BOA FÉ REDD PROJECT

Document Prepared by Ecológica Assessoria Ltda.

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1 PROJECT DETAILS

1.1 Summary Description of the Project

In Brazil, 58.39% of its entire 851,029,591.4 ha territory (IBGE, 2019[1]) is covered by forests, representing almost 497 million hectares of forest area (FAO, 2020[2]) and putting it in second place for nations with most forest area worldwide. Brazil has also been at times the country with the highest levels of deforestation in the world, having lost almost 15 million hectares of its forest area from 2010 to 2020 (FAO, 2020[3]). The expansion of the agriculture frontier due to cattle ranching, soy farming, timber collection, infrastructure and colonization by subsistence agriculturalists has contributed to this historically high deforestation rate, which is concentrated in the northern portion of the country, where the Amazon Rainforest lies.

The primary objective of the Boa Fé REDD Project is to avoid the unplanned deforestation (AUD) of a subsection of the 432.717,83 ha project area, consisting of 100% Amazon rainforest, within a private property in the municipality of Apuí, southern Amazon, owned by NRD Desenvolvimento de Recursos Naturais Ltda. (hereafter, "the company"). The latter is a private Brazilian sustainable development firm engaged in conserving the environment through the "development of sustainable forest management projects, generation of greenhouse gas emission reductions, and extraction of non-timber forest products (NTFPs)", according to land holders' agreement.

Boa Fé shareholders agreement was established on December 31st, 2019. On this date, the owners of Boa Fé defined the structure of the conservation plan, which included sustainable opportunities for income generation, such as the development of a REDD project to prevent illegal deforestation, implementation of a sustainable forest management plan, and harvesting of non-timber forest products (NTFP). Moreover, this agreement also defined the first measures to increase the land conservation, such as hiring employees dedicated for the forest surveillance, preventing the entrance of illegal loggers, hunters or fishers, and providing vehicles for the monitoring control. Therefore, December 31st, 2019 can be considered the start date of the project.

Beyond the project's ecological and carbon benefits, a proportion of the carbon credits generated will be dedicated to improving the social and environmental conditions in the project region, specifically contributing to improving deforestation control, and developing environmental education and other social activities. The contribution to sustainability is being monitored through the application of the SOCIALCARBON® Standard, which is based on six main indicators: Biodiversity; Natural; Financial; Human; Social and Carbon Resources.

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[1] IBGE – Instituto Brasileiro de Geografia e Estatística. Brasil. 2019. Available at: <https://www.ibge.gov.br/cidades-e-estados>.

[2] FAO and UNEP. 2020. The State of the World's Forests 2020. Forests, biodiversity and people. Rome. Available at: <https://doi.org/10.4060/ca8642en>.

[3] FAO. 2020. Global Forest Resources Assessment 2020: Main report. Rome. Available at: < https://doi.org/10.4060/ca9825en>.

The present REDD project is expected to avoid a predicted 105,540 ha of deforestation, equating to 64,578,360 tCO_2e in emissions reductions over the 31-year project lifetime (01-January-2020 to 31-December-2050), with an annual average of 2,083,173 tCO_2e.

The project is located within the agricultural expansion frontier, around 60km south of the Trans-Amazonian Highway – BR-230, and 50km north of the MT-206 highway. This region is also known as the Brazilian Arc of Deforestation. The main deforestation agents acting within the reference region during the historical period were: cattle ranching, mainly producing beef cattle; timber harvesters, acting both legally and illegally; and infrastructure, such as road and highway construction.

However, other planned infrastructure projects will probably increase deforestation pressure in the region even more. Those include the construction project of the Ramal Marcelino, for the disposal of wood. This already has the economic and environmental feasibility certificate issued by SEMA in Novo Aripuanã, the municipal authorization and the licensing of this project at Amazonas Environmental Protection Institute (IPAAM). For this reason, the extension of the branch was considered an important vector of future deforestation within the project area.

Once put into practice, these projects will likely affect demographic growth in affected municipalities, stimulating new economic activities and expansion of area, which, consequently, will create pressure to deforest further and increase deforestation levels. Thus, revenue from the sale of VCUs is essential for the project activity to compete with profitable alternative land-use scenarios.

Part of the project area is located within three different Brazilian protected areas, which are part of the Southern Amazon Mosaic. Therefore, the Boa Fé REDD Project makes an important contribution to the conservation of Southern Amazon biodiversity and also to climate regulation in Brazil and South America. In addition to contributing to the long-term conservation of the region, this project also has the function of establishing a barrier against the advancement of the Brazilian Arc of Deforestation, creating a Southern Amazon biodiversity corridor by adjoining to other protected areas in the region.

1.2 Sectoral Scope and Project Type

14. Agriculture, Forestry, Land Use

Reducing Emissions from Deforestation and Degradation (REDD) through Avoided Unplanned Deforestation.

This is not a grouped project.

1.3 Project Eligibility

The project is eligible under the scopes of the VCS Program Version 4.0:

- The project meets all applicable rules and requirements set out under the VCS Program;
- The project applies a methodology eligible under the VCS Program;
- The implementation of this project activity does not lead to the violation of any applicable law;
- This is an eligible AFOLU project category under the VCS Program: reduced emissions from deforestation and degradation (REDD);

- This project is not located within a jurisdiction covered by a jurisdictional REDD+ program;
- Implementation partners are identified in the project activity;
- This project does not convert native ecosystems to generate GHG. The project area only contains native forested land for a minimum of 10 years before the project start date;
- This project does not occur on wetlands and does not drain native ecosystems or degrade hydrological functions;
- Non-permanence risk will be analyzed in accordance with the VCS Program document AFOLU Non-Permanence Risk Tool.

1.4 Project Design

This project has been designed as a single installation of an activity.

Eligibility Criteria

Not applicable. This is not a grouped project.

1.5 Project Proponent

Organization name	NRD Desenvolvimento de Recursos Naturais Ltda.
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Organization name	Ecológica Assessoria Ltda.: Project developer, Project participant and Project conceiver.
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1.6 Other Entities Involved in the Project

Organization name	Sustainable Carbon Projetos Ambientais LTDA.
Role in the project	Carbon credits trader and Registry Manager
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1.7 Ownership

1.8 Project Start Date

1.9 Project Crediting Period

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	
Large project	x

Year	Estimated GHG emission reductions or removals (tCO_2e)
2020	30,466
2021	84,655
2022	129,944
2023	182,486

2024	238,188
2025	272,476
2016	309,179
2027	364,791
2028	443,708
2029	516,761
2030	627,125
2031	810,284
2032	973,831
2033	1,172,862
2034	1,358,929
2035	1,537,222
2036	1,706,200
2037	1,981,136
2038	2,297,547
2039	2,855,178
2040	3,199,493
2041	3,536,185
2042	3,724,862
2043	4,011,183
2044	4,135,656
2045	4,317,269
2046	4,439,896
2047	4,674,528
2048	4,828,753
2049	4,899,970
2050	4,917,598

Total estimated ERs	64,578,360
Total number of crediting years	31
Average annual ERs	2,083,173

1.11 Description of the Project Activity

The principal objective of the present REDD project is the conservation of 432,717.83 ha of Amazon rainforest area within the property described in section 1.12 of the present VCS PD. This will be achieved through avoidance of unplanned deforestation. It is important to note that this project is not located within a jurisdiction covered by a jurisdictional REDD+ program, nevertheless the State of Amazonas is developing its jurisdictional REDD+ strategy.

The present REDD project is expected to avoid a predicted 105,540 ha of deforestation, equating to 64,578,360 tCO_2e in emissions reductions over the 31-year project lifetime (01-January-2020 to 31-December-2050), including buffer (RF), leakage (DLF) and project efficiency (EI) reductions.

In recent years, the project region has been deforested for the expansion of agricultural and livestock activities, mainly due to the advancement of the so-called arc of deforestation from the south of the Amazon biome. This pressure is expected to continue, given the globalization of markets in the Amazon region and international development policies planned for the region[4].

The main deforestation agents within the Boa Fé REDD project region are: cattle ranching, mainly producing beef; timber harvesters, acting both legally and illegally; and infrastructure, such as highways and construction of roads.

The construction of new infrastructure generally increases regional economic development, facilitating access to and trade of products; however, it will probably affect demographic growth in the region, resulting in higher population pressure and deforestation rates. Furthermore, it is likely that these infrastructure projects will also lead to a considerable increase in migration to the region and colonization through land grabbing[5].

The project area and reference region overlap with Brazilian protected areas, which are part of the Southern Amazon Mosaic. Nonetheless, the municipalities of Apuí and Colniza, composing the majority of the Boa Fé REDD Project's reference region, were within the region of highly concentrated deforestation in the Brazilian Amazon biome known as the arc of Amazon deforestation[6].

Furthermore, according to Idesam, the municipality of Apuí (which contains the project area in its entirety) is an agricultural expansion front in the Amazon and occupies the 9th position of the most deforested

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

[5] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

[6] BECKER, B. K. Geopolítica da Amazônia. Estudos Avançados, v. 19, n. 53, p. 71–86, 2005.

municipalities annually between 2013 and 2019[7]. Despite the barrier to the expansion of deforestation formed by the Southern Amazon Mosaic, some of these protected areas fall within the sustainable use category, and moreover, they are close to the Brazilian arc of deforestation, which increases deforestation pressure and illegal logging.

The general picture of deforestation pressure in the State of Amazonas, where the project is located, is that it has been decreasing since 2004, reaching of 37,22% over the 2018-2019 period[8].

The Boa Fé REDD project committed to conserving the property, despite a consistently negative financial balance. For this reason, and because of competition pressures described in section 2.5, Additionality, the revenue from the present REDD project is essential for the continued conservation of this native rainforest area. Conservation activities involve the prevention of invasion by outside agents and banning of logging and other unpermitted degradation within the project area. Supervision is carried out by eight supervisors from within the project region, who keeps the project owner updated constantly. The supervision team monitors the area on alternate schedules, flying over the area every 10 months. The area counts with 2 stations (one to the north and the other to the south of the area), also composing the team, there is a closer employee who arrives faster when needed, and the local community also helps monitoring the area and communicating the owners with attempt invasion. Lastly, the project owner provides motorcycles when needed.

The total area of the property composing the project area retained its original vegetation cover. There are no buildings, permanent camps or open roads, thus having no infrastructure. Deforestation or extraction of forest products have never been carried out within the project area because the main objective of the project owner is forest conservation combined with sustainable forest management, along with other activities related to the collection of non-timber forest products (NTFPs).

A sustainable forest management plan (SFMP) maybe implemented during the project period, in order to harvest forest products/by-products in a manner consistent with the conservation of the local ecosystem. This type of economic activity enables the harvesting of an economically feasible volume of forest products, however allowing the regeneration of the natural stock in accordance with the growth and recovery rates of the biome. The SFMP is better detailed in the end of this section.

The natural conditions of the region help the conservation of the project area. The road network to access the project area is not good, because these unpaved roads are inadequately maintained and become impassable during the rainy season. In addition, access by river is restricted by waterfalls and/or by innumerable sandbanks during the dry season. It is important to note that there is only one partially navigable large river that crosses the project area (Aripuanã River).

In addition, some Brazilian protected areas composing the Southern Amazon Mosaic overlap with the project area and reference region. Around 32% of the reference region is located within some category of protected area. Figure 1 below displays all the protected areas within the project's reference region. Boa Fé REDD Project takes into consideration the presence of protected areas in its surroundings, thus the present project will only carry out the development and operation of activities that are linked to the rational use of the forest, in an integrated way, to preserve the original vegetation cover of the region.

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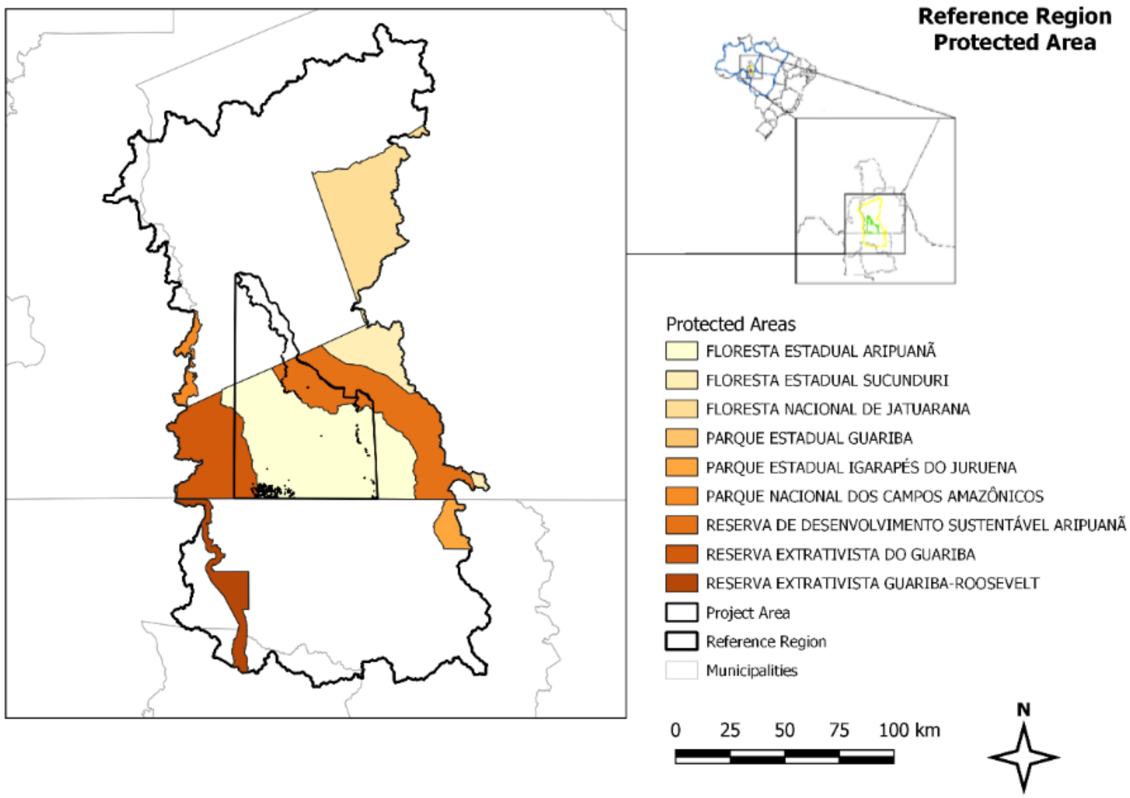
[7] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Relatório de Inteligência Estratégica – Queimadas em Apuí 2019. 02 p.

[8] PRODES Project - Brazilian Amazon Forest Monitoring through Satellite. Instituto Nacional de Pesquisas Espaciais (INPE). Available at: <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>. Last visited on 24/03/2021.

Figure 1. Protected areas within the reference region



In addition, around 81% of the project area is located within three different Brazilian protected areas, which are part of the Southern Amazon Mosaic: Aripuanã Sustainable Development Reserve, Guariba Extractive Reserve, and Aripuanã State Forest. These protected areas are classified within the sustainable use category, where sustainable activities are permitted. Forestry activities can be carried out in these areas in the form of Sustainable Forest Management, provided that it is authorized by the Brazilian Environmental Agency (IBAMA).

The Protected Area Center of Amazonas State (CEUC) was responsible for the management of all the State Protected Areas. In 2015, CEUC was temporary terminated by the Amazonas State Government. Despite the fact that the creation of protected areas is proven to be one of the most effective tools to fight deforestation, these important reserves do not attain their sustainable development goals without the necessary management and monitoring, leaving them vulnerable to criminal activity such as land squatting, illegal wood harvesting and deforestation, particularly in areas close to the arc of deforestation, which is the case in the present project.

In accordance with the Southern Amazon Mosaic Management Plan, CEUC established that sustainable forest management plans are permitted on private lands, provided that the property meets the Decree's single paragraph about the creation of Protected Areas, as follows:

Single paragraph: private lands whose properties are properly registered under Brazilian law are permitted within Aripuanã Sustainable Development Reserve, Guariba Extractive Reserve, and Aripuanã State Forest.

Thus, if a property has a land title issued by the National Institute for Colonization and Agrarian Reform (INCRA), this land is able to conduct a Sustainable Forest Management Plan (SFMP) for IBAMA's approval. Therefore, there are no restrictions for SFMP within the Protected Areas where the Boa Fé REDD project's properties are located.

Therefore, besides forest conservation, the present project aims to improve and quantify its social and environmental benefits through application of the SOCIALCARBON® Methodology. This methodology is an innovative concept developed by the Ecológica Institute to measure the contribution of carbon projects to sustainability. The SOCIALCARBON® Methodology is based on six main indicators: Biodiversity; Natural; Financial; Human; Social and Carbon Resources and aims to deliver high-integrity benefits in each.

<u>Sustainable forest management plan within the Boa Fé REDD project area</u>

The project can apply a sustainable forest management plan (SFMP), but there is no data for this. Use of forests under SFMPs depends on prior authorization of the SFMP by the responsible environmental body, which in the State of Amazonas is the *Instituto de Proteção Ambiental do Amazonas* - IPAAM. The procedures and guidelines for forest management of the area are described below, aiming to achieve economic, social and environmental benefits.

Forest management systems located in the State of Amazonas (within the Amazon biome) using machines to drag and transport logs are based on a minimal cutting cycle of 25 years. The maximum cutting level is 25 m^3/ha (4 – 6 trees/ha) in reduced impact plans, provided that the trees have minimum diameter of 50cm for felling for all species for which specific felling diameters have not yet been specified. Tree selection is conducted according to technical and ecological criteria to promote regeneration of managed tree species, soil preservation and quality of remaining forest. Thus, at least 10% of the remaining trees per species in the effective exploration area per plot are guaranteed, respecting the minimum limit of preservation of at least 3 trees per species per 100 ha, in each subdivision of the plot. The legal requirement estimates that the annual productivity of the managed forest area is 0.86 m^3/ha/year, such that at the end of 35 years, the 30 m^3 previously extracted has been recovered, which completes one cycle[,9,10].

Regarding private properties, sustainable forest management plans cannot be implemented in permanent preservation areas (PPAs). However, legal reserve areas established by the Brazilian Forest Code can be harvested for production of goods and services, subject to the approval of the SFMP by the relevant environmental body.

A complete forest inventory is the next necessary step to assess the area's forestry potential and determine the actual area for sustainable forest management in order to design the SFMP. Thereafter, this area will be divided into 30 large Annual Production Units (APUs), which constitute the forest areas to be managed for the next 30 years (operation cut cycles). In this way, APU1 which will be harvested in, which ensures the regeneration and preservation of the ecosystem. It is important to note that an Annual

[9] BRASIL. Conselho Nacional do Meio Ambiente (CONAMA). Altera a Resolução 406, de 02 de fevereiro de 2009, que estabelece parâmetros técnicos a serem adotados na elaboração, apresentação, avaliação técnica e execução de Plano de Manejo Florestal Sustentável-PMFS com fins madeireiros, para florestas nativas e suas formas de sucessão no bioma Amazônia. Resolução nº. 495, 19 August 2020. **Diário Oficial [da] República Federativa do Brasil**, Brasília, DF, 20 August 2020.

[10] ESTADO DO AMAZONAS. Secretaria de Estado do Meio Ambiente – SEMA. Altera a Resolução CEMAAM n° 17 de 20 de agosto de 2013, na forma deliberada na 47° Reunião Ordinária do CEMAAM. Resolução/CEMAAM N. 30 de 31 de outubro de 2018.

Harvesting Operational Plan shall be carried out before harvesting each APU, which also depends on prior authorization by IPAAM.

Furthermore, Forest Stewardship Council (FSC) Certified Forest Management can be applied to the future SFMP. FSC equates to low-impact harvest systems associated with forest longevity, continued ecological balance, socio-environmental responsibility and financial efficiency.

According to the Brazilian Forest Code, permanent preservation areas (PPAs) at the borders of waterways will be comprehensively preserved, and these comprise around 15% of the total property area, according to the pilot forest inventory. An additional 5% would be designed as protection area from FSC-certified sustainable forest management and Amazonas' State legal requirement. Moreover, some area was considered to be inaccessible or unusable due to the natural conditions of the area (presence of slope or swamps). Therefore, only 70% of the total project area would be subject to planned logging activities. Considering that the rotation cycle would be 30 years, each annual productive unit (UPA) would have around 12,500 hectares.

Generally, within the project area, some planned deforestation is predicted to mainly include implementation of infrastructure, such as opening of main and secondary roads, skidding trails, and timber yards in each annual production unit (*Unidade de Produção Anual - UPA*, in portuguese) within the project area, estimated to be around 1% of each UPA.

Despite the importance of SFMPs for climate change adaptation and mitigation, their implementation is not considered common practice, primarily due to the shortage of human resources and funding required to implement the necessary measures[11].

Implementation of REDD mechanism together with SFMP promotes sustainable forest use because it initiates forest conservation and storage of carbon stocks in forests while reducing pressure for timber from other conserved areas. In this way, biodiversity conservation and development of the local economy can be achieved at once. Furthermore, REDD+ mechanisms in sustainably managed forests can provide a guarantee of purchasing an environmentally responsible product to buyers of wood products, thus catering to the growing market demand[12].

1.12 Project Location

The Boa Fé REDD Project (hereafter "the project") is situated in the Apuí municipality in the State of Amazonas, a region known as Southern Amazon. This municipality is located around 1,000km from Manaus, the capital of the State of Amazonas. The project area belongs to NRD Desenvolvimento de Recursos Naturais Ltda., and covered 100% by native vegetation, totaling 432,717.83 ha. The northern and eastern boundaries of the property are constituted by the Aripuanã River, and to the South by the boundary with the State of Mato Grosso. The full contour coordinates of the project area are found in Appendix I.

There are two road transport options to reach the project area. The main one leaves from Colniza, in the State of Mato Grosso (MT). From this city, it is about 100 km in a 4x4 car: it is necessary to take the MT-206 towards the State of Rondônia (approximately 25 km), and after crossing the Aripuanã river, take a

[11] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO). 10. **Forest management and climate change:** a literature review. Roma, Itália, 2012. 53 p.

[12] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO). 10. **Forest management and climate change:** a literature review. Roma, Itália, 2012. 53 p.

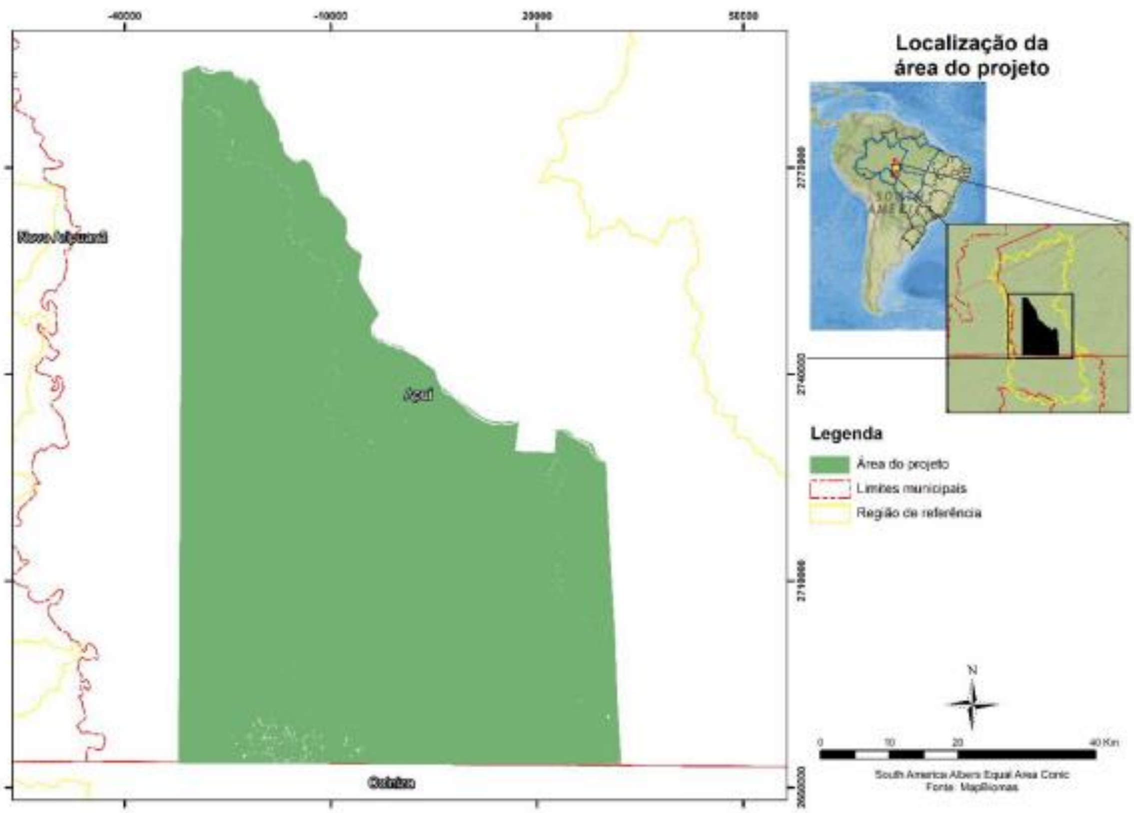
municipal road northwards. However, this is a convenient option only during the dry season (from May to September). The second option is by boat. Leaving from the Humaitá municipality (State of Amazonas - AM), it is necessary to take the Trans-Amazonian Highway (BR-230) towards Apuí (AM) until reaching the Aripuanã River, which forms the property boundary to the east, at a location called Mata-Matá. From this point, the project area is located about 65 km south, which takes almost 3h by boat along the Aripuanã River. Nevertheless, this river has several waterfalls, making it difficult to reach the area during the dry season.

In accordance with VCS requirements, stipulated in Approved VCS Methodology VM0015, version 1.1, the project area may only include areas composed of "forest"[13] for a minimum of ten years prior to the project start date. Therefore, satellite images between 2009 and 2019, were analyzed and classified. The areas within the property that were defined as forest in 2019 and in 2009 were separated and utilized to compose the project area. In addition, some non-forest areas were also excluded, such as rivers, rocks, and non-forest vegetation.

As shown in Figure 2 below, the size of the areas that were considered "non-forest" (i.e. non-forest vegetation or rock formations, as the area has never been deforested) within the project area was 1,987.96 ha. This was excluded from the initial area of 434,705.79 ha, resulting in 432,717.83 ha, which was then defined as project area.

[13] Brazilian Forestry Service. Brazil adopts FAO forest definition: "Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 meters (m) at maturity *in situ*." Available at: <http://www.florestal.gov.br/snif/recursos-florestais/index.php?option=com_k2&view=item&layout=item&catid=14&id=158>. Last visit on: 08 October 2020.

Figure 2 Boa Fé REDD Project - Project area



1.13 Conditions Prior to Project Initiation

General characteristics of the project area and reference region

The Boa Fé REDD Project makes an important contribution to the conservation of Southern Amazonia's biodiversity as well as to climate regulation in Brazil and South America. In addition to contributing to the long-term conservation of the region, this project also functions to establish a barrier against the advancement of the Brazilian Arc of Deforestation, creating a Southern Amazon biodiversity corridor by adjoining with other protected areas in the region.

Preserving such continuous forest environments is one way of ensuring continued gene flow of regional species and limiting the entrance of invasive species from other habitats.

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

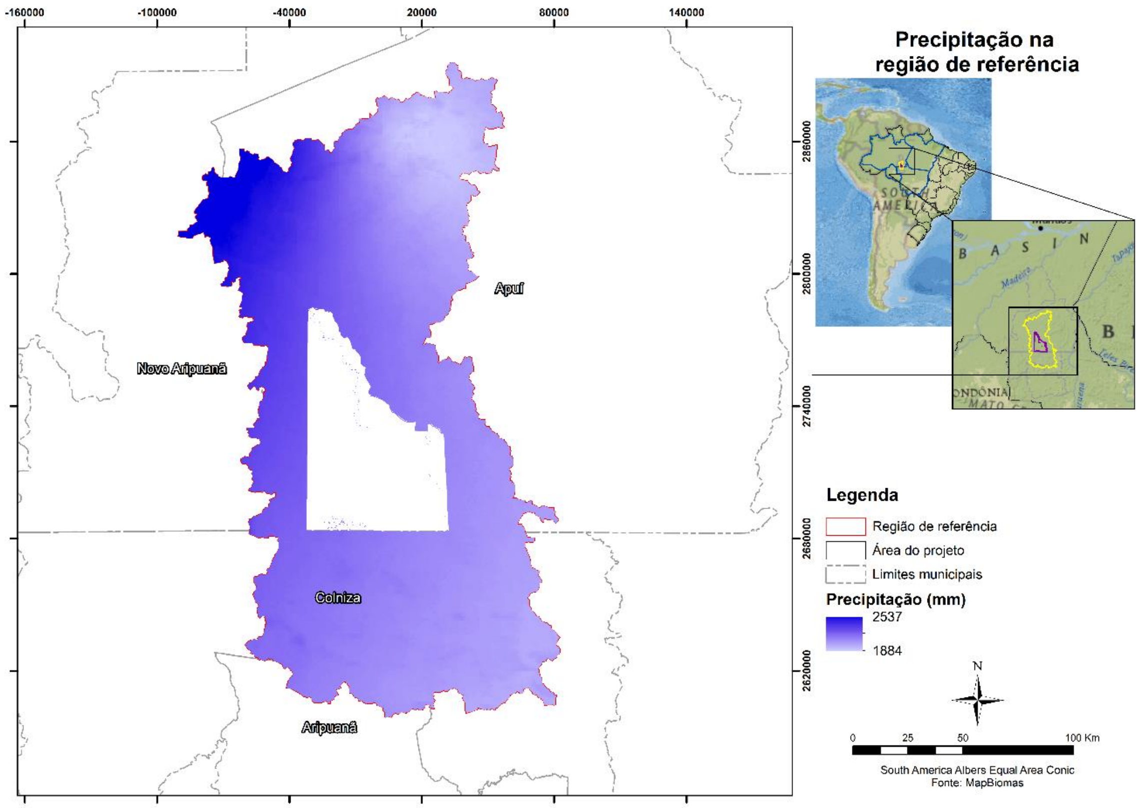
Climate and Hydrography

The project region is classified as Tropical rainforest climate type – Am category – according to the Köppen climate classification[14]. This means that it has no winter season, and the average annual rainfall is high, averaging > 2,100mm/year, while in the rest of the reference region it is 2,125.38 mm, thus, it

[14] KÖPPEN, W.; GEIGER, R. Klimate der Erde. Gotha: Verlag Justus Perthes. 1928.

was verified that the amount of rain in the project area it is within the range of ± 10% of 100% of the average of the rest of the reference region, which varies between 1,912.84 and 2,337.92 mm. This category is also characterized by having a monsoon season associated with heavy rains during the summer, with months that may exceed 400 mm rainfall. The relative humidity in the region is usually above 80%[15].

