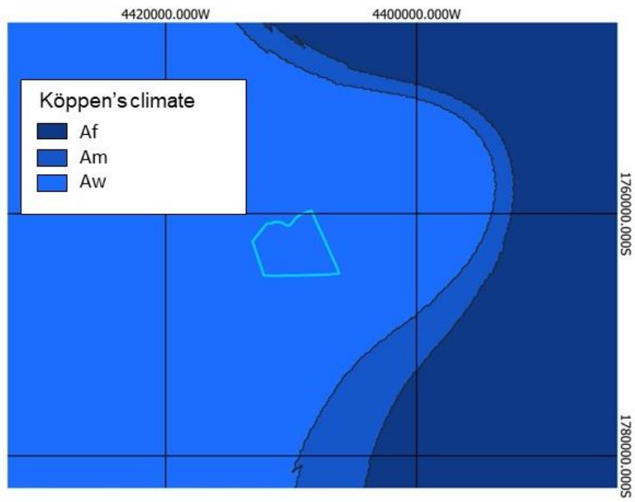

Figure 36. Climate categories encompassing the Farm Belo Horizonte (including PAI-002 area) (light-blue polygon).

HYDROGRAPHY

The Project Instance PAI-002 is located within the aquifers "Fraturado Semiárido" and "Serra do Paraíso", particularly within the hydrographic region of the "Eastern Atlantic"[14] and the subbasin of the rivers Pardo and Cachoeira (Figure 37). The rivers occurring in the PAI-002 are tributaries of the Rio Pardo and Córrego da Solidão (Figure 38).

[15] https://pt.climate-data.org/america-do-sul/brasil/bahia/potiragua-43285/. Accessed: 16 Nov 2022

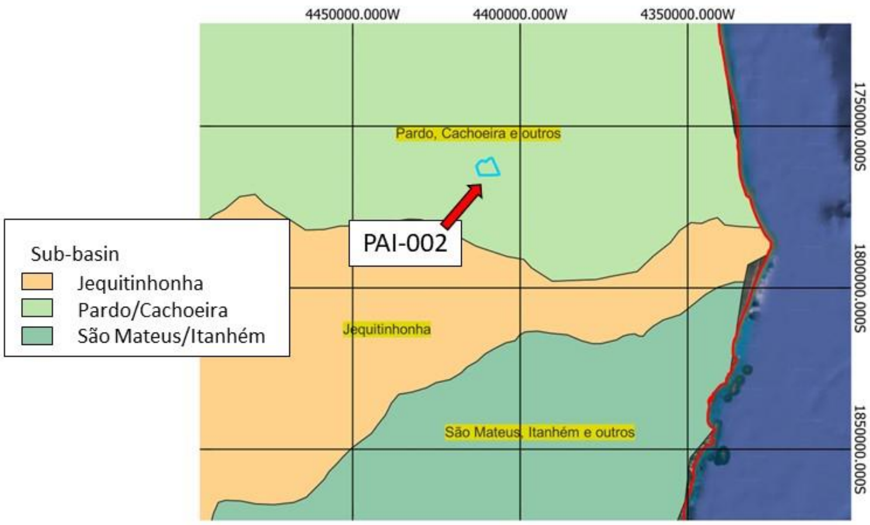

Figure 37. Hydrographic sub-basins occurring in the Farm Belo Horizonte (including PAI-002 area) region Erro! Indicador não definido.

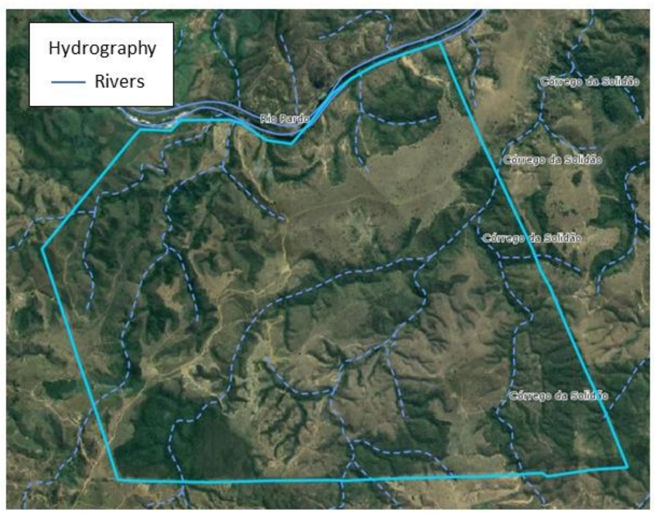

Figure 38. Hydrographic network and springs within the Farm Belo Horizonte (including PAI-002 area).

<u>TYPES OF VEGETATION</u>

The municipality of Potiraguá is embedded within the original distribution of the Dense Ombrophilous Forests and the Seasonal Semideciduous Forests (Figure 39), but the territory is currently dominated by pasture lands, where cattle raising is practiced at low productivity rates and without best soil conservation practices. This is the case of PAI-002, which is mainly occupied by pastures (exotic grasses) (Figure 40).

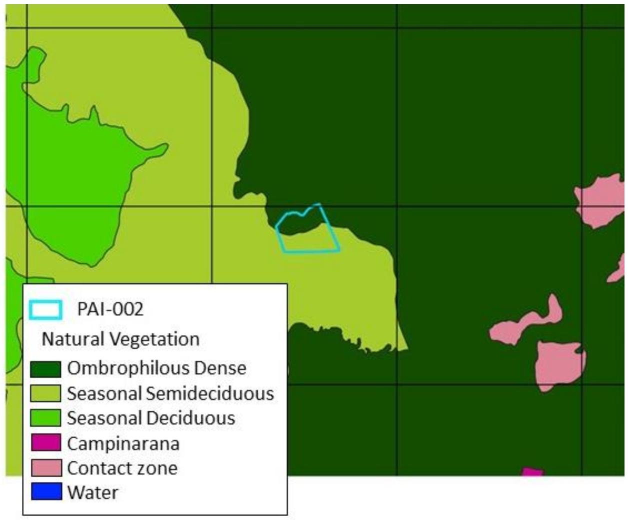

Figure 39. Original vegetation within the region of the Farm Belo Horizonte (including PAI-002 area)[11].

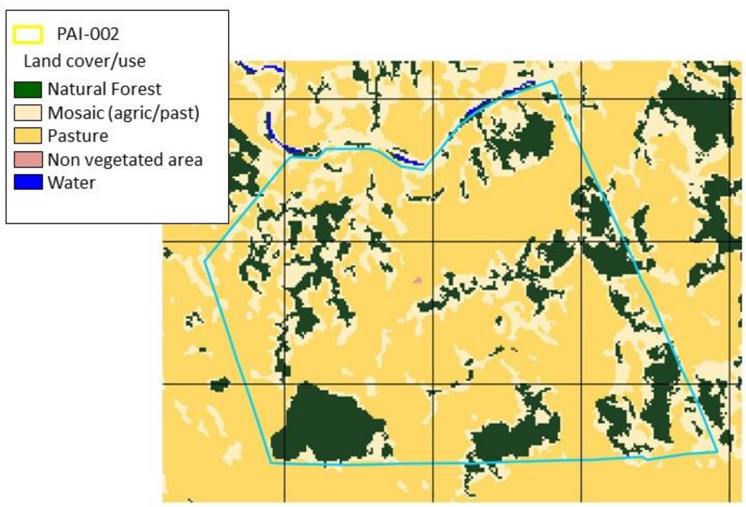

Figure 40. Land-cover and land-use types within Farm Belo Horizonte (including PAI-002 area) in 2021 (Projeto MapBiomas).

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

The following regulations apply to restoration activities in privately owned lands.

Grouped project

Regulation presented in Table 1 are applied to the Grouped project.

Table 1. Laws and regulation applied to the Grouped Project.

Federal Laws	Description
Federal Law n° 6938 31/08/1981 - The National Environmental Policy	Presents the National Environmental Policy, its purposes, mechanisms, and applications.
Federal Constitution, 1988	Cap. VI, On Environment, Art. 225.
Federal Law n° 11428 22/12/2006 – "The Atlantic Forest Law"	Provides the regulations for the use and protection of the native vegetation of the Atlantic Forest Biome.
Decree nº 6660 21/11/2008 - Regulates Law n°11428 22/12/2006	It regulates the provisions of Law n°11428 22/12/2006, which provides for the use and protection of native vegetation of the Atlantic Forest Biome.
Federal Law nº 12,187 12/29/2009 – Establishes the National Policy on Climate	Establishes the National Policy on Climate Change - PNMC, which aims to establish mechanisms that support the mitigation of climate change, including the restoration of native vegetation.
Federal Law n° 12651 25/05/2012 – "The New Brazilian Forestry Code"	It establishes general rules on the Protection of Native Vegetation, including Permanent Preservation Areas, Legal Reserve and Restricted Use areas; forest exploitation, the supply of forest raw materials, the control of the origin of forest products, the control and prevention of forest fires, and provision of economic and financial instruments to achieve its objectives.
Federal Law n° 9985 18/07/2000 – Establishes the National System of Nature Conservation Units	Establishes the National System of Nature Conservation Units – Among its objectives are the conservation of different biological species and genetic resources, the preservation and restoration of natural ecosystems, and the promotion of sustainable development from natural resources.
Federal Law n° 9433 08/01/1997 - "The Water Resources Law"	Institutes the Policy for and the National System of Water Resources.
Decree nº. 8,972 01/23/2017 – Establishes rhe National Policy for the Recovery of Native Vegetation	Establishes the National Policy for the Recovery of Native Vegetation - PROVEG which includes the creation of PLANAVEG - National Plan for the Recovery of Native Vegetation and CONAVEG - National Commission for the Recovery of Native Vegetation. Its objective is to articulate, integrate and promote policies, programs and actions that induce the recovery of forests and other forms of native vegetation, as well as promote the environmental regularization of Brazilian rural properties, in accordance with Federal Law No. 12,651/2012. PLANAVEG foresees the restoration of 12 million hectares in Brazil by 2030

Federal Laws	Description
Law nº. 10,711 08/05/2003 – Provides National Seeds and Seedlings System	Provides for the National Seeds and Seedlings System. It aims to guarantee the identity and quality of plant multiplication and reproduction material produced, marketed, and used throughout the national territory. Establishes the National Registry of Seeds and Seedlings – Renasem, mandatory for activities of production, processing, packaging, storage, analysis, trade, import and export of seeds and seedlings.

Atlantic Forest PAI-001 and PAI-002

Regulation presented in Table 2 are applied to the first and second project instances, that is, PAI-001 and PAI-002, which is located in Bahia State/Brazil. For each new instance, the set of local and regional regulations applied to the project activities will be evaluated.

Table 2. Laws and regulations applied to the PAI-001 and PAI-002

State Laws	Description
State Law Nº 10431 20/12/2006	It provides for the Environment and Biodiversity Protection Policy of the State of Bahia and other measures.
State Law Nº 11612 08/10/2009	It provides for the State Water Resources Policy, the State Water Resources Management System, and other measures.
Decree Nº 15180 02/06/2014	Regulates the management of forests and other forms of vegetation in the State of Bahia, the conservation of native vegetation, the State Forest Registry of Rural Real Estate (CEFIR), and other measures.

1.15 Participation under Other GHG Programs

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

The project has not been registered, nor it is seeking registration, under any other GHG program than VCS. Nonetheless, Re.green sent a Prior Consideration of its Grouped Project to the CDM and Brazilian DNA to screen the possibility of inclusion in the new market mechanism under Article 6.4 of the Paris Agreement. In case of registration of this Grouped Project in the SDM (Sustainable Development Mechanisms), Re.green will guarantee that none of the PAIs of this Grouped Project will be subject to the SDM, controlling their geographic location (a specific SOP will be developed in that case).

1.15.2 Projects Rejected by Other GHG Programs

The project has not been rejected by any GHG program.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The project does not reduce GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading.

1.16.2 Other Forms of Environmental Credit

The project has not sought neither received another form of GHG-related credit.

Supply Chain (Scope 3) Emissions

At the moment, Re.green doesn't have any product or service provided to other entities that could be impacted in its Scope 3 emissions quantification by this Grouped Project. Nonetheless, when applicable Re.green will develop a public statement in their website (according to VCS Standard v.4.4[1]) and this statement will also be sent to any entity interested in investing on this Grouped Project and/or when any harvested wood products and/or non-wood product be sold by each PAI.

1.17 Sustainable Development Contributions

The Brazilian government has committed to the 17 Sustainable Development Goals (SDGs) implemented by the UN. However, the country is among the less effective nationalities in achieving the established goals, according to the "Relatório Luz da Sociedade Civil – Agenda 2030 de Desenvolvimento Sustantável[16], which points to the destruction of social, environmental, economic, civil and political rights. Thus, the proposed project aims to contribute to change this scenario.

The Project Activity promotes ecological restoration in areas suitable for this purpose, increasing forest cover and habitat quality throughout a large territory. The project contributes to the mitigation of climate change by removing CO_2 from the atmosphere and is expected to promote sustainable development by several means, such as diversifying sources of income through activities related to forest restoration (seeds collection, seedling, production, implementation, monitoring, and other), while delivering social and biodiversity co-benefits. It also promotes proper handling of the land by applying soil conservation practices and providing the regularization of the rural properties according to existing legal requirements. In summary, in addition to a large-scale climate change mitigation component, the project also generates benefits related to, Social, Biodiversity and Economic aspects. It is important to mention that the majority of the SDGs described below will be achieved by the Grouped Project as a whole, where individual PAIs will present specific contributions for some of the SDGs. Table 3 below provides a summary of the expected contribution of the project to several SDGs. Depending on the local context of each PAI, the project may also contribute to other SDGs.

[16] https://brasilnaagenda2030.files.wordpress.com/2021/07/por_rl_2021_completo_vs_03_lowres.pdf. Accessed: 07 Nov 2022.

Table 3. Grouped Project contributions to SDGs.

SDGs	Expected benefit
1 NO POVERTY	Contribute to poverty eradication by increasing job offer within rural landscapes and demand for local providers of seeds and seedlings. This will be achieved by expanding project activities in the region, creating new positions for local communities.
5 GENDER EQUALITY	Contribute to gender equity by providing job positions specific for woman over the whole company structure, from field activities to decision makers.
6 CLEAN WATER AND SANITATION	Contribute to potable water by restoring ecosystem related to water resources, including mountains and forests, since large-scale reforestation/restoration activities are the main goals of the grouped project.
8 GOOD JOBS AND ECONOMIC GROWTH	Promotes worthy jobs and economic growth by ensuring employees rights and participation in different job positions hierarchy, while providing opportunity for communities to diversify their income source from sustainable activities, ensuring more economic security to them. In addition, the project developer (e.g. Re.green) is a company engaged in contributing to public policies and voluntary initiatives related to climate change.
9 INNOVATION AND INFRASTRUCTURE	The grouped project proponent is a company totally supported by science and innovation, as reforestation/restoration activities are not currently implemented in the proposed scale. Thus, the grouped project contributes to move science beyond what is required to generate high-quality carbon credits, and assist in the development of new methods, techniques, and equipment to implement and monitor the project activities. In addition, Re.green aims to promote partnerships with local industries/services providers at instances level, assisting in a better organization of the work force available.

SDGs	Expected benefit
	Contributing to sustainable production by delivering sustainable activities and renewable products provided by reforestation/restoration activities.
	Contribute to climate change mitigation by implementing forest reforestation/restoration at large-scale (considering multiple project instances) and consequently sequestering atmospheric carbon. In consequence, the activities contribute to achieving Brazilian NDCs related to climate change mitigation. Notwithstanding, it is expected that more evidence are generated to improve knowledge and understanding about the positive impact on climate change promoted by nature based solutions.
	Contribute to biodiversity conservation by promoting the reintroduction of native plant species of regional occurrence within the project area, including rare, endemic, and endangered species. Considering the planted and regenerating species together and the expected structural attributes of the restored forests, the representativeness of local diversity and ecological indicators achievement are guaranteed, so the area is accepted as an ecological restoration. In the medium term, restoring vegetation with a high diversity, promotes the recovery of fauna associated with the several plant species (pollinators and seed dispersers), and consequently other elements of fauna associated with the former (predators, parasites, symbionts, etc.) and specialist of forest ecosystems. The resulting biodiversity promotes the reconstruction of the biological networks interactions, allowing greater stability to the restoration project in the face of extreme events, including those resulting from climate change.
	Contribute to peace, justice, and efficient institutions by providing regular jobs, where employees have their rights ensured, thus combating the spread of illegal work. In this context, the project proponent aims to act as a multiplier of new practices, by providing better work conditions for rural workers widespread within the Brazilian Atlantic Forest.

SDGs	Expected benefit
17 PARTNERSHIPS FOR THE GOALS	Contribute to different stakeholders' development by promoting the restoration custody chain of the region, which involves several activities related to (but not restricted to) seed collection, seedling production, restoration implementation and monitoring. For these activities many workers and companies are required to achieve the large-scale goals, making the concretization of partnerships a crucial part of the project.

1.18 Additional Information Relevant to the Project

Leakage Management

As described in section 4.3, leakage is not expected to occur. If applicable, the leakage calculation will be done as described in section 4.3, according to the methodological tool "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*"

Commercially Sensitive Information

There isn't any commercially sensitive information that has been excluded from the public version of this project description.

Further Information

There isn't any further information.

2 SAFEGUARDS

2.1 No Net Harm

Starting from lands occupied by anthropic activities carried out within non-native ecosystem, the restoration activities proposed by the Project Proponent will increase native forest cover, promoting GHG removals, while improving landscape connectivity, creating habitat for biodiversity, and generating jobs positions. Also, the improvement in the water cycle of the watershed can be expected, as the future forest cover will be more effective in contributing to water infiltration and reducing erosive processes than pastures, Thus, it is rather difficult and unlikely that the project activities have potential to result in negative environmental and socio-economic impacts. Instead, recovering native forests is expected to only issue environmental, social, and biodiversity benefits.

The relevant laws and regulations covering workers' rights in the Host Country will be followed and placed below. These laws will be applicable to Re.green's workers and contracted companies:

1) The Constitution of the Federative Republic of Brazil (1988): covers the basic rights assured to Brazilian workforce.

2) Consolidation of Labour Laws (Decree n. 5.454 of 1943): covers detailed rights assured to Brazilian workforce and was recently amended by the Labour Reform.

3) Law n. 6.019 of 1974: covers the rights assured to temporary and outsourced workers.

4) Law n. 7.064 of 1982: covers the rights assured to expatriated employees.

5) Law n. 8.036 of 1990: covers the Severance Indemnity Fund ("FGTS")

6) Law n. 8.213 of 1991: covers social security benefits to which Brazilian workforce is entitled to.

2.2 Local Stakeholder Consultation

The local stakeholder consultation of this Grouped Project will be conducted by two analyses. The first one will consider the relevant stakeholders for the whole Grouped Project area, the Atlantic Forest biome. Re.green identified government representants, NGOs, other project developers of environmental services, academics and the Brazilian Designated National Authority to the UNFCCC. For this stakeholders, Re-green sent an e-mail and a letter with an abstract of the Grouped Project and contact information to receive the comments. All communication received will be answered and archived as described in a specific operational procedure of stakeholder communication.

The second analyses will be carried out by each PAI. Local stakeholder consultation process begins with the characterization of the possible stakeholders and is followed by the selection of easily accessible communication mechanisms. Key stakeholders for the project include nurseries, seed collectors, neighbor landowners, local workers, local organizations, indigenous communities, conservation units, rural settlements, and archaeological sites. For the identification of the stakeholders a buffer of 20km radius is set around each PAI. The 20km buffer was selected to be aligned with the AFOLU Non-Permanence Risk Tool provided by VERRA[17]. The 20km buffer is not a requirement when there aren't reliant people on the area, but it was selected to ensure a conservative and robust approach for the stakeholder's characterization.

[17] AFOLU Non-Permanence Risk Tool. V4. https://verra.org/wp-content/uploads/2019/09/AFOLU_Non-Permanence_Risk-Tool_v4.0.pdf

Within this buffer rural settlements, indigenous communities, neighbor landowners, conservation units, archaeological sites, and other possible stakeholders will be mapped. Within and outside the 20km buffer the nurseries, seed collectors, local organizations, and local workers will be also mapped and interviewed. After mapped, the stakeholders are interviewed by a social expert, which is responsible for explaining the project activities and ask specific questions related to the stakeholders.

Following this stage, a meeting will be scheduled with the stakeholders to clarify the aspects related to forest carbon projects and specific project activities, where stakeholders will have the opportunity to ask questions about the project, as well as to express their perceptions and concerns. The information obtained during this stage will be recorded to register the people involved and the main topics discussed. The whole process follows internal operational procedures developed to ensure replication and quality.

For the characterization of the local organizations, we seek to present the activities that will be developed by Re.green in its rural property. Regarding the consultation process, the main goal is to provide a deep understanding of the project activities, in order to identify any impact on the community, register the questions and doubts presented by the stakeholders, open the communication between Re.green and the stakeholders, and evaluate possible partnerships with them.

For the consultation phase a PowerPoint presentation will be developed and presented by each PAI for the communities, explaining the activities and the impacts expected to occur (see table in section 2.3). Also, printed materials and maps will be developed and presented to the stakeholders identified during the characterization phase. An open discussion will be stimulated, as the aim of this consultation is to ensure that all stakeholders understand Re.green's project and any questions are answered.

For both the characterization and consultation stages, reports will be created to ensure that the information are archived. Every PAI included in the Grouped Project will be subject to the processes described above.

2.3 Environmental Impact

The establishment of reforestation/restoration activities does not require environmental impact assessment (EIA). In fact, activities that aim to restore native vegetation are managed to fulfill lost ecological functions, including hydrological services in the basin, and biodiversity conservation, where no negative impact is expected. The Grouped Project aims to combat three environmental threats: climate change, species extinctions, and environmental degradation.

Thus, the following environmental impacts are expected:

Environmental Impact	Effect
Increase of native forest cover	Positive
Climate change mitigation and adaptation	Positive
Conservation and restoration of fauna and flora	Positive
Connectivity of fragmented landscapes	Positive
Conservation of water sources	Positive
Improvement of soils conditions (water infiltration, nutrient cycling, organic matter increase)	Positive

2.4 Public Comments

This section shall be filled once the VCS PD is listed in the Verra site and receive comments from the Global Stakeholder consultation process.

2.5 AFOLU-Specific Safeguards

As described in the VCS Standard v4.4[1] item 3.18.11:

> *"Where AFOLU project activities do not impact local stakeholders, projects are not required to meet the requirements set out in Sections 3.18.12 – 3.18.20 below. The project proponent shall provide evidence that project activities do not impact local stakeholders at validation and each verification."*

As the reforestation/restoration project activity will be develop by each PAI in properties owned and/or controlled by the PAI and aimed to improve the social and biodiversity impacts, this Grouped Project expects that no negative impact will be generated to local stakeholders. Even so, Re.green follows the VCS Standard v4.4 specifications in items 3.18.12 to 3.18.20 in a conservative manner.

The characterization and consultation processes will be conducted to each PAI included in the Grouped Project, as described in the item 2.2 above and in internal operational procedures. The characterization and consultation processes aim to ensure that all relevant stakeholders were considered and consulted by each PAI.

A good relationship with key stakeholders is crucial to enable the carbon project to achieve its climate, environmental and social targets. To ensure that the project succeed the following objectives were established:

- Clarification of the roles and functions of stakeholders in the project.
- Obtain stakeholder feedback related to project impact.
- Develop a regular exchange of information with stakeholders.

The application of the process of characterization and consultation was applied to the PAI 1 to serve as an example for this Grouped Project. The first step was the identification of plausible stakeholders following the buffer of 20km radius around the PAI (as described in item 2.2), the results of the process as showed in

Figure 41.

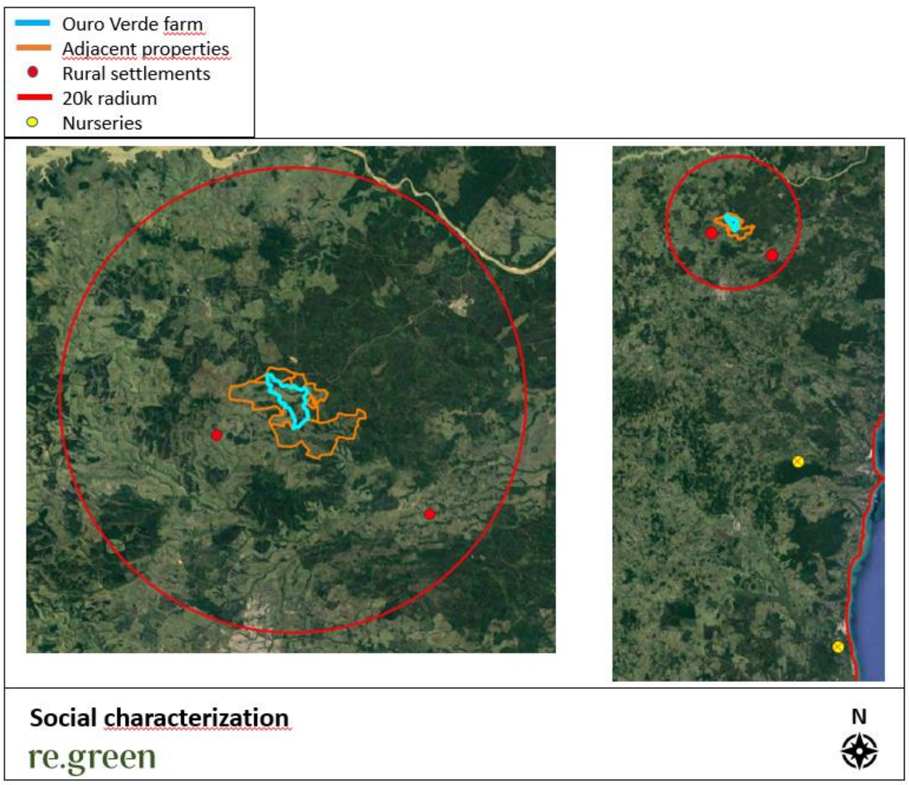

Figure 41. Stakeholders identified map. Buffer radius and nurseries that supply PAI 1.

After identification process, Re.green conducted the consultation of the identified stakeholders. To this process was prepared a MS Power Point presentation, an institutional video (link was shared after the meeting) and printed materials. This tool was used to conduct the consultation with the stakeholders by individual meetings. The material shared has Re.green's contact information and so communication channel was opened.