Figure 3 Variation of annual precipitation in the Reference Region of the Boa Fé REDD Project. Source of precipitation: https://www.worldclim.org/data/worldclim21.html.



The annual rainfall in the project area is, on average, 2,153.14 mm (Figure 3), while in the rest of the reference region it is 2,125.38 mm, thus it was verified that the amount of rain in the project area is within the range of ± 10% to 100% of the average of the rest of the reference region, which varies between 1,912.84 and 2,337.92 mm.

The Am climate type is defined as follows:

1) The driest month have average rainfall <60mm;
2) The project area displays very little monthly and annual variation in temperature, ranging between 23°C and 25°C as a monthly average, the minimum temperature is always >18°C.

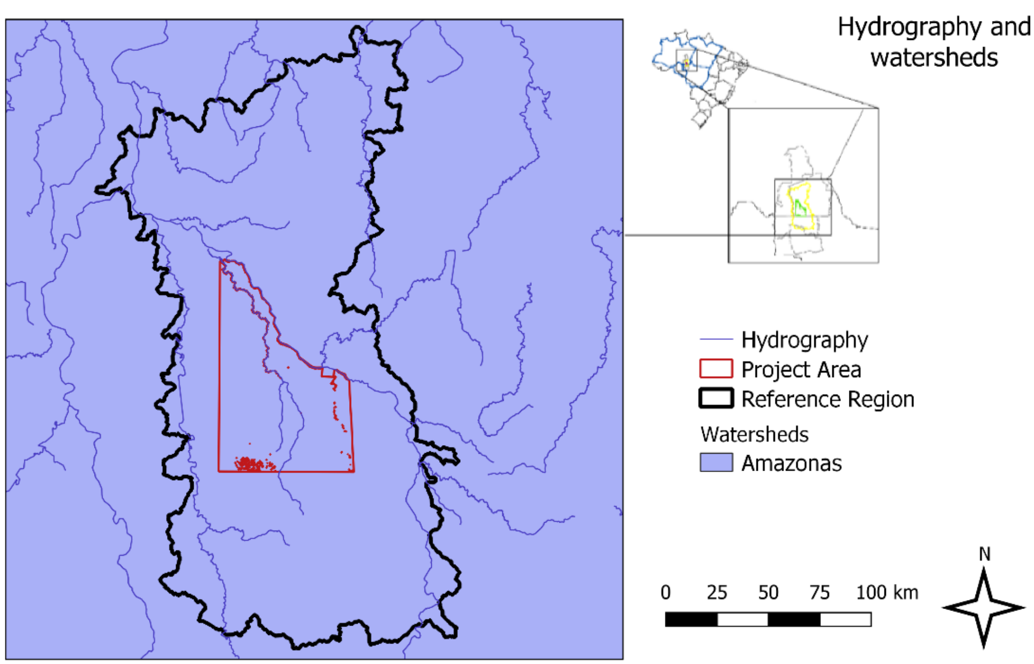
[15] LUZ, Horacio de Figueredo. **Laudo de avaliação da capacidade de uso do solo:** Imóvel Fazenda Boa Fé. Manaus: Ibiraú Florestal, 2014. 26 p.

The project area is located in the climate contact between two Brazilian regions: the north hot-humid and the central seasonal. This region is dominated by dense forests in a hot and humid region, with a shorter or absent dry period. Therefore, the climate in the region, called Monsoon, is the transition between a hot and humid climate with a hot seasonal climate and often humid[16].

In addition, the project area is located within the Tapajós-Madeira watershed, specifically to the right of the Madeira River sub-basin. Figure 4 below shows the hydrography and watersheds in the reference region. It can be noted that the majority of rivers in the region are oriented in the the south-north direction.

Most of the rivers are navigable only for about six months a year (wet season), due to the lower water level during the dry season and the large number of rapids and rocks.

Figure 4 Hydrography and watersheds in the reference region



The project area's entire eastern boundary is the Aripuanã River, a major tributary of the Madeira River. The Aripuanã is a large river, which is over 400m wide at its widest point, having many rocky rapids and a major waterfall named the Sumaúma Waterfall (Figure 5 below).

[16] WWF (Brasil). **Mosaico da Amazônia Meridional:** Vencendo limites geográficos e integrando gestão. Brasília-DF: WWF, 2014. 136 p. Available at:

<https://wwfbr.awsassets.panda.org/downloads/mam_livro_vencendo_limites_geograficos_final.pdf>.Last visit on: October 7th, 2020.

Figure 5 The Sumaúma waterfall on the Aripuanã River located within the project area.

Other important rivers that cross the property in the south-north direction are Guariba and Paxiuba Rivers, in addition to several other streams, including Paxiubinha, Sumaúma and Puma. Due to the rock formations originated from the Southern Amazon Plateau, the rivers begin to form floodplain lands only in its final portion, near to the Aripuanã River[17].

Geology, Topography and Soils

The altitude variation in the reference region is relatively low, and the higher parts do not exceed 500 m above sea level, with values between 22m and 504m, these values are within 99% of the variation in the reference region (Figure 7). Noting that the eastern portion of the region has the highest values.

The great Amazon Plain takes place at most of the project area, noting that at the southern part, on the border with the State of Mato Grosso, there are several small mild hills, which were formed by rocks emerging from the Central Brazil Plateau Crystalline Complex, also known as Southern Amazon Plateau.

There is a mildly hilly relief to the landscape, with streams well distributed across the terrain. Most of the area, especially in the lower course of the rivers, lays over sedimentary substrate where part is periodically flooded during the rainy season, forming floodplain forested lands. Figure 6 below shows the slope map of the project area and reference region. It is possible to note that almost all the project area has a little or no slope and gentle slope, having a slope below 8%.

[17] LUZ, Horacio de Figueredo. **Laudo de avaliação da capacidade de uso do solo:** Imóvel Fazenda Boa Fé. Manaus: Ibiraú Florestal, 2014. 26 p.

Figure 6 Altitude variation in the Boa Fé REDD Project Area. Altitude source: SRTM

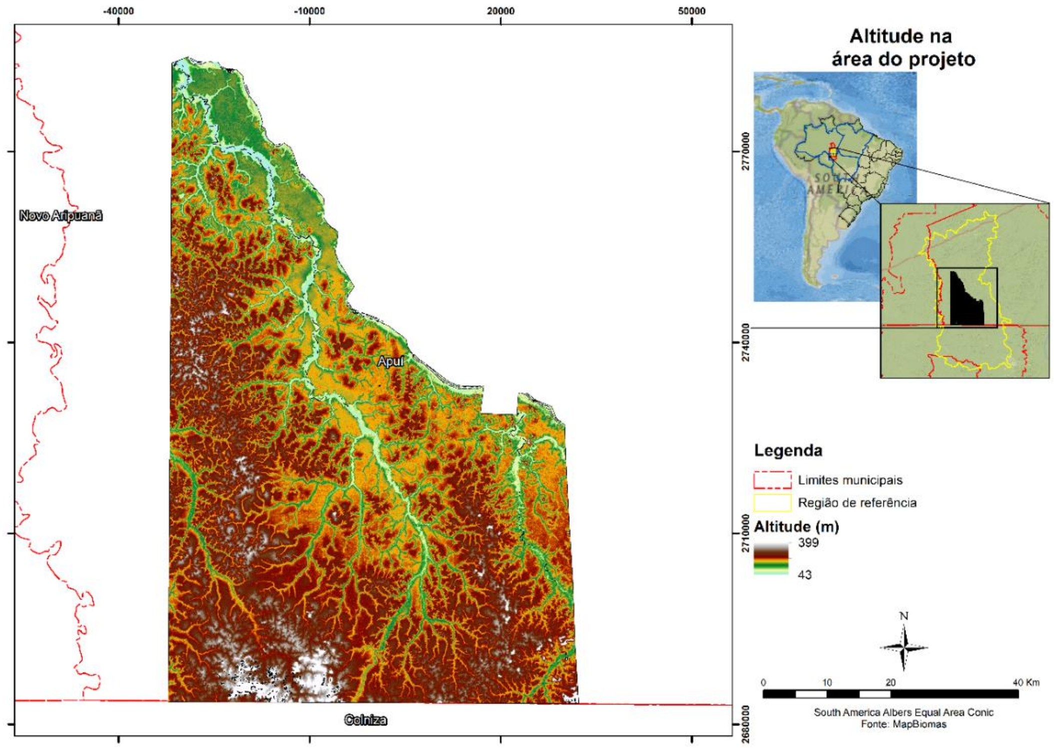
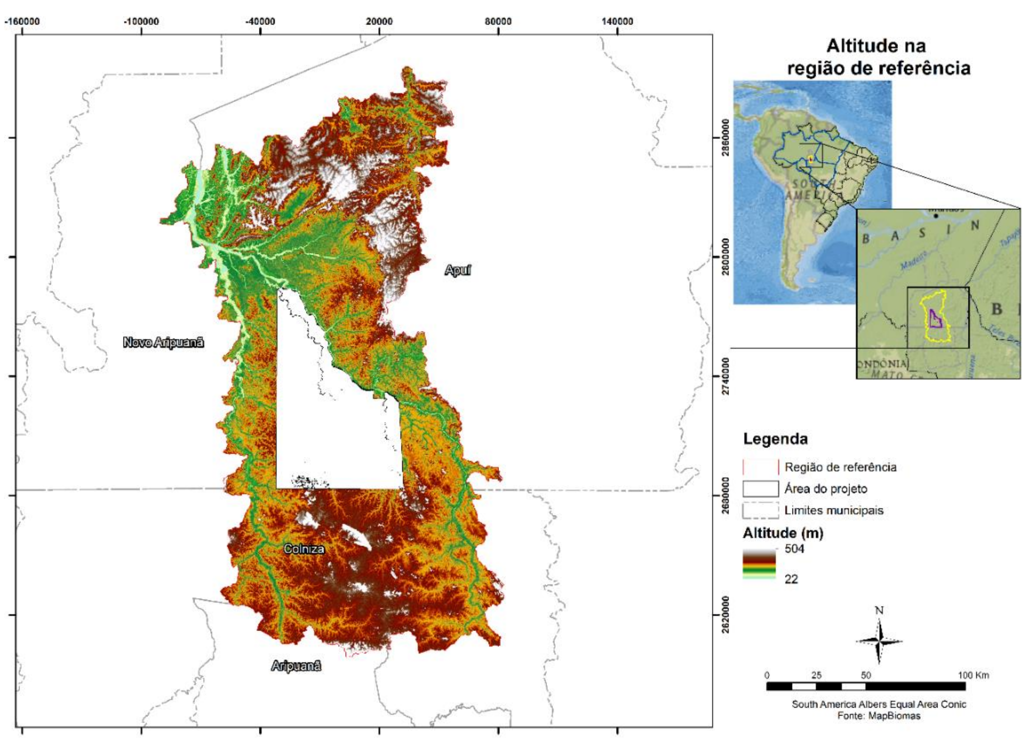


Figure 7 Altitude variation in the Reference Region of the Boa Fé REDD Project. Altitude source: SRTM



The average slope in the project area is 5.02 (Figure 8), while in the remaining 95% of the reference region it is 5.43 (Figure 9). Therefore, the average value of the project area is within the range of ± 10% of the average in this region, which is between 4.89 and 5.97.

Figure 8 Slope variation in the Boa Fé REDD Project Area. Altitude source: SRTM

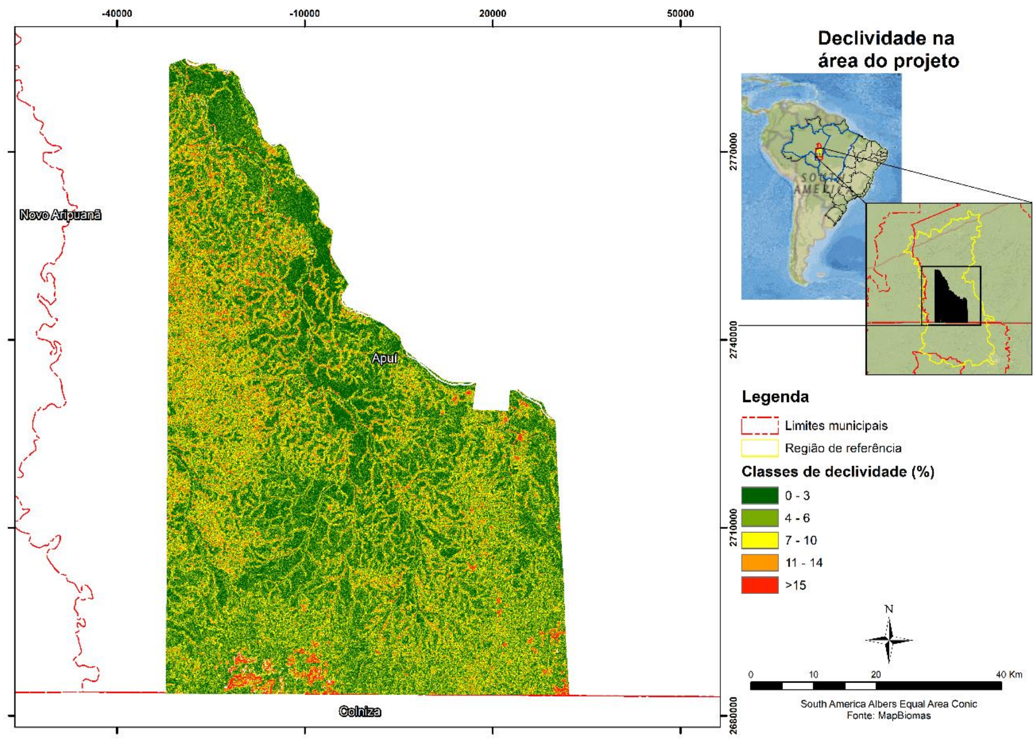
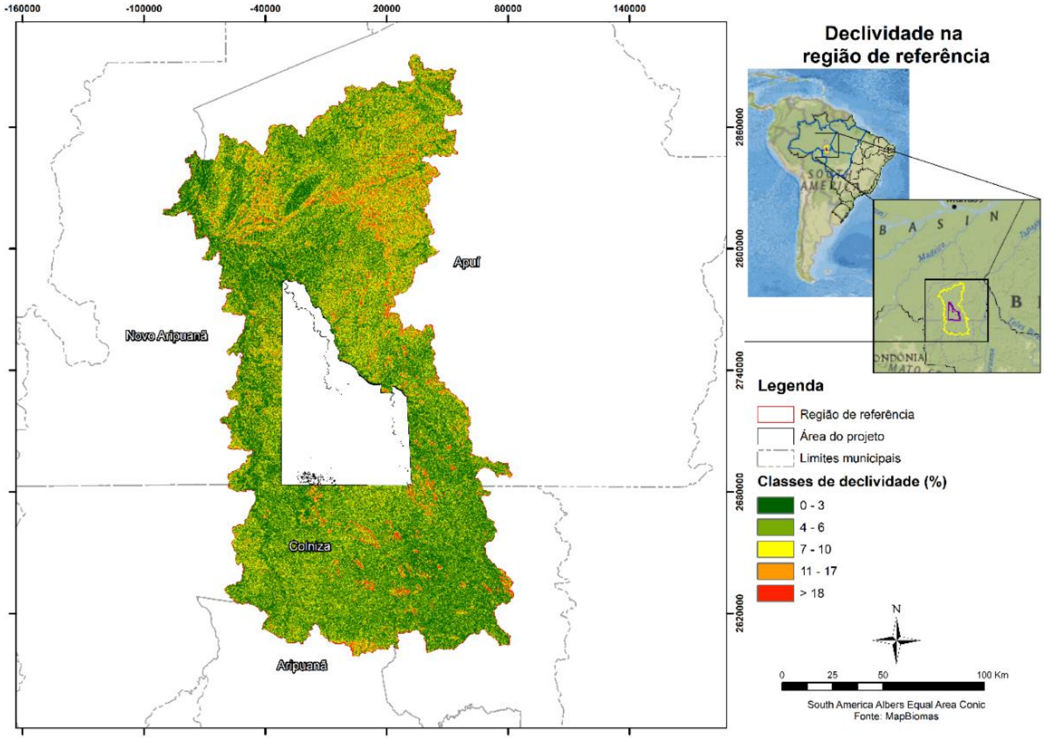
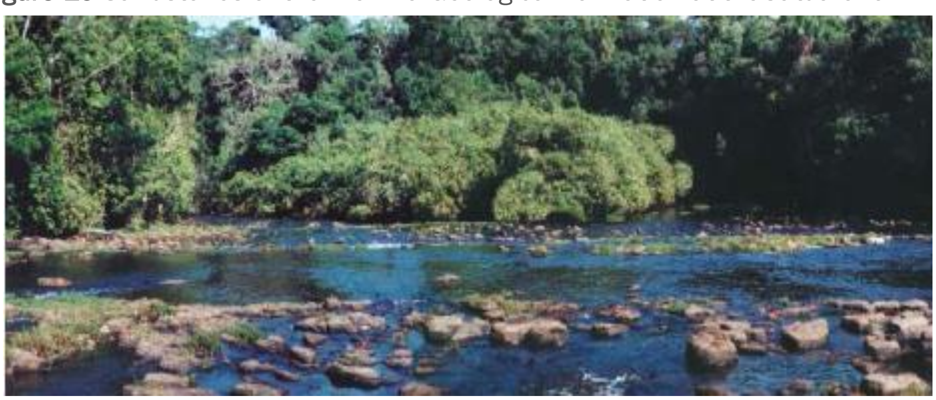


Figure 9 Slope variation in the Boa Fé REDD reference region. Altitude source: SRTM



The predominant rock formation within the project area originates from granites and gneisses of the Central Brazil Plateau Crystalline Complex. The main rock types are acidic and / or sedimentary, such as some sandstones and claystones. Furthermore, the main geological formation in the region is denominated Prainha Formation, which is a sedimentary clastic succession[18]. Figure 10 below shows the Jatuarana River within the project area, noting the sandstones of the Prainha Geological Formation.

Figure 10 Sandstones of the Prainha Geological Formation at the Jatuarana River



Erosive processes acting for thousands of years on the Southern Amazon Plateau have eroded the main river channels flowing from south to north direction, such as the Aripuanã and Roosevelt Rivers. This process has also produced rapids and waterfalls, such as the Sumaúma Waterfall, on the edge of the

[18] LUZ, Horacio de Figueredo. **Laudo de avaliação da capacidade de uso do solo:** Imóvel Fazenda Boa Fé. Manaus: Ibiraú Florestal, 2014. 26 p.

aforementioned Plateau. In addition, all the regional rivers run to the Madeira River in the north, being that the largest plains are located at the end of the Guariba River.

The predominant soil types within the project area are clayey latosols, yellow latosols and red-yellow latosols, from the oxisols group within the aluminum-iron complex, together with medium-high acidity clays. These soils are poor in phosphorus and potassium, with low to medium levels of calcium and magnesium. In addition, these soils have medium to high clay content, with sections with low to moderate sand and silt contents. Furthermore, there is a high concentration of organic matter on the surface soil layers resulting from the thick organic layer under the forest litter. Clay and sandy-clayey soils, notably red-yellow podzolic, are also found in the landscape's slopes, which predominate in less than 10% of the total project area, concentrated in its southern portion.

In addition, dystrophic lithosols with quartz gravel are found at the end of steep slopes and close to streams and hills to the south of the property. Gley hydromorphic soils from grey to dark colors are also found in some floodplains and flooded riverbanks at the end of their course, such as the Guariba, Paxiuba, Paxiubinha, Samaúma and Suçuarana Rivers[19].

Furthermore, according to RADAMBRASIL (1978)[20], there are some small areas of anthropogenic soils, known as "indigenous black soil" (Portuguese: terra preta de índio), generally distributed across the riverbanks. These soils are characterized by having high concentration of nitrogen and phosphorus[21].

<u>Socio-economic conditions</u>

The following socioeconomic analysis considers the municipalities with higher percentages of their areas within the limits of the reference region: Apuí and Nova Aripuanã, both in the State of Amazonas, and Colniza, in the State of Mato Grosso, since they have more influence in the region because of their size, summing up to more than 97% of the reference region.

Analyzing the Gross Domestic Product (GDP) in these municipalities[22], it is verified that the highest proportion of the wealth produced comes from agriculture/livestock and services sectors. The services are generally provided and depending on the agricultural sector. However, Colniza has predominant GDP values from the services sector, followed by industry sector. Moreover, the low level of industrial activity in the other municipalities is notable. In recent years the GDP in the municipality of Colniza was higher than Novo Aripuanã. Figure 11 below shows the GDP by sector in the two main municipalities of the reference region.

[19] LUZ, Horacio de Figueredo. **Laudo de avaliação da capacidade de uso do solo:** Imóvel Fazenda Boa Fé. Manaus: Ibiraú Florestal, 2014. 26 p.

[20] RADAMBRASIL. Levantamento de Recursos Naturais: Geologia, Geomorfologia, Solos, Vegetação, Uso Potencial da Terra. Rio de Janeiro, 1978.

[21] CARRERO, G.C. Dinâmica do Desmatamento e Consolidação de Propriedades Rurais na Fronteira de Expansão Agropecuária no Sudeste do Amazonas. Master thesis, Instituto Nacional de Pesquisas da Amazônia. 68p. 2009.

[22] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

Figure 11 Gross Domestic Product by sector the municipality of Apuí

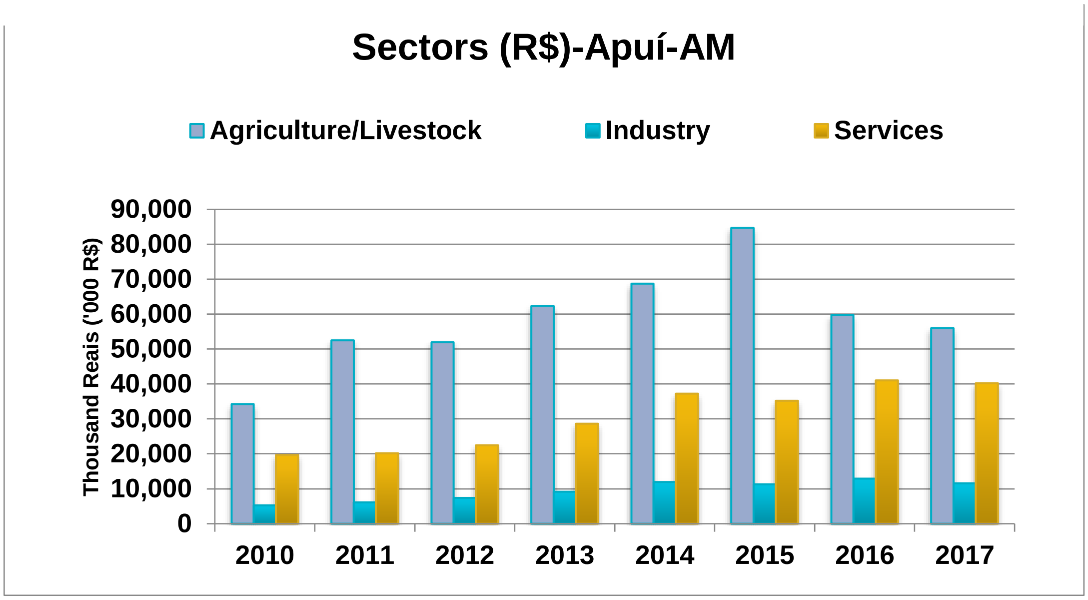
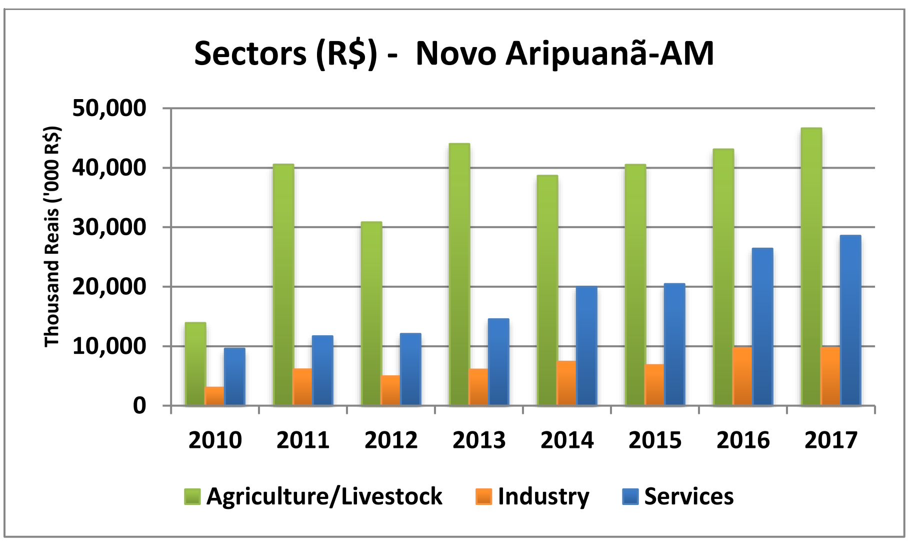


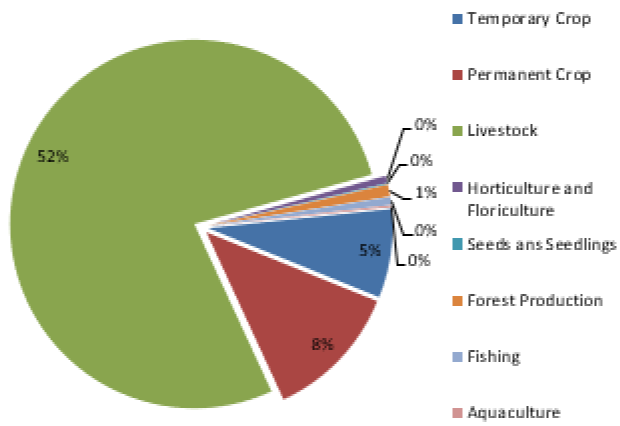
Figure 12 Gross Domestic Product by sector the municipality of Novo Aripuanã



In addition, analysis of Figure 13 below shows that the main land use in the three most important municipalities that compose the reference region is livestock followed by temporary crop, according to the 2017 Agricultural Census[23]. Out of the total land use in the region (around 263,410 ha), almost 52% is livestock, which also shows that this is the main economic activity in the region.

[23] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

Figure 13 Agricultural census 2017 (land use) in the three main municipalities of the reference region



According to IDESAN (2011)[24], the land ownership situation in apuí is chaotic, presenting only 17.6% of titled land, a very low value if compared to other settlements in the Amazon. Thus, the land tenure irresolution contributes to reducing options for legal productive activities, such as forestry, and continues to encourage the expansion of deforestation associated with livestock and land speculation in this region that concentrates most of the deforested area of the municipality, being primarily concentrated in the arc of deforestation, where the only available means of access to the rest of the country are located, according to Razera (2005).

Because of having a border with Mato Grosso State and being directly linked to Rondônia State via the Trans-Amazonian Highway, and as a function of the appreciation of land in these States, Apuí Municipality has seen great demand for land, as pointed out by Razera (2005), because it offers large areas with low prices, or land still considered to be "ownerless".

Traditional means of production such as extractivism and subsistence agriculture are combined with livestock farming and agriculture activities resulting in growth of the regional economy and population, but also in conflicts involving society at large and lands occupied by indigenous and traditional communities[25].

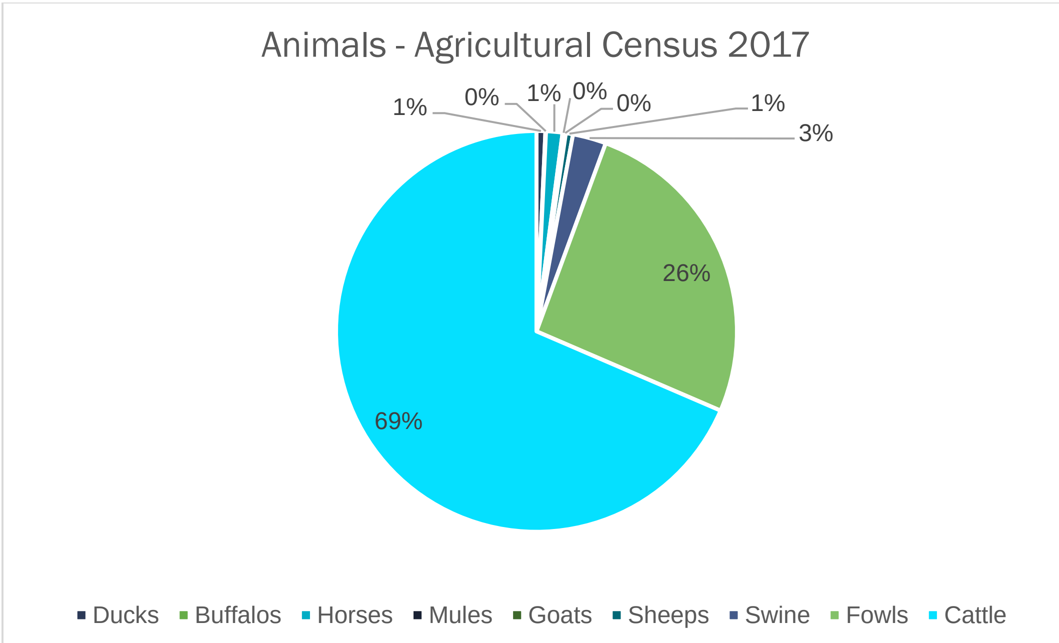
[24]Instituto de Conservação e Desenvolvimento Sustentável do Amazonas (Idesam). **Redução de Emissões do Desmatamento e Degradação Florestal (REDD+) ESTUDO DE OPORTUNIDADES PARA A REGIÃO SUL DO AMAZONAS. 2011**. Available at: https://idesam.org/publicacao/REDD_Estudo_de_Oportunidades_Sul_Amazonas.pdf. Last visit on: October 27th, 2020.

RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[25] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

In addition, the predominant animal types in the three main municipalities of the reference region in 2017 were cattle (69%), fowls (26%), and swine (3%), composing almost 98% of the total. The Figure 14 below shows the distribution of animal types within the reference region in 2017[26].

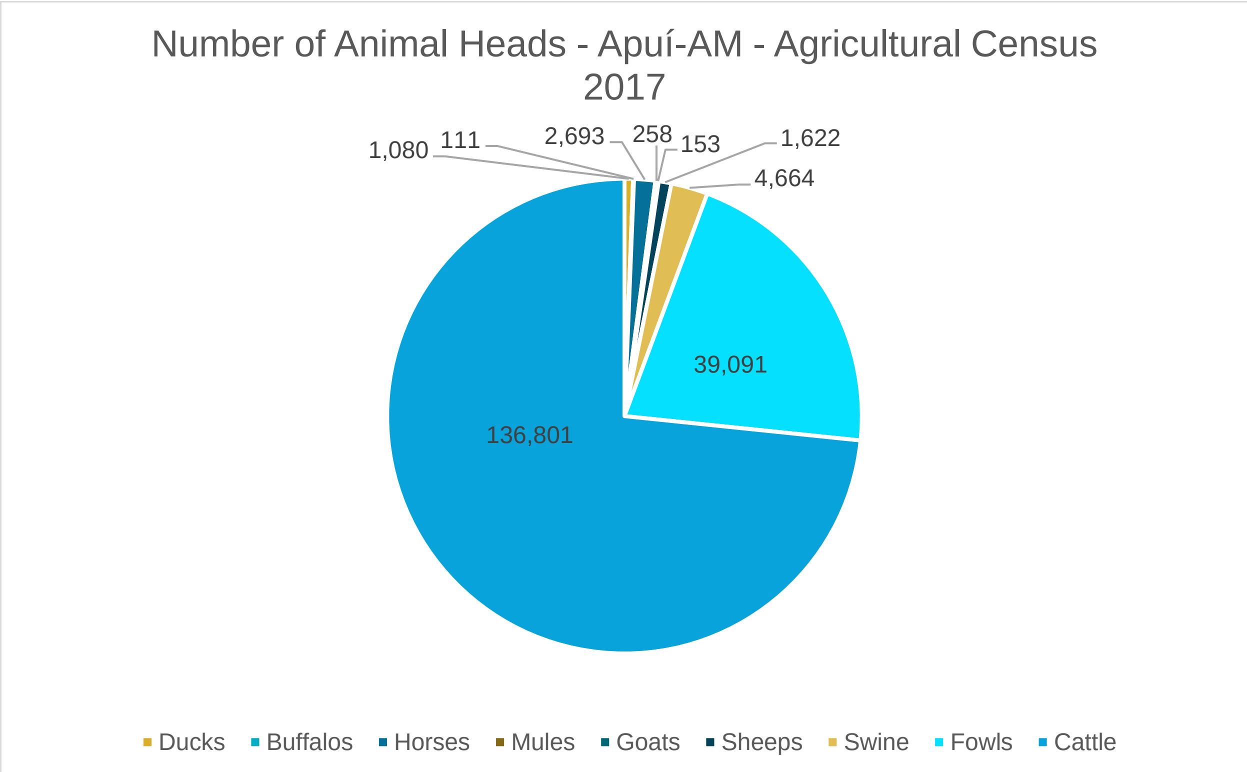
Figure 14 Animal types in the two main municipalities of the reference region in 2017



In 2017, there were around 136,8 thousand heads (Figure 15 below) of cattle within the municipality of Apuí, occupying an area of around 123 thousand hectares of pasturelands. These figures show an average stocking rate of 0.6 heads/ha, which demonstrate the low efficiency cattle ranching model in the region, mainly due to the low cost of the land.

[26] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

Figure 15 Number of Animal Heads - Apuí-AM - Agricultural Census 2017



Brazilian ranchers on average raise just over one head of cattle per hectare of land, but well managed pastures, with better grass production, can support three to five heads per hectare. Nevertheless, this situation is slowly getting better; over the past decade, pasture in the Amazon region has increased by 30% and the number of cattle has increased by 80%[27].

In addition, timber logging is also an important economic activity within the reference region. Usually, timber logging is the first driver of deforestation that reaches previously inaccessible forest lands, followed by land speculators or farmers in search of cheap land. It's a co-evolutionary process, that is, firstly the timber logging harvests all the species with commercial interest, then after clearing roads and settling in these areas, the deforestation continues in areas already explored and unexplored, and thus providing conditions for further expansion of logging and cattle ranching[28]. The illegal logging (without authorization or sustainable management) was reported by residents as a major environmental problem and cause of conflicts in the region[29].

It is important to note that firewood harvesting is also an important economic product within the reference region, mainly in Nova Aripuanã, representing more than 70% of the total extraction production

[27] TOLLEFSON, Jeff. The Global Farm. **Nature**, Washington Dc., v. 466, n. 1, p.554-556, 20 jun. 2010.

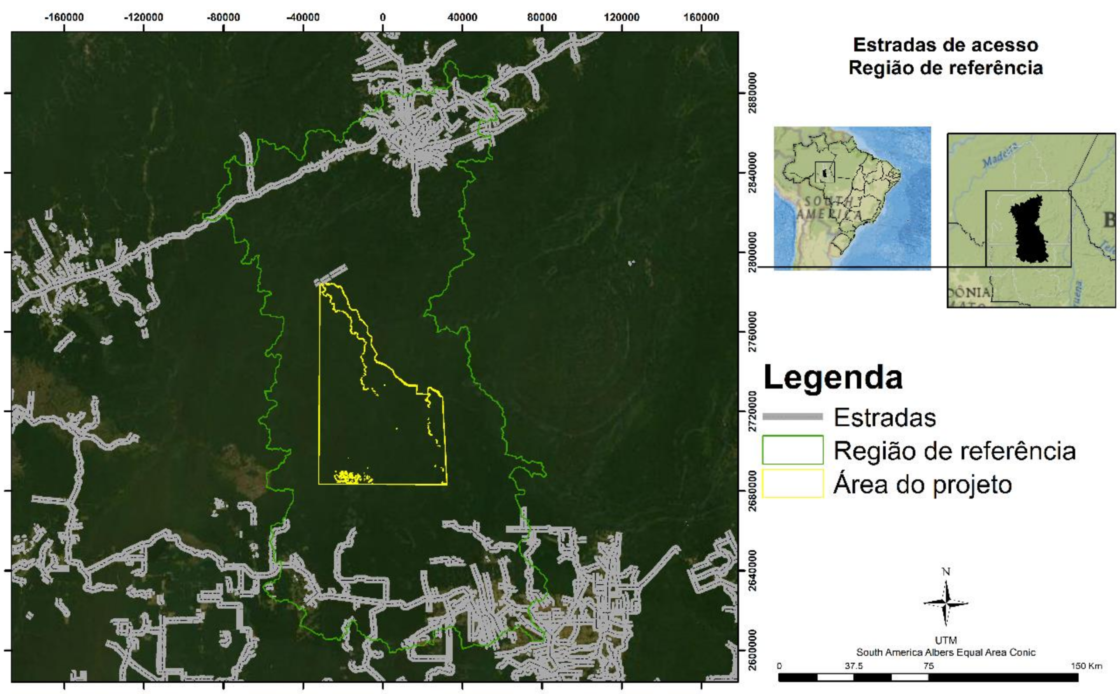
[28] RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[29] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

value in this municipality. However, as detailed in section 3.4 Baseline Scenario (Leakage belt), timber logging (roundwood) showed the highest production values within the reference region during the 2010-2019 period. Although wood harvesting represented by higher timber production was concentrated in the municipalities of Novo Aripuanã and Colniza, copaíba oil and resin from the trees of the genus *Copaifera* were predominant in Apuí.

Highway BR-230 is the main means by which offtake of the majority of production is carried out and provides the link with Porto Velho, the capital of Rondônia State, which is the primary market for the livestock and agriculture market of Apuí. Some segments of the highway are still unpaved and are impassable during the rainy season between December and April, hindering and increasing the price of transport of people and merchandise[30]. Colniza is also connected to Porto Velho via the MT-206, as well as other regions of the country, therefore having a better location in terms of commercial logistics. Figure 15 below shows the main highways for product offtake in the project region.

Figure 16 Main roads and highways present in the reference region



Social conflict issues, primarily land conflict, are common in these regions because they lie at the frontiers of the arc of deforestation and contain a large quantity of unoccupied lands. The following activities are characteristic of the region: forced land settling by squatters or timber harvesters; illegal deforestation and gold, diamond and cassiterite mining present in many of Amazonia's watersheds[31].

[30] CARRERO, G.C. Dinâmica do Desmatamento e Consolidação de Propriedades Rurais na Fronteira de Expansão Agropecuária no Sudeste do Amazonas. Master thesis, Instituto Nacional de Pesquisas da Amazônia. 68p. 2009.

[31] SECRETARIA DO ESTADO DO MEIO AMBIENTE E DESENVOLVIMENTO SUSTENTÁVEL (SDS). Unidades de Conservação do Estado do Amazonas. Manaus, 2007.

Until the early 1960s, the region remained virtually wild and little known, but the construction of Brasília, inaugurated in 1960, and the opening of new roads such as the Belém-Brasilia highway (BR-060), eventually attracted migrants from other regions of Brazil.

More recently, State policies such as the National Integration Program (NIP, or Programa de Integração Nacional, PIN, in Portuguese), created in 1970 with a view to colonizing the Amazon, led to the clearing of new roads in the region, allowing the implementation of colonization programs as an incentive to immigration, primarily in the South and Southeast of the country, creating a great social diversity in the region. The aim was to populate the region with small and medium-sized farmers able to diversify production, opening up new markets and also securing the territory of the Amazon. These communities, initially entirely rural, grew and expanded into urban centers, driven mainly by the creation of the Trans-Amazonian Highway (BR-230)[32].

The lack of alternatives in the frontier region has led many migrants to experiment with alternative income generation options. However, the lack of a resolution regarding land-tenure issues has contributed to reducing the number of legal production options, such as for example, sustainable forest management, and continues to promote deforestation associated with livestock farming and land speculation in this region which concentrates the largest deforested area in southern Amazonas State. According to research carried out by IDESAM, the region has suffered from an urgent need to carry out restructuring at a local level, which is in need of investment in structure, equipment and human resources to attend to the issues surrounding land-tenure[33].

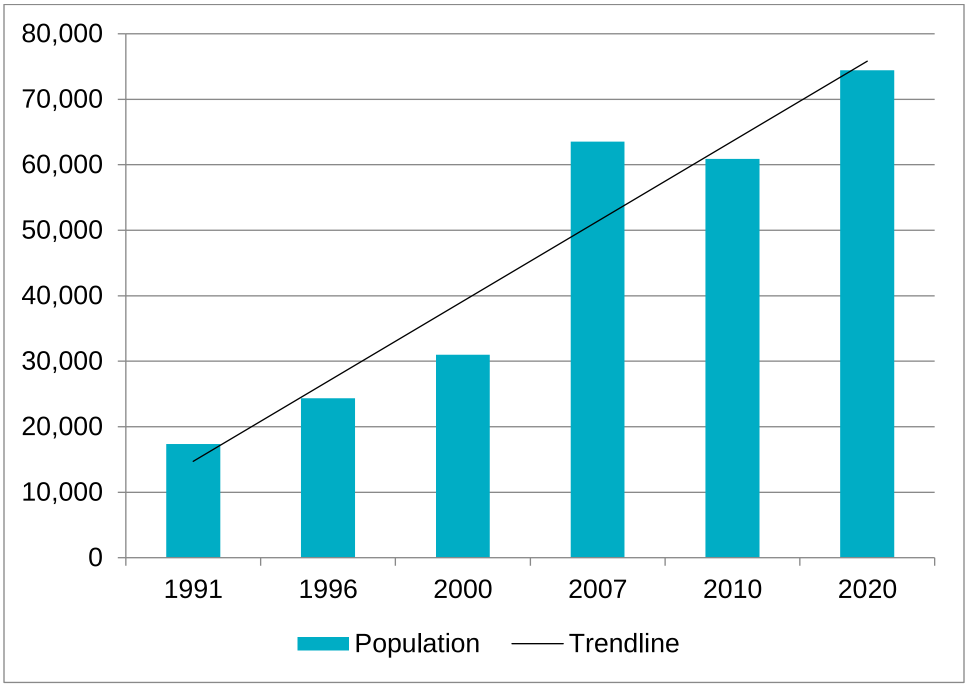
Thus, the population in the three municipalities of the reference region, Colniza, Apuí and Novo Aripuanã, increased during the 1991 – 2020 period, reaching almost 80,000 people in 2020, illustrated in Figure 16 below. Therefore, the population growth rate across the analyzed period for the three main municipalities was 5.1%/year, which is a very high rate[34]. Such increase also indicates the human pressure for clearance of forests in the region, demanding new lands for subsistence and income generation.

[32] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

[33] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

[34] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

Figure 17 Population in the two municipalities of the reference region



The population within the reference region is mainly concentrated in cities and along the highways at north and south of the project area. In general, all the municipalities within the reference region have a low population density, i.e., below 2 inhabitants/km^2 [35].

According to a study carried out in 2010[36], the municipalities concerned were classed in the Medium (between 0.600 and 0.699) and Low (0.500 and 0.599) Human Development categories. Colniza is in the medium category, with indexes of 0.611, and Novo Aripuanã has an index of 0.554, putting it in the Low Human Development class.

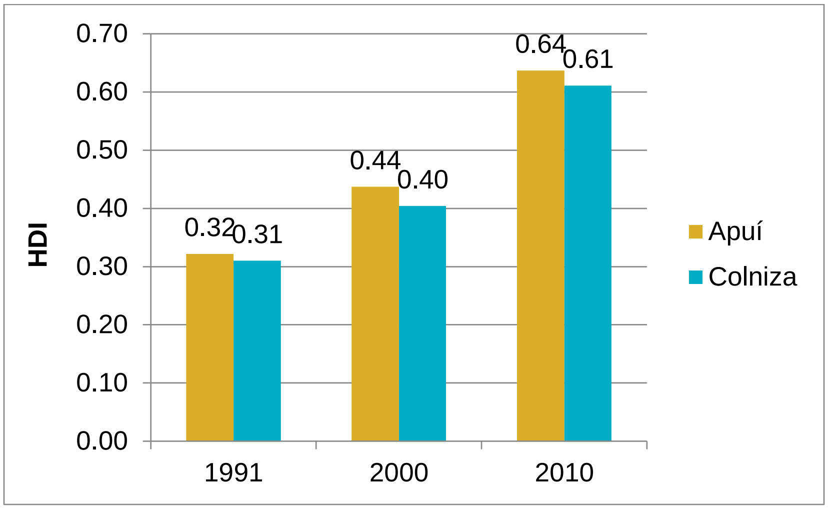
According to Figure 18 below, the relevant HDI scores showed significant growth over the years 1991 to 2010, reaching 89% in Novo Aripuanã. This indicates significant growth in the region, primarily regarding Education HDI. However, of the municipalities studied Aripuanã has a very poor positioning, as it placed 5146th of 5565 Brazilian municipalities. Colniza placed 3884th [37].

[35] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

[36] Atlas of Human Development in Brazil. Available at: <http://www.atlasbrasil.org.br/>. Last visit on: January 26th, 2015.

[37] Atlas of Human Development in Brazil. Available at: <http://www.atlasbrasil.org.br/>. Last visit on: January 26th, 2015.

Figure 18 Human Development Index in the two main municipalities of the reference region



Furthermore, there is an Indigenous Territory (IT), which is entirely surrounded by the Reference Region known as Kawahiva do Rio Pardo, with an area of 411,848 ha. This area shares a boundary to the south with the project area, located in the municipality of Colniza, State of Mato Grosso (Figure 18, subsection biodiversity). Living there is an isolated indigenous tribe about which little is known. FUNAI estimates that their population was around 50 some years ago, but today this number may be far lower. Unfortunately, their survival as a people hangs in the balance, as their forests are constantly being invaded by loggers, many of which are based in Colniza[38].

According to the FUNAI website, this area is traditionally occupied, being currently in the category of a region which is identified but not having official documentation. The "identified" classification means that studies relating to the area have been approved by FUNAI, and they are currently being analyzed by the Ministry of Justice, in order to make a decision regarding issuance of the Official Declaration of traditional indigenous property. Following this stage, the IT will go into Declared status, at which point it is authorized by the Ministry of Justice to undergo physical demarcation. Following this, the IT will be approved by presidential decree, and finally officially documented.

An Indigenous Territory (IT) is a portion of the Brazilian national territory, owned by the Union of the States, inhabited by one or more indigenous peoples, used for its production activities, and indispensable to the preservation of environmental resources, to the inhabitants' wellbeing, and to their physical and cultural reproduction, according to their uses, customs and traditions.

Indigenous peoples' rights to their lands and to traditional settlement is considered an an original right and, furthermore, because it is property of the Union that is in question, the IT is inalienable and unavailable to others, and the rights to it are imprescriptible[39].

[38] Survival International. Available at: <http://www.survivalinternational.org/povos/indios-isolados-brasil/os-ultimos>. Last visit on: January 27th, 2015.

[39] Indigenous National Foundation (FUNAI). Available at: <http://www.funai.gov.br/index.php/indios-no-brasil/terras-indigenas>. Last visit on: January 27th, 2015.

The socio-economic climate described is integrated into the Boa Fé REDD Project's goals, as the application of SOCIALCARBON® Standard aims to deliver appropriate, integrated and quantifiable ecological and socio-economic benefits to the population of the project area.

Biodiversity

Brazil harbours the greatest concentration of biodiversity on the planet. It has a great abundance of life forms – which translates to over 20% of the total species on earth – which raises Brazil to the main nation among the 17 countries with the highest biodiversity levels globally, which contain over 70% of the planet's biodiversity[40].

Brazil has the greatest flora species richness, with 45,835 species described. Furthermore, it contains over 7,000 known species of vertebrates consisting of 692 mammals and 1,026 amphibians, 744 reptiles, 1,901 birds and in the region of 3,000 fish species. It is estimated that between 96,660 and 129,840 of invertebrate species are known. estimated number of known species in Brazil is approximately 170 to 210 thousand, while the total number of species that the country harbours is approximately 1.8 million, putting the known proportion of biodiversity at a mere 11%. New species are described every day in Brazil[41].

It is estimated then that approximately 10% of all the planet's biodiversity is found in the project region, including many threatened species and those which exist only in Amazonia, or endemic species[42].

Two aspects are important in relation to the biological context of the region: (1) biodiversity levels are high because it is a contact region between two biomes, which is at constant risk due to the proximity to the Brazilian arc of deforestation; and (2) at the same time, very little is known about this region's biological diversity[43].

The project area and reference region overlap with Brazilian protected areas, which are part of the Southern Amazon Mosaic. This Mosaic is composed by around 40 National and State protected areas, totaling more than 7 million hectares[44]. This ecological corridor is very important for biodiversity conservation, located in a region suffering from high deforestation pressure due to the expansion of agricultural and livestock activities towards the Amazon rainforest[45]. In addition, the Mosaic helps to maintain endemism, preserving these continuous forest environments (north-south forest connection)

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[40] Brazilian Government Ministry for the Environment (Ministério do Meio Ambiente – MMA). The Brazilian Biodiversity. Available at: <http://www.mma.gov.br/biodiversidade/biodiversidade-brasileira>. Last visit on: October 13th, 2020.

[41] Information System about the Brazilian Biodiversity (SiBBr). Available at: < https://web.archive.org/web/20151108135124/http://www.sibbr.gov.br/areas/?area=biodiversidade >. Last visit on: October 21th, 2020.

[42] Protected Areas Program of the Amazon - ARPA (Brasil) (Org.). Arpa Biodiversidade. Amazonas: WWF - Brasil, 2010. 34 p.

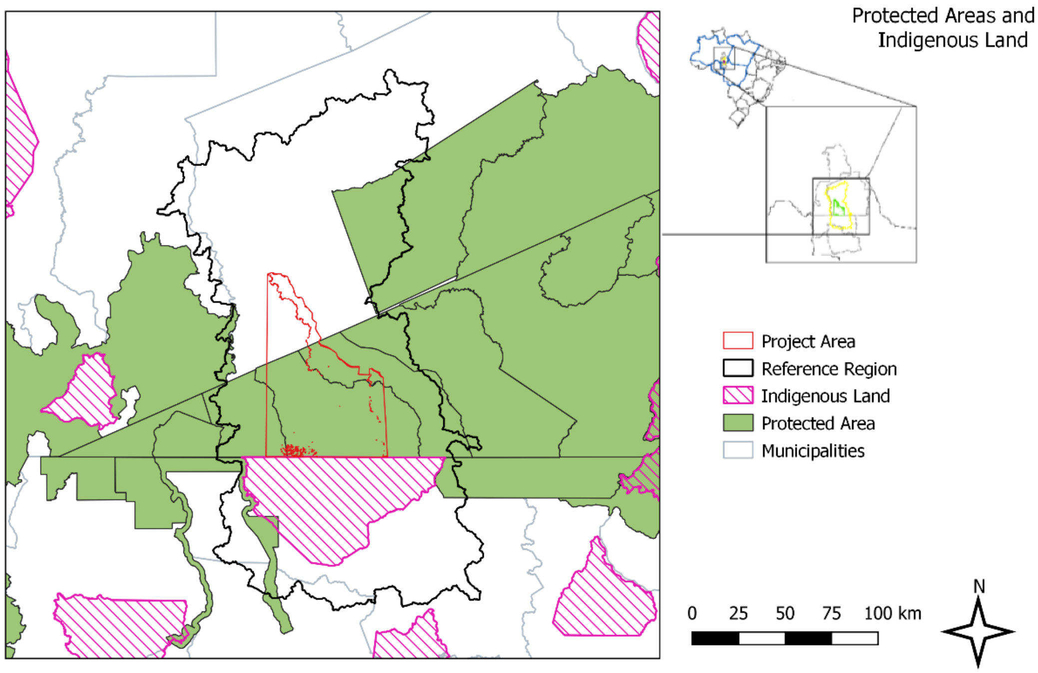
[43] WWF (Brasil). **Mosaico da Amazônia Meridional:** Vencendo limites geográficos e integrando gestão. Brasília-DF: WWF, 2014. 136 p. Available at:<http://d3nehc6yl9qzo4.cloudfront.net/downloads/mam_livro_vencendo_limites_geograficos_final.pdf>. Last visit on: October 13th, 2020.

[44] Government of the State of Amazonas. **Plano de gestão do mosaico de unidades de conservação do Apu**í. Manaus: WWF - Brasil, 2010. 246 p.

45 SECRETARIA DO ESTADO DO MEIO AMBIENTE E DESENVOLVIMENTO SUSTENTÁVEL (SDS). **Unidades de Conservação do Estado do Amazonas**. Manaus, 2007.

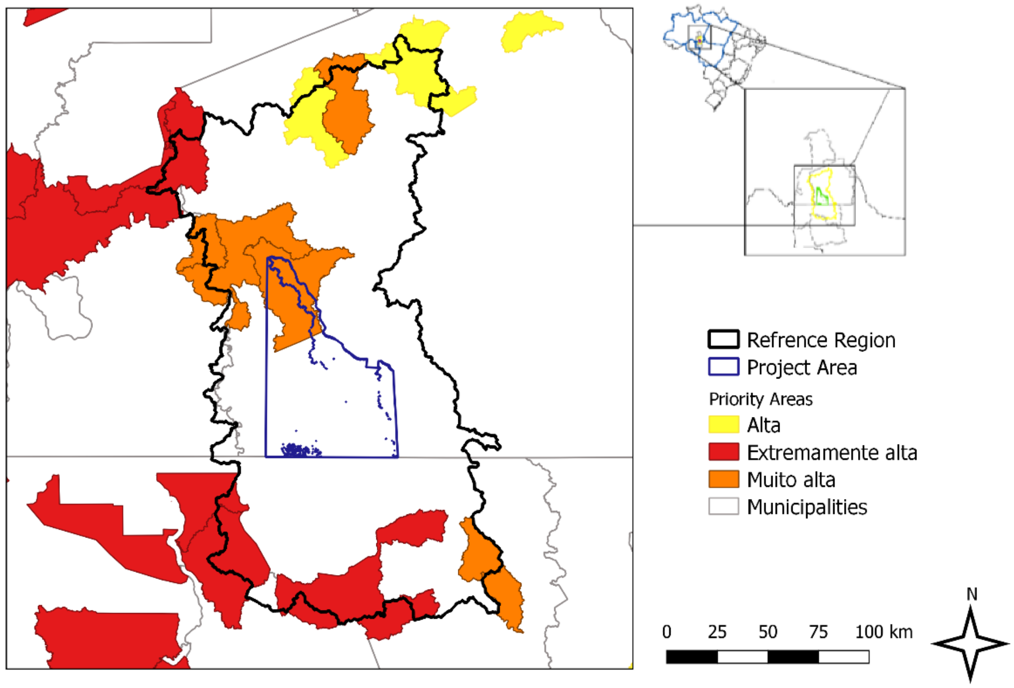
and ensuring the maintenance of gene flow of species, together with containing the advancement of invasive species from other environments. Figure 19 below shows the protected areas and indigenous lands in the Boa Fé REDD Project region.

Figure 19 Protected areas and indigenous lands in the Boa Fé REDD Project's region



The Boa Fé REDD Project will contribute to the expansion of this biodiversity corridor linking the Amazon and Cerrado biomes, in an ecotone region considered to be one of the main areas of endemism in the southern Amazon. Moreover, the present project will also help to better control deforestation in the region, uniting efforts with other Government protected areas against the advancement of the arc of deforestation.

Figure 20 Brazil's priority areas for conservation for the project's region



The Brazilian Government Ministry for the Environment (Ministério do Meio Ambiente) included the Boa Fé REDD project region in its 2006 survey of Brazil's priority areas for conservation[46]. The project area is mostly classed within two categories: "high" and "very high", as detailed in Figure 19 above. This shows the significance of the present REDD project for conservation of Brazilian biodiversity. Thus, the conservation of this private land contributes to the Brazilian Government's conservation proposal and encourages the creation of new conservation projects and areas.

The Southern Amazon Mosaic is located in a well-preserved region within the Legal Amazon, noting its high biological importance. However, this is also one of the least scientifically known regions of Brazil and therefore considered a priority area for wildlife inventories[47].

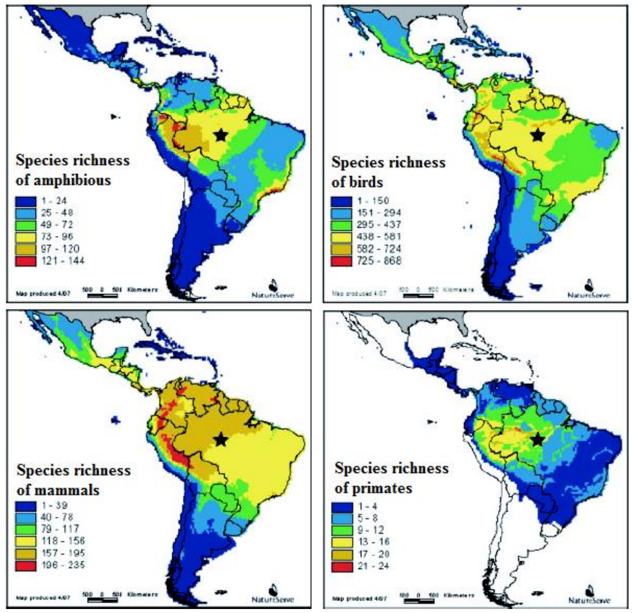
In the regional context, the Southern Amazon Mosaic is within areas of high richness of birds, mammals and amphibian species, according to Figure 20 below. Although scientific research is scarce in the region, it is very likely that the existing biodiversity assessments underestimate the reality. An example was a

[46] Brazilian Government Ministry for the Environment (Ministério do Meio Ambiente – MMA). Brazilian priority areas for biodiversity conservation and sustainable use. Available at: <https://www.mma.gov.br/estruturas/chm/_arquivos/biodiversidade31.pdf >. Last visit on: October 13th, 2020.

[47] WWF (Brasil). **Mosaico da Amazônia Meridional:** Vencendo limites geográficos e integrando gestão. Brasília-DF: WWF, 2014. 136 p. Available at:<http://d3nehc6yl9qzo4.cloudfront.net/downloads/mam_livro_vencendo_limites_geograficos_final.pdf>. Last visit on: October 21th, 2020.

new primate species found in the region (2015), named Zogue-zogue fire tail (*Callicebus miltoni*), that only occurs between the rivers Aripuanã and Roosevelt, just where the project area is located[48].

Figure 21 Species richness of amphibians, birds, mammals and primates within the project region



In addition, it is estimated that there are at least 13 threatened species of fauna, ten of these being mammals. Among those of great conservation interest are: the Golden-White Tassel-ear Marmoset (*Mico chrysoleucus*), the Giant Armadillo (*Priodontes maximus*), the Brazilian Tapir (*Tapirus terrestris*), the Red Brocket (*Mazama americana*), and the Azara's Agouti (*Dasyprocta azarae*). Furthermore, there are several other species expected to be at some grade of risk, such as the Golden Parakeet (*Guaruba guarouba*) and the Hyacinth Macaw (*Anodorhynchus hyacinthinus*), both within the vulnerable category, according to the International Union for Conservation of Nature - IUCN. In addition, the present project contributes to the preservation of species that require large areas, such as the Jaguar (*Panthera onca*)[49]. Table 10 below shows the fauna species within the following IUCN categories: vulnerable and endangered. It can be observed that the present project helps to preserve at least 2% of the Brazilian threatened species, most of them being mammals.

[48] O ESTADO DE SÃO PAULO. Sustentabilidade. Nova espécie de primata é descoberta na Amazônia. March 11th, 2015. Available at: <http://sustentabilidade.estadao.com.br/noticias/geral,nova-especie-de-primata-e-descoberta-na-amazonia,1648925>. Last visit on: October 13th, 2020.

[49] IUCN 2014. The IUCN Red List of Threatened Species. Version 2014. Available at: <http://www.iucnredlist.org>. Last visit on: October 21th, 2020.