The pictures bellow (Figure 42 and Figure 43) provide examples of the stakeholder identification process and individual meetings conducted with the stakeholders in the consultation phase.

Figure 42 (A) Cooplanjé nursery of the Cooplanjé Indigenous Community Cooperative, that supply PAI-001. (B) Cooplanjé Indigenous Community visiting PAI-001.

Figure 43 Example of individual meetings of the stakeholder consultation process (A) Services providers of PAI-001, Trevo Florestal and Forseg (B) Rural settlement Paulo Kageyama (C) Rural Workers Union of Eunápolis/BA (D) Primaflora nursery.

The mechanism for on-going communication with local stakeholders include providing a telephone number and an email for the consulted stakeholders, so they can reach Re.green by different ways, speeding up the process for delivering any commentary. Also, internal procedures are being developed to conduct any communication, where it will describe how to respond the questions or commentaries received and the procedures to designate the question to specific sector of Re.green.

The strategy to maintain continuous communication with stakeholders encompasses:

- Provision of a communication channel where suggestions and complaints are placed.
- Design of clear procedures for receiving and handling complaints, to ensure that stakeholders can express their opinion related to the reforestation/restoration activities, dissemination, monitoring, etc.
- Identification of approaches whereby effective solutions can be identified together with stakeholders.

All the processes of characterization, consultation and communication of the stakeholders follows internal operational procedures of Re.green, and is replicated to each PAI that is added to the Grouped Project.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

Applied Methodology, according with project instance size:

1) AR-ACM0003[18] Afforestation and reforestation project activities implemented on lands other than wetlands.

Applied Tools[19]:

1) AR-AM Tool 02: Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities. Version 1.1

2) AR-AM Tool 03: Calculation of the number of sample plots for measurements within A/R CDM project activities. Version 02.1.0

[18] This methodology is available online at: https://cdm.unfccc.int/methodologies/DB/C9QS5G3CS8FW04MYYXDFOQDPXWM4OE. Accessed: 07 Nov 2022.

[19] These documents can be accessed online at: tps://cdm.unfccc.int/methodologies/DB/C9QS5G3CS8FW04MYYXDFOQDPXWM4OE. Accessed: 07 Nov 2022.

3) AR-AM Tool 08: estimation of non-CO_2 greenhouse gas (GHG) emissions resulting from burning of biomass attributable to an A/R CDM project activity. Version 04.0.0.

4) AR-AM Tool 12: estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities. Version 3.1

5) AR-Tool 14: estimation of carbon stocks and the change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 4.2

6) AR-AM Tool 15: estimation of the increase in GHG emissions attributable to the displacement of pre-project agricultural activities in A/R CDM project activities. Version 02.0

7) AR-AM Tool 16: tool for the estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities. Version 1.0

3.2 Applicability of Methodology

Methodologies and tools	**Applicability criteria**	**Compliance**
AR-ACM0003 A/R Large-Scale Consolidated methodology - Afforestation and reforestation project activities implemented on lands other than wetlands. Version 03.1	The land subject to the project activity is not categorized as 'wetland'.	The area does not fit into the "wetland" category. Project lands are classified based on the pre-project land use, as grasslands, or patches of croplands. To ensure the compliance with the applicability criterium, every new PAI will be assessed by geotechnology databases to prove the existence/non-existence of WETLANDS. In the absence of official or sectoral sources, a questionnaire is applied to the landowners regarding the existence of WETLANDS.

Methodologies and tools	Applicability criteria	Compliance
	Soil disturbance attributable to the project activity does not cover more than 10% of area in each of the following types of land, when the land is included within the project boundary: - Land containing organic soils; - Land which, in the baseline, is subject to land-use and management practices and receive inputs listed in appendices 1 and 2 of the AR-ACM003 methodology.	As previously explained, the project will implement its activities on lands that are currently non-native ecosystems, especially pastureland and other crops. So, it is expected that the measures implemented as part of the project represent substantive improvements in terms of soil management. Organic soils occur in Brazil in a sparse and punctual way, especially in lowlands, so there are few chances of this type of soil to be included in the project. Within the first instance (PAI-001) there are no organic soils (Organosols)[20] (Canto et al. 2020). In the case of PAI-001, project activities will be mainly implemented on pastures with some degradation level. The soils are highly compacted due to cattle trampling, and subsoiling is among the operational activities required for some of the restoration models. The project areas are not subjected to management practices that include the application of inputs, as fertilizers or organic matter. Thus, it is expected that lands in the baseline are not subjected to land-use and management practices described in appendices 2 and 3 of the referred methodology. The implementation of some restoration models includes subsoiling and digging pits (MRN and BRN models). In areas containing ORGANIC SOILS or conforming to the conditions presented in APPENDICES 1 and 2, the soil disturbance caused by the project implementation cannot be higher than 10% of the carbon project area. To ensure the compliance with the applicability criterium, within every PAI areas containing ORGANIC SOILS or outlined in the conditions

[20] http://geoinfo.cnps.embrapa.br/layers/geonode%3Abrasil_solos_5m_20201104. Accessed: 07 Nov 2022.

Methodologies and tools	Applicability criteria	Compliance
		presented in APPENDICES 1 and 2 will be identified. Geotechnology databases are used to prove the existence/non-existence of ORGANIC SOILS. In the absence of official or sectoral sources, a questionnaire is applied to the landowners regarding the previous conditions and management of the area, to define the framework in APPENDICES 1 and 2. When there are areas with ORGANIC SOILS or in the conditions presented in APPENDICES 1 and 2, methods of low soil disturbance are used in these project areas, decreasing the disturbed area to less than 10% of the project area (e.g. digging pits in part of the area instead of subsoiling). When necessary, the soil disturbance will be calculated as follows: -Subsoiling: . Measure the width (m) of the furrow on the soil surface resulting from the subsoiling. . Sum the lengths (m) of the planting rows. . Calculate the % disturbance (% disturbance = (furrow width*sum of row lengths)/ eligible project area) - Digging pits: . Measure width and length of pits (m). . Count the number of pits. . Calculate the % disturbance (% disturbance = (pit width * pit length * number of pits)/eligible project area)

Methodologies and tools	Applicability criteria	Compliance
AR-AM Tool 02: Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities. Version 1.1	- Forestation of the land within the proposed project boundary performed with or without being registered as the A/R project activity shall not lead to violation of any applicable law even if the law is not enforced. This tool is not applicable to small - scale afforestation and reforestation project activities	Project Activities does not lead to the violation of any applicable law. The project does not fall into the small-scale category as it does not fulfill the small-scale A/R conditions set by the CDM methodology (CDM Methodology Booklet). The PAI-001 and PAI-002: - PAI-001 expects to sequester on average 3,950 tCO2eq/year; - PAI-002 expects to sequester on average 13,654 tCO2eq/year; - The project activities are not developed or implemented by low-income communities and individuals as determined by the host Party. According to Article 3 of CIMGC Resolution no. 3, of 03/24/2006, low-income communities are those whose members have a monthly per capita family income of up to half of the National Minimum Wage.
AR-AM Tool 08: Estimation of non-CO2 greenhouse gas (GHG) emissions resulting from burning of biomass attributable to an A/R CDM project activity. Version 04.0.0.	The tool is applicable to all occurrence of fire within the project boundary. Non-CO2 GHG emissions resulting from any occurrence of fire within the project boundary shall be accounted for each incidence of fire which affects an area greater than the minimum threshold area reported by the host Party for the purpose of defining forest, provided that the accumulated area affected by such fires in a given year is	Burning of biomass is not part of the project's management practices, but the occurrence of fires, accidental or otherwise, will be monitored, and is even a monitoring item in the project. In the case of fire and if the accumulated area affected by such fires in a given year is ≥5% of the project area, the AR-AM Tool 08 will be used to quantify the required discounts.

Methodologies and tools	Applicability criteria	Compliance
	≥5% of the project area.	
AR-AM Tool 03: Calculation of the number of sample plots for measurements within A/R CDM project activities. Version 02.1.0	The tool has no internal applicability criteria.	
AR-AM Tool 12: Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities. Version 3.1	The tool has no internal applicability criteria.	
AR-Tool 14: Estimation of carbon stocks and the change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 4.2	The tool has no internal applicability criteria.	

Methodologies and tools	Applicability criteria	Compliance
AR-AM Tool 15 Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity	This tool is not applicable if the displacement of agricultural activities is expected to cause, directly or indirectly, any drainage of wetlands or peat lands.	The expected leakage from the removal of baseline activities in the project area is estimated to be "zero" under the conditions presented in section 10 of the AR-AM Tool 15.
AR-AM Tool 16: tool for the estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities. Version 1.0	This tool is applicable when the areas, in the baseline scenario and the project activity meet the following conditions: a. The areas to which this tool is applied: (i) Is not "wetland"; or, (ii) Does not contain organic soils, (iii) Is not subject to any of the management and input application practices set out in appendices 1 and 2 of the tool. b. The project activity meets the following conditions: (i) The "litter" remains on site and is not removed in the project activity; and, (ii) Soil disturbance attributable to the	The area does not contain organic soils and does not fall into the "wetland" category, as demonstrated previously. The area is not subject to management practices and application of inputs, as demonstrated previously. The "litter" remains on site regardless of project activities. Soil disturbance resulting from project activities follows good soil conservation practices, including planting along contour lines. In restoration models focused only on carbon and conservation, soil disturbance for implementation of the project occurs only in the year of planting. In models that include the harvesting component, soil disturbance occurs in the planting year, and a new soil disturbance will only occur to implementation of the ecological restoration after the end of the single rotation harvesting management.

Methodologies and tools	Applicability criteria	Compliance
	project activity, if any, is: . In accordance with appropriate soil conservation practices, for example follows land contours; . Soil disturbance for soil preparation is limited to the period prior to planting and such disturbance is not repeated in less than 20 years.	

3.3 Project Boundary

Source		Gas		Justification/Explanation
Baseline	Above and below ground (roots) biomass in trees and shrubs	CO2	yes	It is expected that carbon stock in these pools will not increase due to the implementation of the baseline activity. The only vegetation considered in the baseline is grassland. Above and below ground carbon stock in the baseline, present in isolated trees, is accounted as zero. Pre-project trees in the Project Area before the Project were neither harvested, nor cleared, nor removed. They didn't suffer mortality because of competition from trees planted due to the project, or damage because of implementation of the Project activity and they are not inventoried along with the Project trees in monitoring of carbon stocks throughout the crediting period of the project activity.
		CH4	No	This is not a requirement of the methodology
		N2O	No	This is not a requirement of the methodology
		Other	No	This is not a requirement of the methodology
	Dead wood, Litter and Soil Organic Carbon	CO2	yes	As baseline is grassland, it is expected that carbon stock in these pools will not increase due to the implementation of the baseline activity.
		CH4	No	This is not a requirement of the methodology

		N2O	No	This is not a requirement of the methodology
		Other	No	This is not a requirement of the methodology
Project	Above and below ground (roots) biomass in trees and shrubs	CO2	yes	Carbon stock in above ground biomass (in trees and shrubs in the understory) is the major carbon pool affected by the project activity. Carbon stock in below ground biomass is expected to increase as a result of the implementation of the project activities
		CH4	No	This is not a requirement of the methodology
		N2O	No	This is not a requirement of the methodology
		Other	No	This is not a requirement of the methodology
	Dead wood, Litter and Soil Organic Carbon	CO2	yes	It is expected that carbon stock in these pools will increase due to the implementation of the restoration activities.
		CH4	No	This is not a requirement of the methodology
		N2O	No	This is not a requirement of the methodology
		Other	No	This is not a requirement of the methodology

The Figure 44 and Figure 45 illustrate the Grouped Project boundary (where new PAIs can be added over time) and the PAI-001 an PAI-002 boundary, respectively. Each PAI included in this Grouped Project will have a specific and georeferenced boundary to be presented in the Verification process.

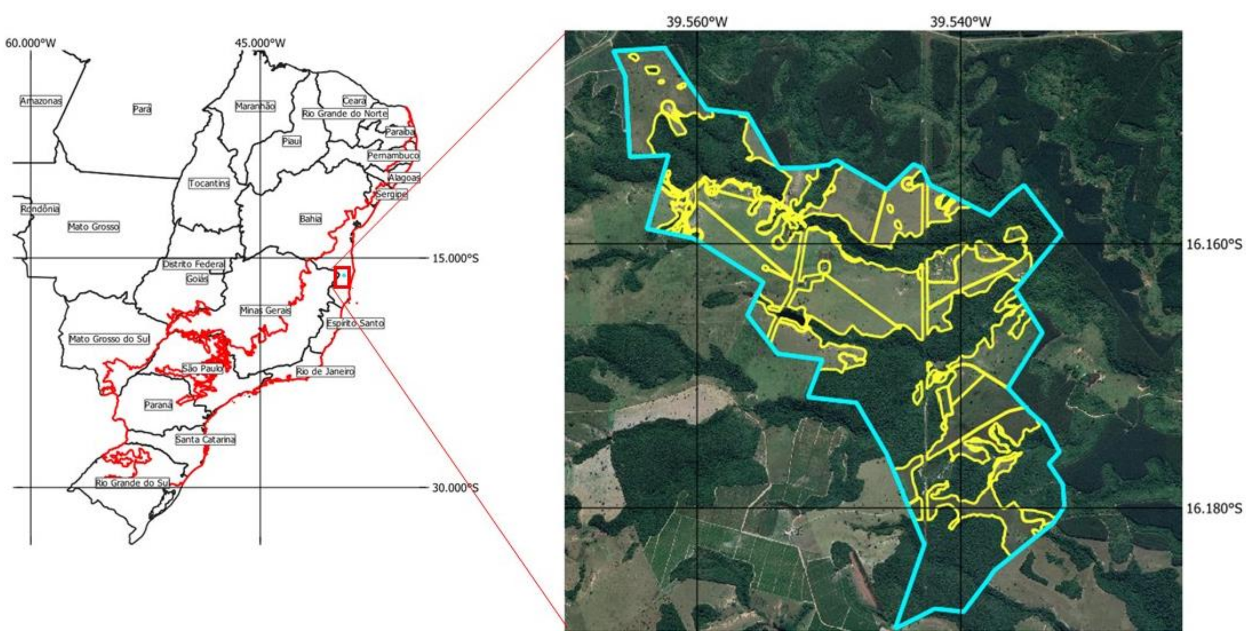

Figure 44. Project zone (red polygon) and PAI-001 boundary (yellow polygons) locations. The blue polygonal represent the whole rural property area that will be managed by the project proponent.

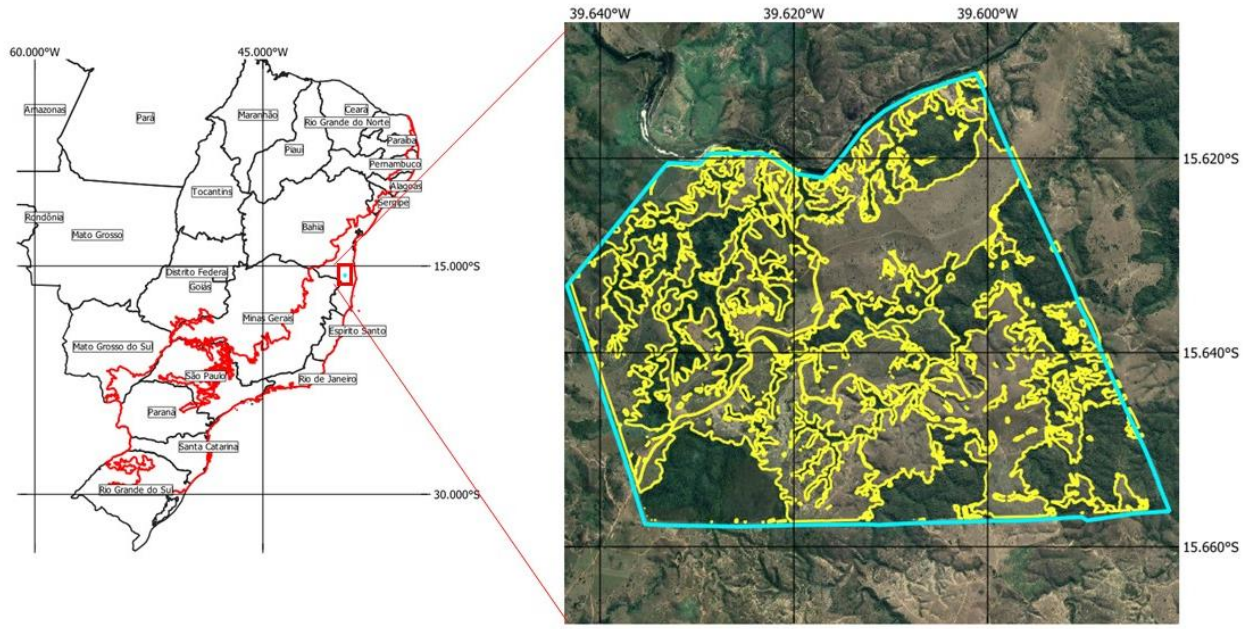

Figure 45. Project zone (red polygon) and PAI-002 boundary (yellow polygons) locations. The blue polygonal represent the whole rural property area that will be managed by the project proponent.

3.4 Baseline Scenario

The baseline scenario was defined by using the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities Version 01".

The previous landowners wouldn't implement reforestation/restoration practices in the total area or in part of their property due to the barriers listed in the section 3.5. In the absence of the project, no reforestation/restoration activities would take place and the target lands would remain without native forest carbon stocks, resulting in none or a small contribution to greenhouse gases (GHG) removals. Thus, the project areas would remain dominated by land-uses with low-carbon stock and continue to be occupied by non-native ecosystems as a consequence of anthropic activities practices (for example: grassland, annual croplands and/or perennial croplands with low carbon stocks).

We, therefore, identify "**Scenario 1: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices)**" as the baseline scenario for each PAI included in the Grouped Project. See section 3.5 to a more detailed description of the identification of the baseline scenario and demonstration of additionality.

3.5 Additionality

The baseline scenario and demonstration of additionality was defined by using the "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities Version 01".

The tool is applicable under the following conditions:

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

b) Afforestation and reforestation project activities are not classified as small-scale activities.

The following steps must be applied:

a) STEP 0. Preliminary screening based on the starting date of the A/R project activity;

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

c) STEP 2. Barrier analysis;

d) STEP 3. Investment analysis (if needed); and

e) STEP 4. Common practice analysis.

Step 0. Preliminary screening based on the starting date of the A/R project activity

The Grouped Project start was on October 04th, 2022, when restoration activities began to be implemented in the first project activity instance, that is, PAI-001.

- The Grouped Project initiated the pipeline listing process within three years of the project start date as required by the VCS Standard, v4.4, as follow: The Grouped Project was inserted in the Verra Registry system and Project Status was changed to "Pipeline listing requested (under development)" in 03/10/2022;
- Re.green received an e-mail from Verra Secretariat confirming that the Project has been listed as under development in 28/10/2022.

In Re.green's bylaws the main objectives of the corporation are: (i) develop and manage restoration ecosystems projects; (xi) develop methodologies, implement projects and operate transaction associated to carbon markets or funds; (xii) develop and manage funding mechanisms to operate in carbon markets, including issuance and commercialization of carbon credits; (xiii) develop certification activities of carbon credits, covering all the steps to this aim.

These objectives in the Re.green bylaw show that the issuance of carbon credits is essential for the Grouped Project to be implemented and was seriously considered in the beginning of the project.

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

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

Realistic and credible alternative land-use scenarios that would have occurred on the land within the proposed project boundary in the absence of the AFOLU project activity under the VCS program were identified. The scenarios are feasible for the project area taking into account relevant national and/or sectoral policies and circumstances, such as historical land uses, practices and economic trends.

The identified alternative land use scenarios include:

Scenario 1: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices)

Justification: As described in this section, Step 2, the continuation of pre-project land-use would remain the same in the absence of the project due to traditional land use practices in the Grouped Project area. The prevalent practices are livestock and grazing activities as the most widespread land use. Agriculture practices, both annual and perennial, are also present in the region, with low carbon stock cultures.

Scenario 2: Project Activities within the project boundary performed without being registered in the carbon VCS/AFOLU program

Justification: Due to the barriers presented in the Step 2 and the prevalent practices in the Grouped Project area, this scenario is unlikely to occur. The reforestation/restoration activity has high investment costs and low or no revenues, especially in Legal Reserves and Permanent Preservation Areas. Without the Grouped Project, landowners probably will not give up productive boundaries of their properties to reforestation/restoration with native species.

Scenario 3: Project Activities performed on at least part of the land within the project boundary of the proposed project.

Justification: As the same reasons of Scenario 2, this scenario is unlike to occur, even in small scales.

Outcome of Sub-step 1a:
List of credible alternative land use scenarios that could have occurred on the land within the project boundary of the VCS AFOLU project:
Scenario 1: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices).
Scenario 2: Project Activities within the project boundary performed without being registered in the carbon VCS/AFOLU program.
Scenario 3: Project Activities performed on at least part of the land within the project boundary of the proposed project.

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

According to the Additionality tool, all the alternative land use scenarios previously identified comply with all applicable laws, regulations, and enforcement practices. No regulatory initiative bans these land use scenarios. Both land use scenarios are legally permissible land uses for the project areas. The reforestation/restoration is regulated by the Forestry Code, but it has been developed after 2001 and need not be taken into account in developing a baseline scenario, as mentioned in EB 23 Report, Annex 19[21]:

> *"National and/or sectoral land-use policies or regulations, which give comparative advantages to afforestation/reforestation activities and that have been implemented since the adoption by the COP of the CDM M&P (decision 17/CP.7, 11 November 2001), need not be taken into account in developing a baseline scenario (i.e. the baseline scenario could refer to a hypothetical situation without the national and/or sectoral policies or regulations being in place)."*

In addition to EB 23 Report, Annex 19, the Forestry Code[22] mentioned the use of incentives from environmental services to achieve their objectives:

Article 41 paragraph 4 of Forestry Code:

> "*Activities of maintenance of Permanent Preservation Areas, or areas of Legal Reserve or restricted use, are eligible for any payments or incentives from environmental services, characterizing additionality for the purposes of Brazilian and international markets for the certified emission reductions of greenhouse gases*."

So, all of the scenarios listed in sub-step 1a are plausible to be implemented and are consistent within mandatory applicable laws and regulations.

Outcome of Sub-step 1b: List of credible alternative land use scenarios that could have occurred on the land within the project boundary of the VCS AFOLU project: ***Scenario 1***: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices). ***Scenario 2***: Project Activities within the project boundary performed without being registered in the carbon VCS/AFOLU program. ***Scenario 3***: Project Activities performed on at least part of the land within the project boundary of the proposed project.

[21] The methodological tool "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities", Version 01 cited the Appendix 19 of the EB23, "National and/or sectoral policies and baseline scenario for Afforestation and Reforestation project activities", to be considered in evaluation of mandatory applicable laws and regulations.

[22] Law nº 12.651 from May 25th of 2012. http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/l12651.htm. Accessed: 07 Nov 2022.

Step 2. Barrier analysis

Sub-step 2a. Identification of barriers that would prevent the implementation of at least one alternative land use scenarios

This Grouped Project faces the barriers listed below, that could prevent its implementation. Scenario 1: "*Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices)*" faces none of the barriers listed.

a) Barrier related to local land use tradition

b) Investment barriers

c) Market risk

d) Technological barriers

e) Institutional barrier: adaptation to the legislation

f) Local traditions barriers

g) Barriers due to local ecological conditions

Outcome of sub-step 2a: The barriers which would prevent one or more of the land uses identified in Sub-step 1b are listed a) to g) above.

***Sub-step 2b.* Elimination of land use scenarios that are prevented by the identified barriers**

Barrier related to local land use tradition

Within the project zone, the main anthropic land-use is pasture (63% of the biome extension), planted mainly with exotic and aggressive African grass species (*Brachiaria*, *Panicum* and *Andropogon*)[23]. According to the Brazilian Agricultural Research Corporation (Embrapa), in general, most of the Brazilian pastures (65% or 130 million hectares) are currently degraded and need some intervention to reverse their state[24]. This prevailing land-use is commonly practiced far below the soil carrying capacity (<0.8 animals/hectare (Dias-Filho, 2014), while carrying capacity in the Atlantic Forest is mostly >3.3

[23] https://www.embrapa.br/en/agrossilvipastoril/sitio-tecnologico/trilha-tecnologica/tecnologias/pastagens. Accessed: 07 Nov 2022.

[24] https://www.embrapa.br/en/agrobiologia/pesquisa-e-desenvolvimento/pastagens. Accessed: 07 Nov 2022.

animals/hectare[25] - Figure 46), and the lack of correct management and pasture renovation activities have resulted in degrading factors as erosion, soil compaction, and fertility impoverishment (Dias-Filho, 2014). Cattle trampling over pastures without proper management is one of the main contributors to soil erosion and compaction, but also is a factor that prevents the establishment of natural regeneration, as the small regenerated plants are damaged by the cattle (Sampaio and Guarino, 2007). In addition, different invading species adapted to these conditions also prevent regeneration by competing for resources (water, nutrients, light) (Rodrigues et al. 2009). In this context, we can't expect that natural regeneration will spontaneously establish in these lands and reach a satisfactory successional trajectory.

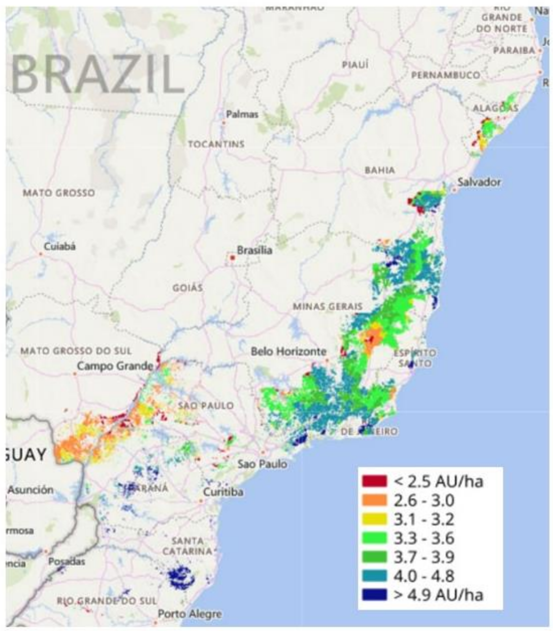

Figure 46. Soil carrying capacity in pastures of the Atlantic Forest Biome[25].

For decades, pastures and other anthropic land-uses have expanded over native primary forests of the Brazilian Atlantic Forest, which nowadays represent only 11%-16% of its original cover, where more than 80% of the remaining fragments are <50 ha, almost half are <100 m from its edges, and conservation units protect only 9% of the biome extension (Ribeiro et al. 2009). Despite many efforts to recover the native forests within the Atlantic Forest, the forest cover in the biome has been almost stagnant over the last 36 years (1985-2021) (Projeto MapBiomas) (Figure 47). In fact, it is already proved that, in the Atlantic Forest, areas covered by primary native forests continue to decrease, while new secondary forest have increased, a trend that threatens the potential for carbon storage, biodiversity conservation, and the delivery of several ecosystem services, as primary forests are irreplaceable (Rosa et al. 2021; Piffer et al. 2022). Furthermore, the increase in secondary and young forest via restoration present a reversal trend in the targeted region, where new forests are commonly re-cleared within a few years after

[25] https://maps.lapig.iesa.ufg.br. Accessed: 07 Nov 2022.

establishment. Thus, regarding this common practice, we can expect that, even in areas with high potential for natural regeneration, new forests won't establish in perpetuity within the biome.

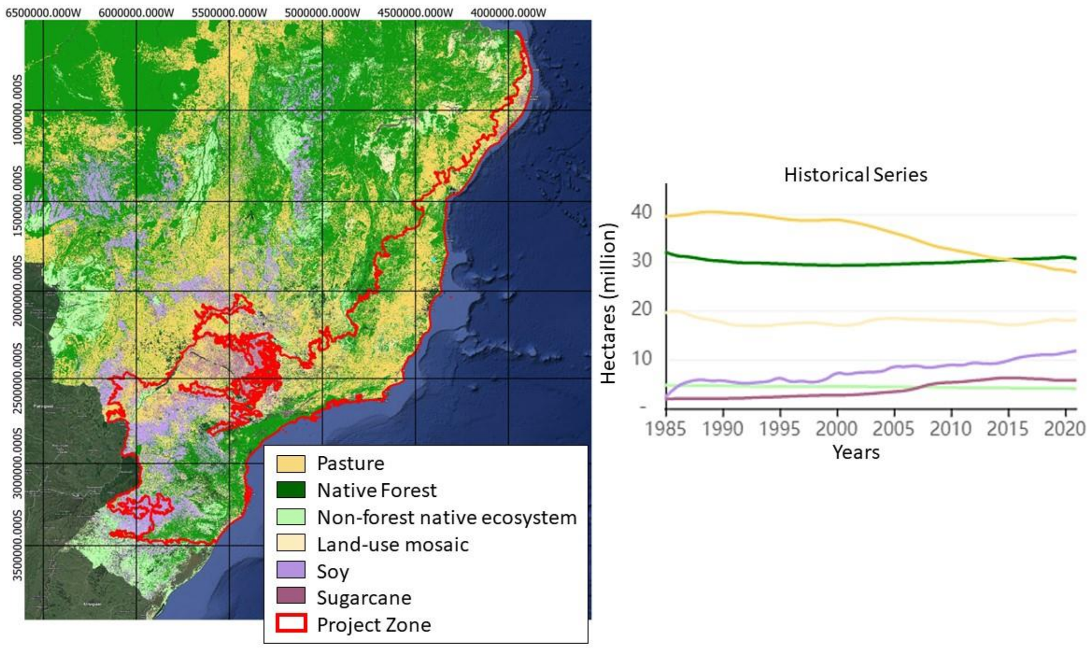

Figure 47. Main land-uses of the Atlantic Forest and the temporal trend among them (1985-2021) (Projeto MapBiomas).

In the last 20 years (from 2001 to 2021), the area occupied by pastures decreased from 38.4 million hectares to 27.9 million hectares within the Atlantic Forest. However, such decrease was mainly due to the substitution of pastures by agricultural activities, mainly soy and sugarcane, which together increased from 9.7 million hectares to 17.5 million hectares in the last 20 years, while native ecosystems have maintained approximately constant (see figure above).

Investment barriers:

There is a lack of public and private investment to establish ecological restoration, which can be hugely expensive (Benini and Adeodato, 2017). Thus, such activities have not been effectively implemented at large scale throughout Brazilian lands and in the Grouped Project region. Without climate finance or other exceptional financial instruments such activities rarely occur. Even marginal areas or lands protected by law (APP and RL) are not commonly restored by rural landowners (Soares-Filho et al. 2014; Azevedo et al. 2017). In fact, there are few efforts to restore large portions of land in the project region. In addition, due to a lack of assets and a reliance on intermittent income and jobs in the informal economy, local landowners have a very limited ability to secure debt finance to begin any type of long-term land use activity, especially reforestation/restoration activities, without additional revenues to landowners.

In Brazil, BNDES (National Bank of Economic and Social Development) offers numerous options for agribusiness development[26], to small, medium, and large companies, cooperatives, and landowners. In the list of possible types of financing and loans, there are 13 agribusiness programs, and just one focused on climate change adaptation (*Adaptação à Mudança do Clima e Baixa Emissão de Carbono - ABC+*). Even in this program, the objectives are:

> *"Enabling a more sustainable agribusiness, including Crop-Livestock-Forest (PLF) integration, pasture recovery, commercial planting of forests and waste treatment, among other activities".*

One of the BNDES Agribusiness Program, Pronaf (National Program for Strengthening Family Agriculture) is the most relevant incentive for landowners since 1995[27]. This Program has 9 sub-Programs within prefixed interest rates of 6% or lower, and in most of them the objectives are fomenting agriculture, machinery acquisition, processing of crops, pasture improvement and grazing activities. Even if landowners access some finance for reforestation/restoration activities, this will not provide additional income to them, and will represent a debt to be paid in the future with resources from other activities. All banks in Brazil, including BNDES, tend to have strict loan approval criteria, and would balk at giving loans for activities without significant revenue potential.

As the mainly activity of this Grouped Project is the reforestation/restoration of non-forest lands, even if there were to exist a specific loan for restoration, the activity doesn't generate any significant income to landowners. In the PAIs that could implement harvesting stands in the beginning of restoration the thinning activity occurs in year 10 and harvesting is spread between years 18 and 30. The BNDES loan for climate change adaptation[28] has a maximum payment period of 12 years with a grace period of 8 years, these conditions are not attractive for the reforestation/restoration proposed in this Grouped Project, even in harvesting stands.

The investment in reforestation/restoration activities with the main objective of generating and commercializing carbon credits requires a large amount of capital, because the cash flow requires high costs in the first years and the revenues will start to materialize, at the earliest, four years after the initial investments. Local landowners may not have financial structure to support these investments and likely will not have the know how to access carbon markets, because of high need for specific knowledge and lack of information. So, investments in reforestation/restoration focused on carbon credit generation presents a high risk to investors.

[26] https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/bndes-apoio-agroindustria. Accessed: 07 Nov 2022.

[27] https://www.embrapa.br/tema-agricultura-familiar/politicas-publicas. Accessed: 07 Nov 2022.

28 https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/programa-abc Accessed: 07 Nov 2022.

Market risk barriers:

Reforestation/restoration activities without revenues from carbon credits likely wouldn't be implemented by landowners because of high costs for restoration activities and no income. Even in the case of a single harvesting with native species for timber in part of the land, this activity itself doesn't generate enough income, and the income that it does generate tends to be deferred into the future for at least fifteen years. Another point is that after reforestation/restoration is implemented on all available open land, landowners would have difficulties in using their land for agriculture or grazing activities in the future.

As described in the "Barrier related to land use local tradition" cattle raising, and agriculture activities such as soya bean and sugar cane, are the most representative land uses of anthropogenic activities in Atlantic Forest biome. These activities represent the production of well-established commodities, and have widespread structure to be implemented in Brazil and in the biome.

Research and development in Brazilian livestock has helped to modernize the sector, with increased production. In the last 40 years the cattle production for milk and meat grew 4 times[29]. The export of beef represents 3% of Brazilian exports and a turnover of R$ 6 billion. It represents 6% of the Gross Domestic Product (GDP) or 30% of the Agribusiness GDP, with a turnover of over R$ 400 billion, which has increased by almost 45% in the last 5 years[30]. In general, the price of commodities are more stable and predictable, which provides a stable market condition. According to the CEPEA/B3[31], the price of live cattle ("*boi gordo*") rises constantly between 2012 and 2020, around 10.1% per year (Figure 48). Furthermore, cattle raising may generate incomes annually with predictable prices, so this alternative is seen as attractive to landowners, as they could invest and receive incomes in the same years configuring a more stable and predictable cashflow.

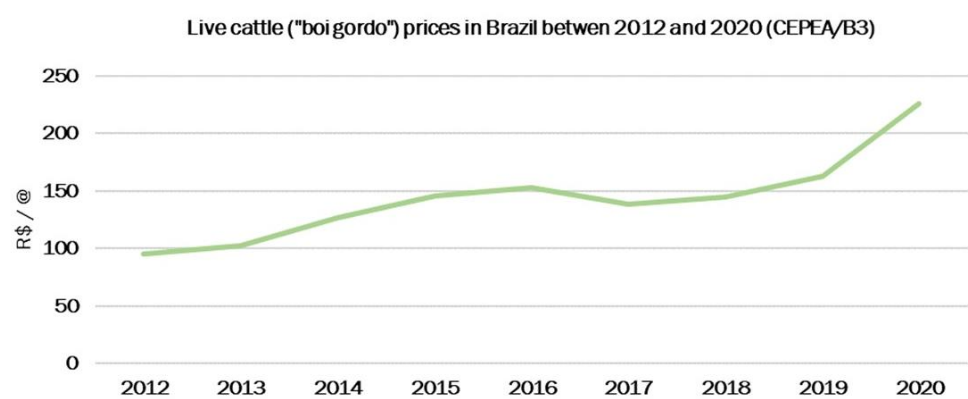

Figure 48. Live cattle ("*boi gordo*") price evaluation between 2012 and 2020[31].

[29] https://www.embrapa.br/grandes-contribuicoes-para-a-agricultura-brasileira/pecuaria. Accessed: 07 Nov 2022.

[30] https://www.embrapa.br/qualidade-da-carne/carne-bovina. Accessed: 07 Nov 2022.

[31] https://www.cepea.esalq.usp.br/br/consultas-ao-banco-de-dados-do-site.aspx. Accessed: 07 Nov 2022.

The same market dynamic is applicable to agriculture in Brazil. Most cultures are commodities and have a well-defined market. The price evolution of soya bean and sugar cane could be estimated in BRL using data from FAO Stat[32] and Exchange rate (R$/USD) from Central Bank of Brazil[33] between 2000 and 2020 (Figure 49). Prices of soya bean rises around 7.5% per year and sugar cane 6.8% per year, from 2000 to 2020. In absolute values the price of soya bean rises from R$305/tonne to R$1,399/tonne and sugar cane prices rises from R$20/tonne to R$81/tonne, in the period. Following the same logic of livestock, these two agricultures have low risk in prices volatility and could generate annual incomes to landowners.

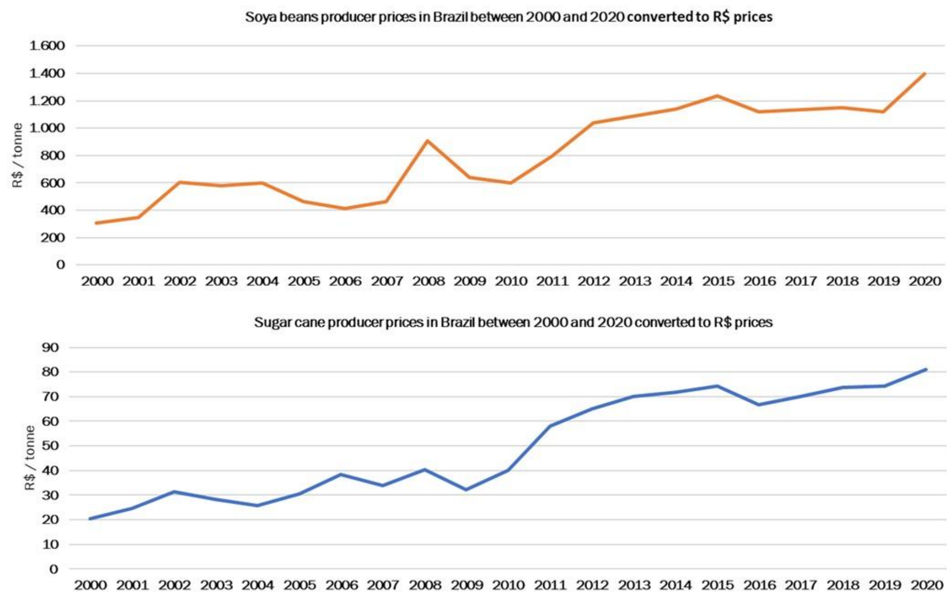

Figure 49. Soy bean and sugar cane price evaluation between 2000 and 2020, estimated from data of FAO Stat and Exchange rate (R$/USD) from Central Bank of Brazil.

Implementing forest restoration in the full project area, in contrast, is costly and uncertain. The first, and perhaps greatest barrier, is that there are no significant income generation streams in restoration In fact, property owners see it as an abdication of the property for other agriculture activities. Payments associated to restoration activities, such as for the provision of environmental services, are not significant and not well-established, with significant uncertainty.

As for the issuance of carbon credits, there are significant barriers for landowners: complex validation system, high initial investment, deferred cashflows, and market uncertainty. Implementing a carbon project has transaction costs with a wide range and depend on variables such as project scale, costs of the technologies used during its implementation, choice of consultants to help in the elaboration of the project, contract VVBs that validate it, choice of international certification standard and time scale of

[32] https://www.fao.org/faostat/en/#data/PP. Accessed: 07 Nov 2022

[33] https://www.bcb.gov.br/estabilidadefinanceira/historicocotacoes.

project activity[34]. Moreover, the development of a carbon projects needs a financial structure to support a cashflow with the first income in the fourth year, with subsequent five years intervals until reaching total carbon credits generation.

So, without this Grouped Project, the most attractive activity probably will be the agriculture activity. Considering the market structure of agricultural and beef commodities and relative predictable prices in livestock, soya bean and sugar cane, the reforestation/restoration activity faces more barrier related to market risks than pre-project land use activities.

Technological barriers:

In the project region, high quality planting material for most of the native plant species used in ecological restoration and timber production are not easily obtained. This is particularly challenging considering the huge amounts of seeds and seedlings required for large-scale projects. The lack of such materials and inadequate silvicultural equipment for planting and harvesting generates difficulties for the development of forest restoration activities in the region, thus preventing scenarios 2 and 3. In contrast, financial investments and programs for lowering taxes, providing technical assistance, assisting the purchase of inputs and machinery related to cattle raising and agricultural production have continuously increased in Brazil[35,36], while the same investments to native ecosystem restoration and forest management/conservation programs still require more attention (Tabarelli et al. 2005; Alves-Pinto et al. 2017; Brancalion et al. 2017; Ruggiero et al. 2019).

Institutional barrier: adaptation to the legislation

In Brazil, the Forest Code (law 12.621/2012) is the Federal Regulation that protects riparian zones, hills and legal reserves. According to this regulation, Permanent Preservation Areas – APP, are protected areas, covered or not by native vegetation, with the environmental function of preserving water resources, the landscape, geological stability, and biodiversity, facilitating the genetic flow of fauna and flora, protecting the soil and ensuring the well-being of human populations, while Legal Reserves are areas located within a rural property or possession, with the function of ensuring the sustainable economic use of the rural property's natural resources, assisting in the conservation and rehabilitation of ecological processes and promoting the conservation of biodiversity, as well as the shelter and protection of wild fauna and native flora.

Despite the ecological importance of these lands, there are currently 21 million hectares of APPs (22%) and legal reserves (78%) requiring restoration actions (Soares-Filho et al. 2014). Within the Atlantic Forest, the regulation provides that private lands must preserve 20% of the rural property with native

[34] https://eesp.fgv.br/sites/eesp.fgv.br/files/ocbio_mercado_de_carbono_1.pdf. Accessed: 07 Nov 2022.

[35] https://www.gov.br/agricultura/pt-br/assuntos/noticias-2022/plano-safra-disponibiliza-r-340-8-bilhoes-para-o-setor-agropecuario#:~:text=Os%20recursos%20para%20os%20pequenos,)%20e%206%25%20ao%20ano. Accessed: 07 Nov 2022.

[36] https://ojoioeotrigo.com.br/2021/10/os-numeros-mostram-agronegocio-recebe-muitos-recursos-e-contribui-pouco-para-o-pais/. Accessed: 07 Nov 2022.

ecosystems[22]. However, the Atlantic Forest is the biome presenting lesser compliance with the regulation (Figure 50). In this context, the activities proposed by the Grouped Project, which includes the restoration of riparian lands and legal reserves assist the enforcement of the regulation, ensuring the ecological functions and benefits provided by these areas, thus promoting more sustainable landscapes in compliance with national requirements.

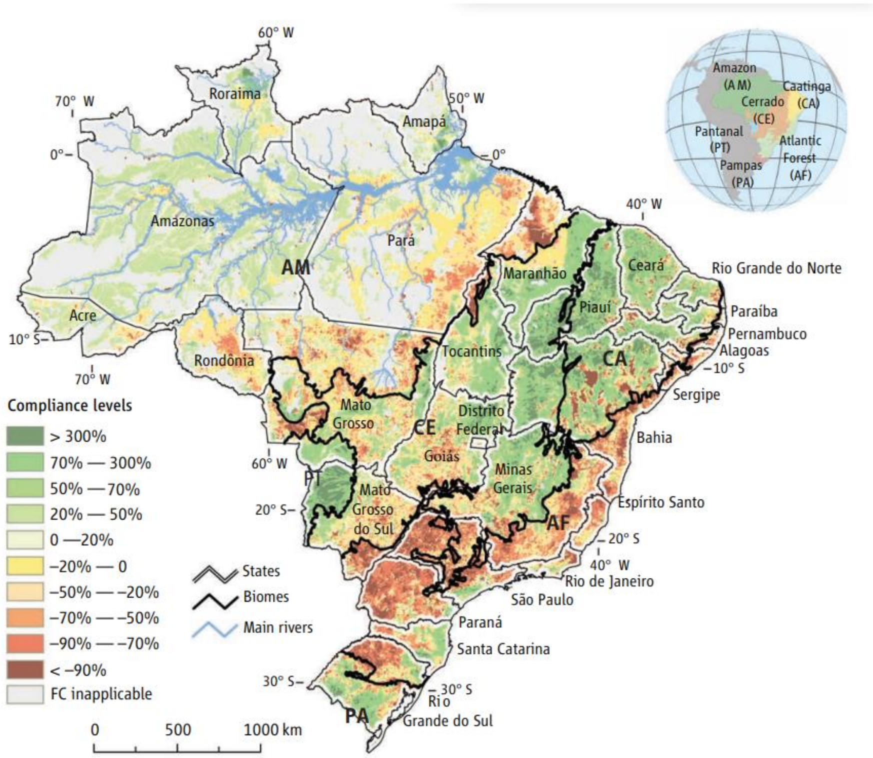

Figure 50. Level of regulation compliance among Brazilian biomes (AM – Amazon; CE - Cerrado; CA – Caatinga; AF – Atlantic Forest; PA – Pampa; PT – Pantanal) (Soares-Filho et al. 2014).

Countless extension of the deadline for registering rural lands in the Rural Environmental Registry (Cadastro Ambiental Rural, or "CAR"), which serves as the foundation for registering to the Environmental Regularization Program (Programa de Regularização Ambiental – PRA), represent another challenge associated with the current implementation of the Forest Code. Additionally, certain regions have not yet fully acceded their rural producers to the PRA, according to the Ministry of Agriculture. This is because the Forest Code is subject to legal uncertainty brought on by several constitutional lawsuits challenging important provisions that have an impact on the PRA, which were filed in the Federal Court but whose decisions were not finalized until 2018 and were not published until 2019. Thus, the restoration activities proposed by Re.green also contribute to the implementation of the PRAs, whose goal is to adapt and promote the environmental regularization of Brazilian rural properties.

Local traditions barriers:

Within the project region, cattle raising is the main activity observed and exotic grasses is the main land cover (See section of *Barrier related to land use local tradition*). For many decades, extensive cattle ranching and agricultural activities have been practiced within the project zone, in many cases with the use of fire for cleaning the land (Custodio, 2006) (Figure 51) and without proper soil conservation management, resulting in degrading processes, as land erosion and soil fertility reduction. The lack of public and private investment and the lack of economically feasible alternatives promotes the continuation of pre-project land uses.

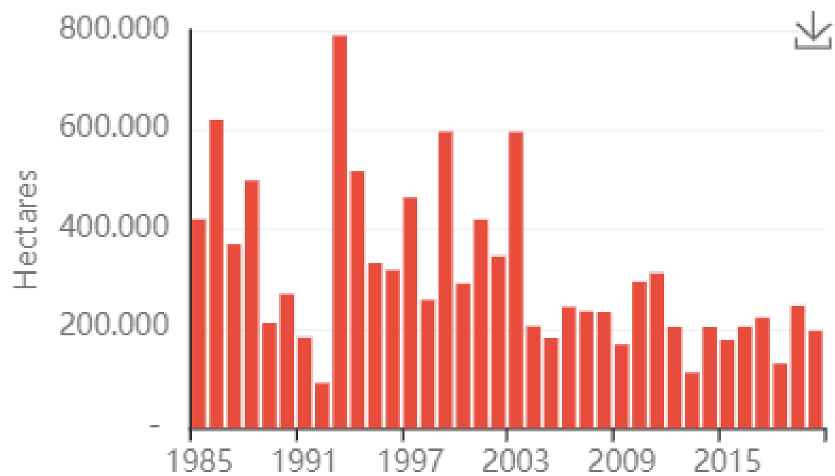

Figure 51. Burned area (hectares) over time within the Atlantic Forest Biome (Projeto MapBiomas**).**

Cattle raising and other agricultural activities present economic importance for the country, and the sector has substantial institutional and sectoral support, with incentives to promote the expansion of the activities throughout the national territory. Regarding cattle raising, the activity requires minimal investment (cattle purchase) to be implemented, and the short cycles of profit generated from the sale of the mature cattle ensure quick reinvestment and economic growth. The drivers that make cattle raising a credible scenario are: i) the persistence and increase of cattle raising activities in the Grouped Project region for a long time, ii) the lack of qualified technical assistance to break traditional paradigms and promote alternative land-uses, and iii) the lack of knowledge and expertise to implement alternative and more sustainable land-uses.

These activities have grown in production in Brazil over the last 20 years, according to FAO Stat[37] (Figure 52). The number of cattle heads increased by 48 million, reaching more than 218 million in 2020. The soya bean production grows 271% and sugar cane 132% between 2000 and 2020. This expressive

[37] https://www.fao.org/faostat/en/#data/QCL. Accessed: 07 Nov 2022.

growth reinforces the argument that livestock and agriculture are traditional activities in Brazil and in the project's area.

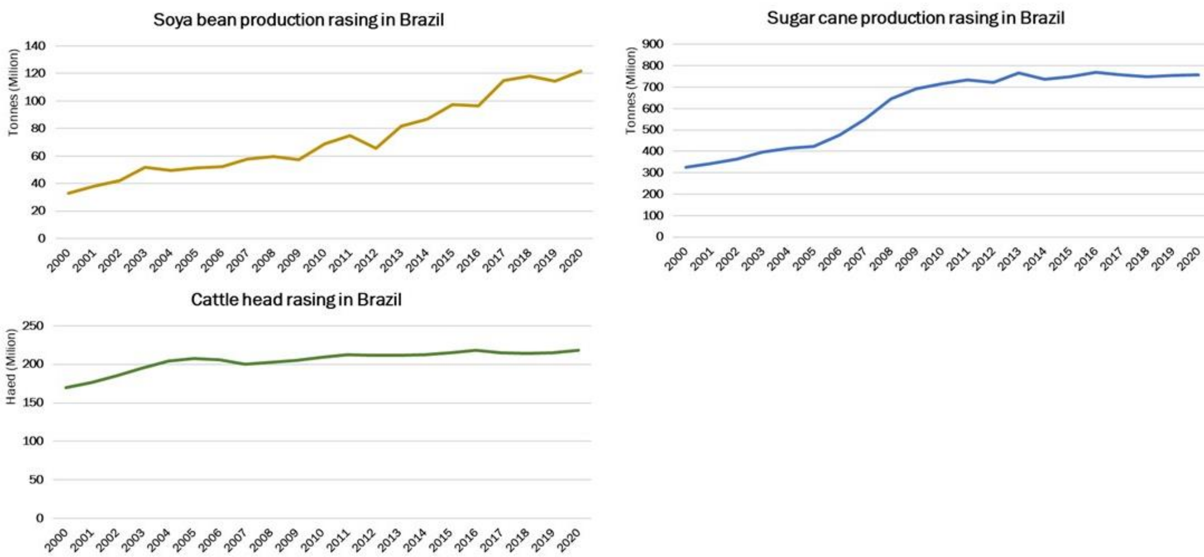

Figure 52. Cattle head (units), soya bean and sugar cane production (tonnes), between 2000 and 2020, according to FAO Stat.

Rural properties inside the project zone have been used for anthropic activities for many decades, convincing landowners to change their production systems is quite challenging due to traditional knowledge prevalence. According to the land-use analysis provided by the Projeto MapBiomas, the areas eligible for implementation of the grouped project activities have been predominantly occupied by pastures for the past 35 years. In this context, reforestation/restoration activities are not likely to occur in extensive private territories occupied by cattle raising and/or agriculture systems. Even in small portions of the land, reforestation/restoration activities are not expected to take place.