Table 1 Species listed by IUCN as vulnerable or endangered categories in Brazil and project region[50]

Fauna	Threatened species in Brazil	Threatened species in the project region	% of Brazil
Mammals	181	10	6%
Non-primates	*149*	*8*	*5%*
Primates	*32*	*2*	*6%*
Birds	219	2	1%
Reptiles	30	1	3%
Amphibians	257	0	0%
Fish	54	0	0%
TOTAL	741	13	2%

Turning to flora biodiversity, the presence of the Amazon and Cerrado biomes makes the region a complex environment with a great diversity of species and vegetation types. Three forest inventories have been carried out in protected areas in the region, revealing a great flora biodiversity[51]:

- Sucunduri State Park: a forest inventory was conducted over 5ha, covering four different vegetation types, resulting in the impressive number of 2,840 trees (DBH>10cm) of 69 families, 218 genders and 365 species;
- Aripuanã Sustainable Development Reserve (where around 18% of the project area is located): a forest inventory was conducted over 3ha, covering two different vegetation types, resulting in 1,419 trees of 39 families and 556 species;
- Guariba Extractive Reserve (encompassing 5% of the project area): two forest inventories were conducted (2ha each), covering four different vegetation types, measuring trees with DBH>10cm.
    - Dense tropical rainforest: 527 trees of 38 families and 177 species;
    - Open tropical rainforest: 505 trees of 41 families and 145 species
    - Savannah: 49 trees of 100 genera and 117 species;
    - Floodplain forest: 495 trees of 34 families and 129 species.

Therefore, the current situation indicates that the rainforests of the Southern Amazon are critically endangered, as well as their great biological diversity and presence in several environment types, in

[50] Government of the State of Amazonas. Plano de gestão do mosaico de unidades de conservação do Apuí. Manaus: WWF - Brasil, 2010. 246 p.

[51] Government of the State of Amazonas. Plano de gestão do mosaico de unidades de conservação do Apuí. Manaus: WWF - Brasil, 2010. 246 p.

addition to the presence of endemic species of extreme importance to the conservation of Amazon biodiversity[52].

Vegetation Cover

The properties composing the project area are 100% covered by native Amazonian vegetation. Thus, the vegetation in the present project was mapped on the basis of IBGE sources[53]. Three main vegetation types were found in the area, which were grouped according to the main category defined by IBGE descriptions[54]: dense alluvial tropical rainforest, dense submontane tropical rainforest and open submontane tropical rainforest. According to IBGE (1992), the main characteristics of the vegetation types existing within the project area are:

- Dense alluvial tropical rainforest: It is a riverside formation or “riparian forest” that occurs along the watercourses occupying the old lands of the quartan plains, being located on lands that are temporarily flooded and are influenced by the water level. The alluvial forest often presents an emerging canopy, however, due to logging, its physiognomy becomes quite open. Besides,occur in areas with high temperature and high precipitation which is well distributed throughout the year. They are most common in low-fertility soils such as latosols and podsols. They are the main vegetation cover type present in the project area, representing approximately 90% of the total.
- Dense submontane tropical rainforest: Over the regions originated in the Precambrian, in mountainous terrains with high precipitation and humidity and absence of pronounced dry period, there is the Ombrophilous Dense Forest, which can be subdivided into Submontana.
- The Dense Submontane Rainforest occurs in the altitudinal range of 50 to 500 meters and is characterized by having a large phanerophytic structure, some exceeding 50 meters in the Amazon and rarely 30 meters in other parts of the country. In addition to the occurrence of camephites, epiphytes and lianas, upper stratum between 25-30 meters.
- Open submontane tropical rainforest: This formation can be observed distributed throughout the Amazon and even outside of it mainly with the facies forest with plains. The open forest with plains, in the states of maranhão/Piauí and in isolated points from the northeast to the state of Espiríto Santo, constitutes secondary communities called babassu forests. In the Amazon, it occurs with four floristic factions between the north latitude 4 ° and the south latitude 16 °, located above 100 m altitude and often reaching around 600 m. Also,are considered the transition forest type between Amazon rainforest and extra-Amazon areas. They are found in climates with up to 60 days without precipitation per year.
- Dense submontane tropical rainforest: extends over the slopes of the mountains and has trees with approximately uniform heights, rarely exceeding 30 meters. It is located at the top of the plateaus and mountains, its canopy is open and it has a high richness of epiphytes.

[52] Nelson, B.W. e A. A. Oliveira. 1999. Avaliação e Ações prioritárias para a Conservação do bioma Floresta Amazônia: Ações Prioritárias para a Conservação da Biodiversidade da Amazônia. Programa Nacional da Diversidade Biológica-PROBIO, MMA.

[53] INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). Manual Técnico da Vegetação Brasileira. Manuais Técnicos em Geociências n° 1, Rio de Janeiro, 1991

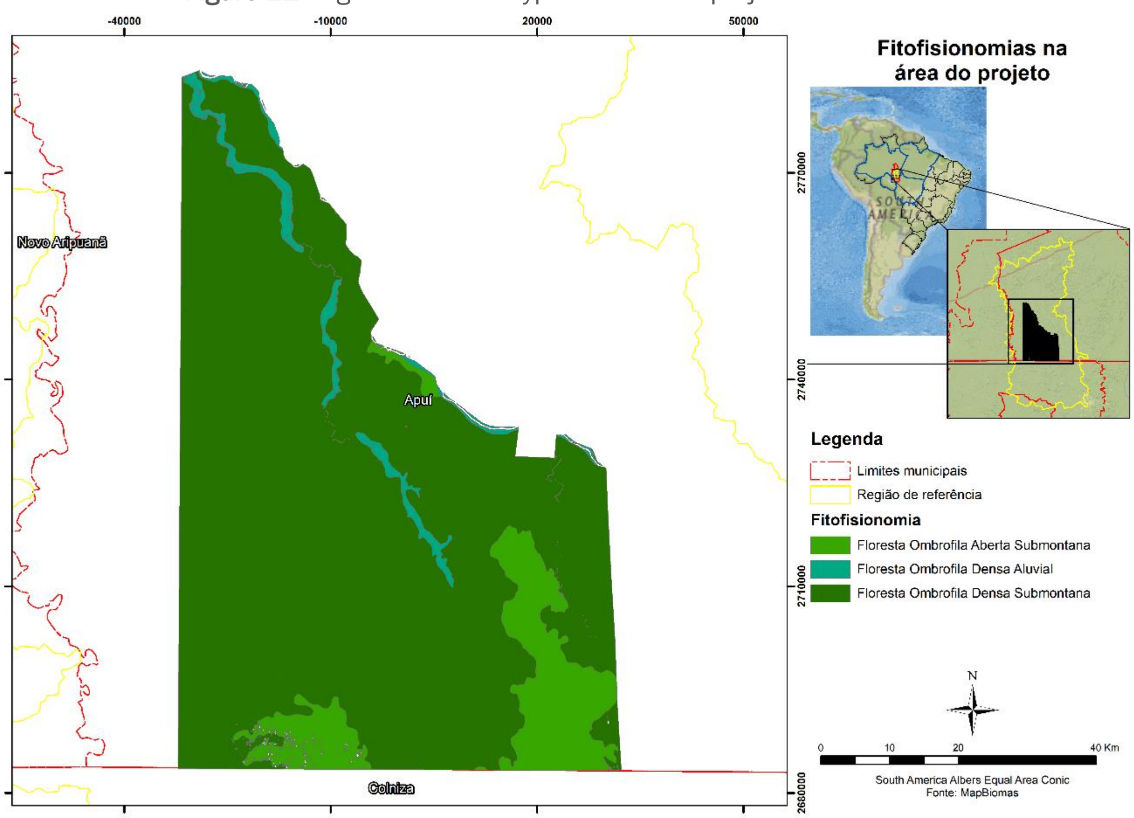
[54] INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). Manual Técnico da Vegetação Brasileira. Manuais Técnicos em Geociências n° 1, Rio de Janeiro, 1991.

The vegetation cover types within the project area, including the respective areas, are detailed in the Table 2 and Figure 21 below.

Table 2 Vegetation cover types within the project area

Vegetation type	Area (ha)	Percentage of the project area (%)
Dense Alluvial Tropical Rainforest	11,693.74	3%
Dense Submontane Tropical Rainforest	375,287.22	87%
Open Submontane Tropical Rainforest	45,736.87	11%
TOTAL	432,717.83	100%

Figure 22 Vegetation cover types within the project area



Pilot Forest Inventory of the Project Area

The vegetation within the project area itself was assessed by the project owner in a 2014 pilot forest inventory[55], consisting of linear samples of 10,000m^2, taken from Boa Fé property. These samples are grouped into 4 lines forming a cross around a central point, which received a reference number. A total of 49 crosses (i.e. 196 samples) were randomly distributed over the Boa Fé property, thus improving the efficiency of the sampling method. This inventory confirmed that the aforementioned four main vegetation types were present in the area: dense tropical rainforest, open tropical rainforest, floodplain forest, and savannah.

The economic potential of the project area's forests was considered satisfactory due to the presence of valuable wood species. Species of commercial interest common in the area include: *Virola spp*, *Bowdichia spp.*, *Caryocar villosum*, and *Manilkara huberi*, among others. The period of highest productivity for logging is from June to August as it has lower rainfall. During this period, the soil conditions do not significantly affect operations performance.

According to Boa Fé's pilot forest inventory, assuming that sustainable forest management would be conducted in 70% of the total area due to the presence of inaccessible or permanent preservation areas, and that only commercial trees above 50cm of Diameter at Breast Height (DBH) would be harvested, the total commercial volume in the Boa Fé property would be around 9,762,438 m^3.

There are three possible timber transportation routes for this forest management plan: the municipal road towards Colniza to the south of the area, in the State of Mato Grosso; the Aripuanã river to the north followed by the BR-230 (Trans-Amazonian Highway); or the BR-174 which will be built across the project area in the coming years. However, each of these options has limiting conditions, especially because of the rainy season. There is also the option of creating a new road from the project area to Apuí, in the north, which is not a probable alternative due to the necessity of carrying out 60 km of deforestation, and moreover, the future implications of this new driver of deforestation in the region.

This pilot forest inventory was compared to other forest inventories in the region, confirming the reliability of the data obtained from the project area. The commercial wood potential in the area was considered good due to the presence of high value species.

The next necessary step is to carry out the survey and evaluation of the local forestry potential, conducting the complete forest inventory on site to determine the actual potential of the project area for sustainable forest management.

The species list from the pilot forest inventory is provided in Table 3 below.

Table 3 Species founded within the project area[56]

N°	Common Name	Scientific Name	Family
1	Abiu	*Pouteria sp*	SAPOTACEAE
2	Abiurana	*Pouteria sp*	SAPOTACEAE
3	Amapá	*Chrysophyllum sp*	SAPOTACEAE

[55] LUZ, Horacio Figueredo. **Relatório Técnico de Valoração do Patrimônio Florestal:** Propriedade Fazenda Boa Fé em Apuí - AM. Salto - SP: Ibiraú Manejo Florestal Ltda., 2014. 38 p

[56] LUZ, Horacio Figueredo. **Relatório Técnico de Valoração do Patrimônio Florestal:** Propriedade Fazenda Boa Fé em Apuí - AM. Salto - SP: Ibiraú Manejo Florestal Ltda., 2014. 38 p

4	Amescla	*Trattinickia sp*	BURSERACEAE
5	Angelim	*Hymenolobium sp*	FABACEAE
6	Angelim Saia	*Parkia sp*	MIMOSACEAE
7	Bajao	*Parkia sp*	MIMOSACEAE
8	Caixeta	*Simarouba amara*	SIMAROUBACEAE
9	Caju-da-Mata	*Anacardium sp*	ANACARDIACEAE
10	Cambará	*Vochysia sp*	VOCHYSIACEAE
11	Canela	*Ocotea sp*	LAURACEAE
12	Carne de Vaca	*Euplassa sp*	PROTEACEAE
13	Caroba	*Jacaranda copaia*	BIGNONIACEAE
14	Catuaba	*Qualea sp*	VOCHYSIACEAE
15	Caucho	*Castilla sp*	MORACEAE
16	Cedro	*Cedrela odorata*	MELIACEAE
17	Chichá	*Sterculia sp*	STERCULIACEAE
18	Cumaru	*Dipteryx odorata*	FABACEAE
19	Cupiúba	*Goupia glabra*	CELASTRACEAE
20	Fava orelha de macaco	*Enterolobium sp*	MIMOSACEAE
21	Fava-bolacha	*Vatairea sp*	FABACEAE
22	Faveiro	*Pterodon pubescens*	FABACEAE
23	Freijó	*Cordia goeldiana*	BORAGINACEAE
24	Garapeira	*Apuleia sp*	CAESALPINIACEAE
25	Ipê	*Tabebuia sp*	BIGNONIACEAE
26	Itaúba	*Mezilaurus itauba*	LAURACEAE
27	Jatobá	*Hymenaea sp*	CAESALPINIACEAE
28	Jequitibá	*Cariniana sp*	LECHYTHIDACEAE
29	Maçaranduba	*Manilkara sp*	SAPOTACEAE

30	Matá matá	*Eschweilera odorata*	LECHYTHIDACEAE
31	Mirindiba	*Buchenavia sp*	COMBRETACEAE
32	Morcegueira	*Trattinickia sp*	BURSERACEAE
33	Muiracatiara	*Astronium sp*	ANACARDIACEAE
34	Oiticica	*Clarisia racemosa*	MORACEAE
35	Parajú	*Manikara sp*	SAPOTACEAE
36	Pau sangue	*Pterocarpus sp*	FABACEAE
37	Pequiá	*Caryocar villosum*	CARYOCARACEAE
38	Peroba	*Aspidosperma sp*	APOCYNACEAE
39	Roxinho	*Peltogyne catingae*	CAESALPINIACEAE
40	Sorveira	*Couma sp*	APOCYNACEAE
41	Sucupira	*Diplotropis sp*	FABACEAE
42	Sucupira-preta	*Bowdichia sp*	FABACEAE
43	Tamarindo	*Martiodendron sp*	FABACEAE
44	Tamboril	*Enterolobium contortisiliquum*	MIMOSACEAE
45	Tauari	*Couratari sp*	LECHYTHIDACEAE
46	Tento	*Ormosia sp*	FABACEAE
47	Ucuuba	*Virola sp*	MYRISTICACEAE

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

In the Amazon, regions known as the agricultural expansion frontier (usually located in remote areas where access is difficult and there is little action/control by government bodies), land occupation takes place in a disorderly manner and without regard for legislation[57].

The conditions of low governance, ill-defined land tenure and land occupation pressure through unofficial roads propagate an ideal scenario for the advancement of deforestation in Southern Amazonas State.

[57] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

This is a problem enabled by the local geo-political situation, which the municipalities do not have the capacity to deal with alone.

Deforestation in the Brazilian Amazon has been taking place at an average rate of 0.35% or 14,800 km^2 per year since 1996[58], showing a downwards trend in recent years. Around 44% of this reduction has been attributed to negative trends in the livestock industry, 37% due to creation of new protected areas, and approximately 18% to causes potentially attributable to command and control campaigns by the federal government[59]. The deforested annual area in the 2010 to 2013 period reduced by 70% compared to the 1996 to 2005 period. Despite this reduction, it is difficult to guarantee with certainty that deforestation is under control, mainly because it is ever more interlinked with commodities traded on the global economy such as meat and soya[60].

Command and control activities are more concentrated in the States of Pará, Mato Grosso and Rondônia, while in Southern Amazonas State they are rare. For the municipalities in the project region, intense deforestation activities began in the mid-1990s. Given the advancement of the frontier associated with improvement of infrastructure, deforestation has tended to continue at the same pace, taking into account the dynamic of the agents involved as presented above and the great expanse of forested land still available[61].

However, despite the clear drop in deforestation in the Amazon between 2010 and 2012, according to Imazon, the deforestation observed in the biome increased for two consecutive years in 2013 and 2014, representing an increase of almost one-third comparing to the previous period[62]. This fact demonstrates that deforestation in the Amazon biome is still not entirely under control.

An excellent study by Antonio Nobre in 2014[63], which collected information from over 200 scientific studies and articles from the Amazon biome, reports that deforestation and degradation of the rainforest had reached 2,018,079 km^2, signifying that up to 47.34% of the entire forest had already undergone some kind of human impact. According to the report, deforestation may put at risk the forest's capacity to "export" moisture to other regions via the so-called "flying rivers" which regulate the climate, causing droughts and other negative effects. The Amazon rainforest survived over thousands of years of volcanic, meteoric, seismic, and glacial impacts, but in under 50 years of human activity, it has been pushed to a significant level of threat.

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[58] PRODES Project - Brazilian Amazon Forest Monitoring through Satellite. Instituto Nacional de Pesquisas Espaciais (INPE). Available at: < https://web.archive.org/web/20151019100331/http://www.obt.inpe.br/prodes/index.php >. Last visited on October 21th, 2020.

[59] SOARES-FILHO, B. et al. **Role of Brazilian Amazon protected areas in climate change mitigation.** Nova York: Columbia University. 2010.

[60] NEPSTAD, Daniel C.; STICKLER, Claudia M.; ALMEIDA, Oriana T.. Globalization of the Amazon Soy and Beef Industries: Opportunities for Conservation. **Conservation Biology,** Belém, v. 20, n. 6, p.1595-1603, 30 mar. 2006.

[61] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

[62] ((O))ECO (Brasil). **Desmatamento na Amazônia:** Repique do ano passado deve se manter em 2014. 2014. Available at: <http://www.oeco.org.br/noticias/28567-repique-do-desmatamento-no-ano-passado-deve-se-manter-em-2014>. Last visit on: 24/03/2021.

[63] NOBRE, Antonio Donato. **O Futuro Climático da Amazônia.** São José dos Campos: Articulación Regional Amazônica (ARA), 2014. 42 p.

Furthermore, the municipality of Apuí (where the project is located), in the south of Amazonas State, was the second most deforested municipality in the whole of the Brazilian Legal Amazonia area in August 2012, according to Imazon and Idesam[64]. The low presence of government in the region, combined with few awareness raising and anti-deforestation initiatives, will leave it ill-prepared to contain deforestation in the coming years.

Therefore, as observed by Idesam (2011)[65], Carrero (2009)[66], Nepstad *et al*. (2006)[67], and Carrero and Fearnside (2011)[68], these data confirm the acceleration of the deforestation dynamic in Southern Amazonas in relation to historical tendencies, indicating a frontier of agricultural expansion.

According to the Brazilian Forest Code (Law Nº 12.651, 25/05/2012[69]), all rural estates located in forest zones should have:

> I - Permanent preservation area: protected areas covered or not by native vegetation, with the environmental function of preserving water resources, landscape, geological stability, biodiversity, gene flow of plants and animals, protecting the soil and ensuring the well-being of human populations
>
> II - Legal Reserve (LR): an area located within a rural property or possession which is required to be segregated, as well as the permanent preservation area, for the sustainable use of natural resources, conservation and rehabilitation of ecological processes, biodiversity conservation and shelter, and protection of native flora and fauna. In the Brazilian Legal Amazon[70], eighty percent (80%) of a rural property should be preserved as LR.
>
> In the Reference Region, although 80% of native vegetation within land properties should be preserved as LR, there is a general non-compliance with the Brazilian Forest Code. According to Razera (2005)[71], the average forest cover rate in the municipality of Apuí was below 60%, and

[64] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Apuí é o segundo município mais desmatado na Amazônia Legal em Agosto de 2012. 2012. Available at: <http://www.idesam.org.br/apui-e-o-segundo-municipio-mais-desmatado-na-amazonia-legal-em-agosto-de-2012/#.VP9SUct0wdU>. Last visit on: 24/03/2021

[65] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

[66] CARRERO, G.C. Dinâmica do Desmatamento e Consolidação de Propriedades Rurais na Fronteira de Expansão Agropecuária no Sudeste do Amazonas. Master thesis, Instituto Nacional de Pesquisas da Amazônia. 68p. 2009.

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

[68] Carrero, G. C., and P. M. Fearnside. Forest clearing dynamics and the expansion of landholdings in Apuí, a deforestation hotspot on Brazil's Transamazon Highway. **Ecology and Society** 16(2): 26. 2011

[69] BRASIL. Law nº. 12.651, of 25 May 2012. Forest Code. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, 25 May 2012.

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

[71] RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

only 20% of the interviewed rural properties were found to comply with the Forest Code, while the actual number of legal properties is assumed to be even lower.

One of the main ways to combat deforestation in Brazil is command and control mechanisms, such as effective monitoring, requiring compliance with environmental legislation along with a greater State presence. However, this does not seem to be implemented in most regions of the country, because of the government's tendency to disregard these responsibilities in comparison with other social goals and economic interests, which has put Brazil among the world's largest deforesters[72]. Given the approval of the new Forest Code (2012) and its general pardoning of those who deforested, a significant increase in annual deforestation rates has been observed[73].

In spite of the legal provisions intended to preserve at least 80% of Amazon Forest coverage, lack of law enforcement by local authorities along with public policies seeking to increase commodity production and encourage land use for agricultural, bio energy and cattle breeding purposes have created a scenario of complete disregard for the mandatory provisions of the Forest Code. In addition, covering vast areas with low demographic density makes tracking of illegal activities and land surveillance very difficult for the authorities[74, 75].

Therefore, all calculations were made assuming that the reference region has a general non-compliance with the Brazilian Forest Code. Thus, the baseline scenario considers the potential of unplanned deforestation in the project area to surpass the limits stipulated by the Law.

In this sense the preparation for REDD+ activities, programs and projects becomes essential for this Southern Amazon Region, not only as a means of promotion of forest conservation, but also as a way of implanting a new productive forest-based economy. This scenario needs to be reinforced because the areas in question hold incomparable biological and cultural diversity, with their traditional inhabitants marginalized from the process of economic development through capitalised livestock production.

In addition, the property makes frontier on the south with a demarcated indigenous area. Thus, composing the legislative scope of this document, it is worth mentioning decree No. 10,088, of November 5, 2019, which aims to create a binding international instrument dealing specifically with the rights of culturally traditional people. The basic concepts, which guide the interpretation of the provisions of the Convention, are the consultation and participation of the people concerned and their right to decide on their own development priorities as it affects their lives, beliefs, institutions, values spiritual and the land they occupy or use.

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[72] Food And Agriculture Organization Of The United Nations (FAO) (2011), "State of the World's Forests 2011." FAO Forestry Paper. Rome, Italy.

[73] NOBRE, Antonio Donato. **O Futuro Climático da Amazônia.** São José dos Campos: Articulación Regional Amazônica (ARA), 2014. 42 p.

[74] MOUTINHO, P. et al. REDD no Brasil: um enfoque amazônico: fundamentos, critérios e estruturas institucionais para um regime nacional de Redução de Emissões por Desmatamento e Degradação Florestal – REDD. Brasília, DF: Instituto de Pesquisa Ambiental da Amazônia, 2011.

[75] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

Annex LXXII to the decree provides for ILO Convention No. 169 on Indigenous and Tribal Peoples, recognizing the right to possession and property and provides measures to be taken to safeguard the rights related to the land and territory that traditional communities inhabit or use collectively.

Recognizing, thus, the aspirations of these communities to take control of their own institutions and habits and their economic development, and to maintain and strengthen their identities, languages and religions, within the scope of the States where they live;

According to PART II - Lands, Article 13, item 2, “The use of the term" lands "in Articles 15 and 16 should include the concept of territories, which covers the entire habitat of the regions that the people concerned occupy or use.

According to Article 14, item 1: “The people concerned should be given the property and possession rights over the lands they traditionally occupy. In addition, in appropriate cases, measures should be taken to safeguard the right of interested people to use land that is not exclusively occupied by them, but which they have traditionally had access to for their traditional and subsistence activities. In this regard, special attention should be paid to the situation of nomadic peoples and itinerant farmers”

It is also worth mentioning decree No. 6,040, of February 7, 2007, which institutes the National Policy for the Sustainable Development of Traditional Peoples and Communities. According to Art. 2 “The PNPCT's main objective is to promote the sustainable development of the Traditional Communities, with an emphasis on recognizing, strengthening and guaranteeing their territorial, social, environmental, economic and cultural rights, with respect and appreciation for their identity, their forms of organization and their institutions.

With that said, it is worth mentioning that the project respects the provisions of the law, and does not interfere with the rights of indigenous peoples.

1.15 Participation under Other GHG Programs

1.16 Other Forms of Credit

1.17 Additional Information Relevant to the Project

2 SAFEGUARDS

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

This project utilizes the approved VCS Methodology VM0015: Methodology for Avoided Unplanned Deforestation, version 1.1, published on 03-December-2012.

Furthermore, the following tools were used:

- VT0001 - Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3.0, published on 01-February-2012;
- AFOLU Non-Permanence Risk Too v4.0, published on 19-September-2019.

3.2 Applicability of Methodology

Table 8 Methodology applicability conditions

Applicability Conditions	Justification of Applicability
a) Baseline activities may include planned or unplanned logging for timber, fuelwood collection, charcoal production, agricultural and grazing activities as long as the category is unplanned deforestation according to the most recent VCS AFOLU requirements.	None of the baseline land-use conversion activities are legally designated or sanctioned for forestry or deforestation, and hence the project activity qualifies as avoided unplanned deforestation. This is in accordance with the definition of unplanned deforestation under the VCS Standard v4.0. The primary land uses in the baseline scenario are: cattle ranching, mainly for producing beef cattle; and timber harvesters, acting both legally and illegally. These unplanned deforestation agents have been attracted due to infrastructure expansion, such as road and highway construction. In addition, there is a highway being constructed within the reference region, which will probably cause an unplanned deforestation increase. Therefore, the present criteria are fulfilled.
b) Project activities may include one or a combination of the eligible categories defined in the description of the scope of the methodology (table 1 and figure 2).	Within the categories of Table 1 and Figure 2 of the methodology, the present project activity falls within category B, “Avoided Deforestation with Logging in the Project Case”. The reason is that the project area contains 100% native vegetation (it has never been deforested in the past), and a sustainable forest management might be planned in the project area. In addition, it is important to note that degradation is not included in either the baseline or project scenario.

c) The project area can include different types of forest, such as, but not limited to, old growth forest, degraded forest, secondary forests, planted forests and agro-forestry systems meeting the definition of "forest".	The REDD project area is 100% made up of Amazon tropical old growth rainforest, as described in section 1.13 of the present VCS-PD. Moreover, as detailed in section 1.12 above, areas that were considered "non-forest" (i.e. non-forest vegetation or rock formations, as the project area has never been deforested) were excluded from the initial area of 434,705.79 ha, resulting in 432,717.83 ha, which was then defined as project area. No deforested, degraded or areas otherwise modified by humans were included in the project area at Project Start Date.
d) At project commencement, the project area shall include only land qualifying as "forest" for a minimum of 10 years prior to the project start date.	The project area consisted of 100% tropical rainforest in 2010 – 10 years prior to project start date – all of which conformed to the FAO definition of forest[96]. This was ascertained using satellite images, as described in section 1.13 of the present VCS-PD.
e) The project area can include forested wetlands (such as bottomland forests, floodplain forests, mangrove forests) as long as they do not grow on peat. Peat shall be defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm. If	As described in section 1.13 of the present VCS PD, around 3% of the project area is covered by dense alluvial tropical rainforest. However, no peat or peat swamp forests were found in the project area[97,98,99]. Therefore, none of the project area grows on peat, satisfying this applicability criterion.

[96] According to the Brazilian Forestry Service, Brazil adopts the FAO forest definition. Available at: <https://www.florestal.gov.br/publicacoes/1737-florestas-do-brasil-em-resumo-2019>. Last visit on: October 09th, 2020.

FAO forest definition: "Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha). The trees should be able to reach a minimum height of 5 meters (m) at maturity *in situ*." Available at: <http://www.fao.org/docrep/006/ad665e/ad665e06.htm>. Last visit on: October 09th, 2020.

[97] LUZ, Horacio de Figueredo. **Laudo de avaliação da capacidade de uso do solo:** Imóvel Fazenda Boa Fé. Manaus: Ibiraú Florestal, 2014. 26 p.

[98] Brazilian Institute of Geography and Statistics (IBGE). Soil types map in Amazonas State. 2010. Available at: <ftp://geoftp.ibge.gov.br/mapas_tematicos/pedologia/unidades_federacao/am_pedologia.pdf>. Last visit on: February 04th, 2015.

[99] Brazilian Geological Service. Inventory and Mapping of the Conventional and Alternative Agrominerals Resources of the Brazilian Territory. Alternative inputs map for agriculture: rocks, minerals and peat. 2010. Available at: <http://www.cprm.gov.br/publique/media/rochagem_inv_cart.pdf>. Last visit on: October 09th, 2020.

the project area includes forested wetlands growing on peat (e.g. peat swamp forests), this methodology is not applicable.	

3.3 Project Boundary

The project area is composed of one property as described in section 1.12. Given that the coordinates represented by this property are extensive, the area contour coordinates of the fazenda (farm) composing the Boa Fé REDD Project are presented in Appendix I.

The project area – defined in accordance with the methodology's rules – as well as the size of the reference region and the leakage belt, are displayed in the Table below.

Table 9. Project Area, Reference Region and Leakage Belt

Name	Net Forest Area (ha)
Project Area	432,717.83
Leakage Belt	191,444.14
Reference Region	3,005,126.19

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

Table 10. Carbon pools included or excluded within the boundary of the proposed AUD project activity

Carbon pools	Included / Excluded	Justification / Explanation of choice
Above-ground	Tree: Included	Carbon stock change in this pool is always significant
	Non-Tree: Excluded	No existence of perennial crops as final class
Below-ground	Included	Stock change in this pool is significant
Dead wood	Exluded	Excluded for simplification. This exclusion is conservative.
Harvested wood products	Excluded	Not significant
Litter	Excluded	Not to be measured according to VCS Methodology Requirements, 4.0.
Soil organic carbon	Excluded	Recommended when forests are converted to cropland. Not to be measured in conversions to pasture grasses and perennial crop according to VCS Methodology Requirements, 4.0.

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

In addition, the Methodology considers the two sources of GHG emissions listed in the Table below. Their inclusion or exclusion within the boundary of the proposed AUD project activity, as well as the respective justification/explanation, are described in the Table below.