The paradigm culturally imposed to these communities and transferred over generations represents a strong barrier related to local customs that makes unfeasible the project scenario without carbon credits incentive. This barrier impacts scenarios 2 and 3, preventing them from being alternative uses of the territory. The fact that within the Project Zone an increase in the expansion of land-uses of low-carbon stocks can be observed, corroborates the argument that local traditions prevent new forests of high potential for carbon removal to establish (See Figure 47, in the section *Barrier related to land use local tradition*). Human induced fire events (dos Santos et al. 2019; Singh and Huang, 2022) and continuous mowing of shrubs and small trees[2] (Dutra et al. 2004; Pereira et al. 2018) also prevent ecological succession to move forward where natural regeneration potential persists, as any tree regenerating within the pasture is subject to these management factors.

Barriers due to local ecological conditions:

The lack of large and continuous native forest cover widely distributed within the project zone makes spontaneous regeneration challenging and unlikely, as seed dispersal from source fragments are crucial to the success of natural regeneration (Rodrigues et al. 2009, Chazdon and Guariguata, 2016). As already mentioned, invading species, and planted grasses adapted to harsh conditions (eroded, compacted, and low fertile soils) prevent regeneration by competing for resources (water, nutrients, light) (Rodrigues et al. 2009).

When fields are fallowed, persistence of grasses, lianas, or fire-tolerant grasses and ferns can lead to a permanently degraded state that will not return to forest without active management interventions (Chazdon and Guariguata, 2016). Thus, even if there were conditions for seed dispersal, the soil would be a harsh medium for new secondary forests to establish.

Also, the conversion of agricultural lands (sugarcane and soy for example) to secondary forests via spontaneous regeneration is not expected in many cases, as agricultural activities are commonly based on heavy machinery usage, herbicides application, and continuous plantation cycles, leading to soil compaction and fertility impoverishment (Bot and Benites, 2005; Cherubin et al. 2016), negatively affecting seeds germination and seedlings growth.

Moreover, pests and diseases, silviculture treatments, genetic data, and suitable edaphoclimatic conditions for native forest species are not deeply studied. On the other hand, there are many companies developing agricultural activities and specific study centers as Embrapa[38] (founded in 1973) putting efforts to develop technological bases for agricultural activities in the tropics.

Summary of barriers faced by each Scenario

As presented in the Table 4 below, each scenario was analyzed considering the barriers applied to them.

Table 4. Summary of barriers faced by each scenario

Alternative Land-use Scenarios	Barrier Faced
Scenario 1: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices)	No barriers faced

[38] https://www.embrapa.br/sobre-a-embrapa

Alternative Land-use Scenarios	Barrier Faced
Scenario 2: Project Activities within the project boundary performed without being registered in the carbon VCS/AFOLU program	Barrier related to land use local tradition Investment barriers Market risk Technological barriers Institutional barrier: adaptation to the legislation Local traditions barriers Barriers due to local ecological conditions
Scenario 3: Project Activities performed on at least part of the land within the project boundary of the proposed project.	Barrier related to land use local tradition Investment barriers Market risk Technological barriers Institutional barrier: adaptation to the legislation Local traditions barriers Barriers due to local ecological conditions

Outcome of Sub-step 2b:

There is only one scenario that faces no impediment to be implemented by barriers analysis presented:

Scenario 1: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices).

Sub-step 2c. Determination of the baseline scenario (if allowed by the Barriers Analysis)

To determine the baseline scenario, we apply the decision tree proposed by "Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities Version 01":

a) Is forestation without being registered as an A/R CDM (in this case VCS) project activity included in the list of land use scenarios that are not prevented by any barrier? No. The result of Sub-step 2b has only one scenario: ***Scenario 1***: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices).

b) Does the list contain only one land use scenario? ***Scenario 1***: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices) is not impeded by any of the barriers. So, the most plausible baseline scenario for the PAIs of the Grouped Project is continuation of the pre-project land use.

Thus, the baseline scenario of this Grouped Project is:

Scenario 1: Continuation of the pre-project land-use (non-native ecosystems as a consequence of anthropic activities practices)

Step 3. Investment analysis

The investment analysis was not carried out because Step 2 was conclusive to determine the Grouped Project additionality.

Step 4. Common practice analysis

The additionality analysis, presented in Step 2, shows that the recovery of pre-project land use through reforestation/restoration activities is not a common practice in the Project region. Despite that, some efforts to boost forested landscapes in the project zone are observed. For example, there is a project in the southern region entitled “Reforestation for multiple purposes as a means of sustainable development” where the goal is to promote reforestation with Eucalyptus species and restoration in marginal lands, as riparian areas and legal reserves. Another project that is under development is the “Conservador da Mantiqueira”, which aims to restore Permanent Protected Areas (APPs) and legal reserves in the central region of the Atlantic Forest. Other project in the region is the “Reforestation Grouped Project at Pratigi Environmental Protection Area”, which aims to restore steep and riparian zones.

These projects are also triggered by carbon mechanisms and hence are not included in the common practice analysis. Regardless of that, they are not at the same scale as the Grouped Project proposed by Re.green, because these projects aims to restore mainly marginal lands, while Re.green’s project aims to restore rural properties as a whole, including flat lands, thus promoting a substantial increase in native forest cover and landscape connectivity. In addition, Re.green activities will only use native tree species, while other projects may also use Eucalyptus (non-native species) as part of a production system. Thus, ecological restoration activities at large scales and reforestation projects with native tree species are not a common practice in the project zone, making Re.green’s activities additional.

3.6 Methodology Deviations

No deviation of methodology was applied in this Project.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

To measure the GHG removals in the baseline and project scenario, each PAI will apply the quantification in accordance with the methodological tools:

1) AR-AM Tool 12: estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities. Version 3.1

2) AR-Tool 14: estimation of carbon stocks and the change in carbon stocks of trees and shrubs in A/R CDM project activities. Version 4.2

3) AR-AM Tool 16: tool for the estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities. Version 1.0.

4) VT0005: Tool for measuring aboveground live forest biomass using remote sensing. Version 1.0

According to the methodology AR-ACM0003, the net anthropogenic GHG removal by sink is:

$$\Delta C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t$$

Where:

$\Delta C_{AR-CDM,t}$	=	Net anthropogenic GHG removals by sink in year t; tCO_2-e
$\Delta C_{ACTUAL,t}$	=	Actual net GHG removals by sink in year t; tCO_2-e
$\Delta C_{BSL,t}$	=	Baseline net GHG removals by sink in year t; tCO_2-e
LK_t	=	GHG emissions due to leakage in year t; tCO_2-e

The equations and rationale for calculating each parameter above are described in the following sections.

4.1 Baseline Emissions

Net GHG removals by sinks in the baseline scenario

$$\Delta C_{BSL,t} = \Delta C_{TREE\_BSL,t} + \Delta C_{SHRUB\_BSL,t} + \Delta C_{DW\_BSL,t} + \Delta C_{LI\_BSL,t} \qquad \text{Equation 1}^{39}$$

[39] For equations 1, 2 and 3, the numbering adopted in the methodology *AR-ACM0003* was maintained.

Where:

$\Delta C_{BSL,t}$	=	Baseline net GHG removals by sinks in year *t*; t CO_2-e
$\Delta C_{TREE\_BSL,t}$	=	Change in carbon stock in baseline tree biomass within the project boundary in year *t*, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO_2-e
$\Delta C_{SHRUB\_BSL,t}$	=	Change in carbon stock in baseline shrub biomass within the project boundary, in year *t*, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”;; t CO_2-e
$\Delta C_{DW\_BSL,t}$	=	Change in carbon stock in baseline dead wood biomass within the project boundary, in year *t*, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO_2-e
$\Delta C_{LI\_BSL,t}$	=	Change in carbon stock in baseline litter biomass within the project boundary, in year *t*, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO_2-e

The methodological tool “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*” (in its most recent version) is used to determine the carbon stock in the baseline scenario.

To determine the carbon stock in trees in the baseline, the following items should be assessed:

1) The carbon stock in pre-existing trees may be considered as zero if:

(a) there are pre-existing trees in the baseline, and the trees are not harvested, deforested, or removed during the entire crediting period of the project activity;

(b) there are pre-existing trees in the baseline, and the trees do not suffer mortality due to competition from the trees planted by the project, or damage caused by the implementation of the project activity, at any time during the crediting period of the project activity;

(c) pre-existing trees are not measured together with the project trees when monitoring carbon stocks, but their continued existence is consistent with the baseline scenario, and is monitored throughout the crediting period of the project activity;

(d) there are no pre-existing trees in the baseline.

The following flow diagram (Figure 53) will be used for each PAI to determine the carbon stock of trees in the baseline scenario.

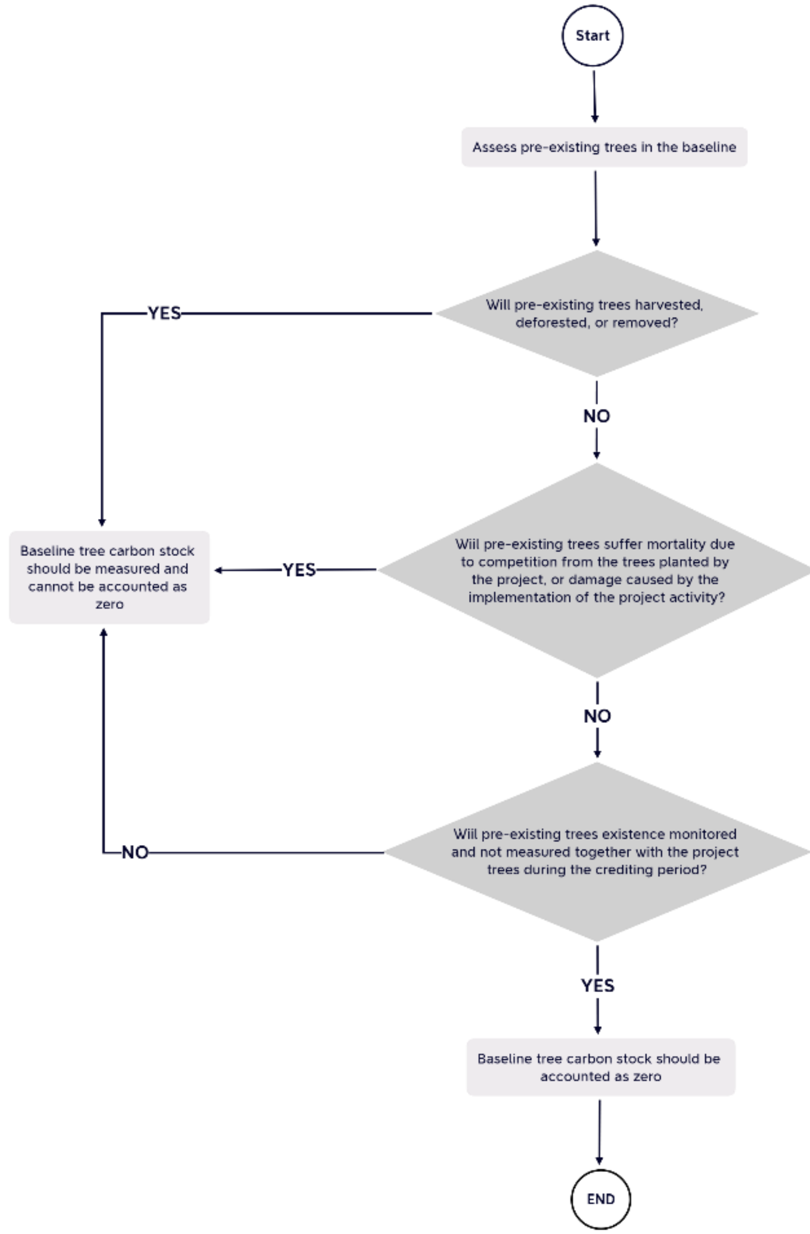

Figure 53. Flow diagram to determine carbon stock in trees in the baseline scenario.

The previous land use was determined as non-forested lands (as described in section 3.5 of this PD), especially agriculture and pasture. Although there may be some trees in the areas, their density will not characterize forest formation according to the Host Country's definition of forest. Preferably, the isolated trees in the project boundary will not be harvested and other forestry and planting activities will be carried out as to avoid competition with existing trees. However, whenever isolated trees occur in the PAI boundary three options will be available:

i) Georeference the pre-existing trees, at the time of inclusion of the PAI in the Grouped Project, and monitor their survival, and not measure these trees during the crediting period of the PAI, and/or;

ii) Harvest the pre-existing trees and apply the baseline discount, and/or;

iii) Pre-exsiting trees aren't harvested but are not georeferenced. So, conservatively, the PAI shall apply the baseline discount of these trees.

If the PAI should apply the discount for pre-existing trees in the baseline, the carbon stock in the baseline tree biomass within the project boundary could be estimated by stratified random sampling or census. According to the density of pre-existing trees the PAI could opt for one of the possible options of measurements below.

Option 1: stratified random sampling, is the most suitable for areas with higher density of trees.

Option 2: census, is the most suitable for areas with lower density of trees.

Option 1 estimated by measurement of sample plots using stratified random sampling, as described in the latest version of the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*" or Option 2) calculated through the census of the area.

For <u>Option 1</u> (measurement of sample plots), consider:

$$C_{TREE\_BL} = \frac{44}{12}\, x CF_{TREE\_BL} x B_{TREE\_BL}$$ Equation 12[40]

$$B_{TREE\_BL} = A\ x\ b_{TREE\_BL}$$ Equation 13

$$b_{TREE\_BL} = \sum_{i=1}^{M} w_i\ x\ b_{TREE\_BL,i}$$ Equation 14

$$u_{C\_BL} = \frac{t_{VAL}\ x\ \sqrt{\sum_{i=1}^{M} w_i^2\ x\ \frac{s_i^2}{n_i}}}{b_{TREE\_BL}}$$ Equation 15

$$b_{TREE\_BL,i} = \sum_{p=1}^{ni} b_{TREE\_BL,p,i}$$ Equation 16

[40] For Equations 12 to 17, the numbering adopted in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2* was maintained.

$$s_i^2 = \frac{n_i \ x \ \sum_{p=1}^{ni} b_{TREE\_BL,p,i}^2 - (\sum_{p=1}^{ni} b_{TREE\_BL,p,i})^2}{n_i \ x \ (n_i - 1)}$$ Equation 17

Where:

C_{TREE_BL}	=	Carbon stock in trees in the tree biomass estimation strata in the baseline; t CO_2e
CF_{TREE_BL}	=	Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$. A value of 0.50 is used, as recommended by the BRAZILIAN FOREST SERVICE - National Forest Information System[41].
B_{TREE_BL}	=	Tree biomass in the tree biomass estimation strata in the baseline; t d.m
A	=	Sum of areas of the tree biomass estimation strata; ha
b_{TREE_BL}	=	Mean tree biomass per hectare in the tree biomass estimation strata in the baseline; t d.m. ha^{-1}
w_i	=	Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata (i.e./); dimensionless
$b_{TREE\_BL,i}$	=	Mean tree biomass per hectare in stratum *i*; t d.m. ha^{-1}
u_{C_BL}	=	Uncertainty in C_{TREE_BL}
t_{VAL}	=	Two-sided Student's t-value for a confidence level of 90 per cent and degrees of freedom equal to n – M, where n is total number of sample plots within the tree biomass estimation strata and M is the total number of tree biomass estimation strata
s_i^2	=	Variance of tree biomass per hectare across all sample plots in stratum *i*; (t d.m. ha^{-1})^2
n_i	=	Number of sample plots in stratum *i*.
$b_{TREE\_BL,p,i}$	=	Tree biomass in the baseline per hectare in plot p of stratum *i*; t d.m. ha^{-1}

[41] https://snif.florestal.gov.br/pt-br/estoques-das-florestas/623-estoque-das-florestas-carbono

In this context, the biomass of the trees per hectare will be calculated as detailed in the Appendix 1 of the tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2*.

$$b_{TREE\_BL,p,i} = \frac{B_{TREE\_BL,p,i}}{A_{PLOT,i}} \times (1 + R_i)$$ Equation 1[42]

$$B_{TREE\_BL,p,i} = \sum_{j} B_{TREE\_BL,j,p,i}$$ Equation 2

$$B_{TREE\_BL,j,p,i} = \sum_{l} B_{TREE\_BL,l,j,p,i}$$ Equation 3

$$B_{TREE\_BL,l,j,p,i} = f_{BL,j}(x_{1,l}, x_{2,l}, x_{3,l}, \ldots)$$ Equation 4

Where:

$b_{TREE\_BL,p,i}$	=	Tree biomass per hectare in sample plot *p* of stratum in the baseline *i*; t d.m. ha^{-1}
$B_{TREE\_BL,p,i}$	=	Tree biomass in sample plot *p* of stratum *i* in the baseline; t d.m
$A_{PLOT,i}$	=	Size of sample plot in stratum *i* in the baseline; ha
R_i	=	Root-shoot ratio for stratum *i*; dimensionless
$B_{TREE\_BL,j,p,i}$	=	Biomass of trees of biome *j* in sample plot *p* of stratum *i* in the baseline; t d.m
$B_{TREE\_BL,l,j,p,i}$	=	Biomass of tree *l* of biome *j* in sample plot *p* of stratum *i* in the baseline; t d.m.
$f_{BL,j}(x_{1,l}, x_{2,l}, x_{3,l}, \ldots)$	=	Above-ground biomass of the tree returned by the allometric equation for biome *j* relating the measurements of tree *l* to the above-ground biomass of the tree; t d.m.

[42] For Equations 1 to 4, the numbering adopted in the Appendix 1 methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2* was maintained.

The value R_i is estimated as $R_i = \frac{e^{(-1.085+0.9256\times\ln b)}}{b}$, where "*b*" is the aboveground tree biomass per hectare (tons of dry matter ha^{-1}), as presented in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Version 04.2*.

For ***Option 2*** (census), consider:

$$C_{TREE\_BL} = \frac{44}{12}\, xCF_{TREE\_BL} x B_{TREE\_BL}$$ Equation 12[43]

Where:

C_{TREE_BL}	=	Carbon stock in trees in the baseline; t CO2e
CF_{TREE_BL}	=	Carbon fraction of tree biomass; t C (t d.m.)$^{-1}$. A value of 0.50[41].
B_{TREE_BL}	=	Tree biomass in the baseline; t d.m. ha^{-1}

In this context, the biomass of the trees will be calculated as detailed in the Appendix 1 of the tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2*.

$$B_{TREE\_BL} = \sum_i B_{TREE\_BL,i}$$ Equation 2[44]

$$B_{TREE\_BL,i} = f_{BL,i}(x_{1,l}, x_{2,l}, x_{3,l}, \ldots) \times (1 + R_i)$$ Equation 4

Where:

[43] For Equation 12 the numbering adopted in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2* was maintained.

[44] For Equations 2 and 4, the numbering adopted in the Appendix 1 methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2* was maintained.

$B_{TREE\_BL,i}$	=	Biomass of tree of biome (native) or species (exotic) *i* in the baseline; t d.m.
$f_{BL,i}(x_{1,l}, x_{2,l}, x_{3,l}, \dots)$	=	Above-ground biomass of the tree returned by the allometric equation for biome (native) *i* relating the measurements of tree *l* to the above-ground biomass of the tree; t d.m.
R_i	=	Root-shoot ratio for stratum *i*; dimensionless;

The value R_i is estimated as $R_i = \frac{e^{(-1.085+0.9256\times\ln b)}}{b}$, where "***b***" is the aboveground tree biomass per hectare (tons of dry matter ha^{-1}), as presented in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Version 04.2*.

According to section 5.12 of the tool, changes in carbon stocks in trees and shrubs in the baseline may be accounted as zero for those lands for which the project participants can demonstrate, that one or more of the following indicators apply:

a. Observed reduction in topsoil depth (e.g. as shown by root exposure, presence of pedestals, exposed sub-soil horizons);

b. Presence of gully, sheet or rill erosion; or landslides, or other forms of mass movement erosion;

c. Presence of plant species locally known to be indicators of infertile land;

d. Land comprises of bare sand dunes, or other bare lands;

e. Land contains contaminated soils, mine spoils, or highly alkaline or saline soils;

f. Land is subjected to periodic cycles (e.g. slash-and-burn, or clearing-regrowing cycles) so that the biomass oscillates between a minimum and a maximum value in the baseline;

g. Conditions (a), (b) and (c) under paragraph 11 apply.

As presented in the section 3.5 of this PD, the previous land use was determined as non-forested lands, especially agriculture and pasture. So, probable the condition "f" and "g" will be applied to the PAI and the carbon stocks in shrubs in the baseline could be accounted as zero.

If the presence of shrubs is observed in the base line condition and these shrubs were harvested, the carbon stock in baseline shrub biomass within the project boundary will be estimated by proportionate crown cover, as described in the latest version of the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*".

Those areas where the shrub crown cover is less than 5 per cent are treated as a single stratum and the shrub biomass in this stratum is estimated as zero. For those areas where the shrub crown cover is more than 5 per cent, the carbon stock in baseline shrub biomass within the project boundary will be estimated as follows:

$$C_{SHRUB,t} = \frac{44}{12} \times CF_s \times (1 + R_S) \times \sum_i A_{SHRUB,i} \times b_{SHRUB,i}$$

Equation 26[45]

$$b_{SHRUB,i} = BDR_{SF} \times b_{FOREST} \times CC_{SHRUB,i}$$

Equation 27

Where:

$C_{SHRUB,t}$	=	Carbon stock in shrubs within the project boundary at a given point of time in year *t*; t CO2-e. [In this Grouped Project represents the carbon stock in baseline shrub biomass at the time of PAI inclusion].
CF_s	=	Carbon fraction of shrub biomass; t C (t.d.m.)$^{-1}$. A value of 0.50[41] t C (t.d.m.)$^{-1}$ is used.
R_S	=	Root-shoot ratio for shrubs; dimensionless. The default value of 0.40 is used.
$A_{SHRUB,i}$	=	Area of shrub biomass estimation stratum *i*; ha
$b_{SHRUB,i}$	=	Shrub biomass per hectare in shrub biomass estimation stratum *i*; t d.m. ha^{-1}

[45] For Equations 26 and 27, the numbering adopted in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2* was maintained.

BDR_{SF}	=	Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 (i.e. 100 per cent) and the default above-ground biomass content per hectare in forest in the region/country where the A/R project activity is located; dimensionless. A default value of 0.10 should be used unless transparent and verifiable information can be provided to justify a different value. [to be defined by the specific PAI at the time of inclusion in the Grouped Project]
b_{FOREST}	=	Mean above-ground biomass in forest in the region or country where the A/R project is located; t d.m. ha^{-1}. Values from Table 3A.1.4 of IPCC GPG-LULUCF 2003 are used unless transparent and verifiable information can be provided to justify different values. [to be defined by the specific PAI at the time of inclusion in the Grouped Project]
$CC_{SHRUB,i}$	=	Crown cover of shrubs in shrub biomass estimation stratum *i* at the time of estimation, expressed as a fraction.

4.2 Project Emissions

Actual net GHG removals by sinks

Actual net GHG removals by sinks are calculated in accordance with the methodology applied and the most recent version of the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*".

$$\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t}$$ Equation 2[46]

Where:

$\Delta C_{ACTUAL,t}$	=	Actual net GHG removals by sinks, in year *t*; t CO_2-e
$\Delta C_{P,t}$	=	Change in the carbon stocks in the project, occurring in the selected carbon pools, in the year *t*; t CO_2-e

[46] For Equations 2 and 3, the numbers adopted by the "*AR-ACM0003, version 02.0*" has been maintained.

$GHG_{E,t}$	=	Increase in non-CO_2 GHG emissions within the project boundary as a result of the implementation of the A/R project activity, in year *t*, as estimated in the tool "Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity"; t CO_2-e

A. CHANGE IN THE CARBON STOCKS IN PROJECT OCCURRING IN THE SELECTED CARBON POOLS, IN THE YEAR *T*

$$\Delta C_{P,t} = \Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t} + \Delta C_{DW\_PROJ,t} + \Delta C_{LI\_PROJ,t} + \Delta SOC_{AL,t} \quad \text{Equation 3}$$

Where:

$\Delta C_{P,t}$	=	Change in the carbon stocks in project, occurring in the selected carbon pools, in the year *t*; t CO2-e
$\Delta C_{TREE\_PROJ,t}$	=	Change in carbon stock in tree biomass in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{SHRUB\_PROJ,t}$	=	Change in carbon stock in shrub biomass in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO_2-e
$\Delta C_{DW\_PROJ,t}$	=	Change in carbon stock in dead wood in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO_2-e
$\Delta C_{LI\_PROJ,t}$	=	Change in carbon stock in litter in project in year *t*, as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO_2-e
$\Delta SOC_{AL,t}$	=	Change in carbon stock in SOC in project, in year *t*, in areas of land meeting the applicability conditions of the tool "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities", as estimated in the same tool; t CO_2-e

TREES

The **average carbon stock in trees** within the stratum for estimation of tree biomass will be calculated as follows (all the time-dependent quantities refer to the time of measurement):

$$\Delta C_{TREE\_PROJ,t} = C_{TREE}$$

Then,

$$C_{TREE} = \frac{44}{12} \times CF_{TREE} \times B_{TREE}$$ Equation 12[47]

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

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

Where:

C_{TREE}	=	Carbon stock in trees in the tree biomass estimation strata; t CO_2e
CF_{TREE}	=	Carbon fraction in tree biomass; t C (t d.m.)$^{-1}$ A value of 0.50[41] is used
B_{TREE}	=	Tree biomass in the tree biomass estimation strata; t d.m
A	=	Sum of areas of the tree biomass estimation strata; ha
b_{TREE}	=	Mean tree biomass per hectare in the tree biomass estimation strata; td.m.ha^{-1}
Wi	=	Ratio of the area of stratum *i* to the sum of areas of tree biomass estimation strata (i.e., $w_i = A_i/A$); dimensionless
$b_{TREE,i}$	=	Mean tree biomass per hectare in stratum *i*; td.m.ha^{-1}

The parameter $b_{TREE,i}$ should be calculated using two options:

Option 1: census using remote sensing and/or field measurements.

Option 2: stratified random sampling.

Option 1: $b_{TREE,i}$ is calculated using a allometric equation correlating aboveground tree biomass and data collected from remote sensing and/or field measurements. This allometric equation should be adjusted according to "*VT0005: Tool for measuring aboveground live forest biomass using remote sensing. Version*

[47] For equations 12 to 15 the numbering adopted in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Version 04.2*. has been maintained.

1.0", and could considered different phytophysiognomies and/or a role biome. The allometric equation selected for each PAI should be from National Forest Inventories and or other verified information (for example: relevant scientific publication).

Each stratum of the PAI could be measured by a remote sensing equipment (for example: a drone with LiDAR equipment) and the quantification of the above ground biomass will use the data collected as an independently parameter (for example: average high of each pixel) to calculate the predictive variable (aboveground tree biomass). Finally the $b_{TREE,I}$ will be calculated as follows:

$$b_{TREE,i} = AGB_i \times (1 + R_i)$$ Equation 1[48]

$$AGB_i = f_j(x_{1,j}, x_{2,j}, x_{3,j}, \ldots)$$ Equation 2

Where:

AGB_i	=	Aboveground tree biomass per hectare in stratum *i*; t d.m. ha^{-1}
R_i	=	Root-shoot ratio for stratum *i*; dimensionless
$f_i(x_{1,j}, x_{2,j}, x_{3,j}, \ldots)$	=	Above-ground biomass of the tree returned by the allometric equation for stratum *i* which represents a ratio between measurement of remote sensing data and aboveground tree biomass;t d.m..

The value R_i is estimated as $R_i = \frac{e^{(-1.085+0.9256\times\ln b)}}{b}$, where b is the aboveground tree biomass per hectare (tons of dry matter ha-1), as presented in the methodological tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Version 04.2.

As the remote sensing data will be collected for all area of each stratum of the project activity, this monitoring approach will represent a census of the aboveground biomass. Some plots could be used as a field measurement to calibrate the allometric equation.

Option 2: $b_{TREE,i}$ is calculated using stratified random sampling using a allometric equation. The equation chosen will be presented by each PAI when it's included in the Grouped Project and should meets condition 6(c) of the tool "*Demonstrating appropriateness of allometric equations for estimation of aboveground tree biomass in A/R CDM project activities*", version 01.0.0. The allometric equation selected for each PAI should be from National Forest Inventories and or other verified information (for example: relevant scientific publication).

[48] For Equation 1 and 2 of this section no tool numbering reference was adopted.

The calculation will follow:

$$b_{TREE,p,i} = \frac{B_{TREE,p,i}}{A_{PLOT,i}} \times (1 + R_i)$$ Equation 1[49]

$$B_{TREE,p,i} = \sum_j B_{TREE,j,p,i}$$ Equation 2

$$u_C = \frac{t_{VAL} \times \sqrt{\sum_{i=1}^{M} w_i^2 \times \frac{s_i^2}{n_i}}}{b_{TREE}}$$ Equation 15

Where:

$b_{TREE,p,i}$	=	Tree biomass per hectare in sample plot *p* of stratum *i*; t d.m. ha^{-1}
$B_{TREE,p,i}$	=	Tree biomass in sample plot *p* of stratum *i*; t d.m.
$A_{PLOT,i}$	=	Size of sample plot in stratum *i*; ha
$B_{TREE,j,p,i}$	=	Biomass of trees of species *j* in sample plot *p* of stratum *i*; t d.m.
R_i	=	Root-shoot ratio for stratum *i*; dimensionless
u_C	=	Uncertainty in C_{TREE}
t_{VAL}	=	Two-sided Student's t-value for a confidence level of 90 per cent and degrees of freedom equal to n – M, where n is total number of sample plots within the tree biomass estimation strata and M is the total number of tree biomass estimation strata
s_i^2	=	Variance of tree biomass per hectare across all sample plots in stratum *i*; (t d.m. ha^{-1})
n_i	=	Number of sample plots in stratum *i*.

[49] For the equations of 1, 2 and 15, the numbering adopted in Appendix 1 of the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Version 04.2* was maintained.

If the estimate from Equation (15) is higher than 10 per cent, its conservativeness can be increased by applying the uncertainty discount provided in Appendix 2 of the tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*", version 04.2.

The value R_j is estimated as $R_j = \frac{e^{(-1.085+0.9256\times\ln b)}}{b}$, where b is the aboveground tree biomass per hectare (tons of dry matter ha-1), as presented in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" Version 04.2*.

$$B_{TREE,j,p,i} = f_j(x_{1,j}, x_{2,j}, x_{3,j}, \dots) \qquad \text{Equation 4}$$

Where:

$B_{TREE,j,p,i}$	=	Biomass of tree *j* in sample plot *p* of stratum *i*; t d.m.
$f_i(x_{1,j}, x_{2,j}, x_{3,j}, \dots)$	=	Above-ground biomass of the tree returned by the allometric equation for stratum *i* which represents a ratio between measurement of the tree diameter (DBH) and tree height and aboveground tree biomass;t d.m..

The parameter $f_i(x_{1,j}, x_{2,j}, x_{3,j}, \dots)$ represents the allometric equation reflecting DBH and height (Ht), and can be considered in the two forms below:

f : as phytophysiognomies, per type; or

f : as biome, per type.

SHRUB

In the project scenario each PAI should stratify the project boundary according to the shrub crown cover. Those areas where the shrub crown cover is less than 5 per cent are treated as a single stratum and the shrub biomass in this stratum is estimated as zero. For those areas where the shrub crown cover is more than 5 per cent, the carbon stock in project shrub biomass within the project boundary will be estimated as follows:

$$C_{SHRUB,t} = \frac{44}{12} \times CF_s \times (1 + R_S) \times \sum_i A_{SHRUB,i} \times b_{SHRUB,i}$$ Equation 26[50]

$$b_{SHRUB,i} = BDR_{SF} \times b_{FOREST} \times CC_{SHRUB,i}$$ Equation 27

Where:

$C_{SHRUB,t}$	=	Carbon stock in shrubs within the project boundary at a given point of time in year *t*; t CO2-e. [In this Grouped Project represents the carbon stock in project shrub biomass at the time of PAI verification].
CF_s	=	Carbon fraction of shrub biomass; t C (t.d.m.)$^{-1}$. A default value of 0.50[41] t C (t.d.m.)$^{-1}$ is used.
R_S	=	Root-shoot ratio for shrubs; dimensionless. The default value of 0.40 is used.
$A_{SHRUB,i}$	=	Area of shrub biomass estimation stratum *i*; ha
$b_{SHRUB,i}$	=	Shrub biomass per hectare in shrub biomass estimation stratum *i*; t d.m. ha^{-1}
BDR_{SF}	=	Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 (i.e. 100 per cent) and the default above-ground biomass content per hectare in forest in the region/country where the A/R project activity is located; dimensionless. A default value of 0.10 should be used unless transparent and verifiable information can be provided to justify a different value. [to be defined by the specific PAI at the time of each verification]
b_{FOREST}	=	Mean above-ground biomass in forest in the region or country where the A/R project is located; t d.m. ha^{-1}. Values from Table 3A.1.4 of IPCC GPG-LULUCF 2003 are used unless transparent and verifiable information can be provided to justify different values. [to be defined by the specific PAI at the time of each verification]
$CC_{SHRUB,i}$	=	Crown cover of shrubs in shrub biomass estimation stratum *i* at the time of estimation, expressed as a fraction.

[50] For Equations 26 and 27, the numbering adopted in the methodological tool "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" version 04.2* was maintained.

DEAD WOOD AND LITTER

Dead wood and litter will be calculated in accordance with the AR-TOOL 12 "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities, Version 03.0". The dead wood will be calculated as:

$$C_{DW\_PROJ,i,t} = C_{TREE\_PROJ,i,t} \times DF_{DW}$$

Where:

$C_{DW\_PROJ,i,t}$	=	Carbon stock in dead wood in stratum *i* at a given point of time in year *t*; t CO2e
C_{TREE_PROJ}	=	Carbon stock in trees biomass in stratum *i* at a point of time in year *t*, as calculated in tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO2e
DF_{DW}	=	Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; percent
I	=	1, 2, 3, … biomass estimation strata within the project boundary
t	=	1, 2, 3, … years elapsed since the start of the A/R CDM project activity

Value of the conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass (DF_{DW}) could be selected according to the guidance provided in the "AR-TOOL 12 "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities, Version 03.0", unless transparent and verifiable information can be provided to justify a different value in the inclusion of each PAI.

The carbon stock in litter will be calculated as:

$$C_{LI\_PROJ,i,t} = C_{TREE\_PROJ,i,t} \times DF_{LI}$$

Where:

C_{LI_PROJ}	=	Carbon stock in litter in stratum i at a given point of time in year t; t CO2e
C_{TREE_PROJ}	=	Carbon stock in trees biomass in stratum i at a point of time in year t, as calculated in tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO2e
DF_{LI}	=	Conservative default factor expressing carbon stock in litter as a percentage of carbon stock in tree biomass; percent

Value of the conservative default factor expressing carbon stock in litter as a percentage of carbon stock in tree biomass (DF_{LI}) could be selected according to the guidance provided in the “AR-TOOL 12 “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities, Version 03.0”, unless transparent and verifiable information can be provided to justify a different value in the inclusion of each PAI.

The rate of change of deadwood biomass over a period of time is calculated assuming a linear change. Therefore, the rate of change in carbon stock in deadwood over a period of time is calculated as follows:

$$dC_{DW\_PROJ,(t1,t2)} = \frac{C_{DW\_PROJ,t2} - C_{DW\_PROJ,t1}}{T}$$

where:

$dC_{DW\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in dead wood within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1
$C_{DW\_PROJ,t2}$	=	Carbon stock in dead wood within the project boundary at a point of time in year t2; t CO2e
$C_{DW\_PROJ,t1}$	=	Carbon stock in dead wood within the project boundary at a point of time in year t1; t CO2e
T	=	Time elapsed between two successive estimations (T=t2 – t1); yr

Change in carbon stock in deadwood within the project boundary in year t (t1 ≤ t ≤ t2) is given by:

$$\Delta C_{DW\_PROJ,t} = dC_{DW\_PROJ,(t1,t2)} \times 1\ year\ for\ t1 \leq t \leq t2$$

where:

$\Delta C_{DW\_PROJ,t}$	=	Change in carbon stock in dead wood within the project boundary in year t; t CO2e
$dC_{DW\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in dead wood within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1

The rate of change of litter biomass over a period of time is calculated assuming a linear change. Therefore, the rate of change in carbon stock in litter over a period of time is calculated as:

$$dC_{LI\_PROJ,(t1,t2)} = \frac{C_{LI\_PROJ,t2} - C_{LI\_PROJ,t1}}{T}$$

where:

$dC_{LI\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in litter within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1
$C_{LI\_PROJ,t2}$	=	Carbon stock in litter within the project boundary at a point of time in year t2; t CO2e
$C_{LI\_PROJ,t1}$	=	Carbon stock in litter within the project boundary at a point of time in year t1; t CO2e
T	=	Time elapsed between two successive estimations (T=t2 – t1); yr

Change in carbon stock in litter within the project boundary in year t (t1 ≤ t ≤ t2) is given by:

$$\Delta C_{LI\_PROJ,t} = dC_{LI\_PROJ,(t1,t2)} \times 1\, year\; for\; t1 \leq t \leq t2$$

where:

$\Delta C_{LI\_PROJ,t}$	=	Change in carbon stock in litter within the project boundary in year t; t CO2e
$dC_{LI\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in litter within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1

SOIL ORGANIC CARBON

Soil organic carbon will be calculated based on the “AR-AM Tool 16: tool for the estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities. Version 1.0”. The estimation of soil organic carbon considers the soil type, clay content, the level of degradation of pastures and their management, including the application of inputs, all to obtain an estimate of the carbon stock at the immediate time before the start of the project ($SOC_{INITIAL}$). The result is then compared to soil organic carbon stock in reference ecosystems (SOC_{REF}) to define how much carbon could be assimilate in this pool over time:

$$SOC_{INITIAL,i} = SOC_{REF,i} \times f_{LU,i} \times f_{MG,i} \times f_{IN,i}$$

Where:

$SOC_{INITIAL,i}$	=	SOC stock at the beginning of the A/R project activity in stratum i of the areas of land; t C ha-1
$SOC_{REF,i}$	=	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation ñ

		normally forest) by climate region and soil type applicable to stratum i of the areas of land; t C ha-1
$f_{LU,i}$	=	Relative stock change factor for baseline land-use in stratum i of the areas of land; dimensionless
$f_{MG,i}$	=	Relative stock change factor for baseline management regime in stratum i of the areas of land; dimensionless
$f_{IN,i}$	=	Relative stock change factor for baseline input regime (e.g. crop residue returns, manure) in stratum i of the areas of land; dimensionless
I	=	1, 2, 3, … strata of areas of land; dimensionless

The values of $SOC_{REF,i}$, $f_{LU,i}$, $f_{MG,i}$ and $f_{MG,i}$ could be selected according to the guidance provided in the "AR-AM Tool 16: tool for the estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities. Version 1.0", unless transparent and verifiable information can be provided to justify a different value in the inclusion of each PAI.

Then, the rate of change in SOC stock in project scenario until the steady state is reached is estimated as follows:

$$dSOC_{t,}i = (SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i}))/20 \text{ years}$$

$$\text{for } t_{PREP,i} < t \leq t_{PREP,i} {}_{+20}$$

Where:

$d_{SOCt,i}$	=	The rate of change in SOC stock in stratum i of the areas of land in year t; t C ha-1 yr-1
$SOC_{REF,i}$	=	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation ñ normally forest) by climate region and soil type applicable to stratum i of the areas of land; t C ha-1
$SOC_{INITIAL,i}$	=	SOC stock at the beginning of the A/R project activity in stratum i of the areas of land; t C ha-1
$SOC_{LOSS,i}$	=	Loss of SOC caused by soil disturbance attributable the A/R project activity, in stratum i of the areas of land; t C ha-1
i	=	1, 2, 3, … strata of areas of land; dimensionless
t	=	1, 2, 3, … years elapsed since the start of the A/R project activity

Each PAI will provided that the soil disturbance attributable to project activity in the strata where SOC will be accounted will be less than 10% of the area of the stratum. Hence, the carbon loss could be considered as zero. The change in SOC stock for all the strata of the areas of land, in year t. will be calculated as indicated in Equation 8 of the tool:

$$\Delta SOC_{AL,t} = \frac{44}{12} \times \sum_i Ai \times dSOC_{t,i} \times 1\text{year}$$

Where:

$\Delta SOC_{AL,t}$	=	Change in SOC stock in areas of land meeting the applicability conditions of this tool. in year t; t CO2-e
Ai	=	The area of stratum i of the areas of land; ha
$dSOC_{t,i}$	=	The rate of change in SOC stocks in stratum i of the areas of land; t C ha-1 yr-1
i	=	1, 2, 3, … strata of areas of land; dimensionless

B. CHANGE INCREASE IN NON-CO2 GHG EMISSIONS WITHIN THE PROJECT BOUNDARY AS A RESULT OF THE IMPLEMENTATION OF THE A/R PROJECT ACTIVITY, IN YEAR T

In accordance with the methodology applied, the only source of GHG emissions accounted for the projects is those from burning, whether accidental or not.

The methodological tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" [51] is used for calculation of GHG emissions by fires.

$$GHG_{E,t} = GHG_{SPF,t} + GHG_{FMF,t} + GHG_{FF,t} \qquad \text{Equation 1}^{52}$$

Where:

$GHG_{E,t}$	=	Emission of non-CO_2 GHGs resulting from burning of biomass and forest fires within the project boundary in year *t*; t CO_2-e
$GHG_{SPF,t}$	=	Emission of non-CO_2 GHGs resulting from use of fire in site preparation in year *t*; t CO_2-e
$GHG_{FMF,t}$	=	Emission of non-CO_2 GHGs resulting from use of fire to clear the land of harvest residue prior to replanting of the land or other forest management, in the year *t*; t CO_2-e
$GHG_{FF,t}$	=	Emission of non-CO_2 GHGs resulting from fire in the year *t*; t CO_2-e

[51] See https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-08-v4.0.0.pdf

[52] For equation 1, the numbering adopted in the methodological tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" Version 04.0.0* has been maintained.

The three circumstances admitted by the tool in which there may be GHG emissions in the projects are:

- *Non-CO_2 emissions resulting from use of fire in preparation of the area;*
- *Non-CO_2 emissions resulting from the use of fire to clean the area of harvest waste before replanting or a new forest management phase; and*
- *Non-CO_2 emissions resulting from forest fire.*

As described in previously sections, this Grouped Project does not use fire as a clearing technique ($GHG_{SPF,t}$ and $GHG_{FMF,t}$). Thus, only the third option, forest fires, can occur, which are usually accidental and not part of the usual management practices.

In case of forest fires, the area affected will be monitored according to parameter $A_{BURN,i,t}$ described in section 5.2. The emissions of non-CO_2 resulting from forest fire will be calculated as per the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*":

$$GHG_{FF,t} = GHG_{FF\_TREE,t} + GHG_{FF\_DOM,t}$$ Equation 6[32]

Where:

$GHG_{FF,t}$	=	Emission of non-CO_2 GHGs resulting from forest fire, in year *t*; tCO_2-e
$GHG_{FF\_TREE,t}$	=	Emission of non-CO_2 GHGs resulting from the loss of aboveground biomass of trees due to forest fire, in year *t*; tCO_2-e
$GHG_{FF\_DOM,t}$	=	Emission of non-CO_2 GHGs resulting from the loss of dead organic matter due to forest fire, in year *t*; tCO_2-e

As per the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*", emission of non-CO_2 GHGs resulting from the loss of aboveground tree biomass due fire is calculated using the above ground biomass in trees of relevant strata in last verification and a combustion factor. For the first verification, emission of non-CO2 GHGs resulting from the loss of trees due to natural or anthropogenic forest fire is assumed to be zero.

$$GHG_{FF\_TREE,t} = 0.001 * \sum_{i=1}^{M} A_{BURN,i,t} * b_{TREE,i,t_L} * COMF_i * \left(EF_{CH4,i} * GWP_{CH4} + EF_{N2O,i} * GWP_{N2O}\right)$$ Equation 7[53]

[53] For Equation 7 and 8 the numbering adopted in the methodological tool *"Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" version 04.0.0*. was maintained.

Where:

$GHG_{FF\_TREE,t}$	=	Emission of non-CO_2 GHGs resulting from the loss of aboveground biomass of trees due to forest fire, in year *t*; tCO_2-e
$A_{BURN,i,t}$	=	Area burnt in stratum *i* in year *t*; ha
b_{TREE,i,t_L}	=	Mean aboveground tree biomass per hectare in stratum *i* in year *tL* which is the year in which last verification was carried out before occurrence of the fire; t d.m. ha^{-1} Where aboveground biomass of living trees is not burnt by fire, $b_{TREE,i,tL}$ may be set equal to zero
$COMF_i$	=	Combustion factor for stratum *i*; dimensionless
$EF_{CH4,i}$	=	Emission factor for CH_4 in stratum *i*; g CH4 (kg dry matter burnt)$^{-1}$
GWP_{CH4}	=	Global warming potential for CH4; dimensionless
$EF_{N2O,i}$	=	Emission factor for N_2O in stratum *i*; g N_2O (kg dry matter burnt)$^{-1}$
GWP_{N2O}	=	Global warming potential for N2O; dimensionless
I	=	1, 2, 3 … *M* strata
T	=	1, 2, 3, . years elapsed since the start of the project activity

As per the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*", emission of non-CO_2 GHGs resulting from the loss of dead organic matter due to fire is calculated using the dead organic matter stock at the last verification. For the first verification period emission of non-CO_2 GHGs resulting from the loss of dead organic matter due to fire is assumed to be zero, and for subsequent verification periods emission of non-CO2 GHGs is estimated as follows:

$$GHG_{FF\_DOM,t} = 0.07 * \sum_{i=1}^{M} A_{BURN,i,t} * \left(C_{DW,i,t_L} + C_{LI,i,t_L}\right) \quad \text{Equation 8}$$

Where:

$GHG_{FF\_DOM,t}$	=	Emission of GHGs resulting from the loss of dead organic matter due to fire, in year *t*; t CO_2-e
$A_{BURN,i,t}$	=	Area burnt in stratum *i* in year *t*; ha
C_{DW,i,t_L}	=	Carbon stock in dead wood in stratum *i* in year *tL* which is the year in which last verification was carried out before occurrence of the fire, as estimated using the "Tool for estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO_2-e
C_{LI,i,t_L}	=	Carbon stock in litter in stratum i in year tL which is the year in which last verification was carried out before occurrence of the fire, as estimated using the "Tool for estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"; t CO_2-e
I	=	1, 2, 3 … *M* strata
T	=	1, 2, 3, . years elapsed since the start of the project activity

4.3 Leakage

To calculate leakage emissions, the methodological tool "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*" will be applied.

$$LK_t = LK_{AGRIC,t} \qquad \text{Equation 4}$$

Where:

LK_t	=	GHG emissions due to leakage in the year t; t CO2-e
$LK_{AGRIC,t}$	=	Leakage due to the displacement of agricultural activities in year t, as estimated in the tool "Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R project activity"; t CO_2-e

In the methodological tool "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*" is described that:

> *§9 Leakage emission attributable to the displacement of agricultural activities due to implementation of an A/R CDM project activity is estimated as the decrease in carbon stocks in the affected carbon pools of the land receiving the displaced activity.*
>
> *Note 1. Displacement of an agricultural activity by itself does not result in leakage emission. Leakage emission occurs when the displacement leads to an increase in GHG emissions relative to the GHG emissions attributable to the activity as it exists within the project boundary.*
>
> *Note 2. Increase in GHG emission occurring outside the project boundary attributable to the secondary effects of the A/R CDM project activity (e.g. changes in demand, supply or price of goods) is considered insignificant for the purpose of this tool and hence accounted as zero.*

As established in item 5.3, one of the criteria for eligibility of the PAIs is evaluation of the proposed area for the project to determine whether there has been or will be displacement of agricultural activity to a new area. If the PAI pre-project agriculture activity does not result in displacement to other lands and/or the displacement of an agricultural activity occurs by itself then the PAI does not result in leakage emissions, and GHG emissions due to leakage may be considered as zero.

The AR-TOOL 15 "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*" states that leakage emission attributable to the displacement of grazing activities under the following conditions is considered insignificant and hence accounted as zero (§10):

> (a) Animals are displaced to existing grazing land and the total number of animals in the receiving grazing land (displaced and existing) does not exceed the carrying capacity of the grazing land;
>
> (b) Animals are displaced to existing non-grazing grassland and the total number of animals displaced does not exceed the carrying capacity of the receiving grassland;
>
> (c) Animals are displaced to cropland that has been abandoned within the last five years;
>
> (d) Animals are displaced to forested lands, and no clearance of trees, or decrease in crown cover of trees and shrubs, occurs due to the displaced animals;
>
> (e) Animals are displaced to zero-grazing system.

Within the Project Zone, extensive cattle raising has been the main land use for more than three decades. In this region, there are many rural properties that can absorb the moved cattle without the need for opening new areas. This is feasible as cattle raising in Brazil is practiced at very low productivity rates, where about 0.4-0.8 animal/ha are commonly observed in the pasturelands[54].

In the case of the Project Activity Instances of the project, the previous landowner has specific alternatives to move the cattle:

- he cattle can be sold to slaughterhouses as they reach maturity;
- The cattle can be sold to neighbour properties where cattle raising is the main activity and pasture is the main land-cover;
- The cattle can be gradually moved to remaining pasture lands within the project area until every animal be sold to slaughterhouses or neighbours.

Thus, the most likely scenario is that the cattle will be displaced to existing grazing lands, but without overcoming land carrying capacity. Considering this and according to the AR-TOOL 15, leakage emissions attributable to the displacement of cattle raising in the Project Area is considered insignificant and hence measured as zero.

$LK_t = 0$

If the area qualifies for the calculation of leakage emissions due to displacement of activity, the following equations of the tool "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*", will be applied:

$$LK_{AGRIC,t} = \frac{44}{12} \times (\Delta C_{BIOMASS,t} + \Delta SOC_{LUC,t})$$ Equation 1[55]

$$\Delta C_{BIOMASS,t} = [1{,}1 \times b_{TREE} \times (1 + R_{TREE}) + b_{SHRUB} \times (1 + R_S)] \times CF \times A_{DISP,t}$$ Equation 2

$$\Delta SOC_{LUC,t} = SOC_{REF} \times (f_{LUP} \times f_{MGP} \times f_{INP} - f_{LUD} \times f_{MGD} \times f_{IND}) \times A_{DISP,t}$$ Equation 3

[54] https://www.infoteca.cnptia.embrapa.br/bitstream/doc/986147/1/DOC402.pdf

[55] For Equations 1, 2 and 3, the numbering adopted in the methodological tool "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*" has been maintained.

Where:

$\Delta C_{BIOMASS,t}$	=	Decrease in carbon stock in the carbon pools of the land receiving the activity displaced in year *t*; t d.m. Note. The factor of 1.1 is used to account for the carbon stock in the dead wood and litter pools as a fixed percentage of the carbon stock in living trees
CF	=	Carbon fraction of woody biomass; dimensionless. A value of 0.50[41] is used.
$A_{DISP,t}$	=	Area of land from which agricultural activity is being displaced in the year *t*; ha
b_{TREE}	=	Mean above-ground tree biomass in land receiving the displaced activity; t d.m. ha^{-1}.
R_{TREE}	=	Root-shoot ratio for trees in the land receiving the displaced activity; dimensionless A default value of 0.25 is used unless transparent and verifiable information can be provided to justify a different value.
b_{SHRUB}	=	Mean above-ground shrub biomass in land receiving the displaced activity; t d.m. ha^{-1}. The value of this parameter is obtained by applying one of the applicable methods from the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" to the land receiving the displaced activity.
R_S	=	Root-shoot ratio for shrubs in the land receiving the displaced activity; dimensionless. The default value of 0.40 is used unless transparent and verifiable information can be provided to justify a different value.
$\Delta SOC_{LUC,t}$	=	Change in soil organic carbon (SOC) stock due to land-use change in the land receiving the displaced activity in year *t*; tC ha^{-1}. The value of this parameter may be set to zero if: (a) The only displaced activity being received in the land is grazing activity; or (b) The value of the parameter as estimated from Equation (3) is less than zero (i.e. negative).
SOC_{REF}	=	SOC stock corresponding to the reference condition in native lands by climate region and soil type applicable to the land receiving the displaced activity; t C ha^{-1}. The value of this parameter is taken from Table 3 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities".
f_{LUP}, f_{MGP}, f_{INP}	=	Relative SOC stock change factors for land-use, management practices, and inputs respectively, applicable to the receiving land before the displaced activity is received; dimensionless. The value of these parameters is taken from Tables 4, 5, and 6 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities"

$f_{LUD}, f_{MGD}, f_{IND}$	=	Relative SOC stock change factors for land-use, management practices, and inputs respectively, applicable to the receiving land after the displaced activity has been received; dimensionless. The value of these parameters is taken from Tables 4, 5, and 6 of the "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities".
t	=	1, 2, 3... years elapsed since the start of the A/R project activity.