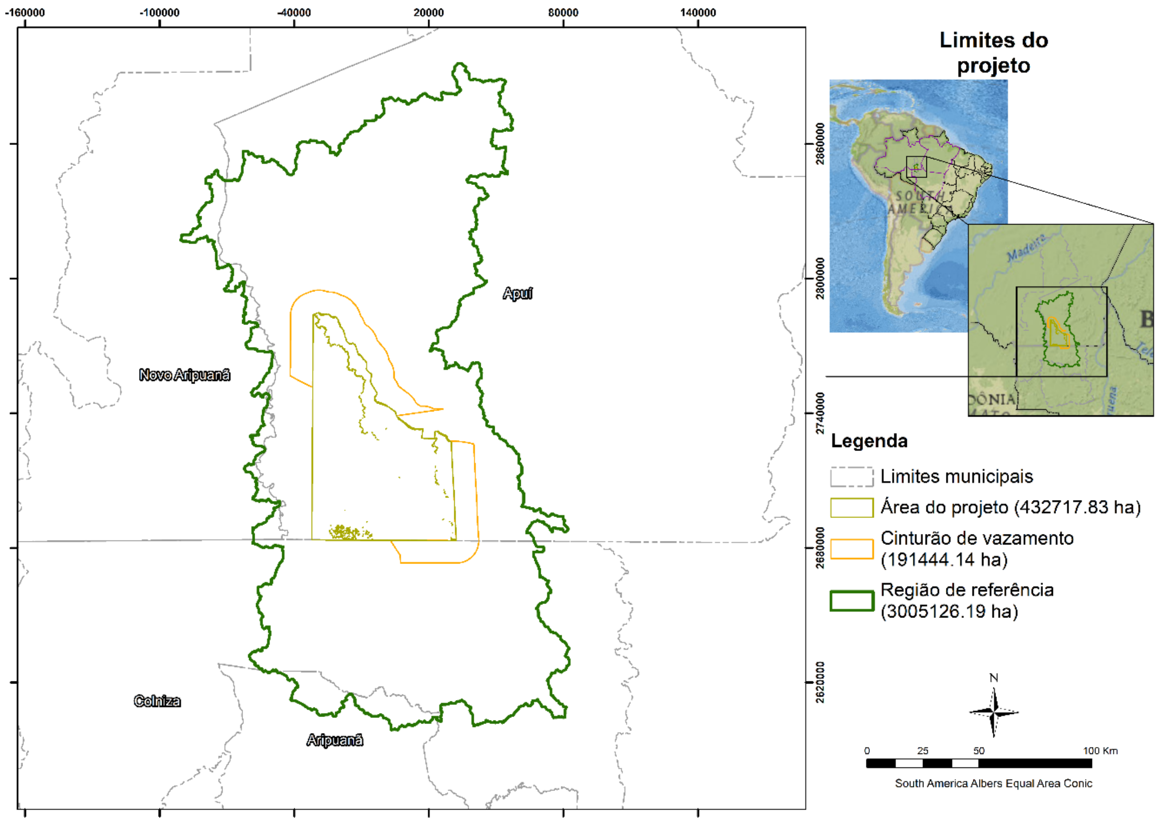
Table 11. Sources and GHG included or excluded within the boundary of the proposed AUD project activity

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

Source	Gas	Included?	Justification/Explanation
	Other	Excluded	No other GHG gases were considered in this project activity.

The map of the project's boundaries, including the locations of project area, reference region and leakage belt, is shown at the Figure 24 below.

Figure 24. Project boundaries



3.4 Baseline Scenario

In the baseline scenario, forest is expected to be converted to non-forest by the agents of deforestation acting in the reference region, project area and leakage belt, as described below. Therefore, the project falls into the AFOLU-REDD category, specifically: Avoided unplanned deforestation (AUD). The revenue from the present REDD project is essential to maintain this area as standing forest, as described under additionality (Section 3.5), as well as to carry out the present project's leakage management activities.

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

Definition of the property boundaries

The Reference Region

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

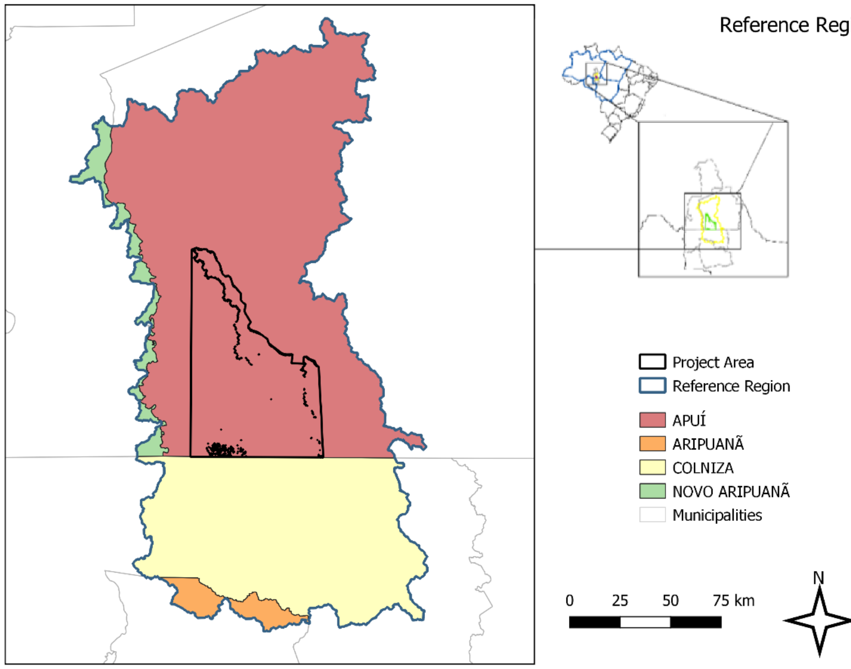
The RR was defined in accordance with two criteria:

- The methodology recommendation that projects over 100,000ha in size should have RRs 5 – 7 times bigger than the project area. The Boa Fé REDD project has 3,005,126.19 ha, 6.94 times the project area.
- The conditions determining the likelihood of deforestation within the project area being similar or expected to become similar to those found within the reference region, depending on: the landscape configuration and ecological conditions (elevation, slope, vegetation, and rainfall), socio-economic and cultural conditions, and agents and drivers of deforestation (agent groups, infrastructure or other drivers). The latter condition was the most important for adjusting the RR in order for it to more accurately represent the land-use dynamics. Specifically, this was based on the waterways (watersheds) and infrastructure (roads), which are the principal means of human and product transportation in the region. As such, from the areas directly surrounding the project, the RR was expanded to meet the nearest main waterways and roads.

To define the project area, hydrographic basins were used within an area of 19.4 million hectares around the project area, from the drainage network produced by the SRTM digital elevation model. For each of these basins, the average values of elevation, slope and precipitation and the percentages of different types of vegetation were determined. Based on these values, basins were selected that presented values close to these parameters to the values of the project area. Then, an attempt was made to select basins until reaching an extension of approximately seven times the size of the project area.

The RR sums to 3,005,126.19 ha and is distributed over 4 municipalities, Apuí, Novo Aripuanã in the Amazonas State and Colniza and Aripuanã in the Mato Grosso State. Although the reference region is distributed across four municipalities, two of them sum to the majority of the reference region, Apuí in the State of Amazonas, and Colniza, in the State of Mato Grosso. The other two, Nova Aripuanã and Aripuanã, comprise a smaller percentage.

Figure 25. Boa Fé REDD project's reference region distributed among 4 municipalities.



Maps below show some of the criteria that were taken into account in order to adjust the Boa Fé REDD Project's Reference Region.

Figure 26. Distribution of annual precipitation (mm), in number of pixels, in the Reference Region (RR) and in the Project Area (PA)

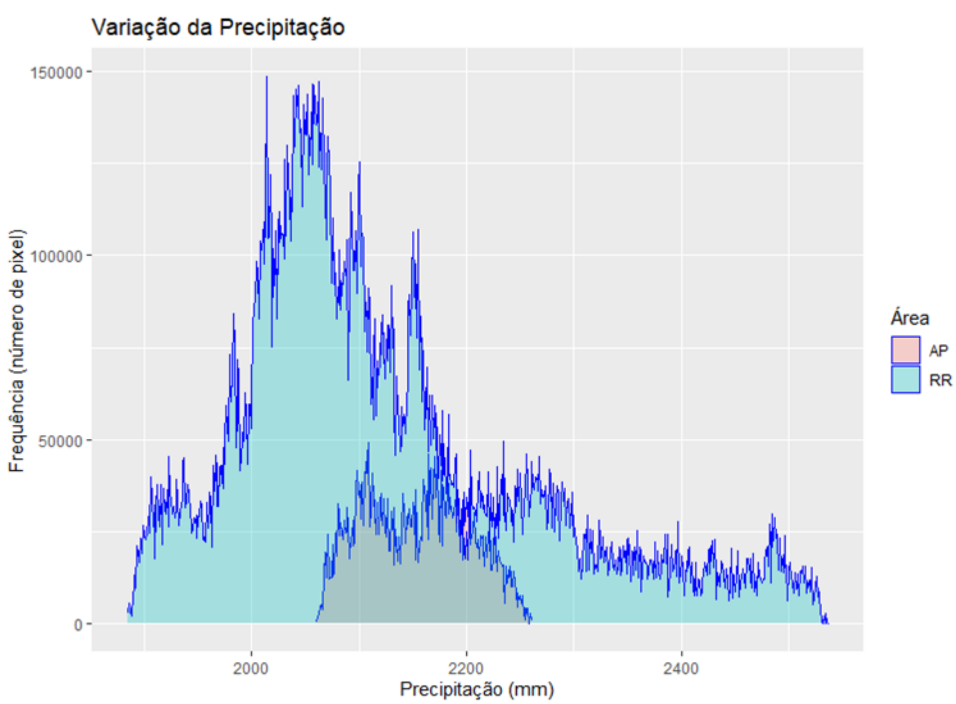
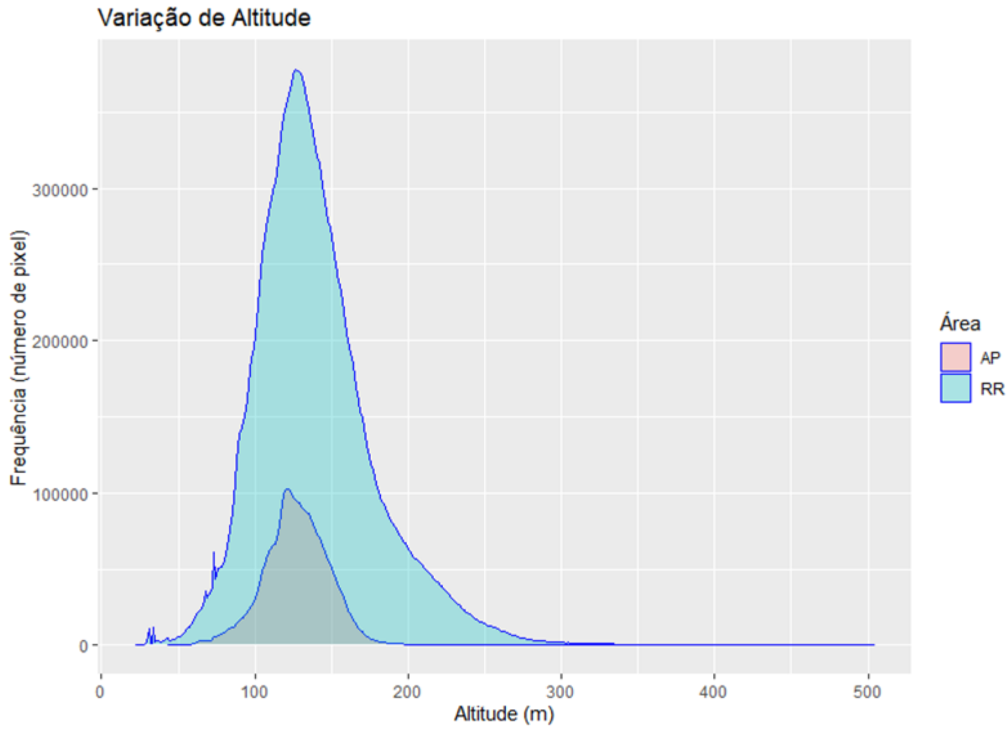


Figure 27 Altitude distribution (m), in number of pixels, in the Reference Region (RR) and in the Project Area (PA)



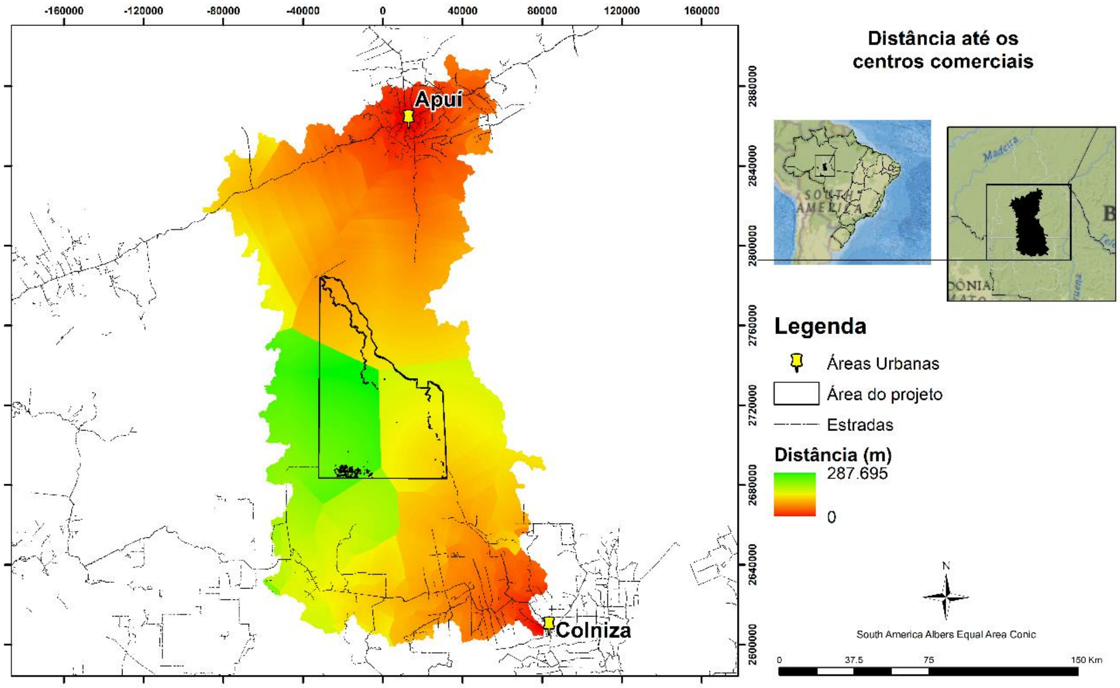
<u>**Definition of the Leakage Belt**</u>

To determine the leakage belt area, the opportunity cost methodology was carried out. Therefore, the economic viability of livestock production was spatialized in the Reference Region of the project, which consists of the difference between the sale price of the cattle (per ton) and the average cost of production (per ton) plus the cost of transportation to take the product to the nearest consumer center.

The methodology for calculating road transport costs for livestock in the region considered the sum of the distance that would be travelled in a straight line between the pasture areas and the open accesses (local highways and roads) with the distance travelled to the nearest commercial center (Apuí or Colniza).

Figure 28 represents the total distance in the reference region.

Figure 28 Surface distances (m) to the nearest commercial centers (Apuí and Colniza) in the Reference Region (RR)

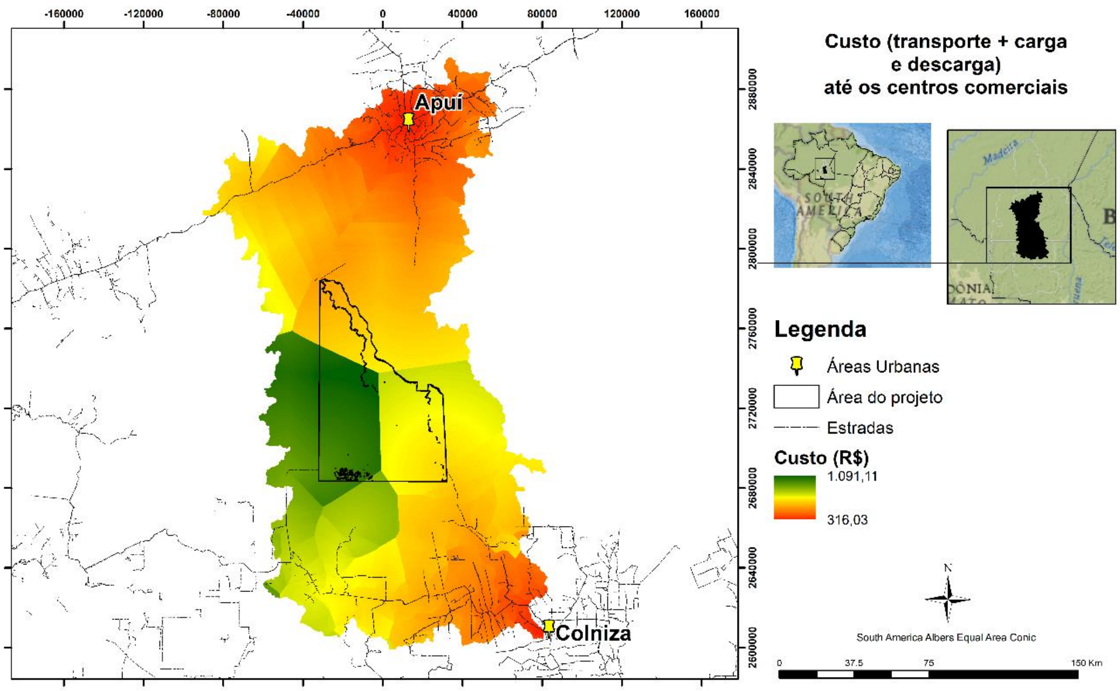


For monetary costs, the freight table, for road transportation of cargo capacity was considered[100]. In Apuí, each animal weighs an average of 13 arrobas[101], so it was considered 1 three-axle truck carrying an average of 72 cattle heads at the price of R$ 2.6941/km + R$ 316.03 of loading and unloading. Figure 29 illustrates the freight values that would be paid at each point in the reference region.

[100] Freight table available in Resolution nº 5,890, of May 26th, 2020. Available in < https://www.legisweb.com.br/legislacao/?id=396001> Last access in 03/11/2020

[101] A Cadeia Produtiva da Carne Bovina no Amazonas./Gabriel Cardoso Carrero; Gabriela Albuja; Pedro Frizo; Evando Konrad Hoffmann; Cristiano Alves; Caroline de Souza Bezerra. IDESAM, 2015. Available in: <http://www.idesam.org.br/publicacao/cadeia-produtiva-corte-amazonas.pdf>

Figure 29. Surface costs (R$) for road transportation to the nearest commercial centers (Apuí and Colniza) in the Reference Region (RR)



Combining these two data, the economically viable areas for livestock production would be where the sum of revenues minus total costs are positive. In the region, the costs per animal considering a productive area of 20 hectares and an extensive breeding system are on average approximately R$ 906.00[102]. As reported in interviews in Apuí, the average price of the arroba varies between R$ 80 and R$ 92[103] The analysis used the minimum value of R$ 80. Thus, for an average of 13 arrobas per animal, R$ 1,040.00.

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

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

Where:

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

S$x: Selling price of product Px; $/t

[102]The costs of animal production are described in <https://idesam.org/publicacao/relatorio-viabilidade-pecuaria.pdf>. The value of R$906.00 is accounted considering these costs, and is available in table 7 of <http://www.idesam.org.br/publicacao/cadeia-produtiva-corte-amazonas.pdf>

[103] A Cadeia Produtiva da Carne Bovina no Amazonas./Gabriel Cardoso Carrero; Gabriela Albuja; Pedro Frizo; Evando Konrad Hoffmann; Cristiano Alves; Caroline de Souza Bezerra. IDESAM, 2015. Available in: <http://www.idesam.org.br/publicacao/cadeia-produtiva-corte-amazonas.pdf>

PCxi: Average in situ production costs for one ton of product Px in stratum i; $/t

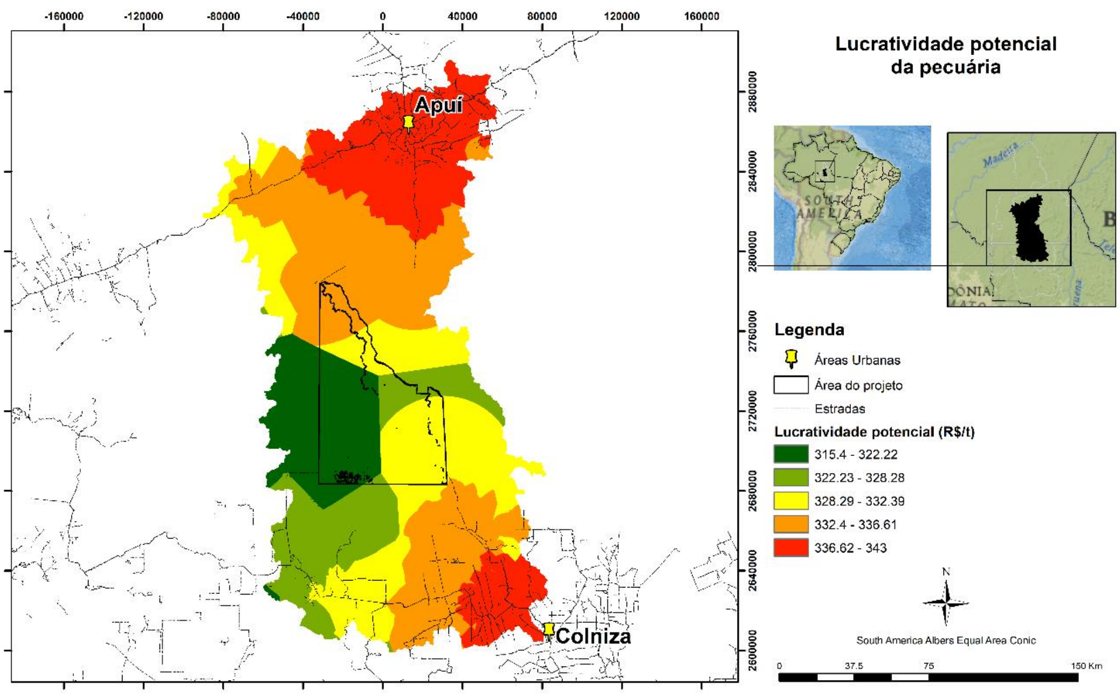
TDv: Transport distance on land, river or road of type v; km

TCv: Average transport cost per kilometer for one ton of product Px on land, river or road of type v; $/t/km

V: 1, 2, 3 ...V, type of surface to on which transport occurs; dimensionless

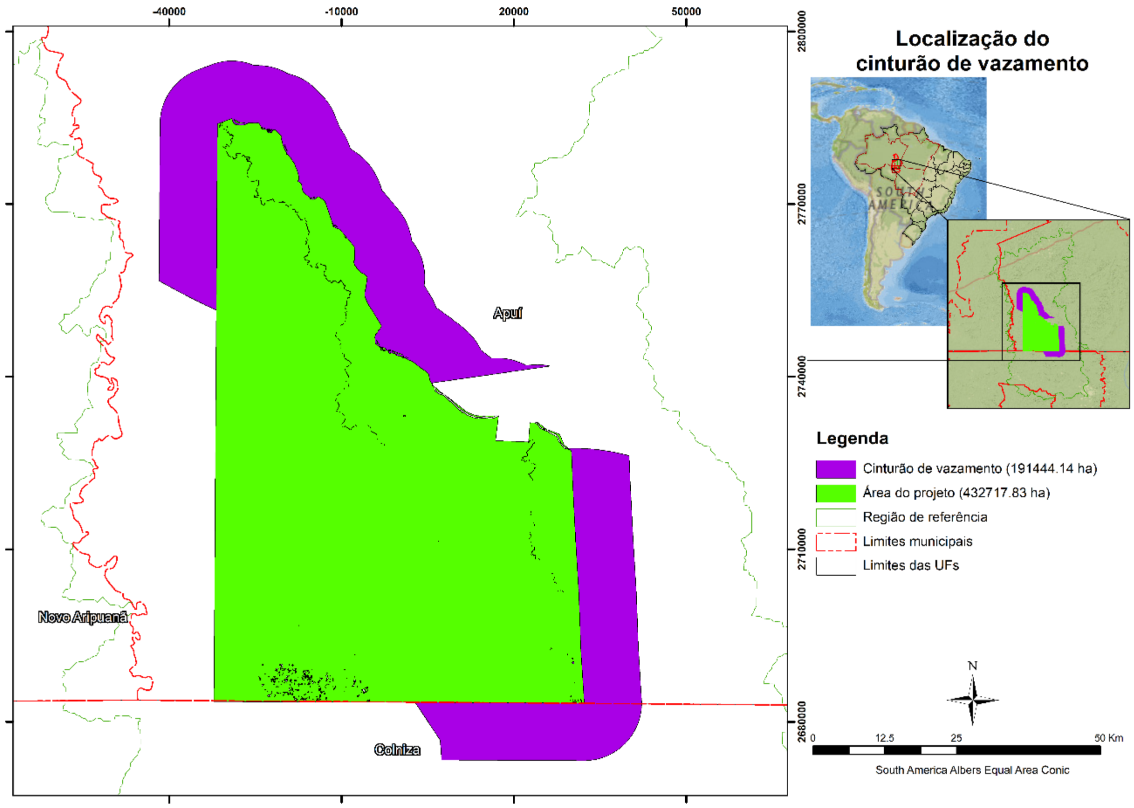
The location of these areas is illustrated in figure 6 below.

Figure 30. Potential profitability areas for cattle ranching within the Reference Region (RR) and the Project Area (PA)



From this analysis, it is taken into consideration that areas with a higher profitability value should be more attractive for cattle ranching. Thus, classification by natural breaks was made based on the profitability values, highlighting the values from the 3rd class. In addition, it is considered that adjacent viable areas to the project area, according to the opportunity cost analysis within a 10km radius, would be where deforestation could occur directly due to the project's activity. In more distant areas, the increase in deforestation as it is already occurring is probably associated with the proximity to rivers and roads. Thus, based on an overlap of both information, the area of the leakage belt was defined, comprising an area of 191,444.14 ha. The Figure below illustrates its location.

Figure 31. Location of the Leakage Belt



Analysis of historical Land-Use/Land-Cover change

GIS mapping, remote sensing techniques

To carry out the assessment of land use and land cover (LU/LC) for the baseline period (2010-2019), remote sensing satellite analysis was carried out, which is described below.

The historical reference period is the period in which analysis of LU/LC-change within the reference region and project area is carried out. The historical reference period for the present project during the assessment of the first baseline period comprised analysis of images from 2010-2019. In accordance with the methodology, the analysis shall be made using the data obtained from monitoring LU/LC changes in the reference region during the historical reference period.

To map the dynamics of land use in the reference region, images from 2010 to 2019 produced by MapBiomas (collection 5.0) were used, made available in raster format on the program's website (http://mapbioma.org/).

In order to compose the entire reference region, four Landsat scenes per year (orbit/point: 229/66, 230/67, 230/65 and 230/66) from the reference period were necessary (Table 10 below). The final mapping resolution was of 30 m pixel.

MapBiomas is a multi-institutional initiative of the Greenhouse Gases Emissions Estimation System[104] promoted by the Climate Observatory. The MapBiomas creation involves NGOs, universities, and technology companies. In MapBiomas, the image classification methodology utilizes for each year, all Landsat images available in each period (Landsat 5 [L5], Landsat [L7] and Landsat [L8]) with a cloud cover less than or equal 50%. Thus, a representative mosaic of each year is generated by selecting cloudless pixels from the available images. For each pixel, metrics that describe its behaviour during the year are extracted and can contain up to 105 layers of information with an artificial intelligence classifier, Random Forest. The acquisition of Landsat images is done via Google Earth Engine, with sources from NASA (American Space Agency) and USGS (US Geological Survey).

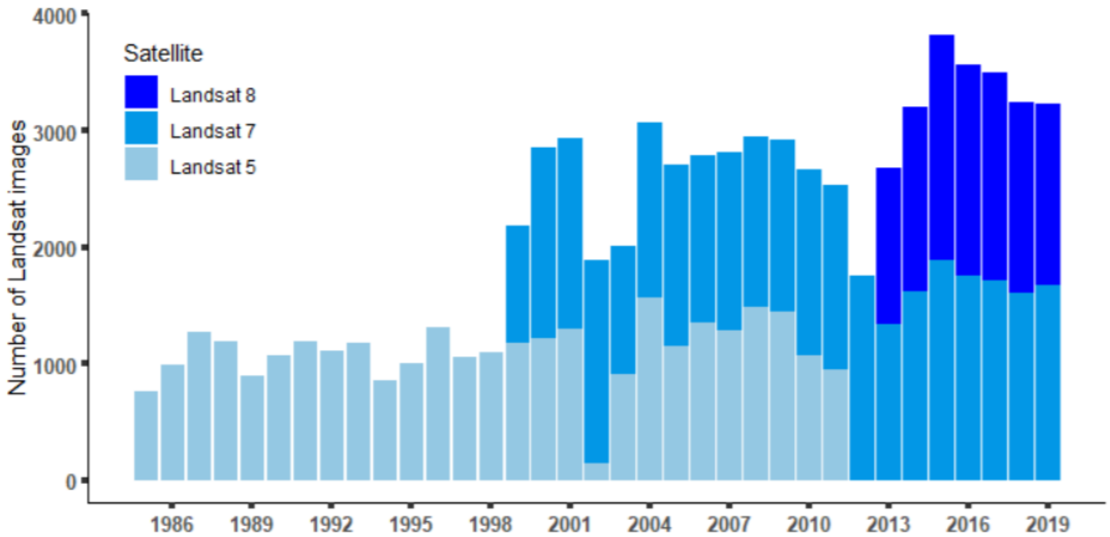
The algorithm uses samples obtained by reference maps, generation of stable collections from previous MapBiomas series and direct collection by visual interpretation of Landsat images to classify as a single map per class. This classification then goes through the stages of the spatial filter, applying neighbourhood rules and temporal filters, in particular changes in coverage and use that are impossible or not allowed, to reduce spatial and temporal inconsistencies.

Table 12. Satellite images used to map land use and land cover in the reference region

Vector (Satellite or plane)	Sensor	Resolution		Coverage	Acquisition Date	Scene	
		Spatial (m)	Spectral (µm)	(km^2)	2009 to 2019	Path	Row
Satellite	Landsat TM	30	0.45-2.35	34,225	2009-2019	229	66
Satellite	Landsat TM	30	0.45-2.35	34,225	2009-2019	229	67
Satellite	Landsat TM	30	0.45-2.35	34,225	2009-2019	230	65
Satellite	Landsat TM	30	0.45-2.35	34,225	2009-2019	230	66

[104] SEEG website. Available at: http://seeg.eco.br/en/ Last visited on 18/06/2020

Figure 32 Number of Landsat images for mapping the Amazon. Source: MapBiomas

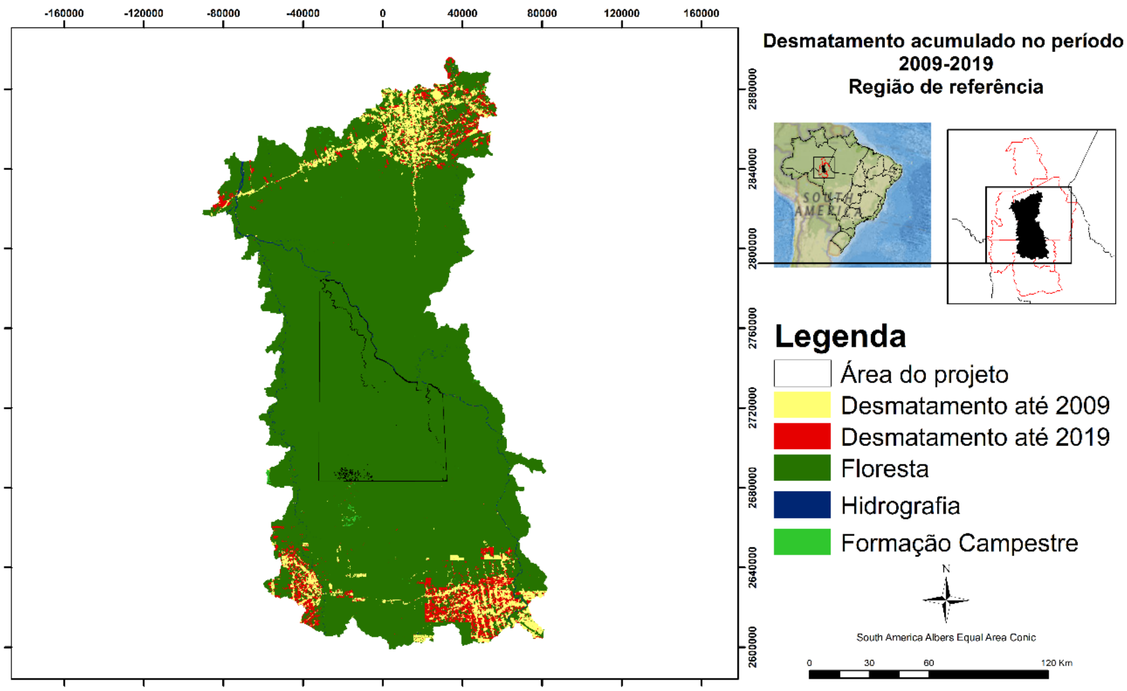


<u>Definition of classes of Land-Use and Land-Cover (LU/LC)</u>

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

Stratification was carried out in the forest class, sub-dividing it into 6 types of forest with different carbon stocks; however, the “non-forest” category was not stratified, and it has homogenous carbon stocks. Satellite images were used to generate the land-use and land-cover map in 2019 at the project start date, shown in the figure below.

Figure 33 Land use and land cover map comparing 2009 and 2019.



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

Table 13 List of all land use and land cover classes existing at the project start date within the reference region, project area and leakage belt.

Class identifier		Trend in carbon stock[1]	Presence in[2]	Baseline activity[3]			Description (including criteria for unambiguous boundary definition)
IDcl	Name			LG	FW	CP	
1	Dense Alluvial Tropical Rainforest	decreasing	RR, PA, LK	no	no	no	According to official classification of the types of vegetation of Brazil (SIVAM). Predominantly Dense Alluvial Tropical Rainforest.
2	Dense Submontane Tropical Rainforest	decreasing	RR, PA, LK	no	no	no	According to official classification of the types of vegetation of Brazil (SIVAM). Predominantly Dense Submontane Tropical Rainforest.
3	Open Submontane Tropical Rainforest	decreasing	RR, PA, LK	no	no	no	According to official classification of the types of vegetation of Brazil (SIVAM). Predominantly Open Submontane Tropical Rainforest.
4	Dense Lowland Tropical Rainforest	decreasing	RR	no	no	no	According to official classification of the types of vegetation of Brazil (SIVAM). Predominantly Open Alluvial Tropical Rainforest.
5	Savannah Forest	decreasing	RR	no	no	no	According to official classification of the types of vegetation of Brazil (SIVAM). Predominantly Open Submontane Tropical Rainforest.
6	Pioneer vegetation in areas with riverine influence	decreasing	RR	no	no	no	According to official classification of the types of vegetation of Brazil (SIVAM).
7	No forest	increasing	RR, PA, LK	no	no	no	Mosaic of anthropic areas: pasture, annual, perennial crops and roads according to the satellite image classification

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

The LU/LC-change categories that could occur within the project area and leakage belt during the first baseline period, in both the baseline and project case, are identified in the potential LU/LC-change matrix and the list of LU/LC-change categories during the project crediting period are shown in Tables below.

It is shown that deforestation could occur in the baseline and project scenarios within both the PA and LK areas, the hectares show the quantities of deforestation during the crediting period associated with each identifier. The deforestation presented within the PA and LK are shown in the LU/LC-change map comparing 2009 with 2019. It is important to note that while the latter shows only deforestation from 2010–2019, the Tables below display deforestation across the whole crediting period.

Table 14 Potential land-use and land-cover change matrix.

		Initial LU/LC class						
	IDcl	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	Dense Lowland Tropical Rainforest	Savannah Forest	Pioneer vegetation in areas with riverine influence	No forest
Final Class	Dense Alluvial Tropical Rainforest	I1/F1	0	0	0	0	0	0
	Dense Submontane Tropical Rainforest	0	I2/F2	0	0	0	0	0
	Open Submontane Tropical Rainforest	0	0	I3/F3	0	0	0	0
	Dense Lowland Tropical Rainforest	0	0	0	I4/F4	0	0	0
	Savannah Forest	0	0	0	0	I5/F5	0	0
	Pioneer vegetation in areas with riverine influence	0	0	0	0	0	I6/F6	0
	No forest	I1/F7	I2/F7	I3/F7	I4/F7	I5/F7	I6/F7	I7/F7

Table 15 Potential land-use and land-cover change matrix showing associated conversion levels in Project Area and Leakage Belt over the crediting period in both, the baseline and project scenarios.

BASELINE SCENARIO

	PA	Initial LU/LC class			
	IDcl	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	Non Forest in the PA
Final Class	Dense Alluvial Tropical Rainforest	8,888.90	0.00	0.00	0.00
	Dense Submontane Tropical Rainforest	0.00	293,120.62	0.00	0.00
	Open Submontane Tropical Rainforest	0.00	0.00	25,167.36	0.00
	Non Forest in the PA	2,804.84	82,166.60	20,569.51	0.00

	LB	Initial LU/LC class			
	IDcl	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	Non Forest in the LK
Final Class	Dense Alluvial Tropical Rainforest	1,574.31	0.00	0.00	0.00
	Dense Submontane Tropical Rainforest	0.00	76,235.29	0.00	0.00
	Open Submontane Tropical Rainforest	0.00	0.00	52,569.99	0.00
	Non Forest in the LK	2,995.95	44,424.96	10,413.46	100.98

PROJECT SCENARIO

	PA	Initial LU/LC class			
	IDcl	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	Non Forest in the PA
Final Class	Dense Alluvial Tropical Rainforest	11,580.00	0.00	0.00	0.00
	Dense Submontane Tropical Rainforest	0.00	371,955.26	0.00	0.00
	Open Submontane Tropical Rainforest	0.00	0.00	44,902.75	0.00
	Non Forest in the PA	113.74	3,331.96	834.12	0.00

	LB	Initial LU/LC class			
	IDcl	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	Non Forest in the LK
Final Class	Dense Alluvial Tropical Rainforest	1,574.31	0.00	0.00	0.00
	Dense Submontane Tropical Rainforest	0.00	76,235.29	0.00	0.00
	Open Submontane Tropical Rainforest	0.00	0.00	52,569.99	0.00
	Non Forest in the LK	2,995.95	44,424.96	10,413.46	100.98

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

Table 16 List of land-use and land-cover change categories.

IDct	Name - Initial	Trend in carbon stock[1]	Presence in	Activity in the baseline case			Name - Final	Trend in carbon stock	Presence in	Activity in the project case		
				LG	FW	CP				LG	FW	CP
I1/F1	Dense Alluvial Tropical Rainforest	constant	RR, PA, LK	no	no	no	Dense Alluvial Tropical Rainforest	constant	RR, PA, LK	no	no	no
I1/F7	Dense Alluvial Tropical Rainforest	decreasing	RR, PA, LK	no	no	no	Non Forest	constant	RR, PA, LK	no	no	no
I2/F2	Dense Submontane Tropical Rainforest	constant	RR, PA, LK	no	no	no	Dense Submontane Tropical Rainforest	constant	RR, PA, LK	no	no	no
I2/F7	Dense Submontane Tropical Rainforest	decreasing	RR, PA, LK	no	no	no	Non Forest	constant	RR, PA, LK	no	no	no
I3/F3	Open Submontane Tropical Rainforest	constant	RR, PA, LK	no	no	no	Open Submontane Tropical Rainforest	constant	RR, PA, LK	no	no	no
I3/F7	Open Submontane Tropical Rainforest	decreasing	RR, PA, LK	no	no	no	Non Forest	constant	RR, PA, LK	no	no	no
I4/F4	Dense Lowland Tropical Rainforest	constant	RR	no	no	no	Dense Lowland Tropical Rainforest	constant	RR	no	no	no
I4/F7	Dense Lowland Tropical Rainforest	decreasing	RR	no	no	no	Non Forest	constant	RR	no	no	no
I5/F5	Savannah Forest	constant	RR	no	no	no	Savannah Forest	constant	RR	no	no	no
I5/F7	Savannah Forest	decreasing	RR	no	no	no	Non Forest	constant	RR	no	no	no
I6/F6	Pioneer vegetation in areas with riverine influence	constant	RR, LK	no	no	no	Pioneer vegetation in areas with riverine influence	constant	RR, LK	no	no	no
I6/F7	Pioneer vegetation in areas with riverine influence	decreasing	RR, LK	no	no	no	Non Forest	constant	RR, LK	no	no	no
I7/F7	Non Forest	constant	RR, LK	no	no	no	Non Forest	constant	RR, LK	no	no	no

Analysis of land-use and land-cover change

The deforestation activities caused the transformation from the initial land use/ land cover (LU/LC) class of tropical rainforest and its sub-types to the final class of non-forest. The annual deforestation values in the Reference Region, Project Area, and Leakage Belt during the historical reference period (2010-2019) can be seen in the Tables and Figures that will follow.

According to the GIS analysis, between 2010 and 2019, there was a deforestation of 126,857.61 ha within the reference region, with an average oscillation of approximately 12,685.76 ha/year. There was a significant increase in deforestation rate during that period (R^2 = 0.60, p = 0.0055), as shown in the figures and Tables below:

Figure 34 Deforestation dynamics, between the years 2010 and 2019, in the region of reference (RR) and project area. Source: MapBiomas and IPE data

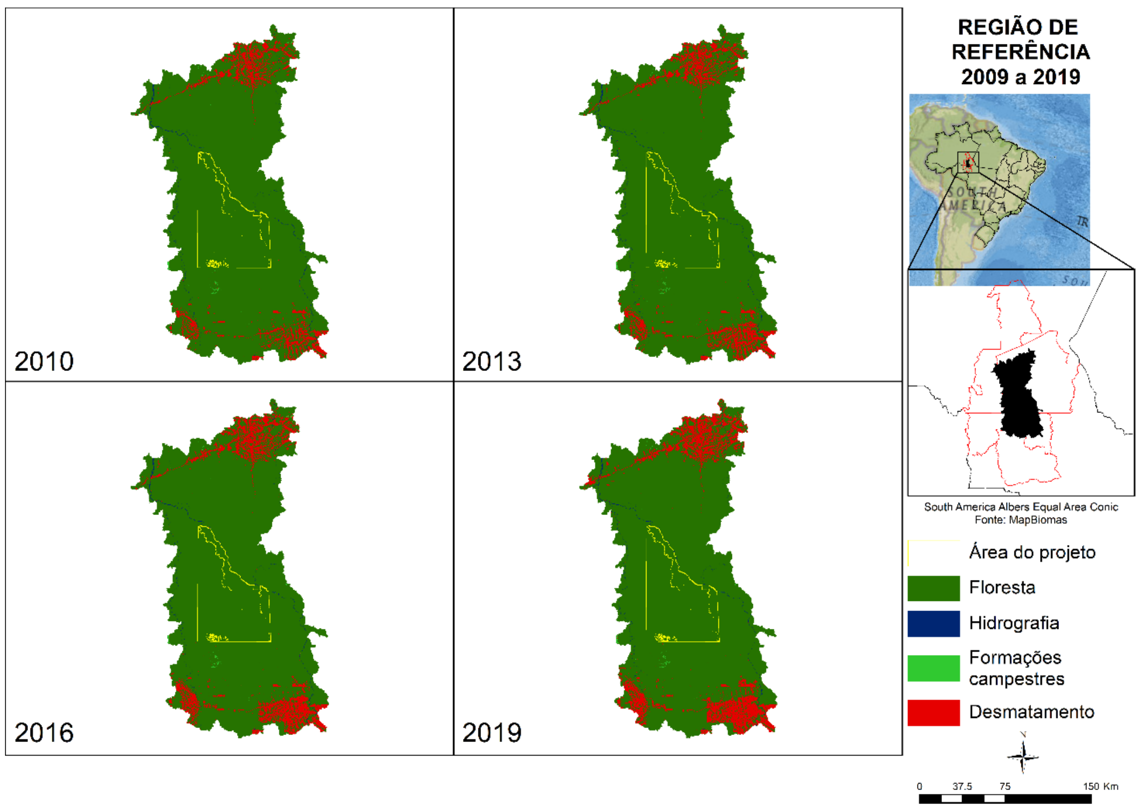
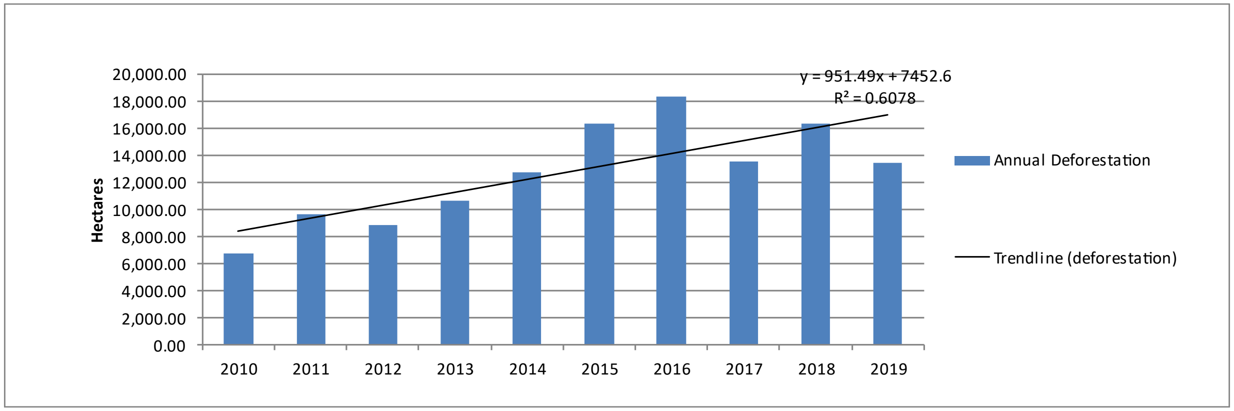


Table 17 Annual deforestation in the Reference Region between 2010-2019

Total deforestation											
Year	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	Dense Lowland Tropical Rainforest	Savannah Forest	Pioneer vegetation in areas with riverine	Total Forest area (ha)	No Forest in RR (ha)	annual ABSLRR t	cumulative ABSLRR	R: annual rate of forest cover change
2010	53,255.57	1,696,646.40	1,031,439.64	22,454.45	5,281.89	1,369.86	2,810,447.81	174,718.27	6,784.03	6,784.03	-
2011	53,073.62	1,695,211.16	1,023,452.77	22,416.20	5,257.31	1,369.86	2,800,780.92	184,385.16	9,666.89	16,450.92	0.34%
2012	52,961.15	1,694,025.30	1,015,936.30	22,361.30	5,232.75	1,369.86	2,791,886.66	193,279.42	8,894.26	25,345.18	0.32%
2013	52,862.10	1,692,897.10	1,006,596.70	22,310.45	5,187.88	1,369.86	2,781,224.09	203,941.99	10,662.57	36,007.75	0.38%
2014	52,730.16	1,691,098.35	995,846.97	22,236.18	5,172.75	1,369.86	2,768,454.27	216,711.81	12,769.82	48,777.57	0.46%
2015	52,592.63	1,688,129.60	982,715.04	22,112.98	5,164.05	1,369.86	2,752,084.16	233,081.92	16,370.11	65,147.68	0.59%
2016	52,333.57	1,684,847.39	968,099.53	21,975.81	5,120.78	1,369.05	2,733,746.13	251,419.95	18,338.03	83,485.71	0.67%
2017	52,144.19	1,682,775.77	957,681.71	21,163.77	5,105.34	1,369.05	2,720,239.83	264,926.25	13,506.30	96,992.01	0.50%
2018	51,804.43	1,680,201.48	944,890.26	20,521.20	5,075.13	1,369.05	2,703,861.55	281,304.53	16,378.28	113,370.29	0.60%
2019	51,687.48	1,677,472.16	935,664.24	19,124.56	5,056.83	1,368.96	2,690,374.23	294,791.85	13,487.32	126,857.61	0.50%

Figure 35 Variation in the deforestation rate in the reference region between the years 2010 and 2019.



In the leakage area, there was a deforestation of 44.10 ha, and an average of 4.41 ha/year. The location of these areas can be seen in the Figure below. There was no significant increase in the rate of deforestation in the leakage belt within this analyzed period ($R^2 = 0.012$, $p = 0.32$). The quantitative values per year are indicated in the Table below:

Figure 36. Deforestation dynamics between the years 2010 and 2019 in the leakage belt. Source: MapBiomas and IPE data

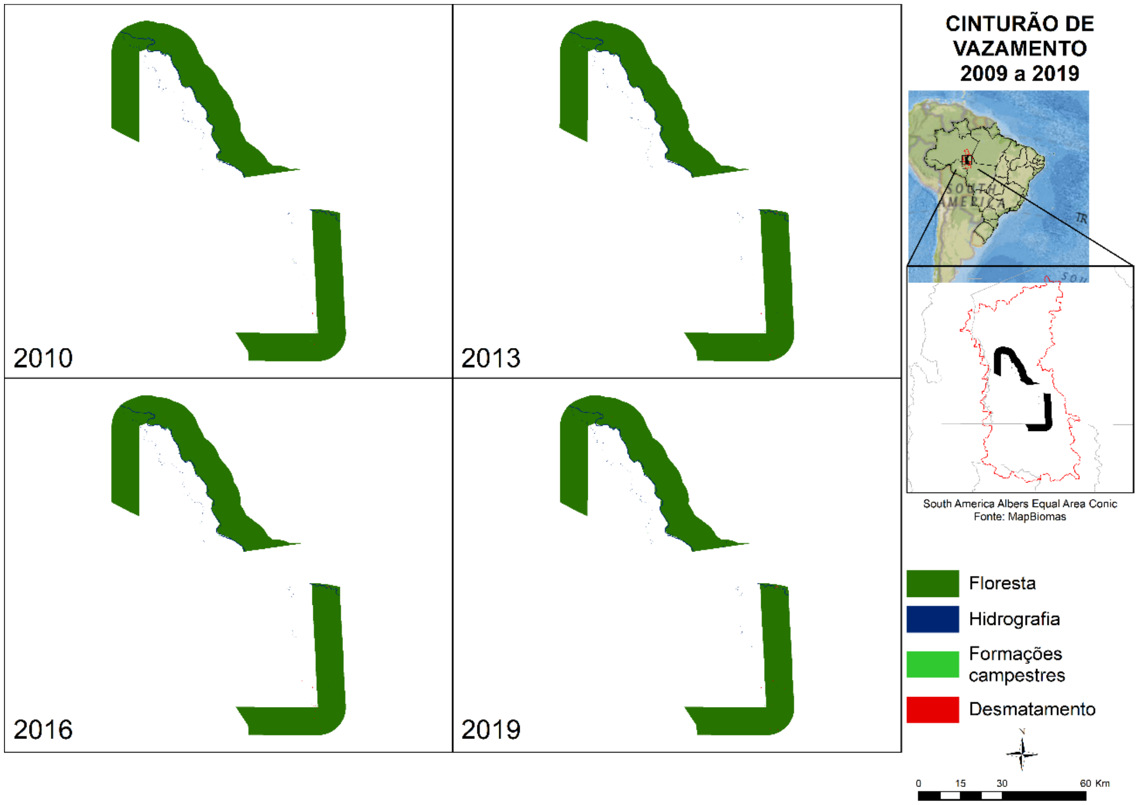
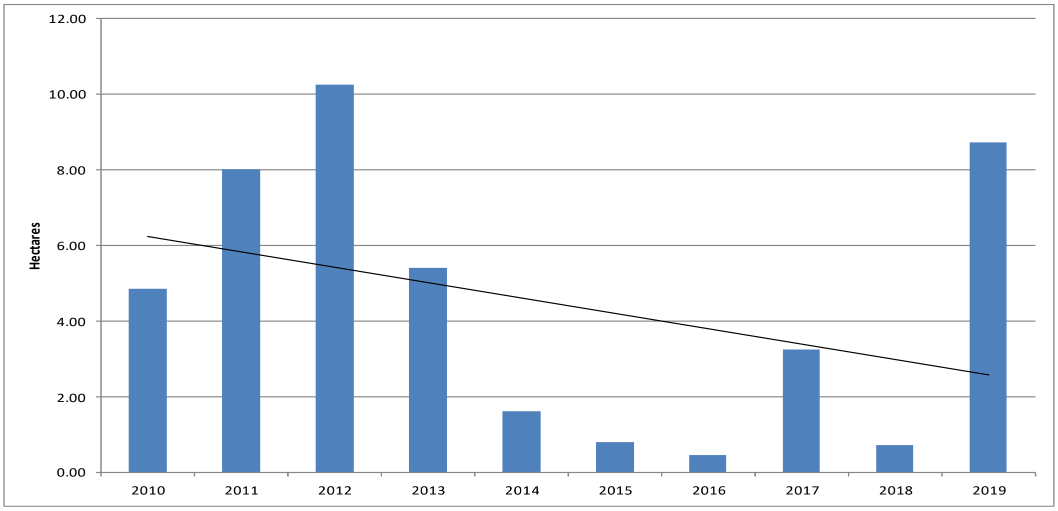


Table 18. Annual deforestation in the Leakage Belt between 2010-2019

Total deforestation								
Year	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Dense Lowland Tropical Rainforest	Total Forest area (ha)	No Forest in LK (ha)	annual ABSLLK t	cumulative ABSLLK	R: annual rate of forest cover change
2010	4,573.32	120,688.69	62,991.19	188,253.20	61.74	4.86	4.86	-
2011	4,573.05	120,682.30	62,989.84	188,245.19	69.75	8.01	12.87	0.00%
2012	4,572.24	120,673.93	62,988.76	188,234.93	80.01	10.26	23.13	0.01%
2013	4,571.97	120,671.32	62,986.24	188,229.53	85.41	5.40	28.53	0.00%
2014	4,571.88	120,670.24	62,985.79	188,227.91	87.03	1.62	30.15	0.00%
2015	4,571.88	120,669.88	62,985.34	188,227.10	87.84	0.81	30.96	0.00%
2016	4,571.79	120,669.61	62,985.25	188,226.65	88.29	0.45	31.41	0.00%
2017	4,571.79	120,666.37	62,985.25	188,223.41	91.53	3.24	34.65	0.00%
2018	4,571.70	120,665.92	62,985.07	188,222.69	92.25	0.72	35.37	0.00%
2019	4,570.26	120,660.25	62,983.45	188,213.96	100.98	8.73	44.10	0.00%

Figure 37 Variation in the deforestation rate in the leakage belt between the years 2010 and 2019.



Map accuracy assessment

The results of MapBiomas undergo an accuracy assessment, which for the entire Amazon Biome is on average 95%. However, to meet the particularities of the region, an independent evaluation was carried out for the reference region from years 2009-2019.

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

The table below shows the accuracy analysis carried out for each year and each land use class:

Table 19 Summary of confusion matrices from the evaluation of MapBiomas from 2009 to 2019

	Producer accuracy				User accuracy			
Year	Forest	Hydrography	Pioneer vegetation	Deforestation	Forest	Hydrography	Pioneer vegetation	Deforestation
2009	91.84%	89.09%	88.89%	90.20%	90.00%	98.00%	80.00%	92.00%
2010	95.92%	94.34%	84.31%	91.49%	94.00%	100.00%	86.00%	86.00%
2011	100.00%	87.72%	84.00%	93.75%	90.00%	100.00%	84.00%	90.00%
2012	88.00%	98.00%	78.00%	88.00%	93.62%	84.48%	88.64%	86.27%
2013	97.96%	98.00%	83.93%	91.11%	96.00%	98.00%	94.00%	82.00%
2014	100.00%	92.45%	93.33%	88.89%	96.00%	98.00%	84.00%	96.00%
2015	90.00%	98.00%	82.00%	94.00%	100.00%	92.45%	89.13%	83.93%
2016	84.62%	89.29%	95.12%	88.24%	88.00%	100.00%	78.00%	90.00%
2017	100.00%	94.34%	84.91%	91.84%	90.00%	100.00%	90.00%	90.00%
2018	97.96%	92.59%	89.80%	91.67%	96.00%	100.00%	88.00%	88.00%
2019	100.00%	86.21%	82.98%	90.00%	90.00%	100.00%	78.00%	90.00%

Analysis of agents, drivers and underlying causes of deforestation

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

- Identification of agents of deforestation

The main municipalities in the reference region are part of the Brazilian arc of deforestation, where the economics of colonization have been based on logging, followed by the establishment of pasturelands for livestock, mainly producing beef cattle. These areas are deforested or even abandoned after being used as pasturelands. This pressure is expected to continue, given the globalization of markets in the Amazon region and international development policies planned for the region[105].

Since the beginning, land speculation has been the main land use pattern. In general, it can be said that these municipalities are proof of the region's misguided colonization policy, with lots sold, abandoned or invaded by squatters and ranchers. In addition, there are reports of invasions of public land by squatters. Conflicts over land ownership are frequent, which in addition to the absence of government have resulted in a high crime rate. The lack of proper land documentation is considered by residents, farmers and religious leaders as the greatest obstacle to local development. The actions of squatters and illegal loggers generates a climate of insecurity and day to day reality of families living with violence in all its forms.

The main deforestation agents identified in the region are:

- Timber harvesting, acting both legally and illegally;
- Livestock, especially cattle ranching, mainly for beef cattle production.

Those deforestation agents are better described below.

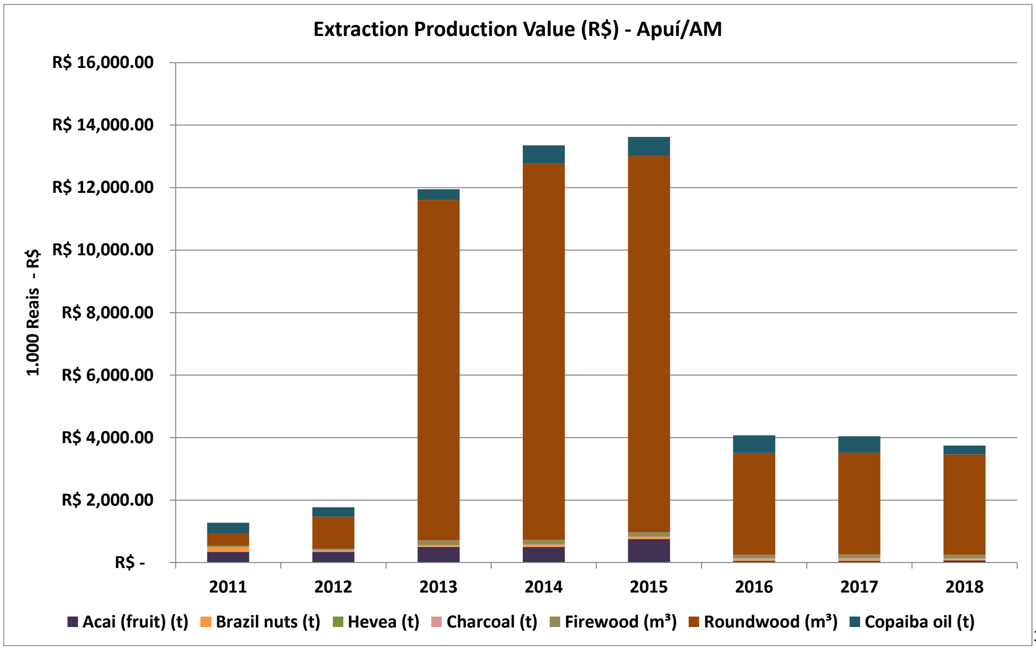
Timber harvesting

As previously mentioned in section 1.13 (socio-economic conditions) above, timber logging (both legal and illegal) is an important economic activity within the reference region. Economic data[106] sources between 2010 and 2019 (see Figures below), show that timber stands out as having the highest values of annual production in the project area municipalities of Apuí, Novo Aripuanã and Colniza, where almost 98% of the project area is located.