4.4 Net GHG Emission Reductions and Removals

According to the methodology AR-ACM0003, the net anthropogenic GHG removal by sink is:

$$\Delta C_{AR-CDM,t} = \Delta C_{ACTUAL,t} - \Delta C_{BSL,t} - LK_t$$

Where:

$\Delta C_{AR-CDM,t}$	=	Net anthropogenic GHG removals by sink in year t; tCO_2-e
$\Delta C_{ACTUAL,t}$	=	Actual net GHG removals by sink in year t; tCO_2-e
$\Delta C_{BSL,t}$	=	Baseline net GHG removals by sink in year t; tCO_2-e
LK_t	=	GHG emissions due to leakage in year t; tCO_2-e

For the ex-ante estimation of the GHG emissions and removals for the project instances within the project scenario, the following approaches were used. The actual net GHG removals by sinks are calculated using equation 2 of the AR-ACM0003 methodology as follows:

$$\Delta C_{ACTUAL,t} = \Delta C_{P,t} - GHG_{E,t}$$

$\Delta C_{ACTUAL,t}$	=	Actual net GHG removals by sinks, in year t; t CO2-e.
$\Delta C_{P,t}$	=	Change in the carbon stocks in project, occurring in the selected carbon pools, in year t; t CO2-e
$GHG_{E,t}$	=	Increase in non-CO2 GHG emissions within the project boundary as a result of the implementation of the A/R CDM project activity, in year t, as estimated in the tool "Estimation of non-CO2 GHG

emissions resulting from burning of biomass attributable to an A/R CDM project activity”; t CO2-e

EMISSIONS

Considering GHG emissions, as stated in section 5.5.14 of the A/R CDM Methodology AR-ACM0003:

> “*GHG emissions resulting from removal of herbaceous vegetation, combustion of fossil fuel, fertilizer application, use of wood, decomposition of litter and fine roots of N-fixing trees, construction of access roads within the project boundary, and transportation attributable to the project activity shall be considered insignificant and therefore accounted as zero*”.

Thus, the increase in non-CO2 GHG emissions within the project boundary as a result of the implementation of the Project Activities was considered by using the AR-TOOL 08 “*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*”. In summary it can be stated that:

i) Fire is used for site preparation or as part of the reforestation project activity;
ii) The project includes activities of harvesting but does not induce fire to clear the land of harvested residue or any other forest management practice;
iii) In case of PAI-001 and new PAIs to be added to the project, no fire is admitted in the areas from the start of the management proposed the project proponent, and due to mitigation actions (firebreaks, and brigades training) the risk is considered low.

Considering these conditions, Project Emissions due to burning are accounted as zero:

$GHG_{E,t} = 0$

In the case that fires in the Project Area occurring in the future, the emissions of non-CO2 GHGs resulting from the loss of aboveground tree biomass due to fire will be calculated using the AR-TOOL 08.

REMOVALS

Regarding GHG removals due project activities within the project scenario ($\Delta C_{ACTUAL,t}$), the following carbon compartments were considered: trees (aboveground and roots), soil organic carbon, dead wood, and litter. Thus, change in the carbon stocks in carbon pools in Project Scenario ($\Delta C_{P,t}$), occurring in the selected carbon pools were calculated according to the equation 3 of AR-ACM0003 methodology:

$$\Delta C_{P,t} = \Delta C_{TREE\_PROJ,t} + \Delta C_{SHRUB\_PROJ,t} + \Delta C_{DW\_PROJ,t} + \Delta C_{LI\_PROJ,t} + \Delta SOC_{AL\_PROJ,t}$$

$\Delta C_{P,t}$	=	Change in the carbon stocks in project, occurring in the selected carbon pools, in year t; t CO2-e

$\Delta C_{TREE\_PROJ,t}$	=	Change in carbon stock in tree biomass in project in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO2-e
$\Delta C_{SHRUB\_PROJ,t}$	=	Change in carbon stock in shrub biomass in project in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO2-e
$\Delta C_{DW\_PROJ,t}$	=	Change in carbon stock in dead wood in project in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO2-
$\Delta C_{LI\_PROJ,t}$	=	Change in carbon stock in litter in project in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO2-e
$\Delta SOC_{AL\_PROJ,t}$	=	Change in carbon stock in SOC in project, in year t, in areas of land meeting the applicability conditions of the tool “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”, as estimated in the same tool; t CO2-e

TREES

To calculate ex-ante projections of the carbon stock in tree biomass, the AR-TOOL 14 *“Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”, version 04.2* was used. Under the Section 8.2 of this tool, ex-ante projection of carbon stock in tree biomass can be estimated by existing data related to growth and development of trees over time. Thus, to calculate the above and below-ground biomass/carbon we used the equations 3.2.5 of the IPCC “Good Practice Guidance for Land Use, Land-Use Change and Forestry”, where equation A was used to calculate the annual carbon increment of the restoration models without harvesting activities where data is in biomass units per hectare (t/ha/year), while equation B was used in calculations related to restoration models including harvesting activities, where input data is volume (m^3/ha/year), as presented below:

EQUATION 3.2.5
AVERAGE ANNUAL INCREMENT IN BIOMASS

$G_{TOTAL} = G_W \bullet (1 + R)$	**(A)**	In case aboveground biomass increment (dry matter) data are used directly. Otherwise G_W is estimated using equation B or its equivalent
$G_W = I_V \bullet D \bullet BEF_1$	**(B)**	In case net volume increment data are used to estimate G_W.

Where:

G_{TOTAL}	=	average annual increment in above and below-ground biomass, tonnes d.m. ha-1 yr-1;
G_w	=	average annual aboveground biomass increment, tonnes d.m. ha-1 yr-1
R	=	root-to-shoot ratio appropriate to increments, dimensionless;
I_V	=	average annual net increment in volume suitable for industrial processing, m3 ha-1 yr-1;
D	=	basic wood density, tonnes d.m. m-3 ;
BEF	=	biomass expansion factor for conversion of annual net increment (including bark) to aboveground tree biomass increment, dimensionless;

To project the accumulation of aboveground carbon in the restoration activities, annual biomass increment values obtained in the literature were used. For assisted natural regeneration (ARN models), the results of the study proposed by Poorter et al. (2016) was used as reference, as the vegetation type of the project region is the same of those encompassed in the study, that is, tropical forests. This study found that, for neotropical secondary forests, the average annual aboveground biomass increment is approximately 6 tAGB/ha/year. It is important to highlight that the aboveground increment is constant until the 20th year of restoration, from which there is a decrease in the annual accumulation rate. Thus, considering an increment of 6 tAGB/ha/year until the 20th year, it is possible to estimate that at the 20th year after restoration starts these forests stock 120 tAGB/ha. To calculate the increment after the 20th years, we used the results of the study conducted by Lindner and Sattler (2012) within the Atlantic Forest biome, which found that naturally regenerated forests can reach about 252 tAGB/ha at the 60th year.

As the difference in the carbon stored at the 20th and 60th years after restoration starts is 132 tAGB/ha, it is possible to estimate that naturally regenerated forests present an increment equal to 3.3

tAGB/ha/year[56] from the 20th year to the 60th years (Table 6). The values presented were used to estimates biomass accumulation (parameter G_{TOTAL}) for the ARN restoration model.

For planting models (BRN and MRN) without harvesting, different values were adopted. For BRN model (full planting within sites of low natural regeneration potential) the annual carbon increment adopted until the 20th year is 10 tAGB/ha/year. This value is very close to those observed in the Brazilian literature (Gardon et al. 2020; Gardon, 2021; Brancalion et al. 2021), and highly conservative when compared to that provided by the IPCC for broadleaf species plantation in tropical regions[57]. However, these studies include some sites where the effective management and monitoring were not properly undertaken. So, it is expected that the annual increment in the restored areas be higher as a result of the carefully planned management and monitoring actions proposed by project proponent. After the 20th year, a different value is used. Considering an increment of 10 tAGB/ha/year until the 20th year, at the 20th year after planting these forests stock 200 tAGB/ha. The study conducted by Brancalion et al. (2021) and Preiskorn (2011) within full planting restorations of the Atlantic Forest presenting about 60y, evidence that restored forests can reach about 277 tAGB/ha/year, on average.

Considering the difference in the carbon stock at the 20th and 60th years (77 tAGB/ha) after restoration starts, it is possible to estimate that full planting restorations present an increment equal to 1.92 tAGB/ha/year[58] after the 20th years (Table 6). For MRN model (intermediate planting within sites of medium natural regeneration potential) the annual biomass increment adopted is expected to be the average between ARN and BRN models (8.0 tAGB/ha/year until the 20th year and 2.6 tAGB/ha/year after the 20th year) (Table 6). The values presented were used to estimates biomass accumulation (parameter G_{TOTAL}) for the MRN and BRN restoration models without planned harvesting.

For planting models involving harvesting activities (e.g. a single cycle of selective harvesting) different assumptions were adopted. To calculate volume (m³) increment over time (parameter *Iv*), 35 models for estimating the diameter at breast height (DBH - cm) of different species over time were used to estimate the average DBH of the timber species (Rolim and Piotto, 2018).

For ex-ante purposes, this averaged data was separated in two categories: i) Average DBH for timber species of fast growth; and ii) Average DBH for timber species of slow growth. Also, an equation for estimating stem height (m) and another for estimating volume (m³) derived from the same 35 native species of commercial interest were used (Rolim and Piotto, 2018).

[56] Considering an increment until the 20th year equal to 3 tC/ha/year, at this year restoration would have stored 60 tC/ha. As 86 tC/ha is the difference between the 20th and 60th year carbon stocks, and there is a 40 year-timeframe between the two estimates, it is possible to estimate that the increment after the 20th year is 1.65 tC/ha/year: (126-60)/(60-20) = 1.65.

[57] www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch04_Forest%20Land.pdf

[58] Considering an increment until the 20th year equal to 5 tC/ha/year, at this year restoration would have stored 100 tC/ha. As 38 tC/ha is the difference between the 20th and 60th year carbon stocks, and there is a 40-year timeframe between the two estimates, it is possible to estimate that the increment after the 20th year is 0.96 tC/ha/year: (138.5-100)/(60-20) = 0.96.

To estimate the biomass stock from the volume curves, we considered a initial planting density of 1666 seedlings/ha[59] and conversion factors were applied: i) biomass expansion factor (*BEF*) = 1.15 (AR-TOOL 14); ii) average wood density for 15 native species (*Astronium concinnum, Astronium graveolens, Cariniana legalis, Centrolobium robustum, Cordia trichotoma, Dalbergia nigra, Handroanthus heptaphyllus, Handroanthus impetiginosus, Hymenaea courbaril, Manilkara bella, Paratecoma peroba, Parkia pendula, Paubrasilia echinata, Plathymenia reticulata, Zeyheria tuberculosa*) that will possibly be used for timber production within the Grouped Project: (*D*) = 0.561 g/cm^3 (for species of medium cycle) and 0.693 g/cm^3 (for species of long cycle). Therefore, the average annual biomass increments at the harvesting age for medium cycle woody species (cutting age estimated at the ~18th year) is about 7.94 tAGB/ha/year, while for the long cycle woody species (cutting age estimated at the 27th year) it is about 5.04 tAGB/ha/year (Table 6). The values presented were used to estimates biomass accumulation (parameter *Gw*) for the MRN and BRN reforestation models during the harvesting cycle period.

It is important to remember that harvesting activities are designed only to MRN and BRN restoration models, and the carbon increment estimates are the same for the harvesting cycle of both restoration models. Cutting age for species of fast growth is estimated to begin at the 18th years after restoration, while for slow growth species it is estimated to begin at the 27th year, but continuous monitoring will be used to take a final decision of the harvesting intensity. The single-one rotation will be conducted in an extended manner, expected to occur during the 15th and 30th years after planting.

Thinning event was estimated to occur 10 years after planting[60]. Thinning is required to manage competition among trees and keep forest productive high. It was assumed that, up to the cutting age, the biomass increment is calculated from diameter, height, wood density, biomass expansion factor, and wood volume (m^3) for native species of medium/long cycle available in the literature (Rolim and Piotto, 2018). However, this study has limitations related to the lack of correct management (e.g. thinning) and poor soils that underestimates the growth of the species. Thus, after analysis of this study by experts from re.green and discussion with the authors of the reference, it is estimated that the growth of the selected species may be up to 20% higher than that obtained by Rolim and Piotto, 2018.

To keep restoration processes on track after harvesting cycle, the harvested systems are improved by the planting of seedlings in substitution to the harvested trees, while the regenerating trees that established over the harvesting cycle are maintained. Thus, the expected biomass increment after harvesting cycle is estimated as the carbon increment over time expected for ecological restoration activities without harvesting (BRN and MRN models).

The proportion of roots (parameter *R*) was estimated as a function of the carbon stored in the aboveground pool applied to the equation provided by AR-TOOL 14 and replicated in Table 6. On average this value represented about 23%.

[59] This initial planting density is not fixed and can change according to operational plans.

[60] The thinning % and period, as the harvesting % and period are not fixed, and can change according to operational plans.

The annual increment of biomass obtained in the literature for the different models were used to calculate the parameters G_W and G_{TOTAL}, which substitute the parameter b_{TREE} in the following equation. This parameter was used to calculate parameter B_{TREE} of the following equation, by multiplying the annual increment by the time elapsed since restoration starts and the restored area (parameter A). The total area (hectares) designed for the restoration models regarding the ex-ante calculations is placed in the table below:

Table 5. Grouped Project implementation area per restoration model by year.

Restoration Models	Grouped Project implementation area per restoration model (hectares) by year									
	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
ARN (without harvesting)	1300	1600	2400	2400	2400	2400	2400	2400	2400	2400
MRN (without harvesting)	2080	2560	3840	3840	3840	3840	3840	3840	3840	3840
BRN (without harvesting)	832	1024	1536	1536	1536	1536	1536	1536	1536	1536
MRN (with harvesting)	208	256	384	384	384	384	384	384	384	384
BRN (with harvesting)	780	960	1440	1440	1440	1440	1440	1440	1440	1440
Total per year	5200	6400	9600	9600	9600	9600	9600	9600	9600	9600
ARN: Assisted natural regeneration restoration model; MRN: Intermediate planting restoration model; BRN: Full planting restoration model.										

To calculate the parameter C_{TREE_PROJ} the biomass data (B_{TREE}) was transformed into carbon stock by using a conversion factor equal to 0.5 (CF_{TREE}) (Table 6). The estimation of the carbon stock in trees within the tree biomass estimation strata was calculated according to equations provided in the AR-TOOL 14 and placed below:

$$B_{TREE} = A \times b_{TREE}$$

Where:

B_{TREE}	=	Tree biomass in the tree biomass estimation strata; t d.m.
A	=	Sum of areas of the tree biomass estimation strata; ha
b_{TREE}	=	Mean tree biomass per hectare in the tree biomass estimation strata; t d.m. ha-1

$$C_{TREE\_PROJ} = 44/12 \times CF_{TREE} \times B_{TREE}$$

Where:

C_{TREE_PROJ} = Carbon stock in trees in the tree biomass estimation strata; t CO2e

CF_{TREE} = Carbon fraction of tree biomass; t C (t d.m.)-1 .

B_{TREE} = Tree biomass in the tree biomass estimation strata; t d.m.

Table 6. Aboveground and belowground carbon increment for trees

Parameter	Symbol	Value	Source
Annual carbon increment for Natural Regeneration model without harvesting (ARN)	G_{TOTAL} or b_{TREE}	6.0 tAGB/ha/year (>0-20 years); 3.3 tAGB/ha/year (>20 years)	Lindner and Sattler, 2012; Poorter et al. 2016
Annual carbon increment for Intermediate Planting restoration model without harvesting (MRN)	G_{TOTAL} or b_{TREE}	8.0 tAGB/ha/year (>0-20 years); 2.62 tAGB/ha/year (>20 years)	Average value between ARN and BRN models
Annual carbon increment for Full Planting restoration model without harvesting (BRN)	G_{TOTAL} or b_{TREE}	10.0 tAGB/ha/year (>0-20 years); 1.92 tAGB/ha/year (>20 years)	Preiskorn, 2011; Gardon et al. 2020; Gardon, 2021; Brancalion et al. 2021
Annual carbon increment for Intermediate Planting restoration model with one harvesting cycle (MRN)	G_W, G_{TOTAL} or b_{TREE}	Before harvesting: ~7.94 tAGB/ha/year (>0-18 years for medium cycle woody species), ~5.04 (>0-27 years for long cycle woody species); After harvesting: 8.0 (until the 20th year after harvesting); 2.62 (>20 years after harvesting)	Rolim and Piotto, 2018; Average value between ARN and BRN models.
Annual carbon increment for Full Planting restoration model with one harvesting cycle (BRN)	G_W or b_{TREE}	Before harvesting: ~7.94 tAGB/ha/year (>0-18 years for medium cycle woody species), ~5.04 (>0-27 years for long cycle woody species); After harvesting: 10.0 (until the 20th year after harvesting); 1.92 (>20 years after harvesting)	Preiskorn, 2011; Rolim and Piotto, 2018; Gardon et al. 2020 ; Gardon, 2021 ; Brancalion et al. 2021

Parameter	Symbol	Value	Source
Biomass Expansion Factor	*BEF*	1.15	AR-TOOL 14 - Appendix 1
Carbon Fraction	*CF*	0.5	Value recommended by the BRAZILIAN FOREST SERVICE - National Forest Information System[61]
Roots:Shoot ratio calculation	*R*	Varies according to aboveground biomass stock applied in the equation: ROOT:SHOOT ratio = (EXP(-1.085+0.9256*LN(aboveground biomass stock in tAGB/ha)))/(aboveground biomass stock in tAGB/ha). The average ROOT:SHOOT ratio (R) over the crediting period obtained for the Grouped Project is 23%.	AR-TOOL 14

Finally, the change in carbon stock in trees was calculated as follows:

$$\Delta C_{TREE\_PROJ,t} = C_{TREE\_PROJ,t2} - C_{TREE\_PROJ,t1}$$

Where:

$\Delta C_{TREE\_PROJ,t}$	=	Change in carbon stock in trees during the period between two points of time t1 and t2; t CO2e
$C_{TREE\_PROJ,t1}$	=	Carbon stock in trees as estimated at time t1; t CO2
$C_{TREE\_PROJ,t2}$	=	Carbon stock in trees as estimated at time t2; t CO2

61 https://snif.florestal.gov.br/pt-br/estoques-das-florestas/623-estoque-das-florestas-carbono

SHRUBS

Due to the lack of scientific data related to this group of plants, in the ex-ante projections of the carbon stock in shrub biomass, it was conservatively considered that change in carbon stock of shrub species is zero:

$\Delta C_{SHRUB\_PROJ,t} = 0$

Nevertheless, shrubs carbon stocks will be monitored over the project crediting period and will be included in the ex-post calculation, according to AR-TOOL 14 (see section 4.2).

DEAD WOOD AND LITTER

Dead wood and litter estimate were conducted in accordance with the AR-TOOL 12 "*Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities*", Version 03.0". Values of the conservative default-factors expressing carbon stock in dead wood and litter as a percentage of carbon stock in tree biomass ware selected. These values were defined as percentage, based on climatic and elevation criteria available in the AR-TOOL 12. Thus, for both dead wood and litter pools, it was considered that the project occurs in tropical biomes, at altitudes below 2000 m, and in regions where the annual precipitation is between 1000-1600 mm, resulting in a proportion of dead wood equal to 1% (parameter DF_{DW}) and 1% for litter (parameter DF_{LI}), being these percentages appleade relative to the aboveground stock in live trees (Table 7).

It is important to state that these ex-ante estimates can vary according to the new PAIs that will be added to the grouped project, and as new scientific studies and data related to forest restoration and carbon sequestration are developed.

Table 7. Carbon increment values for dead trees and litter.

Parameter	Value	Source
Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; percent (DF_{DW})	>0-20 years: 1% of aboveground carbon stock; > 20 years: 1% of aboveground carbon stock	Table 5 of the AR-TOOL 12
Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; percent (DF_{LI})	>0-20 years: 1% of aboveground carbon stock; > 20 years: 1% of aboveground carbon stock	Table 6 of the AR-TOOL 12

The carbon stock in dead wood was estimated as is indicated in the AR-TOOL 12:

$$C_{DW\_PROJ,i,t} = C_{TREE\_PROJ,i,t} \times DF_{DW}$$

Where:

$C_{DW\_PROJ,i,t}$	=	Carbon stock in dead wood in stratum i at a given point of time in year t; t CO2e
C_{TREE_PROJ}	=	Carbon stock in trees biomass in stratum i at a point of time in year t, as calculated in tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO2e
DF_{DW}	=	Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass; percent
I	=	1, 2, 3, … biomass estimation strata within the project boundary
t	=	1, 2, 3, … years elapsed since the start of the A/R CDM project activity

The carbon stock in litter was estimated as is indicated in the AR-TOOL 12:

$$C_{LI\_PROJ,i,t} = C_{TREE\_PROJ,i,t} \times DF_{LI}$$

Where:

C_{LI_PROJ}	=	Carbon stock in litter in stratum i at a given point of time in year t; t CO2e
C_{TREE_PROJ}	=	Carbon stock in trees biomass in stratum i at a point of time in year t, as calculated in tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities"; t CO2e

DF_{LI}	=	Conservative default factor expressing carbon stock in litter as a percentage of carbon stock in tree biomass; percent

The rate of change of deadwood biomass over a period of time is calculated assuming a linear change. Therefore, the rate of change in carbon stock in deadwood over a period of time is calculated as follows:

$$dC_{DW\_PROJ,(t1,t2)} = \frac{C_{DW\_PROJ,t2} - C_{DW\_PROJ,t1}}{T}$$

where:

$dC_{DW\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in dead wood within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1
$C_{DW\_PROJ,t2}$	=	Carbon stock in dead wood within the project boundary at a point of time in year t2; t CO2e
$C_{DW\_PROJ,t1}$	=	Carbon stock in dead wood within the project boundary at a point of time in year t1; t CO2e
T	=	Time elapsed between two successive estimations (T=t2 – t1); yr

Change in carbon stock in deadwood within the project boundary in year t (t1 ≤ t ≤ t2) is given by:

$$\Delta C_{DW\_PROJ,t} = dC_{DW\_PROJ,(t1,t2)} \times 1\ year\ for\ t1 \le t \le t2$$

where:

$\Delta C_{DW\_PROJ,t}$	=	Change in carbon stock in dead wood within the project boundary in year t; t CO2e
$dC_{DW\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in dead wood within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1

The rate of change of litter biomass over a period of time is calculated assuming a linear change. Therefore, the rate of change in carbon stock in litter over a period of time is calculated as:

$$dC_{LI\_PROJ,(t1,t2)} = \frac{C_{LI\_PROJ,t2} - C_{LI\_PROJ,t1}}{T}$$

where:

$dC_{LI\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in litter within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1
$C_{LI\_PROJ,t2}$	=	Carbon stock in litter within the project boundary at a point of time in year t2; t CO2e
$C_{LI\_PROJ,t1}$	=	Carbon stock in litter within the project boundary at a point of time in year t1; t CO2e
T	=	Time elapsed between two successive estimations (T=t2 – t1); yr

Change in carbon stock in litter within the project boundary in year t (t1 ≤ t ≤ t2) is given by:

$$\Delta C_{LI\_PROJ,t} = dC_{LI\_PROJ,(t1,t2)} \times 1\, year\ for\ t1 \leq t \leq t2$$

where:

$\Delta C_{LI\_PROJ,t}$	=	Change in carbon stock in litter within the project boundary in year t; t CO2e
$dC_{LI\_PROJ,(t1,t2)}$	=	Rate of change in carbon stock in litter within the project boundary during the period between a point of time in year t1 and a point of time in year t2; t CO2e yr-1

SOIL ORGANIC CARBON

Soil organic carbon was fully calculated based on the AR-TOOL 16 "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*". The estimation of soil organic carbon considers the soil type, clay content, the land-use type and management, including the application of inputs, all to obtain an estimate of the carbon stock at the immediate time before the start of the project ($SOC_{INITIAL,i}$). The result is then compared to soil organic carbon stock in reference ecosystems ($SOC_{REF,i}$) to define how much carbon could be assimilated in this pool over time.

$$SOC_{INITIAL,i} = SOC_{REF,i} \times f_{LU,i} \times f_{MG,i} \times f_{IN,i}$$

Where:

$SOC_{INITIAL,i}$	=	SOC stock at the beginning of the A/R CDM project activity in stratum i of the areas of land; t C ha-1
$SOC_{REF,i}$	=	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation ñ normally forest) by climate region and soil type applicable to stratum i of the areas of land; t C ha-1
$f_{LU,i}$	=	Relative stock change factor for baseline land-use in stratum i of the areas of land; dimensionless
$f_{MG,i}$	=	Relative stock change factor for baseline management regime in stratum i of the areas of land; dimensionless
$f_{IN,i}$	=	Relative stock change factor for baseline input regime (e.g. crop residue returns, manure) in stratum i of the areas of land; dimensionless
I	=	1, 2, 3, … strata of areas of land; dimensionless

The values of $SOC_{REF,i}$, $f_{LU,i}$, $f_{MG,i}$ and $f_{MG,i}$ were taken from the Table 8 and Table 9 provided in the AR-TOOL 16:

Table 8. Default reference SOC sotcks (SOCREF) for mineral soils (tC.ha-1 in 0-30 cm depth)

Climate region	HAC soils[(a)]	LAC soils[(b)]	Sandy soils[(c)]	Spodic soils[(d)]	Volcanic soils[(e)]
Boreal	68	NA	10	117	20
Cold temperate, dry	50	33	34	NA	20
Cold temperate, moist	95	85	71	115	130
Warm temperate, dry	38	24	19	NA	70
Warm temperate,	88	63	34	NA	80
Tropical, dry	38	35	31	NA	50
Tropical, moist	65	47	39	NA	70
Tropical, wet	44	60	66	NA	130
Tropical montane	88	63	34	NA	80