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

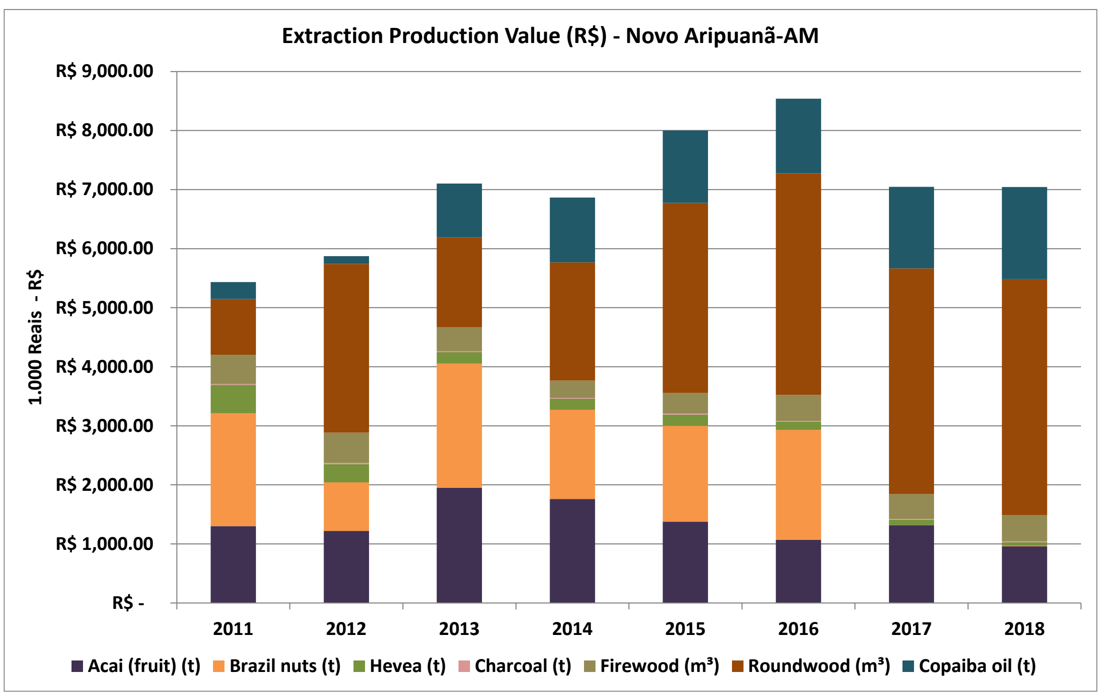
[106] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

Figure 38 Extraction Production Value (R$) - Apuí/AM



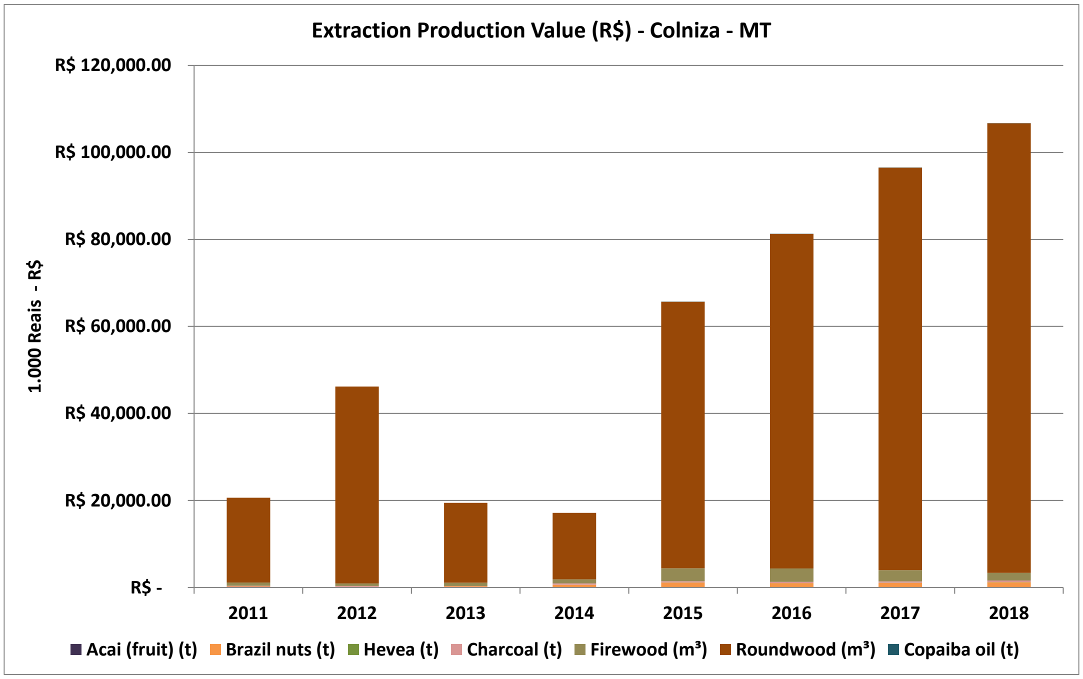
[107]

Figure 39 Extraction Production Value (R$) - Novo Aripuanã/AM



[107] IBGE Cidades – Extração vegetal e silvicultura - <https://cidades.ibge.gov.br/brasil/am/novo-aripuana/pesquisa/16/12705>

Figure 40 Extraction Production Value (R$) - Colniza/MT



Colniza had the highest production values for timber, mainly due to the available connection via highways to other regions of Brazil, leading to a higher average unit price.

Usually, timber logging is the first deforestation agent that reaches previously inaccessible forest lands, using existing roads or creating illegal ones, followed by land speculators or farmers in search of cheap land.

After harvesting all the commercial valuable species, the deforestation continues in areas already explored and unexplored, and thus providing conditions for further expansion of logging and cattle ranching[108]. It is important to note that illegal logging (without authorization or sustainable management) was reported by residents as a major environmental problem and cause of conflicts in the region[109].

The Figures below show the annual quantity of timber logging produced, separated in firewood and roundwood, in the main municipalities of the reference region. The municipality of Colniza was the main responsible for the expansion of this activity, which increased more than 6 times during the analyzed period (Roundwood, 2011 – 2019).

[108] RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[109] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

Figure 41 Roundwood - Produced quantity[110]

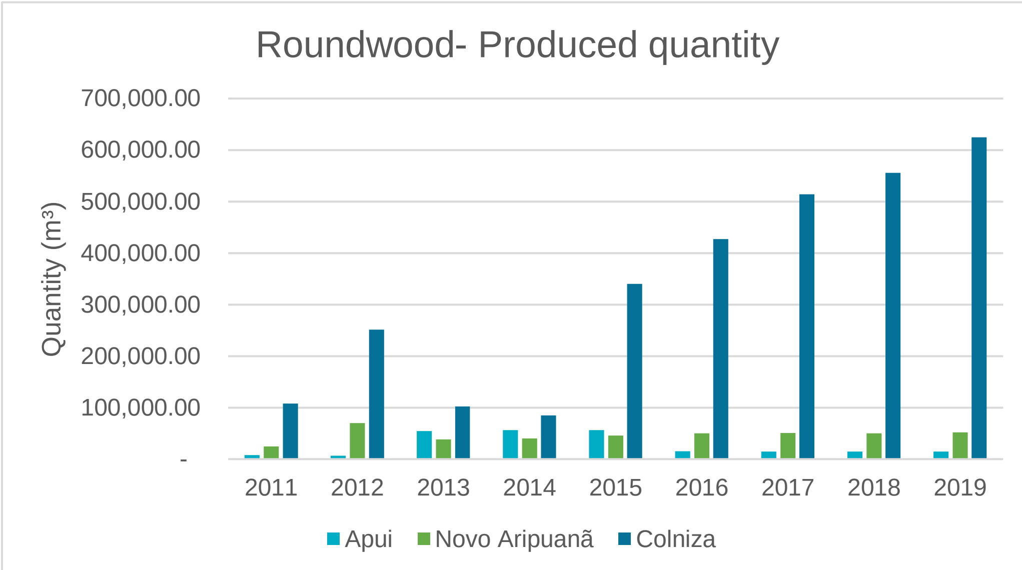
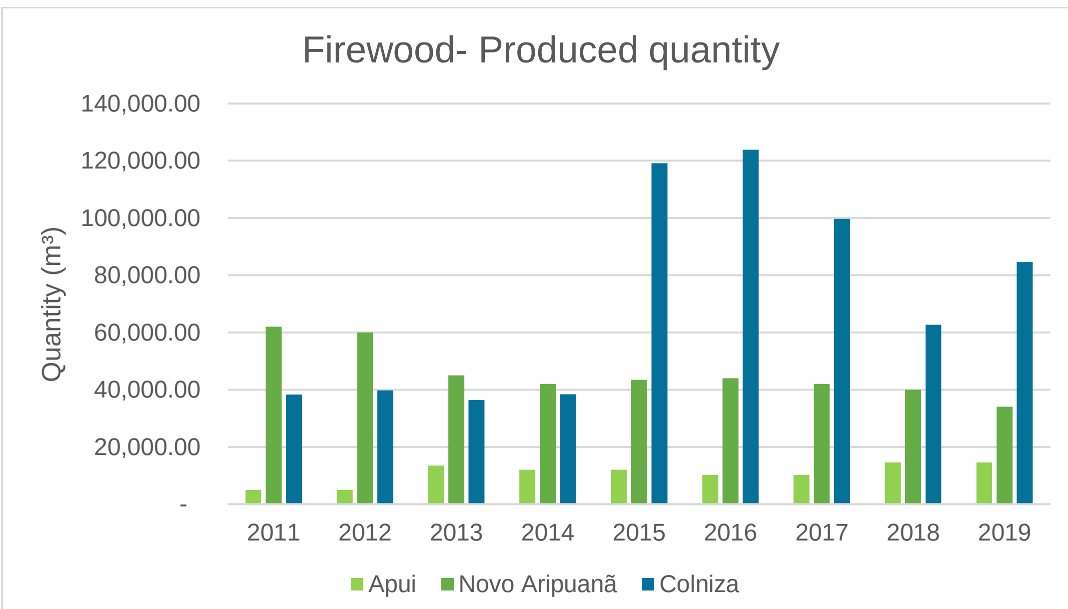


Figure 42 Firewood - Produced quantity



It can be concluded that timber, whether firewood or roundwood, represents a product of much more attractive value compared to other types, being even more advantageous when combined with animal production afterwards, where there is no need for forest management.

[110] IBGE Cidades – Extração vegetal e silvicultura - <https://cidades.ibge.gov.br/brasil/am/novo-aripuana/pesquisa/16/12705>

Cattle ranching

According to Razera (2005)[111], the lack of economic alternatives has created the conditions for livestock farming to establish itself as the main economic activity causing settlement of deforested areas in Amazonia.

Cattle farming in the Amazon is primarily due to low land prices combined with adequate rainfall levels[112]. The Amazon region attends to national and regional demand. Analysis of supply and demand show that livestock farming could expand even more to attend to the majority of global demand. This scenario is extremely worrying in relation to Amazon deforestation levels.

Livestock farmers do not pay for the public lands which they acquire legally or illegally, and furthermore they harvest timber without paying the government and, in this way, they accumulate capital freely to reinvest into their operations. Thus land speculation and cattle farming contribute to the advancement of deforestation in more isolated regions[113]. In this way, the predominance of the free market (with no legal restrictions) will lead to the expansion of cattle farming especially of the type based upon indiscriminate deforestation.

Figure 43. Cattle ranching in the project region[114]

[111] RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[112] BRANDÃO, Fernanda. **Tendências para o consumo de carne bovina no Brasil**. 2013. 102 f. Thesis (Doctor grade) - Curso de Agronegócio, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2013.

[113] RAZERA, Allan. Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí. 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[114] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

In Amazonas State, livestock represents 28% of the land use, equivalent to 1,141,768 ha. Until 2018, there was 80,959 agricultural establishments in the State[115].

In addition, the low efficiency of the cattle ranching model verified in the region (1.2 animal units per hectare), mainly due to the low cost of the land, leads to the necessity of more areas to raise cattle comparing to well managed pasturelands in other Brazilian regions.

Pastureland (either planted, natural or degraded) represents the main land use after forest (natural and protected areas) in the main municipalities of the reference region, which also shows that this is the main economic activity in the region[116][117].

Figure 44 Land Use - Apuí %

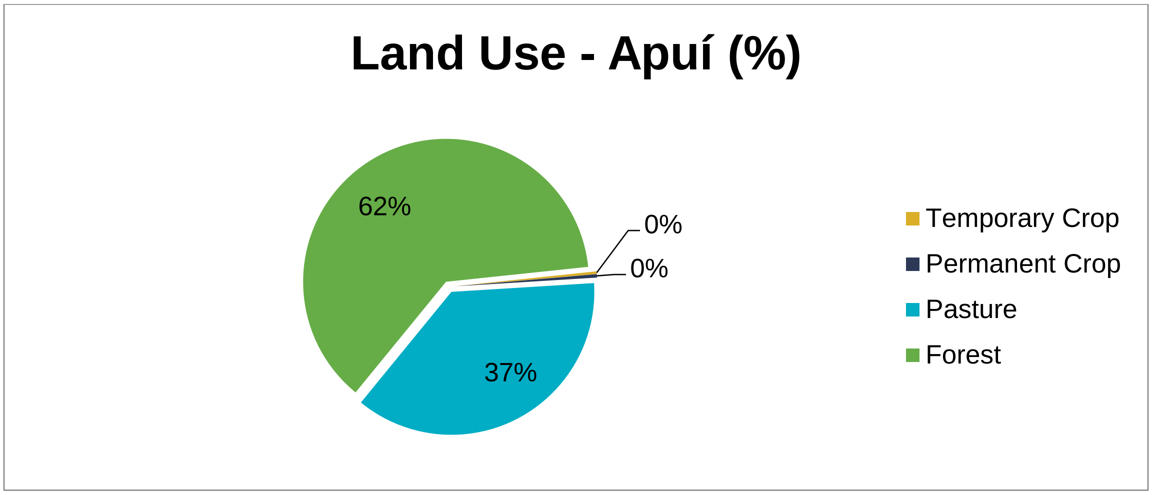
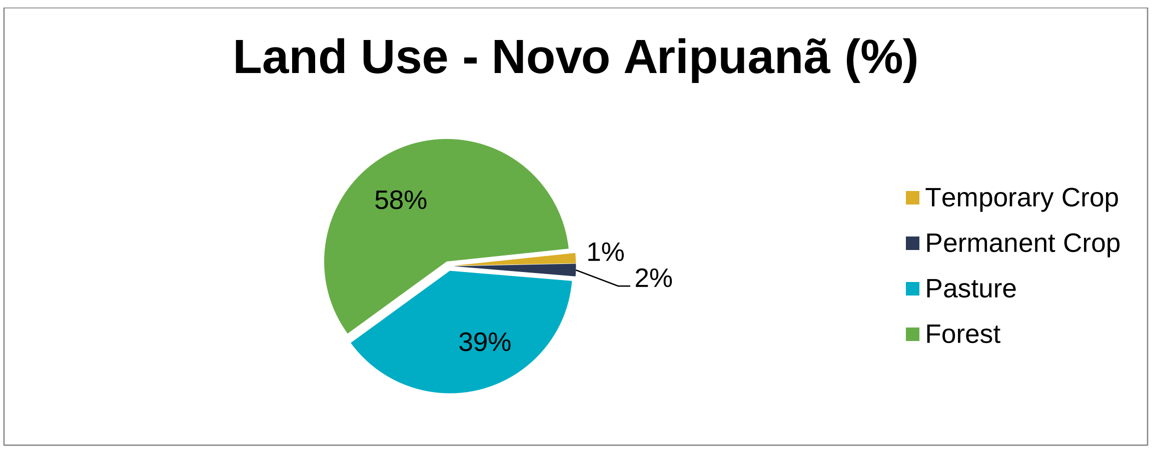


Figure 45 Land Use - Novo Aripuanã %



115 Available in <https://censoagro2017.ibge.gov.br/templates/censo_agro/resultadosagro/estabelecimentos.html?localidade=13>Last visited on 29/12/2020

116 The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

117 Available in < https://cidades.ibge.gov.br/brasil/am/novo-aripuana/pesquisa/24/76693>

Figure 46 Land Use - Colniza %

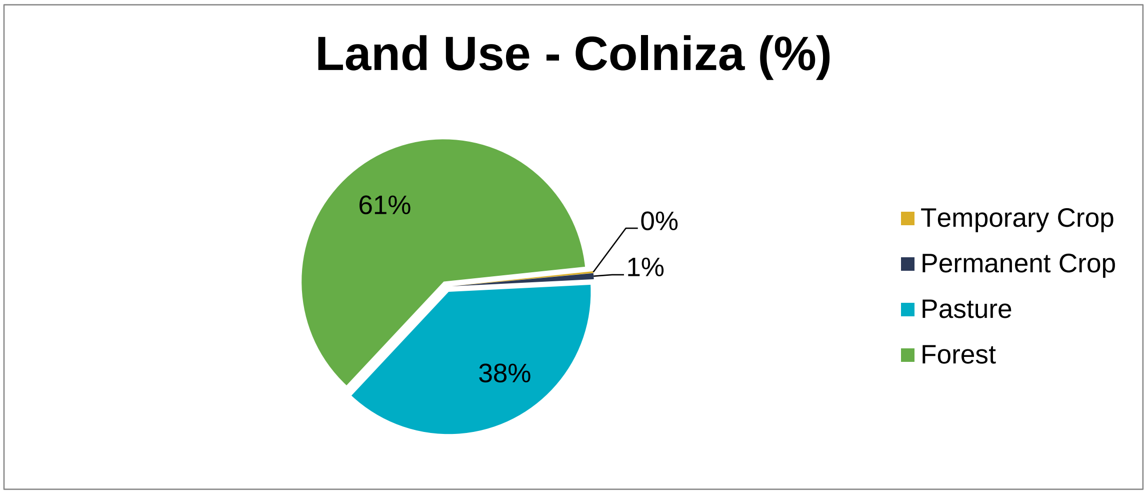
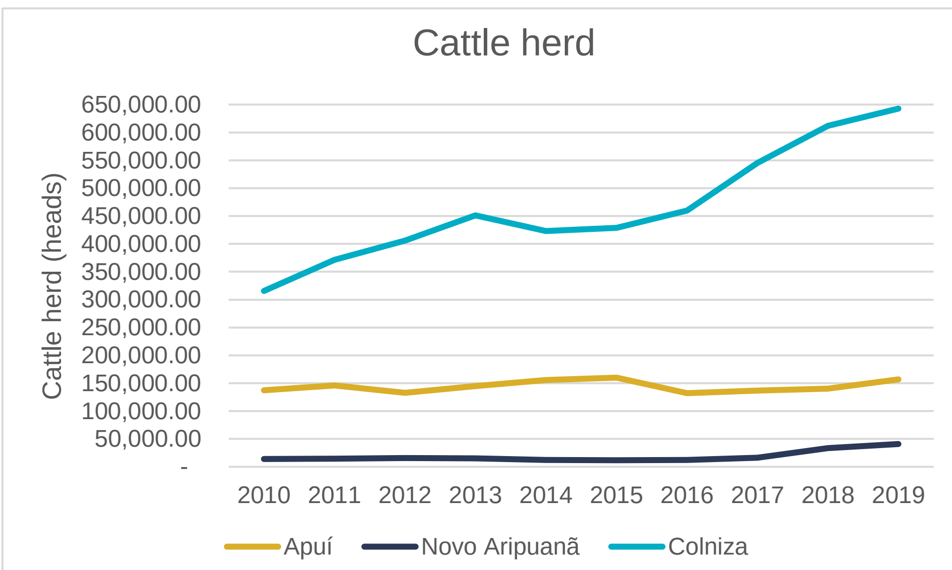


Figure below shows the increase of the cattle herd in the main municipalities composing the reference region across the period 2010 - 2019. It is possible to note that the total number increased around 56% over this period. Considering the stocking rate in the region (1.2 animals/ha), this would mean that cattle ranching alone was responsible for the deforestation of around 300 thousand hectares of Amazon rainforest in the analyzed municipalities. The main municipality responsible for the cattle ranching expansion was Colniza (in the State of Mato Grosso), which is located in the south of the project area.

Figure 47 Annual livestock in the three main municipalities of the reference region, in heads of cattle[118]



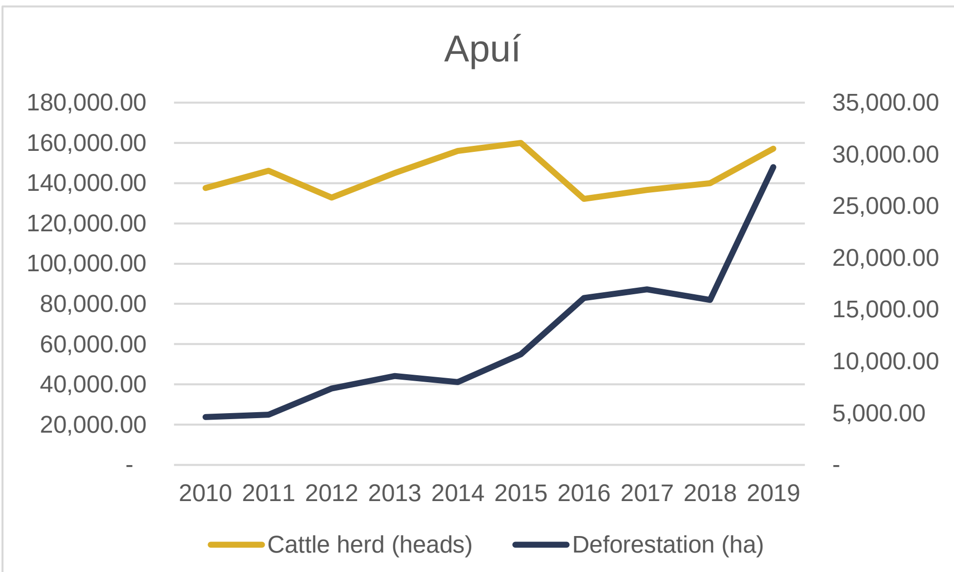
[118] Available in <https://cidades.ibge.gov.br/brasil/am/novo-aripuana/pesquisa/24/76693>

Furthermore, according to the figure above, despite having a considerably smaller herd size than Colniza, the livestock numbers in Novo Aripuanã increased significantly as in the period 2015 to 2018, which was the period in which it can be observed a growth in deforestation, going from 5,319.03 ha deforested in 2015 to 15,243.89 ha in 2016.

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

Graphs below relates deforestation numbers with cattle herd in the region. According to PRODES satellite data[119], it can be noticed that in all municipalities analyzed, the increase in deforestation follows the trend of an increase in the cattle herd.

Figure 48 Deforestation numbers with cattle herd in Apuí



119 Available in < http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/rates>

Figure 49 Deforestation numbers with cattle herd in Novo Aripuanã

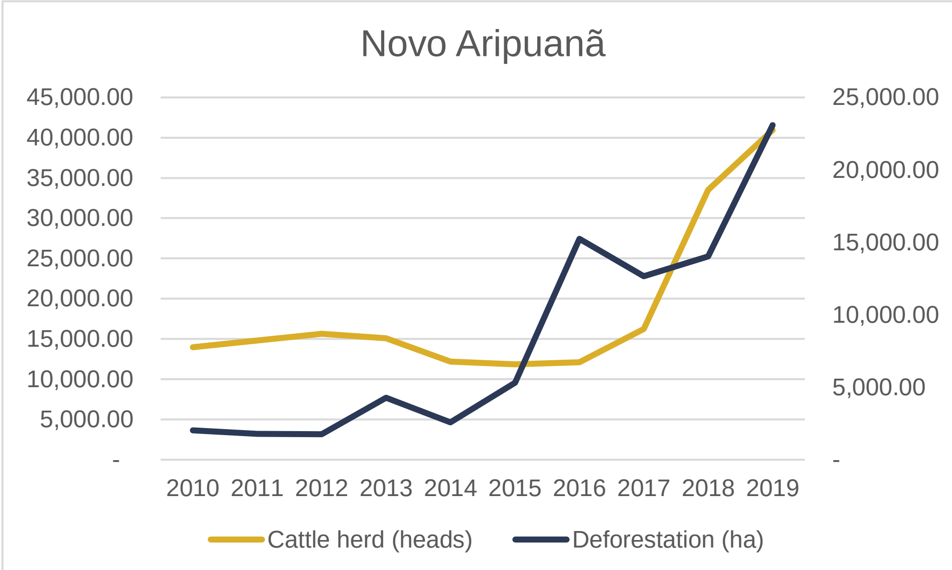
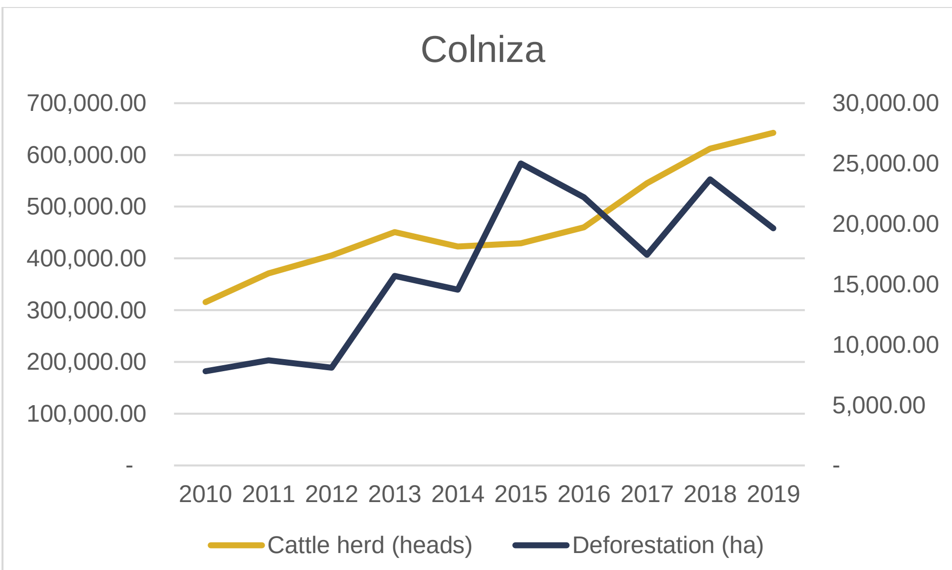


Figure 50 Deforestation numbers with cattle herd in Colniza



The increase in livestock activity can be related to migrants that invested in buying animals in other regions, and credit lines available to buy cattle. As the municipalities are frontiers from one state to another, cattle ranching is preferred due to ease in selling to near states, with cheaper logistics and guarantee of disease-free meat.

The report Relatório de Inteligência Estratégica da Aliança do Apuí[120] concludes that 56% of the total area deforested in 2019, approximately 15 thousand ha, was concentrated in polygons larger than 100 ha, an indication that most of the recent deforestation is attributed to the investment in the formation of

[120] IDESAM, 2019. Available in <https://idesam.org/wp-content/uploads/2019/10/Relat%C3%B3rio-Intelig%C3%AAncia-Estrat%C3%A9gica_Alian%C3%A7a-Apu%C3%AD.pdf>

farms and agricultural expansion by families that arrived in Apuí in the last decade. These families or groups invest in the purchase or possession of the land and formation of pastures with the expectation of future financial returns, either with the productive activity or with the sale of the improvements. Other deforestation seems to be the investment of small and medium-sized landowners (old or recent residents).

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

Some of the factors that characterize and drive deforestation and subsequent cattle ranching are the low cost of the forested area; reasonable soil fertility (provided by the ashes after the burning of the forest); well-structured soil and mainly flat conditions of the area; tradition of farming existing in the municipalities and the meat market of the region[121].

Key driver variables are detailed in section below.

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

1) Population growth

Population is a variable that significantly predict quantity of future deforestation. The local residents are expected to carry out unplanned deforestation, which involves economic activities. As described previously in section 1.10 (socio-economic conditions), the population in the five municipalities of the reference region increased around 70,000 people during the 1991 – 2010 period, which is equivalent to a 221% increase. Although the growth rate appears to be decreasing, the population in the municipalities is still growing at an average rate of 4%/year in the last decade (2000-2010)[122]. Such increase also indicates the human pressure for clearance of forests in the region, demanding new lands for subsistence and income generation.

According to Idesam (2011)[123], the population of Apuí municipality, where the project area is located, more than tripled over the last 15 years. This population growth is tightly correlated with deforestation, and the municipality climbed from tenth to third position in the ranking of Amazonas State's most deforested municipalities between 2000 and 2009. The local population is primarily composed of migrants, crop and livestock farmers, and timber harvesters, the majority of whom come from other regions of Brazil. The lack of economic alternatives then turns this population into the primary deforestation agents in the region.

Therefore, although the population growth rate is expected to decrease in the future, the very high rate identified in the past years leading to the population increase is an important variable affecting the amount of deforestation in the reference region.

121 Available in <http://www.idesam.org.br/publicacao/cadeia-produtiva-corte-amazonas.pdf> Last visited on 29/12/2020

122 The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

123 INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos nº1).

However, an important factor that will probably contribute to the decrease in deforestation in the reference region was the human development index (HDI) improvement. The analysis of the average HDI in the municipalities covering the reference region shows a noteworthy increase of almost 100% in the period 1991 – 2010, mainly in the education of the population. This can be a factor that is contributing to the decrease in the population growth rate in the region[124].

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

As previously described above, the prices of timber logs and arroba (livestock) are the main reason why the cattle herd increased in the period, reaching more than 500 thousand animals in the three main municipalities composing the reference region. In addition, during the same period, the timber logging also increased, being one of the main produced products in the three municipalities.

It is important to note that timber stands out as having the highest values among the total annual production in the project area municipalities[125]. In addition, according to Razera (2005)[126], given the large increase in pastureland property values, creation of new areas for livestock raising has been stimulated and intensified, raising cattle numbers and, consequently, increasing deforestation.

Research developed to determine leakage belt accounted approximately R$1040,00 per animal in the region, on an average of R$80,00 per arroba. Considering data of 2018, that indicated 33,523 animals in Novo Aripuanã and 140,000 in Apuí, the amount of money produced by the activity in the region would surpass 180 million reais per year.

Furthermore, forested property values are almost 6 times cheaper than established pasturelands. Thus, this disparity promotes the purchase of new forested areas, deforestation and further creation of new pasturelands[127].

Thus, partly due to the expansion of globalization, deforestation rates in Amazonia appear to be linked to the growth of the international market, especially of beef[128].

b) **Driver variables explaining the location of deforestation**

1) **Distance from deforested areas**

Forested areas are influenced by their proximity to areas that have already been deforested. The distance from previously deforested areas is one of the major causes of forest degradation in the Amazon biome and their spatio-temporal dynamics are highly influenced by annual deforestation patterns. In addition,

[124] Atlas of Brazil Human Development. Available at: <http://atlasbrasil.org.br>. Last visited on: February 13th, 2015.