[(a)] Soils with high activity clay (HAC) minerals are lightly to moderately weathered soils, which are dominated by 2:1 silicate clay minerals (in the World Reference Base for Soil Resources (WRB) classification these include Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, Regosols; in USDA classification includes Mollisols, Vertisols, high-base status Alfisols, Aridisols, Inceptisols);

[(b)] Soils with low activity clay (LAC) minerals are highly weathered soils, dominated by 1:1 clay minerals and amorphous iron and aluminium oxides (in WRB classification includes Acrisols, Lixisols, Nitisols, Ferralsols, Durisols; in USDA classification includes Ultisols, Oxisols, acidic Alfisols);

[(c)] Includes all soils (regardless of taxonomic classification) having > 70% sand and < 8% clay, based on standard textural analyses (in WRB classification includes Arenosols; in USDA classification includes Psamments);

[(d)] Soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols);

[(e)] Soils derived from volcanic ash with allophanic mineralogy (in WRB classification Andosols; in USDA classification Andisols)

Table 9. Relative stock change factors (*fLU,i , fMG,i and fMG,i*) for grassland management (net effect over a period of 20 years)

Factor type	Level	Climate regime	Factor value	Description
Land use (f_{LU})	All	All	1.00	All permanent grassland is assigned a land-use factor of 1
Management (f_{MG})	Non-degraded grassland	All	1.00	Non-degraded and sustainably managed grassland, but without significant management improvements
Management (f_{MG})	Moderately degraded grassland	Temperate/Bore al	0.95	Overgrazed or moderately degraded grassland, with somewhat reduced productivity (relative to the native or nominally managed grassland) and receiving no management inputs
		Tropical	0.97	
		Tropical Montane	0.96	
Management (f_{MG})	Severely degraded	All	0.70	Lands are identified as degraded lands using the "Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities"
Input (f_{IN})	Low/Medium	All	1.00	All grassland without input of fertilizers is assigned an input factor of 1
	High	All	1.11	Grasslands with direct application of fertilizers - organic or inorganic

For each stratum of the areas of land which is subjected to soil disturbance attributable to project activity and for which the total area disturbed, over and above the area disturbed in the baseline, is greater than 10% of the area of the stratum, the following carbon loss is accounted:

$$SOC_{LOSS,i} = SOC_{INITIAL,i} * 0.1$$

For all other strata:

$$SOC_{LOSS,i} = 0$$

Where:

$SOC_{INITIAL,i}$	=	SOC stock at the beginning of the A/R CDM project activity in stratum i of the areas of land; t C ha-1
$SOC_{LOSS,i}$	=	Loss of SOC caused by soil disturbance attributable the A/R CDM project activity, in stratum i of the areas of land; t C ha-1
0.1	=	The approximate proportion of SOC lost within the first five years from the year of site preparation
i	=	1, 2, 3, … strata of areas of land; dimensionless

Then, the rate of change in SOC stock in project scenario until the steady state is reached and is estimated as follows:

$$dSOC_{t,i} = 0; \text{ for } t < t_{PREP,i}$$

$$dSOC_{t,i} = (SOC_{LOSS,i}))/1 \text{ year; for } t = t_{PREP,i}$$

$$dSOC_{t,i} = (SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i}))/20 \text{ years; for } t_{PREP,i} < t \leq t_{PREP,i} + 20$$

Where:

$dSOC_{t,i}$	=	The rate of change in SOC stock in stratum i of the areas of land in year t; t C ha-1 yr-1
$SOC_{REF,i}$	=	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation ñ normally forest) by climate region and soil type applicable to stratum i of the areas of land; t C ha-1
$SOC_{INITIAL,i}$	=	SOC stock at the beginning of the A/R CDM project activity in stratum i of the areas of land; t C ha-1

$SOC_{LOSS,i}$	=	Loss of SOC caused by soil disturbance attributable the A/R CDM project activity, in stratum i of the areas of land; t C ha-1
i	=	1, 2, 3, … strata of areas of land; dimensionless
t	=	1, 2, 3, … years elapsed since the start of the A/R CDM project activity

The change in SOC stock for all the strata of the areas of land, in year t is calculated as indicated in equation 8 of the tool:

$$\Delta SOC_{AL,t} = \frac{44}{12} \times \sum_i Ai \times dSOC_{t,i} \times 1\text{year}$$

Where:

$\Delta SOC_{AL,t}$	=	Change in SOC stock in areas of land meeting the applicability conditions of this tool. in year t; t CO2-e
Ai	=	The area of stratum i of the areas of land; ha
$dSOC_{t,i}$	=	The rate of change in SOC stocks in stratum i of the areas of land; t C ha-1 yr-1
I	=	1, 2, 3, … strata of areas of land; dimensionless

In the Grouped Project boudary, the main types of soils found are Ferralsol, Lixisol, and Acrisol, soils of low clay activity. However, soils of high clay activity can be observed, as Cambisol and Mollisol. Therefore, for ex-ante estimates the reference soil organic carbon stock value used was equal to the average between these two soil type (high and low clay activity) occurring in “tropical-moist” climate region, as described in AR-TOOL 16:

$SOC_{REF,i}$ = 56 tC/ha

According to the tool, to estimate soil carbon stock at the moment before the start of the project (parameter $SOC_{INITIAL,i}$), the reference values need to be corrected according to factors that represent the land-use type, management activities and inputs applied, which affected the reference stock in the past. This is critical to estimate the additional carbon sequestration resulting from project activities.

For ex-ante estimates in pasture areas, it was considered that the restorations will be implanted in conditions ranging from non-degraded pastures to severely degraded pastures, so:

$f_{LU,I}$ = 1.00

$f_{MG,I}$ = 0.89

Pastures involving intensive management activities and high yield with additional applications of inputs are not common in the project region, thus only pastures at input conditions that range from low to medium were used, so:

$f_{IN,I}$ = 1.00

Such conditions result in an ex-ante estimate for $SOC_{INITIAL,i}$ of:

$SOC_{INITIAL,i} = SOC_{REF,i} \times f_{LU,i} \times f_{MG,i} \times f_{IN,i}$

$SOC_{INITIAL,i} = 56 \times 1.00 \times 0.89 \times 1.00$

$SOC_{INITIAL,i}$ = 49.84 tC/ha

Soil disturbance attributable to project activity in the strata where SOC was accounted is less than 10% of the area of the stratum. Hence, the carbon loss is taken as zero:

$SOC_{LOSS,i} = 0$

The tool specifies that the soil organic carbon increment is constant and linear until 20 years, at which time the pool is expected to reach an equilibrium state, that is, the reference value, and does not sequester more carbon. Considering that the difference between the reference stock and the initial stock is equal to 6.16 tC/ha, this would be the value that could be added to the soil over 20 years, resulting:

$dSOC_{t,i} = (SOC_{REF,i} - (SOC_{INITIAL,i} - SOC_{LOSS,i}))$/20 years; for $t_{PREP,i} < t \leq t_{PREP,i} + 20$

$dSOC_{t,i} = (56 - (49.84 - 0))$/20 years; for $t_{PREP,i} < t \leq t_{PREP,i} + 20$

$dSOC_{t,i}$ = 0.31 tC/ha

Table 10. Carbon values and factors adjustments for soil organic carbon.

Parameter	Symbol	Value	Source
Reference SOC (tC ha-1)	$SOC_{REF,i}$	56.00	Table 3 of "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*", Version 01.1.0. Tropical moist climate.
Land use factor	$f_{LU,i}$	1.00	Table 6 of "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*", Version 01.1.0. All permanent grassland.
Management factor	$f_{MG,i}$	0.89	Table 6 of "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*", Version 01.1.0. Lands are identified as non-degraded, degraded, and severely degraded. So the average value was used.
Input factor	$f_{IN,i}$	1.00	Table 6 of "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*", Version 01.1.0. Grassland without input of fertilizers.
SOC at the beginning of the project activity	$SOC_{INITIAL,i}$	49.84	Calculated with equation 01 of the tool "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities".
Rate of change in SOC stock	$dSOC_{t,i}$	>0-20 years: 0.31 tC/ha/year; > 20 years: 0 tC/ha/year	Calculated with equation 06 of the tool "Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities"
Carbon loss	$SOC_{LOSS,i}$	0	As no soil disturbance beyond subsoiling and opening holes to plant trees takes place, there is no SOCloss.

It is important to state that the ex-ante estimates consider only pastures as the previous land-use, as for the two PAIs that are under implementation the previous land-use is pasture. For this reason, only pasture values were used in the modelling. However, these ex-ante estimates can vary according to the new PAIs that will be added to the grouped project and their specific conditions of land-use, climate, and soil. Also, these values can be set according to new scientific studies and data related to forest restoration and carbon sequestration that will be developed.

LEAKAGE

To calculate leakage emissions, the methodological tool "*Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity*" will be applied.

$$LK_{AGRIC,t} = 44/12 \text{ x } (\Delta C_{BIOMASS,t} + \Delta SOC_{LUC,t})$$

$$\Delta C_{BIOMASS,t} = (1.1 \text{ x } b_{TREE} \text{ x } (1+R_{TREE}) + b_{SHRUB} \text{ x } (1 + Rs)) \text{ x } CF \text{ x } A_{DISP,t}$$

$$\Delta SOC_{LUC,t} = SOC_{REF} \text{ x } (f_{LUP} \text{ x } f_{MGP} \text{ x } f_{INP} - f_{LUD} \text{ x } f_{MGD} \text{ x } f_{IND}) \text{ x } A_{DISP,t}$$

Where:

$LK_{AGRIC,t}$	=	Leakage emission resulting from displacement of agricultural activities in year t; t CO2e
$\Delta C_{BIOMASS}$		Decrease in carbon stock in the carbon pools of the land receiving the activity displaced in year t; t d.m. Note. The factor of 1.1 is used to account for the carbon stock in the dead wood and litter pools as a fixed percentage of the carbon stock in living trees.
CF		Carbon fraction of woody biomass; dimensionless. A default value of 0.47 is used unless transparent and verifiable information can be provided to justify a different value.
$A_{DISP,t}$		Area of land from which agricultural activity is being displaced in year t; ha
b_{TREE}		Mean above-ground tree biomass in land receiving the displaced activity; t d.m. ha-1 The value of this parameter is obtained by applying one of the applicable methods from the tool "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities" to the land receiving the displaced activity. Where the land receiving the displaced activity is unidentified, value of is set equal to the applicable value of mean aboveground biomass in forest in the region or country where the A/R CDM project activity is located, as obtained from Table 3A.1.4 of the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC GPG-LULUCF 2003) unless transparent and verifiable information can be provided to justify a different value.

R_{TREE}	Root-shoot ratio for trees in the land receiving the displaced activity; dimensionless. A default value of 0.25 is used unless transparent and verifiable information can be provided to justify a different value.
b_{SHRUB}	Mean above-ground shrub biomass in land receiving the displaced activity; t d.m. ha-1 . The value of this parameter is obtained by applying one of the applicable methods from the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities” to the land receiving the displaced activity.
Rs	Root-shoot ratio for shrubs in the land receiving the displaced activity; dimensionless. The default value of 0.40 is used unless transparent and verifiable information can be provided to justify a different value.
$\Delta SOC_{LUC,t}$	Change in soil organic carbon (SOC) stock due to land-use change in the land receiving the displaced activity in year t; tC.ha-1 . The value of this parameter may be set to zero if: (a) The only displaced activity being received in the land is grazing activity; or (b) The value of the parameter as estimated from Equation (3) is less than zero (i.e. negative).
SOC_{REF}	SOC stock corresponding to the reference condition in native lands by climate region and soil type applicable to the land receiving the displaced activity; t C ha-1 . The value of this parameter is taken from Table 3 of the “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”
$f_{LUP}, f_{MGP}, f_{INP}$	Relative SOC stock change factors for land-use, management practices, and inputs respectively, applicable to the receiving land before the displaced activity is received; dimensionless. The value of these parameters is taken from Tables 4, 5, and 6 of the “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”.
$f_{LUD}, f_{MGD}, f_{IND}$	Relative SOC stock change factors for land-use, management practices, and inputs respectively, applicable to the receiving land after the displaced activity has been received; dimensionless. The value of these parameters is taken from Tables 4, 5, and 6 of the “Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities”.
t	1, 2, 3, …years elapsed since the start of the A/R CDM project activity

For the ex-ante estimates, leakage was considered zero (see section 4.3):

$LK_{AGRIC,t}$ = 0

BASELINE

The baseline net GHG removals by sinks are calculated as follows:

$$\Delta C_{BSL,t} = \Delta C_{TREE\_BSL,t} + \Delta C_{SHRUB\_BSL,t} + \Delta C_{DW\_BSL,t} + \Delta C_{LI\_BSL,t}$$

Where:

$\Delta C_{BSL,t}$	=	Baseline net GHG removals by sinks in year t; t CO2-e
$\Delta C_{TREE\_BSL,t}$	=	Change in carbon stock in baseline tree biomass within the project boundary in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO2-e
$\Delta C_{SHRUB\_BSL,t}$	=	Change in carbon stock in baseline shrub biomass within the project boundary, in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities”; t CO2-e
$\Delta C_{DW\_BSL,t}$	=	Change in carbon stock in baseline dead wood biomass within the project boundary, in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO2-e
$\Delta C_{LI\_BSL,t}$	=	Change in carbon stock in baseline litter biomass within the project boundary, in year t, as estimated in the tool “Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities”; t CO2-e

For ex-ante estimates of baseline GHG removals, it was considered that biomass in shrub, dead wood and litter compartments are zero.

For shrubs, this criterion was adopted as the lands are aligned with the AR-TOOL 14 indicators:

- It is not expected that the area of shrub crown cover be higher than 5 per cent of a single stratum.
- It is expected that, in the business-as-usual condition, lands included in the Grouped Project are subjected to periodic cycles (e.g. slash-and-burn, or clearing-regrowing cycles) so that the biomass oscillates between a minimum and a maximum value in the baseline;
- It is expected the presence of gully, sheet or rill erosion; or landslides, or other forms of mass movement erosion occurring in part of the lands included in the Grouped Project;

For trees, this decision was adopted according to AR-TOOL 14, as Re.green intend to monitor isolated trees across the areas over the project crediting period regarding its survival, but not included in the carbon estimates. If trees in the baseline are not monitored, then trees in baseline will be measured and the carbon stocks will be discounted as baseline removal, according to AR-TOOL 14.

For dead wood and litter, carbon stocks in the baseline were also considered zero as these parameters are defined according to aboveground biomass of living trees, which carbon stocks were considered zero for this ex-ante estimates, as explained above.

Thus, the annual estimated GHG emission removals are presented below:

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
Year 2022	0	0	0	0
Year 2023	0	84115	0	84115
Year 2024	0	276367	0	276367
Year 2025	0	638538	0	638538
Year 2026	0	1184066	0	1184066
Year 2027	0	1927927	0	1927927
Year 2028	0	2883514	0	2883514
Year 2029	0	4062225	0	4062225
Year 2030	0	5473459	0	5473459
Year 2031	0	7124711	0	7124711
Year 2032	0	9021766	0	9021766
Year 2033	0	10756362	0	10756362
Year 2034	0	12482801	0	12482801
Year 2035	0	14078394	0	14078394
Year 2036	0	15663156	0	15663156
Year 2037	0	17223498	0	17223498
Year 2038	0	18747672	0	18747672
Year 2039	0	20225840	0	20225840
Year 2040	0	21650042	0	21650042
Year 2041	0	22686850	0	22686850
Year 2042	0	23581538	0	23581538
Year 2043	0	24628985	0	24628985

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
Year 2044	0	25610967	0	25610967
Year 2045	0	26495798	0	26495798
Year 2046	0	27283048	0	27283048
Year 2047	0	27972488	0	27972488
Year 2048	0	28564039	0	28564039
Year 2049	0	29057751	0	29057751
Year 2050	0	29453776	0	29453776
Year 2051	0	30356372	0	30356372
Year 2052	0	31164777	0	31164777
Year 2053	0	31972202	0	31972202
Year 2054	0	32778806	0	32778806
Year 2055	0	33584697	0	33584697
Year 2056	0	34389956	0	34389956
Year 2057	0	35194643	0	35194643
Year 2058	0	35998808	0	35998808
Year 2059	0	36802491	0	36802491
Year 2060	0	37605726	0	37605726
Year 2061	0	38391727	0	38391727
Year 2062	0	39156650	0	39156650
Year 2063	0	39890184	0	39890184
Year 2064	0	40592371	0	40592371
Year 2065	0	41263247	0	41263247
Year 2066	0	41902850	0	41902850
Year 2067	0	42511210	0	42511210
Year 2068	0	43088360	0	43088360
Year 2069	0	43634327	0	43634327

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
Year 2070	0	44149140	0	44149140
Year 2071	0	44663867	0	44663867
Year 2072	0	45178510	0	45178510
Year 2073	0	45662825	0	45662825
Year 2074	0	46109838	0	46109838
Year 2075	0	46500942	0	46500942
Year 2076	0	46836148	0	46836148
Year 2077	0	47115464	0	47115464
Year 2078	0	47338900	0	47338900
Year 2079	0	47506463	0	47506463
Year 2080	0	47618164	0	47618164
Year 2081	0	47674010	0	47674010
Year 2082	0	47674010	0	47674010
Year 2083	0	47674010	0	47674010
Year 2084	0	47674010	0	47674010
Year 2085	0	47674010	0	47674010
Year 2086	0	47674010	0	47674010
Year 2087	0	47674010	0	47674010
Year 2088	0	47674010	0	47674010
Year 2089	0	47674010	0	47674010
Year 2090	0	47674010	0	47674010
Year 2091	0	47674010	0	47674010
Year 2092	0	47674010	0	47674010
Year 2093	0	47674010	0	47674010
Year 2094	0	47674010	0	47674010
Year 2095	0	47674010	0	47674010

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
Year 2096	0	47674010	0	47674010
Year 2097	0	47674010	0	47674010
Year 2098	0	47674010	0	47674010
Year 2099	0	47674010	0	47674010
Year 2100	0	47674010	0	47674010
Year 2101	0	47674010	0	47674010
Year 2102	0	47674010	0	47674010
Year 2103	0	47674010	0	47674010
Year 2104	0	47674010	0	47674010
Year 2105	0	47674010	0	47674010
Year 2106	0	47674010	0	47674010
Year 2107	0	47674010	0	47674010
Year 2108	0	47674010	0	47674010
Year 2109	0	47674010	0	47674010
Year 2110	0	47674010	0	47674010
Year 2111	0	47674010	0	47674010
Year 2112	0	47674010	0	47674010
Year 2113	0	47674010	0	47674010
Year 2114	0	47674010	0	47674010
Year 2115	0	47674010	0	47674010
Year 2116	0	47674010	0	47674010
Year 2117	0	47674010	0	47674010
Year 2118	0	47674010	0	47674010
Year 2119	0	47674010	0	47674010
Year 2120	0	47674010	0	47674010
Year 2121	0	47674010	0	47674010

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions or removals (tCO_2e)
Year 2122	0	47674010	0	47674010
Total	0	47674010	0	47674010

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	CF_{TREE}
Data unit	t C (t d.m.)$^{-1}$
Description	Carbon fraction in tree biomass; t C (t d.m.)$^{-1}$
Source of data	Value recommended by the BRAZILIAN FOREST SERVICE - National Forest Information System[62]
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	National data recommended by the environmental agency for forest ecosystems in Brazil, which is responsible for the National Forest Inventory.
Purpose of Data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Comments	N/A

Data / Parameter	CF_S
Data unit	t C (t d.m.)$^{-1}$
Description	Carbon fraction of shrub biomass; t C (t d.m.)$^{-1}$

62 https://snif.florestal.gov.br/pt-br/estoques-das-florestas/623-estoque-das-florestas-carbono

Source of data	Value recommended by the BRAZILIAN FOREST SERVICE - National Forest Information System[63]
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	National data recommended by the environmental agency for forest ecosystems in Brazil, which is responsible for the National Forest Inventory.
Purpose of Data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Comments	N/A

Data / Parameter	Rj
Data unit	Dimensionless
Description	Root-shoot ratio for stratum *i*
Source of data	AR-TOOL14, version 4.2: "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM activities*"
Value applied	$R_j = \frac{e^{(1.085+0.9256 \times \ln b)}}{b}$ Where, *b* is the estimated aboveground biomass in trees.
Justification of choice of data or description of measurement methods and procedures applied	Default value available in AR-TOOL 14.
Purpose of Data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Comments	N/A

Data / Parameter	Rs
Data unit	Dimensionless
Description	Root-shoot ratio for shrubs

63 Ibidem

Source of data	AR-TOOL14, version 4.2: “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM activities*”
Value applied	0.40
Justification of choice of data or description of measurement methods and procedures applied	Default value available in AR-TOOL 14.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	BDR_{SF}
Data unit	Dimensionless
Description	Ratio of shrub biomass per hectare in land having a shrub crown cover of 1.0 (i.e. 100 per cent)
Source of data	AR-TOOL 14, version 4.2: “*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM activities*”
Value applied	0.10
Justification of choice of data or description of measurement methods and procedures applied	Default value available in AR-TOOL 14.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	D
Data unit	$g.cm^3$ or $t.m^3$
Description	Basic wood density
Source of data	Zanne, A. E., Lopez-Gonzalez, G., Coomes, D.A., Ilic, J., Jansen, S., Lewis, S.L., Miller, R.B., Swenson, N.G., Wiemann, M.C., and Chave, J. 2009. Global wood density database. Dryad. Identifier: http://hdl.handle.net/10255/dryad.235.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.

Justification of choice of data or description of measurement methods and procedures applied	This database was chosen for being the largest available wood density database.
Purpose of Data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Comments	The definition of the value depends on the restoration models and set of species designated to each PAI. For restoration models including harvesting the values are defined according to the set of species planted, which are categorized into different groups according to species growth rate (e.g. average for fast growing species, slow growing species, etc). For restoration models without harvesting, the value is defined according to the set of species planted (e.g. average value for the set of species planted) and/or species expected to occur in the area.

Data / Parameter	DF_{LI}
Data unit	percent
Description	Conservative default factor expressing carbon stock in litter as a percentage of carbon stock in tree biomass
Source of data	Value of the conservative default factor expressing carbon stock in litter as a percentage of carbon stock in tree biomass is selected according to the guidance provided in the relevant table in Section 8 of the AR-TOOL 12 "*Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities*", unless transparent and verifiable information can be provided to justify a different value.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of measurement methods and procedures applied	The default value of the AR-TOOL 12 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Comments	N/A

Data / Parameter	DF_{DW}
Data unit	percent

Description	Conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass
Source of data	Value of the conservative default factor expressing carbon stock in dead wood as a percentage of carbon stock in tree biomass is selected according to the guidance provided in the relevant table in Section 8 of the AR-TOOL 12 *"Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities"*, unless transparent and verifiable information can be provided to justify a different value.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of measurement methods and procedures applied	The default value of the AR-TOOL 12 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Comments	N/A

Data / Parameter	Allometric equation for trees in baseline
Data unit	Kg or Ton
Description	Allometric equation for estimating tree biomass in the baseline based on forest structure (e.g. DBH, H, and/or WD)
Source of data	A species-specific or group-of-species-specific allometric equation derived from trees growing in edapho-climatic conditions similar to those in the project area is considered appropriate, and hence can be used for ex post estimation of tree biomass, if at least one of the following conditions is satisfied: (a) The equation is used in the national forest inventory, or the national GHG inventory, of the Host Party; (b) The equation has been used in commercial forestry sector of the Host Party for ten years or more; (c) The equation was derived from a data set of at least 30 sample trees, and the value of coefficient of determination (R^2) obtained was not less than 0.85.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of measurement methods and procedures applied	Parameters DBH, H, and/or WD are used in the selected allometric equation to calculate tree biomass.
Purpose of Data	• *Calculation of project emissions*

Comments	N/A

Data / Parameter	Allometric equation for trees in project scenario
Data unit	Kg or Ton
Description	Allometric equation for estimating tree biomass in the project scenario based on forest structure (e.g. DBH, H, and/or WD)
Source of data	A species-specific or group-of-species-specific allometric equation derived from trees growing in edapho-climatic conditions similar to those in the project area is considered appropriate, and hence can be used for ex post estimation of tree biomass, if at least one of the following conditions is satisfied: (a) The equation is used in the national forest inventory, or the national GHG inventory, of the host Party; (b) The equation has been used in commercial forestry sector of the host Party for ten years or more; (c) The equation was derived from a data set of at least 30 sample trees, and the value of coefficient of determination (R^2) obtained was not less than 0.85.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of measurement methods and procedures applied	Parameters DBH, H, and/or WD are used in the selected allometric equation to calculate tree biomass.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	SOC_{REF}
Data unit	t C ha-1
Description	Reference SOC stock corresponding to the reference condition in native lands (i.e. non-degraded, unimproved lands under native vegetation ñ normally forest) by climate region and soil type applicable to stratum i of the areas of land.
Source of data	Default values provided in the AR-TOOL 16 “*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*” are used, unless transparent and verifiable information can be provided to justify different values.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.

Justification of choice of data or description of measurement methods and procedures applied	The default value of the AR-TOOL 16 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	$f_{LU,i}$
Data unit	dimensionless
Description	Relative stock change factor for baseline land-use in stratum i of the areas of land
Source of data	Default values provided in the AR-TOOL 16 "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*" are used, unless transparent and verifiable information can be provided to justify different values.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of measurement methods and procedures applied	The default value of the AR-TOOL 16 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	$f_{MG,i}$
Data unit	dimensionless
Description	Relative stock change factor for baseline management regime in stratum i of the areas of land
Source of data	Default values provided in the AR-TOOL 16 "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*" are used, unless transparent and verifiable information can be provided to justify different values.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of	The default value of the AR-TOOL 16 is used unless transparent and verifiable information can be provided to justify a different value.

measurement methods and procedures applied	
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	$f_{IN,i}$
Data unit	dimensionless
Description	Relative stock change factor for baseline input regime (e.g. crop residue returns, manure) in stratum i of the areas of land
Source of data	Default values provided in the AR-TOOL 16 "*Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities*" are used, unless transparent and verifiable information can be provided to justify different values.
Value applied	To be filled in the specific PAI at the inclusion of the PAI.
Justification of choice of data or description of measurement methods and procedures applied	The default value of the AR-TOOL 16 is used unless transparent and verifiable information can be provided to justify a different value.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	$COMF_i$
Data unit	dimensionless
Description	Combustion factor for stratum *i*
Source of data	Default value from the methodological tool "*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0
Value applied	**Age range** / **Default value** 3-5 years: 0.46 6-10 years: 0.67 11-17 years: 0.50 18 years or more: 0.32

Justification of choice of data or description of measurement methods and procedures applied	The default value for "*Tropical forest*" from the methodological tool "*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0 is used.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	$EF_{CH4,i}$
Data unit	g kg^{-1} dry matter burnt
Description	Emission factor for CH_4 in stratum *i*
Source of data	Default value from the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" Version 04.0.0*.
Value applied	6.8
Justification of choice of data or description of measurement methods and procedures applied	The default value for "*Tropical forest*" from the methodological tool "*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0 is used.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	GWP_{CH4}
Data unit	dimensionless
Description	Global warming potential for CH_4
Source of data	Default value from the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0
Value applied	21
Justification of choice of data or description of	The default value from the methodological tool "*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0 is used.

measurement methods and procedures applied	
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	$EF_{N2O,i}$
Data unit	g kg[-1] dry matter burnt
Description	Emission factor for N_2O in stratum *i*
Source of data	Default value from the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity" Version 04.0.0*.
Value applied	0.2
Justification of choice of data or description of measurement methods and procedures applied	The default value for "*Tropical forest*" from the methodological tool "*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0 is used.
Purpose of Data	• *Calculation of project emissions*
Comments	N/A

Data / Parameter	GWP_{N2O}
Data unit	dimensionless
Description	Global warming potential for N_2O
Source of data	Default value from the tool "*Estimation of non-CO_2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0
Value applied	310
Justification of choice of data or description of measurement methods and procedures applied	The default value from the methodological tool "*Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity*" Version 04.0.0 is used.
Purpose of Data	• *Calculation of project emissions*

Comments	N/A

5.2 Data and Parameters Monitored

Data / Parameter	Ai
Data unit	ha (hectares)
Description	The area of stratum i of the areas of land
Source of data	GPS, and/or from geo-referenced remote sensing data (e.g. satellite image and/or drone) and softwares
Description of measurement methods and procedures to be applied	The area shall be delineated either on the ground, using GPS, and/or from geo-referenced remote sensing data and softwares. For example. the area of each stratum containing different restoration models in a particular PAI can be preliminarily established based on satellite images within GIS software (e.g. QGIS, ArcGIS, etc). This is required to start the process of feasibility evaluation of a determined PAI. After that, and before restoration implementation, new aerial images are obtained (e.g. satellite images and/or drone flights) and the effective areas of implementation are designed. During crediting period, GPS, satellite images and/or drone flights will be conducted to monitor restoration activities and any correction needed in the area of each stratum is made.
Frequency of monitoring/recording	At each verification period.
Value applied	Ex-post. To be filled in the specific PAI at the inclusion of the PAI and monitored at each verification
Monitoring equipment	GPS, ArcGIS, QGIS, Drone, and/or Google Earth Pro software.
QA/QC procedures to be applied	Team members involved in the monitoring have been made aware of accurate measurements, and have been provided with training on GPS/GIS application
Purpose of data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Calculation method	Measurement
Comments	The stratification for ex-post estimations is based on the actual implementation of the project management plan. When

	necessary, the stratums of the project boundary may be updated, according to the development of the stand models. All changes will be monitored, and the justification of the change will be presented in each verification event. See section 5.3 for further detail.

Data / Parameter	*Aplot,i*
Data unit	ha (hectares)
Description	Area of sample plot in stratum *i*
Source of data	Field measurement
Description of measurement methods and procedures to be applied	The area shall be delineated either on the ground, using GPS, and/or from geo-referenced remote sensing data and softwares.
Frequency of monitoring/recording	At each verification period.
Value applied	Ex-post
Monitoring equipment	Measuring tape, GPS, ArcGIS, QGIS, and/or Google Earth Pro software.
QA/QC procedures to be applied	Team members are trained in all inventory procedures including layout of plots as well as GPS and GIS applications. Team members are fully aware of all procedures and the importance of collecting data as accurately as possible.
Purpose of data	• *Calculation of project emissions*
Calculation method	Measurement
Comments	See section 5.3 for further detail.

Data / Parameter	DBH (diameter at breast height)
Data unit	cm
Description	Diameter at breast height of trees within the plot presenting DBH ≥5 cm.
Source of data	Field measurement

Description of measurement methods and procedures to be applied	Typically measured 1.3 m aboveground. Measure DBH of all trees above 5cm of DBH in the sample plots using a measuring tape and/or a probe.
Frequency of monitoring/recording	At each verification period.
Value applied	Ex-post
Monitoring equipment	Measuring tape and/or probe.
QA/QC procedures to be applied	Field teams are trained in all inventory procedures. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible. Field measurements shall be checked by a qualified person to correct any errors in techniques.
Purpose of data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Calculation method	Measurement
Comments	See section 5.3 for further detail.

Data / Parameter	H (total height)
Data unit	m
Description	Total height of plants within restoration patches.
Source of data	Field measurement and/or remote sensing
Description of measurement methods and procedures to be applied	Field measurement: Measure H in the sample plots using a clinometer and/or measuring rod. and/or Remote sensing: Height of restoration patches measured by remote sensing (e.g. satellite images, aerial images, drone flights, etc.)
Frequency of monitoring/recording	At each verification period.
Value applied	Ex-post
Monitoring equipment	Clinometer, measuring rod and/or remote sensing.

QA/QC procedures to be applied	Field measurement: Field teams are trained in all inventory procedures. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible, as provided by the BRAZILIAN FOREST SERVICE. Field measurements shall be checked by a qualified person to correct any errors in techniques. and/or Remote sensing: Teams are trained to use remote sensing equipment and process data according to best practices and following robust guidelines and approved methodologies.
Purpose of data	• *Calculation of baseline emissions* • *Calculation of project emissions*
Calculation method	Measurement
Comments	See section 5.3 for further detail.

Data / Parameter	CC_{SHRUB}
Data unit	fraction
Description	Crown cover of shrubs in shrub biomass estimation stratum i at the time of estimation, expressed as a fraction.
Source of data	Field measurement
Description of measurement methods and procedures to be applied	For woody shrub species, all individuals with their crowns intercepting the transect line installed within the sample plot will have their crown measured using a measure tape. The measure must be taken according to the crown length intercepting the transect. The total length of interception is then summed up and calculated as a proportion of the total transect length.
Frequency of monitoring/recording	At each verification period.
Value applied	Ex-post
Monitoring equipment	Measuring tape

QA/QC procedures to be applied	Field teams are trained in all inventory procedures. Field-team members are fully aware of all procedures and the importance of collecting data as accurately as possible. Field measurements shall be checked by a qualified person to correct any errors in techniques.
Purpose of data	• *Calculation of project emissions*
Calculation method	Measurement
Comments	See section 5.3 for further detail.

Data / Parameter	T
Data unit	*Years*
Description	Time elapsed between two successive estimations (T=t2 – t1)
Source of data	Project and verification records.
Description of measurement methods and procedures to be applied	Counting years since project starts and/or last verification events occur.
Frequency of monitoring/recording	At each verification period.
Value applied	Ex-post
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of data	• *Calculation of project emissions*
Calculation method	T=t2-t1
Comments	If the two successive estimations of carbon stock in a carbon pool are carried out at different points of time in year t2 and t1, (e.g. in the month of September in year t1 and in the month of July in year t2), then a fractional value will be assigned to T.

5.3 Monitoring Plan

The monitoring plan establishes procedures for monitoring and verifying the implementation of project activities, the removal of GHG associated with the implementation and development of the areas under forest restoration process and the consequent change in carbon stock in the different carbon pools throughout the project period.

Main objective:

- Quantify GHG emission removals in areas restored by different restoration models in the eligible areas of the grouped project's PAIs (ex-post estimates).

Specific objectives:

- Determine the restored areas and respective strata (by restoration model, management phase, and year of planting);
- Design the shape, size and frequency of parameters to be measured in Monitoring Plots (PMP);
- Define the number of PMP and their location according to project activities stratification and reasonable statistical thresholds (e.g. uncertainty);
- Establish CO_2 calculation for the baseline.

As described in section 4.2, to calculate project emissions (removals) the required field parameters to be monitored are: *Ai*, $b_{TREE,i}$., and $b_{SHRUB,i}$:

1- **Area of stratum i of the areas of land (*Ai*)**

First, the area of each stratum containing different restoration models in a particular PAI is preliminarily established based on satellite images within GIS software (e.g. QGIS, ArcGIS, etc). This is required start the process of feasibility evaluation of a determined PAI. After that, and before restoration implementation, most recent aerial images are obtained (e.g. satellite images and/or drone flights) and the effective areas of implementation are designed. During crediting period, GPS, satellite images and/or drone flights will be conducted to monitor restoration activities and any correction needed in the area of each stratum is made. Thus, at each verification, the following table will be produced for each PAI:

Example of table produced to monitor the area of each PAI

PAI ARR patch ID	Coordinate X (central point of the stand)	Coordinate Y (central point of the stand)	*Ai* (hectares)	Variation regarding last verification (ha)	Justification of the variation

2- **Mean aboveground tree and shrub biomass per hectare in stratum (b_{TREE} and b_{SHRUB})**

As presented in section 4.2, the parameter b_{TREE} and b_{SHRUB},will be calculated using two options:

Option 1: census using remote sensing and/or field measurements.

Option 2: stratified random sampling

OPTION 1

The above ground live forest biomass parameter b_{TREE} and b_{SHRUB} may be estimated based on remote sensing, aiming to reduce the need for extensive ground-based sampling by leveraging remotely sensed data calibrated using ground-based sampling plots and/or literature reviewed available statistical data.

Remotely sensed data may be acquired from platforms such as ground sensors, aerial sensors (planes or unmanned aerial vehicles – UAVs) and/or orbital sensors. Remote sensing data can be acquired by sensors that provide visible RGB imagery, multispectral imagery, hyperspectral imagery, RADAR imagery, point clouds derived from aerial photogrammetry and/or LiDAR, and others. Each PAI will acquire remotely sensed data for all the project area, so the estimation of b_{TREE} and b_{SHRUB} will be a census approach.

All remote sensing data acquired from orbital sources are obtained from institutional datasets and/or commercial companies, as well as aerial (planes) commercial sources. For these datasets, acquisition parameters follow the commercially provided limitations for spatial, spectral, temporal and radiometric resolutions.

Data sourced from UAV platforms can be acquired using specific spatial, spectral, temporal and radiometric resolutions, depending on flight parameters. Flight parameters can vary depending on equipment used. Equipment can be interpreted as the combination of both the platform (UAV) and sensor or multisensors used. Thus, flight parameters are based on the flight altitude, frontal overlap, side overlap, flight speed and others, but are also based on the sensors used, that can vary on onboard technology. UAV flight parameters should at least have 50% frontal and side overlaps for imagery acquisition but may vary in altitude, depending on resolutions needed, and on speed, depending on flight conditions. Flights must also be aware of climate conditions and can occur both in sun or overcast condition.

Remotely sensed raw data can be composed of RGB, multispectral, hyperspectral, radar and/or LiDAR images, scenes, and data. Raw images, scenes and data may be post-processed for acquisition of subproducts such as ortomosaics, pointclouds, digital elevation models, vegetation indices, and others. Pointclouds from both aerophotogrametry and LiDAR can be processed to obtain diverse forest structure metrics such as forest canopy height, standard deviation, canopy rugosity, canopy gap, vertical forest stratum, leaf area index, and/or others.

As an example, forest structure metrics and/or vegetation indices can be used along with biome compatible biomass estimation equations to spatially explicitly estimate the above ground live forest biomass of the restoration projects. Equations used must be provided from literature review, preferably but not limited to peer-reviewed journals, and express a regression between the forest structure metrics and biomass. Each PAI may evaluate the appropriate equation and ensure that equation meets the requirements of the "VT0005: Tool for measuring aboveground live forest biomass using remote sensing. Version 1.0". Biomass is expressed as a unit of mass per hectare ($Mg.ha^{-1}$), while structure metrics can vary in units depending on the metric used and pixel/dimension size.

Normally, the biomass estimation equations using remotely sensed data estimates all above ground biomass, so the parameter b_{TREE} and b_{SHRUB} will be estimated together as total above ground biomass. Due to the actual challenge of estimating these two parameters separately, all the conversion factors used to convert the above ground biomass into CO_2 stocks will be the most conservative between the "tree" and the "shrub" assumptions. For example, the Root-shoot ratio for trees (R_i parameter) is an equation based on the above ground biomass and the Root-shoot ratio for shrubs (R_S parameter) has a default value of 0.40. If applying the R_i equation results in a value bellow the default of 0.40, then this result may be used both for tree and shrub total biomass estimation.

Calibration methods may be applied by each PAI using local plot samples. Similarly to the above mentioned equation, a regression model can be used to address the relationship between local plot above ground live forest biomass ($Mg.ha^{-1}$) and respective forest structure metrics. Thus, calibration can be achieved by statistical comparison between datasets, where differences are summed or subtracted to achieve a more precise result. The field measurements to be adopted in the calibration plot samples will be done similar as described in the Option 2 approach (Figure 55).

OPTION 2

Stratification

Since carbon stocks can vary greatly depending on the species planted, planting arrangements, and local potential for natural regeneration, first it is necessary to stratify the PAIs for correct sampling. This implies, for example, establishing plots in a manner that allow the evaluation of the results obtained in reforestation patches consisting of native species for timber production and in restoration patches aimed at conservation. Thus, to ensure the correct stratification of the PAIs, the spatial planning of the stratification of the areas for allocation of sample plots will be carried out in order to represent the different restoration models, considering the management phases for restoration models including thinning and harvesting activities and the age of the restorations. It will allow to calculate the average values of the different restoration models implemented, minimizing variation of the results obtained and, consequently, uncertainty. As an example, a diagram of stratification process can be observed in Figure 54.

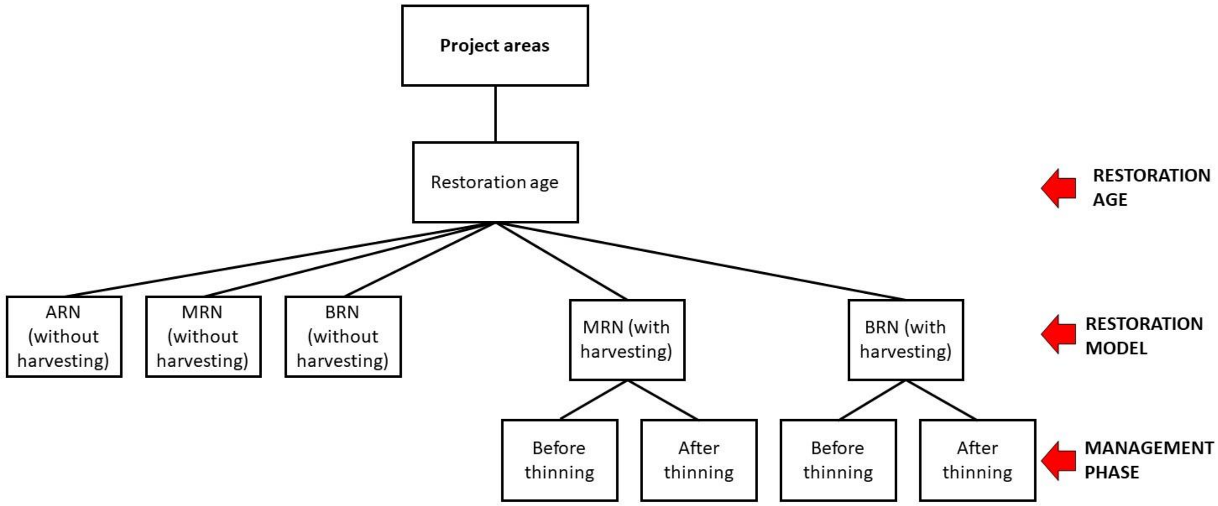

Figure 54. Example of stratification process

Field measurements

Data collection will be conducted in sample plots that will be variable or fixed and resampled at each monitoring and verification event. For measuring living trees, plots with circular, square, or rectangular shapes will be used. For measuring living shrubs, transects will be installed within the superior plots. The plots shapes and dimensions will be defined according to: (i) Larger plots capture more local variability (within the plot) and therefore reduce global variability (between plots); (ii) Plots shall be applicable to the different restoration models proposed by Re.green; and (iii) Plot sizes shall be suitable for integration with remote sensing data obtained from different platforms (drones, aircraft and satellites). It is important to highlight that, the plot format and total area can be altered due to operational conditions. For example, square and circular sample plots can be observed in Figure 55.

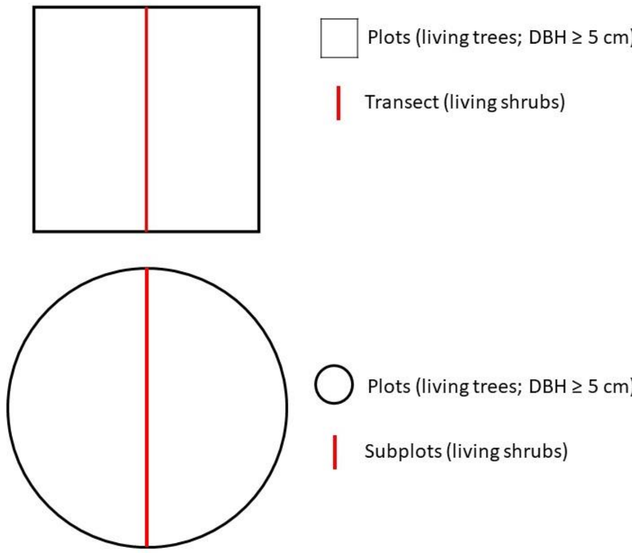

Figure 55. Example monitoring plots design.

Living trees

Field workers will identify the species and measure total height and diameter at 1.30 m (DBH) of all living trees (including palms) with at least one stem presenting DBH ≥5 cm and located within the sample plots. The DBH (cm) will be obtained by using a measuring tape or forestry probe. When using a measuring tape to calculate DBH (cm), the circumference at breast height (CBH - cm) at 1.3 height will be measured using a measuring tape or forestry probe, and the CBH is transformed into DBH by dividing the CBH per the **π** value (e.g. 3.14). In the cases where a probe is used, the result of the measure is already obtained in diameter. For individuals with defects or irregularities in the trunk at the time of diameter measurement, the diameter should be taken just below the irregularity. For individuals with bifurcations below the diameter measurement point, the diameters of all stems should be measured at the previously fixed position, provided that at least one of the trunks has DBH ≥5 cm, and the equivalent diameter[64] is subsequently calculated. In certain species, the roots can influence the measurements, and in these cases the diameters should be measured just above the zone of influence of the roots. See below the procedures for measuring DBH.

[64] Batista, J. L. F., Couto, H. D., Silva Filho, D. D. (2014). Quantificação de recursos florestais: árvores, arvoredos e florestas. Oficina de Textos, São Paulo, Brasil.

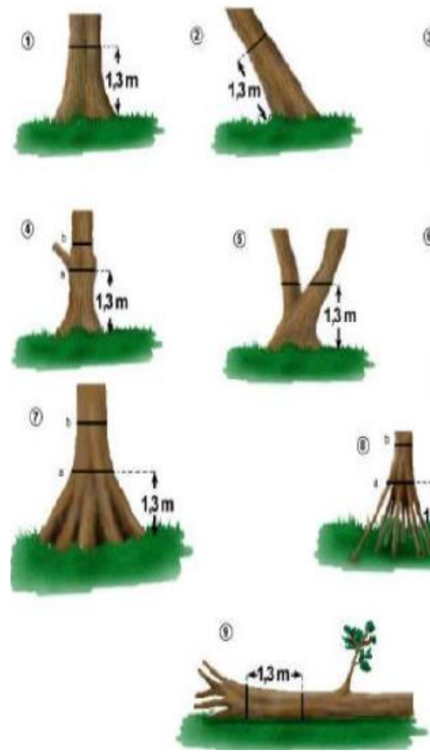

Figure 56. Protocol for diameter measurement.

According to the field manual provided by the Brazilian Forest Service[65], the height of the trees will be measured using a clinometer and/or a measuring rod. When using measuring rods, the following procedure shall be observed. In each sample plot, the total heights of at least three individuals representative of the upper, middle and lower forest layers will be measured with a clinometer. The heights of these three measured trees will serve as a reference for estimating the heights of the other individuals. The heights of the other trees will be estimated with the measuring rod and comparison with the heights measured of the first three trees measured with a clinometer. The measuring rod will be graded with tape every 1 m and 0.5 m intervals (Figure 57).

[65]https://snif.florestal.gov.br/images/pdf/publicacoes/publicacoes_ifn/manual_de_campo/Manual_de_Campo_IFN__Versao_7_4_1.pdf

Figure 57. Measuring heights with a reference (Source: Brazilian Forest Service).

Living shrubs

For woody shrub species, all individuals with their crowns intercepting the transect line installed within the sample plot will have their crown measured. The measure must be taken according to the crown length intercepting the transect. The total length of interception is then summed up and calculated as a proportion of the total transect length. See below the procedures for measuring crown cover.

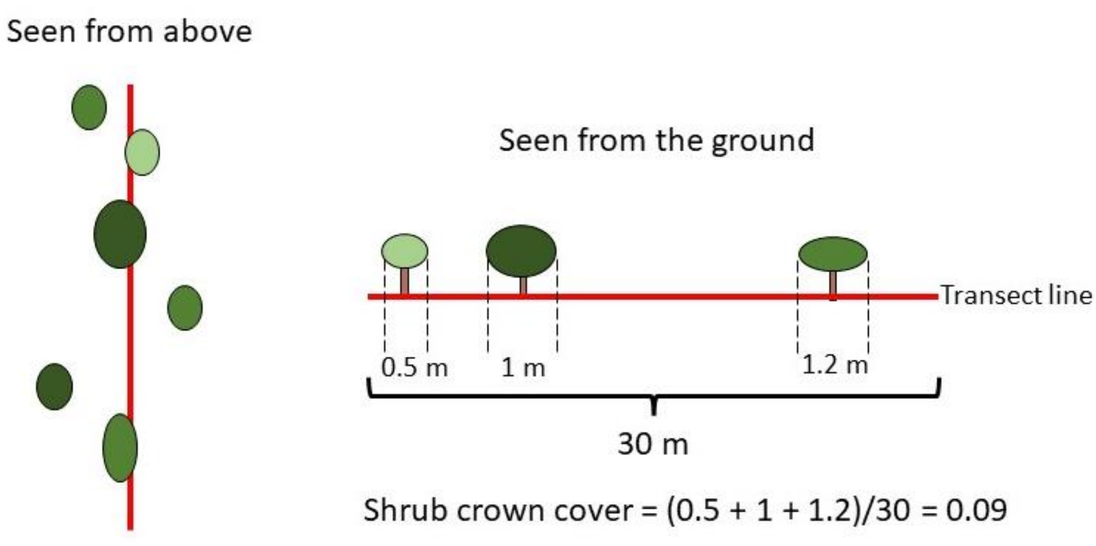

Figure 58. Example of procedures for measuring crown cover.

ALLOCATION AND NUMBER OF SAMPLE PLOTS

To install the plots in the field, the method called "systematic selection of sample plots with random start" to select the sample plots will be used, as provided in the AR-TOOL 14.

The number of plots required for measuring the variation within the project boundary and strata shall be estimated by using the AR-TOOL 03 "*Calculation of the number of sample plots for measurements within A/R CDM project activities*"[66]. The number of plots to be established and measured will be estimated as follows:

$$n = \frac{N \times tVAL^{2} \times (\sum_i wi \times si)^2}{N \times E^{2} + tVAL^2 \times \sum_i wi \times si^2}$$

where:

n	=	Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless
N	=	Total number of possible sample plots within the project boundary (i.e. the sampling space or the population); dimensionless
t_{VAL}	=	Two-sided Students t-value at infinite degrees of freedom for the required confidence level; dimensionless
Wi	=	Relative weight of the area of stratum *i* (i.e. the area of the stratum *i* divided by the project area); dimensionless
Si	=	Estimated standard deviation of biomass stock in stratum *i*; t d.m. (or t d.m. ha-1)
E	=	Acceptable margin of error (i.e. one-half the confidence interval) in estimation of biomass stock within the project boundary; t d.m. (or t d.m. ha-1), i.e. in the units used for s_i
i	=	*1, 2, 3,* . biomass stock estimation strata within the project boundary

[66] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-03-v2.1.0.pdf

According to the Tool, the following simplified equation will be used for estimating the number of sample plots for a small sampling fraction (that is, when area sampled is less than 5% of the PAI area):

$$n = \left(\frac{tval}{E}\right)^2 \times \left(\sum_i wi \ \times si\right)^2$$

where:

n	=	Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless
t_{VAL}	=	Two-sided Students t-value at infinite degrees of freedom for the required confidence level; dimensionless
E	=	Acceptable margin of error (i.e. one-half the confidence interval) in estimation of biomass stock within the project boundary; t d.m. (or t d.m. ha-1), i.e. in the units used for s_i
Wi	=	Relative weight of the area of stratum *i* (i.e. the area of the stratum *i* divided by the project area); dimensionless
Si	=	Estimated standard deviation of biomass stock in stratum *i*; t d.m. (or t d.m. ha-1)
i	=	1, 2, 3, . biomass stock estimation strata within the project boundary

For determining the number of sampling plots among strata, the following equation is used:

$$ni = n \times \left(\frac{wi \ \times si}{\sum_i wi \ \times si}\right)$$

where:

ni	=	Number of sample plots allocated to stratum *i*; dimensionless
n	=	Number of sample plots required for estimation of biomass stocks within the project boundary; dimensionless
Wi	=	Relative weight of the area of stratum *i* (i.e. the area of the stratum *i* divided by the project area); dimensionless
Si	=	Estimated standard deviation of biomass stock in stratum *i*; t d.m. (or t d.m. ha-1)
i	=	1, 2, 3, . biomass stock estimation strata within the project boundary

APPENDIX 1

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