[125] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

[126] RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[127] The Brazilian Institute for Geography and Statistics (IBGE): <http://www.ibge.gov.br/home/>.

[128] Fearnside, P. M. 2005. Deforestation in Brazilian Amazonia: history, rates and consequences. **Conservation Biology** 19(3):680-688.

forest fragmentation results from deforestation and disturbance, with subsequent edge effects extending deep into remaining forest areas[129,130].

As described under the “projection of the location of future deforestation” section below, a regression was carried out between currently deforested areas and future deforestation, which yielded a significant result. This was used in the step projection of location of future deforestation, which carried out the projection used for calculation of GHG reductions. The probability of “non-forest” at time t+1 depends upon the arrangement of cells of “forest” and “non-forest” at time t. Thus, the presence of “non-forest” is a driver variable predicting quantity and location of future deforestation.

2) Roads, highways, access roads and navigable rivers

Access roads are means of communication, which influence the spatial distribution of land-uses. Access roads have an influence on fragmentation, population densities, agriculture and pastureland. The possible creation of new access roads, added to the already plentiful rivers in the region, increases anthropogenic pressure and, consequently, the intensity of deforestation[131,132,133].

As previously mentioned, Novo Aripuanã, Apuí and Colniza are frontiers municipalites, close to the States of Rondônia, Mato Grosso and Pará, in addition to other cities in Amazonas. This condition makes the land in these regions extremely attractive to agricultural and livestock activities, due to easy transportation and access to other regions.

In 2020, Apuí municipality was among the 10 municipalities with higher deforestation in the Legal Amazon from February to June, and in 2019, was the seventh municipality[134]. This fact may be explained by proximity to the federal highway BR-230, called Rodovia Transamazônica. Located at south of the highway, Apuí is front of livestock expansion in the Amazon.

According to official information, this highway is the third largest Brazilian highway, with 4.223 km of extension, and crossing 7 States: Paraíba, Ceará, Piauí, Maranhão, Tocantins, Pará and Amazonas. It was constructed in the 70’s to promote settlements along the road and connection with the rest of the country.

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

[130] IMAZON. Carbon emissions from deforestation and forest fragmentation in the Brazilian Amazon. 2011. Available at: <http://imazon.org.br/publicacoes/carbon-emissions-from-deforestation-and-forest-fragmentation-in-the-brazilian-amazon/?lang=en>. Last visit on: February 12th, 2015.

[131] HAWBAKER, T.J.; RADELOFF, V.C.; HAMMER, R.B.; CLAYTON, M.K. Road density and landscape pattern in relation to housing density, land ownership, land cover, and soils. Landscape Ecology, v.20, p.609-625, 2004.

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

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

[134] Available in <https://idesam.org/wp-content/uploads/2020/10/Boletim_05_Dezembro2020.pdf>

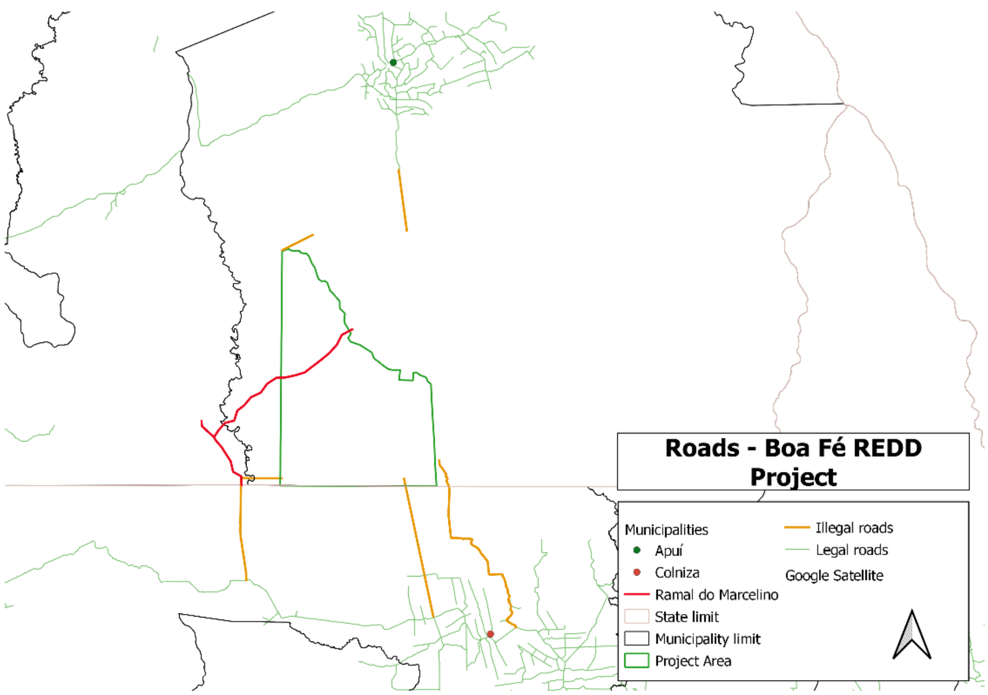
The main objective was to transform the Amazon into a region that supplied primary products to the domestic and foreign markets and to increase livestock, due to the high prices of meat in the 1970's market and the beginning of the development of the activity in the region[135].

In addition, a very important factor is the presence of illegal roads which promote deforestation of forests that are not connected to official highways. These roads facilitate access by illegal loggers and legal forestry activities, which stand out as the primary deforestation vectors.

It can be observed that the reference region shows deforested areas far from urban centers, where there are no governmental organs present. Thus, deforestation has expanded to remote areas, via roads that provide access to forests. This is one of the principal reasons that the southern Amazonas region can be considered a new frontier of deforestation expansion[136].

Regarding the influence of access roads, both already existing and unofficial roads were taken into account: one to the North, leaving from the municipal center of Apuí, and three to the South. Access from the North has grown over recent years, with new areas being created to the south of the municipality and serving for offtake of limestone extracted from the Jatuarana State Forest Reserve. Further, to the south of the reference region, an access road is present, branching off from the Mato Grosso State highway and continuing to the north of Apuí Municipality. These access roads are expanding and very frequently used during dry periods in the region, as they are not concrete paved which impedes transport in the wet season.

Figure 51 Access roads in the region



135 Available in < https://epg.unifesspa.edu.br/images/Artigos/NilzaLimaMarinho.pdf> Last visited on 29/12/2020

136 INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos n°1).

The future deforestation dynamics are expected to be affected by the planned expansion of the Ramal do Marcelino road, that is predicted to connect the road located southwest of the property to the south of Apuí cutting through the project area from west to east. This road will represent an important connection from Colniza to Apuí, a main livestock and timber route, and the construction is already authorized by the municipality of Novo Aripuanã. As shown in figure above, this extension will probably connect to the illegal road *Vicinal da Coruja,* located in south of Apuí. The south roads also lead to State highway MT-206, connecting Amazonas and Mato Grosso States.

It is important to note that the increase in economic development that comes with the construction of roads, for example in terms of power lines and increased access, will probably result in higher population pressure and deforestation rates in the project area. Studies carried during the first decade of the 21st Century indicate that over 2/3 of deforestation events in the Amazon took place within 50km of paved roads (Nepstad et al., 2000[137]).

The presence of navigable rivers can also be considered a driver for deforestation, facilitating transport of harvests and production, even more so in areas without road access. However, in the reference region under study, a large proportion of the rivers are non-navigable given the presence of many waterfalls and rocks. For this reason, only main rivers were taken into account, and these were considered to have an influence on deforestation.

3) Presence of protected areas

The reference region is surrounded by several Conservation Units, with the project area partially inserted within one. The closest units are listed below:

- PARQUE NACIONAL DOS CAMPOS AMAZÔNICOS
- FLORESTA ESTADUAL MANICORÉ
- PARQUE ESTADUAL GUARIBA
- RESERVA EXTRATIVISTA DO GUARIBA
- FLORESTA ESTADUAL ARIPUANÃ
- RESERVA DE DESENVOLVIMENTO SUSTENTÁVEL ARIPUANÃ
- FLORESTA ESTADUAL SUCUNDURI
- PARQUE ESTADUAL SUCUNDURI
- FLORESTA NACIONAL DE JATUARANA
- FLORESTA NACIONAL DO ARIPUANÃ
- RESERVA EXTRATIVISTA GUARIBA-ROOSEVELT
- PARQUE ESTADUAL IGARAPÉS DO JURUENA

In addition, the southern part of the project area borders the Kawahiva indigenous land of Rio Pardo, with an isolated and nomadic indigenous community, occupying the entire demarcated territory.

[137] NEPSTAD, D.; CAPOBIANCO, J.P.; BARROS, A.C.; CARVALHO, G.; MOUTINHO, P.; LOPES, U.; LEFEBVRE, P. Avança Brasil: os custos ambientais para a Amazônia. Belém: Editora Alves, 24 p. 2000.

Therefore, the presence of protected areas in the surroundings of the project area would in theory decrease the likelihood of deforestation, affecting the location of future deforestation.

However, between 2012 and 2015, 237.3 thousand hectares were deforested within Conservation Units (UCs) in the Amazon. In that period, the occupants may have obtained a gross income of R $ 300 million from the sale of timber illegally harvested from the PAs, which created an enormous investment potential in deforestation, with logging being the main agent of deforestation[138]. Deforestation has increased within some protected areas and the percentage share of deforestation in conservation units in the total deforested in the Legal Amazon doubled from 6% to 12% between 2008 and 2015. In 2015, deforestation within conservation units was 79% higher than in 2012. In the last 4 years, the area of devastated forest in conservation units in the Legal Amazon rose 80%, against 35% of deforestation in general.

In more recent years, between 2018 and 2019, deforestation at the units grew 35% between August 2018 and July 2019 (going from 767 km² to 1,035 km²). The growth rate of deforestation in these units was higher than that recorded in the entire Amazon biome (29.5%)[139].

The political scenario is intrinsically related to the upward trend. 2020 was the second worst year for Indigenous Lands and Conservation Units since 2008. The 188 thousand hectares of forests destroyed in these territories are second only to the almost 200 thousand hectares registered in 2019. In addition, they represent 90% more than the average between 2009 and 2018[140].

In addition, the current government has an anti-environmental policy, decreeing cuts in the inspection bodies and increasingly discouraging the conservation of protected areas, including reducing conservation goals, where the proposal of the Ministry of the Environment would be to disregard the objective of reducing the deforestation and illegal fires by 90% in the country, as provided in the government's Pluriannual Plan (PPA) until 2023. The guarantee of preservation would be restricted only to a specific area of 390 thousand hectares of native vegetation[141]. More information about the political scenario in Brazil and its environmental impacts is detailed in the section below.

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

Identification of underlying causes of deforestation

In addition, there are underlying causes that also promote deforestation in the region. Due to being located at the frontiers of the arc of deforestation and displaying a large amount of unoccupied lands, the reference region has a considerable social conflict issues, primarily land conflict. Land is occasionally illegally

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

[139] Available in < https://www.oeco.org.br/reportagens/desmatamento-em-unidades-de-conservacao-atinge-maior-indice-dos-ultimos-10-anos/>

[140] Available in < https://www.socioambiental.org/pt-br/noticias-socioambientais/destruicao-de-areas-protegidas-na-amazonia-explode-com-bolsonaro>

[141] Available in < https://www12.senado.leg.br/noticias/materias/2020/08/04/politica-ambiental-do-governo-prejudica-o-brasil-avaliam-senadores>

occupied by squatters and illegal loggers[142]. Thus, the main underlying causes of deforestation within the reference region are associated with land conflicts (tenure issues), and the lack of public policies promoting sustainable alternatives to combat deforestation and degradation activities.

According to Razera (2005)[143], the absence of economic alternatives has created the conditions for livestock farming to establish itself as the primary land occupation activities in deforested areas in Amazonia, being primarily concentrated in the arc of deforestation, where preferably there is some means of access to the rest of the country.

The continued lack of resolution of land tenure issues contributes to reducing legal production options and continues to promote the expansion of deforestation associated with cattle farming and land speculation in southern Amazonas. According to studies conducted in the region by Idesam, there is a pressing need for restructuring at a local level, which is lacking investment in infrastructure, equipment, and human resources to attend to strong land-tenure demand. The low presence of Governance and lack of land-tenure documentation, with thousands of rural producers owning non-documented properties, promotes a scenario of forest destruction for exploration of natural resources and creation of pastureland, driving the tendency for the frontier to grow[144].

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

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

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

In the beginning of 2019, the fusion of Environment and Agriculture Ministries was a clear attempt to obtain more rights for the expansion of agriculture and livestock. The decision was canceled a few days later, after pressure from environmentalists and others in the sector; however, major changes occurred

[142] SECRETARIA DO ESTADO DO MEIO AMBIENTE E DESENVOLVIMENTO SUSTENTÁVEL (SDS). Unidades de Conservação do Estado do Amazonas. Manaus, 2007.

[143] RAZERA, Allan. **Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: uma análise da pecuária de corte no município do Apuí.** 2005. 109 f. Thesis (Master grade) - Curso de Biologia, Universidade Federal do Amazonas - UFAM, Amazônia, 2005.

[144] INSTITUTO DE CONSERVAÇÃO E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS (IDESAM). Reduções de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para a Região Sul do Amazonas. Manaus: Idesam, 2011. 45 p. (Relatórios Técnicos n°1).

in the ministerial office, limiting the reach and autonomy of the Environmental Ministry, with the absence of mention to combat of deforestation in the office's functions being highlighted by specialists[145].

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

The deforestation in the Amazon Rainforest was widely reported in 2019, as it was the third largest in history, with an increase of 29.5% in comparison to 2018. In total, 9,762 km^2 of the forest were deforested during the year. In August, during the peak of fire warnings in the forest, fact that caused climate effects in São Paulo, 2,790 km away from the Amazon[146], the government tried to deviate attention from the fires, claiming they were fake news[147]. The number of wildfires in Brazilian forests increased 70% in 2019, the highest rate in 7 years. According to National Spatial Research Institute (INPE), the most affected biome was the Amazon, with 51.9%.

Also, during August, Germany and Norway announced the suspension of transfers to Amazon Programs after affirming that the Brazilian Government was not playing its part in fighting deforestation. The contribution to protecting the rainforest amounted to more than 133 million, destined to the Amazon Fund[148].

Even though fire alerts increased in the period between 2019 and 2020, the Brazilian Government reduced the budget for forest fire prevention and control personnel. A reduction of 58% reached the brigade teams, with budget ranging from 23.78 million reais in 2019 to 9.99 million in 2020[149].

In June 2020, investment funds that manage approximately 4 trillion American dollars in assets asked Brazilian government to suspend the deforestation in the Amazon Rainforest. In an open letter, they

[145] Available in < https://www.socioambiental.org/pt-br/blog/blog-do-isa/a-anatomia-do-desmonte-das-politicas-socioambientais > Last visited on 29/12/2020

[146] Available in <https://www.economist.com/the-americas/2019/08/22/forest-fires-in-the-amazon-blacken-the-sun-in-sao-paulo> Last visited on 29/12/2020

[147] Available in <https://www.theguardian.com/environment/2019/sep/09/amazon-fires-brazil-rainforest> Last visited on 29/12/2020

[148] Available in <https://brasil.elpais.com/brasil/2019/08/15/politica/1565898219_277747.html> Last visited on 29/12/2020

[149] Avaliable in < https://g1.globo.com/natureza/noticia/2020/09/12/em-um-ano-governo-bolsonaro-corta-verba-para-brigadistas-em-58.ghtml> Last visited on 29/12/2020

warned of the systematic, reputational, operation and regulatory risks of clients and projects in Brazil, in addition to the survival of the forest[150].

Government agencies such as INPE and IBAMA, responsible for deforestation monitoring have suffered funding cutoffs, dismissals and had their functions and increasing deforestation data publicly questioned and denied by the government[151].

The quantity of national parks and conservation units in the country's forests was already questioned by the government, that intended to extinguish those by decree[152], an unconstitutional action, after announcing the intention to review the conservation units' law (SNUC) and the existing units[153]. In addition, the Minister of the Environment speaks publicly, in a video released during investigations, of his intention to take advantage of the Covid-19 pandemic to approve several controversial changes to environmental protection and avoid critics and Justice processes.

There are also several threats to the national environmental license process, which has existed since 1981, including from the Minister of the Economy, who wants to loosen the process to favor mining companies, even with the several recent cases of environmental crimes of breaches of poorly executed and maintained mining dams from companies in the country[154].

Specialists affirm that, with the current pace of dismantling of the inspection structure and environmental legislation demonstrated since the first 6 months of the current government, the forest destruction can reach an irreversible limit in 4 to 8 years. Recent scientific research show that if an area of 40% of the original forest gets deforested, the rest cannot sustain the functioning of the tropical rainforest, and in this scenario, part of the forest may not be able to sustain itself. The Amazon has so far lost approximately 20% of its original coverage[155].

The development of REDD projects and a new culture of sustainable management and production, in addition to the profit from carbon credit sales, to encourage the maintenance of standing forest, goes against the non-environmental policy currently adopted by the country. Despite having, since 2015 the National Commission for REDD+, established by decreet, which is responsible for coordinate and monitor the implementation of the National REDD+ Strategy in Brazil, it can be noticed that the main effort comes

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[150] Available in <https://noticias.uol.com.br/ultimas-noticias/rfi/2020/06/23/fundos-de-investimentos-estrangeiros-cobram-de-bolsonaro-fim-do-desmatamento-da-amazonia.htm?cmpid=copiaecola> Last visited on 29/12/2020

[151] Available in < https://g1.globo.com/natureza/noticia/2019/08/02/cronologia-reacao-do-governo-ao-uso-de-dados-sobre-desmatamento-leva-a-exoneracao-de-diretor-do-inpe.ghtml> Last visited on 29/12/2020

[152] Available in <http://www.ihu.unisinos.br/78-noticias/589958-em-live-bolsonaro-reclama-que-nao-consegue-extinguir-parques-por-decreto> Last visited on 29/12/2020

[153] Available in <https://www.oeco.org.br/noticias/ricardo-salles-quer-rever-todas-as-unidades-de-conservacao-federais-do-pais-e-mudar-snuc/.> Last visited on 29/12/2020

[154] Available in <https://brasil.elpais.com/brasil/2019/01/27/opinion/1548547908_087976.html> Last visited on 29/12/2020

[155] Available in <https://www.bbc.com/portuguese/brasil-48805675> Last visited on 29/12/2020

from landowners and project developers, since there is no guideline or effective planning from the government to amplify the development of new projects.

The future trend of these underlying causes of deforestation will tend to remain as verified in the past years, as Brazilian government policies and recent changes in Brazilian environment laws still prioritize large agricultural and ranching companies[156]. This is a gap that needs to be addressed by projects seeking to develop alternative sources of income as well as ongoing training, being from private companies, NGOs, or donors.

Analysis of chain of events leading to deforestation

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

Most of the deforestation occurred in the Amazon region is related to the implementation of infrastructure projects, population increase and agricultural and cattle ranching activities, mainly in the region known as the "Brazilian arc of deforestation", where the present project is located. The historical deforestation occurred during the last 10 years within the reference region followed this same pattern. Additionally, several other subjacent causes related to political, economic and social issues lead to an increased pressure over the region.

Currently, global demand for agricultural commodities has increased the opportunity cost of conserving areas of standing forests in the Amazon biome. Specifically, in the project's region, timber companies are considered to be the pioneers in colonizing previously inaccessible areas, entering via the means of illegal roads to harvest forests through selection of commercial species. Afterwards, those degraded lands are occupied by property speculators and finally, cattle ranchers.

Those two land-use changes (timber harvesting and cattle ranching) are the main deforestation agents in the region, being possible to relate the deforestation curve to the increase in livestock and wood production in the region, all of which are growing. The profit from both products is also considerably higher than the production of other common products in the region, such as a*çaí* and *copaiba* oil.

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

The project area has no production activity, which makes the area vulnerable to invasions and illegal deforestation, even more since it is partially inside a conservation unit. The increase of deforestation in protected areas of the country is aggravating the risks of the area, that is surrounded by conservation units. This risk increases when it is considered that the authorized expansion of a road intends to cross

[156] MOUTINHO, P. et al. REDD no Brasil: um enfoque amazônico: fundamentos, critérios e estruturas institucionais para um regime nacional de Redução de Emissões por Desmatamento e Degradação Florestal – REDD. Brasília, DF: Instituto de Pesquisa Ambiental da Amazônia, 2011.

the project area, becoming a road that allows access to several protected areas that until then were of difficult to access and preserved.

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

Conclusion

The conduction of the Step 3 and available evidence allows to analyze that the most likely future deforestation trend within the reference region and project area is conclusive.

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

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

Projection of Future Deforestation

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

Selection of Baseline Approach

As described in sections above, the deforestation rates measured in different historical sub-periods in the reference region reveal a clear trend, and this trend is an increase of the deforestation rate. The analysis of presented evidence related to deforestation agents and drivers, in addition to underlying causes, allows to conclude that the deforestation rate is increasing, and it is likely that this trend will continue in the future.

Thus, the selected baseline approach is the Time function approach. With this approach, the rate of baseline deforestation is estimated by extrapolating the historical trend observed within the reference region (or its strata) as a function of time using either linear regression, logistic regression or any other statistically sound regression technique. It requires multiple deforestation measurements during the past 10-15 years.

Quantitative projection of future deforestation

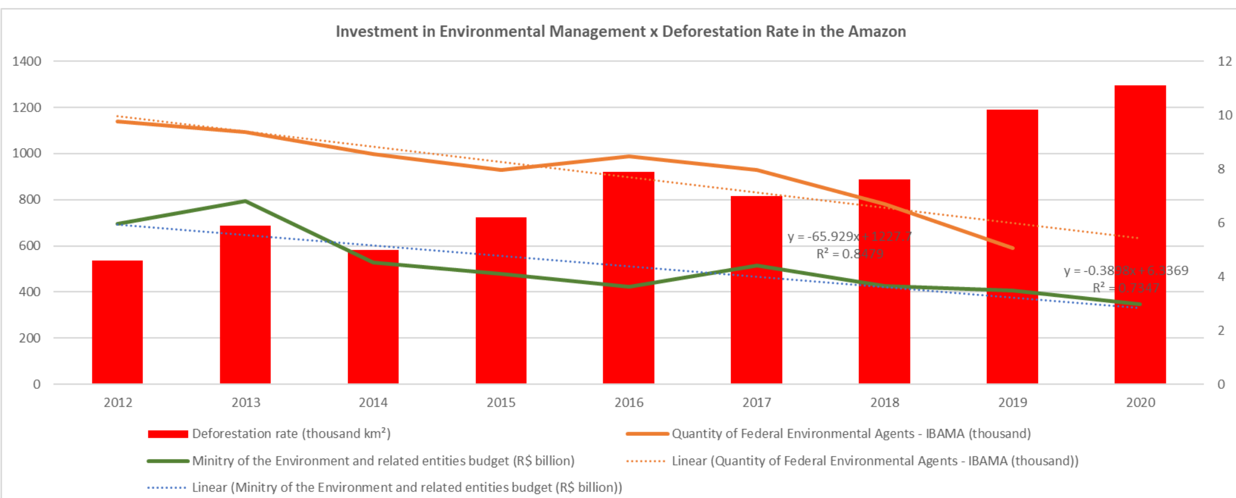
For the deforestation baseline, a simple linear regression model was used from 2009 to 2019 (around 12,685.76 ha/year in the reference region). As previously described, there was an increase in the deforestation rate between 2009 and 2019 ($R^2 = 0.6$ and $p = 0.0055$). The equation that describes this increase is:

$$y = -0.7275706 + 0.0003635 * t$$

For each year, there is an increase of 0.0003635 in the deforestation rate. This pattern makes the linear model the most appropriate for future projections.

In addition, due to external issues that will influence the rate of deforestation after 2020, described in the subsection chain events leading to deforestation and better detailed below, the deforestation rate was increased in 38.77%.

This value was obtained utilizing two variables that have a major influence in Brazilian deforestation rates: decrease of the Brazilian Environmental Ministry budget for conducting deforestation control programs; and decrease in the quantity of federal environmental agents from IBAMA[157]. The analysis below shows the correlation between these variables with the deforestation rates in the Amazon biome between 2012-2020. The year of 2012 was chosen as the first year in this analysis due to the new Brazilian Forest Code, which was established in 2012, and changed several regulations and requirements regarding forest protection in rural properties.



A strong correlation between the two analyzed variables with deforestation rates could be noted (-0.74 and -0.87, respectively), which is shown below.

[157] Brazilian Institute of Environment and Renewable Natural Resources. Available at: <https://www.ibama.gov.br/index.php>.

CORRELATION ANALYSIS	*Deforestation rate (thousand km²)*
Minitry of the Environment and related entities budget (R$ billion)	-0.74
Quantity of Federal Environmental Agents - IBAMA (thousand)	-0.87

Based on the proposed measures by the Federal Government for the next years on the environmental sector, which include the extinction of ICMBio – the federal agency responsible for the management of protected areas in Brazil[158,159], and a greater reduction in the Brazilian Environmental Ministry budget[160,161,162], the expected increase in future deforestation was calculated based on the correlation with the variables described above.

Considering that these two figures (Brazilian Environmental Ministry budget and quantity of federal agents) would continue to decrease in a linear regression according to the historical trendline since 2012, the expected reduction of each variable in 2025 (i.e., half of the first baseline period) compared to the average between the 2012-2020 period would reach 71% and 60% respectively. After that, these values were multiplied by the respective correlation with deforestation (described in table above), and then the average between them was calculated, reaching a value of 53%. This value was finally multiplied by a conservative factor, calculated as the average R^2 obtained in the graphic above (73.62%), reaching a final value of 38.77%. This means that, based on the reductions and setbacks proposed for the environmental sector in Brazil as from 2020, deforestation is expected to increase around 38.77% by 2025 compared to the 2012-2020 rates.

Projection of the annual areas of baseline deforestation in the reference region, leakage belt and project area:

Based on the selection of baseline approach, using the linear model, tables below show the results of the projection in reference region, leakage belt and Project area.

158 Available at: <https://www.oeco.org.br/noticias/extincao-do-icmbio-ja-estava-sendo-planejada-ha-dois-anos/>. Last visited on March 21st, 2021.

159 Available at: <https://www.redebrasilatual.com.br/ambiente/2021/02/militares-junho-relatorio-extincao-icmbio/>. Last visited on March 21st, 2021.

160 Available at: <https://www.bbc.com/portuguese/brasil-53384399>. Last visited on March 21st, 2021.

161 Available at: <https://climainfo.org.br/2020/09/02/orcamento-de-2021-para-meio-ambiente-tera-corte-de-r-184-milhoes/>. Last visited on March 21st, 2021.

162 Available at: <https://noticias.uol.com.br/meio-ambiente/ultimas-noticias/redacao/2021/01/22/orcamento-do-meio-ambiente-e-o-menor-em-21-anos-diz-observatorio-do-clima.htm>. Last visited on March 21st, 2021.

Table 20 Annual areas of baseline deforestation in the reference region

Project year t	Stratum i in the reference region (ha)						Total (ha)	
	$ABSLRR_1$ Dense Alluvial Tropical Rainforest	$ABSLRR_2$ Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest	$ABSLRR_4$ Dense Lowland Tropical Rainforest	$ABSLRR_5$ Savannah Forest	ABSLRR 6 Pioneer vegetation in areas with riverine influence	annual $ABSLRR_t$	cumulative ABSLRR
2020	266.85	7,029.51	16,976.71	232.68	103.00	13.01	24,621.76	24,621.76
2021	217.11	8,119.60	17,098.55	186.14	100.54	18.96	25,740.90	50,362.66
2022	210.96	8,893.71	17,415.85	178.39	113.30	11.64	26,823.85	77,186.51
2023	212.57	9,767.35	17,580.76	187.89	104.47	16.36	27,869.40	105,055.91
2024	222.10	10,360.34	17,967.40	189.98	111.57	24.67	28,876.06	133,931.97
2025	307.88	10,995.68	18,179.13	238.10	103.81	18.23	29,842.83	163,774.80
2026	303.65	11,669.37	18,379.48	276.72	96.80	42.72	30,768.74	194,543.54
2027	324.09	12,350.59	18,554.11	309.20	84.57	30.26	31,652.82	226,196.36
2028	365.18	13,045.62	18,610.70	342.95	91.40	38.39	32,494.24	258,690.60
2029	397.97	13,673.75	18,736.55	337.40	87.98	58.53	33,292.18	291,982.78
2030	419.89	14,382.15	18,784.44	351.42	54.65	53.53	34,046.08	326,028.86
2031	504.22	15,125.62	18,609.99	396.85	60.62	58.03	34,755.33	360,784.19
2032	535.28	16,048.08	18,342.91	397.84	47.07	48.04	35,419.22	396,203.41
2033	566.10	16,710.24	18,225.87	423.64	61.23	50.71	36,037.79	432,241.20
2034	636.01	17,433.65	18,014.25	420.32	52.58	53.84	36,610.65	468,851.85
2035	700.67	18,200.96	17,747.48	395.02	46.23	47.23	37,137.59	505,989.44
2036	694.98	18,923.08	17,499.04	397.70	52.89	50.69	37,618.38	543,607.82
2037	804.40	19,644.34	17,114.52	381.29	59.20	49.61	38,053.36	581,661.18
2038	810.98	20,523.80	16,661.01	356.82	48.88	40.84	38,442.33	620,103.51
2039	827.26	21,157.46	16,360.39	353.86	45.11	41.52	38,785.60	658,889.11
2040	793.21	21,766.34	16,116.70	301.51	50.00	55.80	39,083.56	697,972.67
2041	813.94	22,301.47	15,807.37	312.20	56.15	45.45	39,336.58	737,309.25
2042	774.61	23,059.17	15,261.06	310.63	75.09	64.37	39,544.93	776,854.18
2043	779.22	23,558.70	14,892.70	363.46	72.22	43.03	39,709.33	816,563.51
2044	779.59	23,951.28	14,648.04	340.74	57.81	52.96	39,830.42	856,393.93
2045	807.74	24,543.20	14,008.74	422.52	89.54	36.95	39,908.69	896,302.62
2046	754.98	24,825.99	13,769.26	489.65	77.30	27.96	39,945.14	936,247.76
2047	803.93	25,268.53	13,165.23	586.61	81.23	34.94	39,940.47	976,188.23
2048	796.84	25,551.38	12,768.97	649.34	92.76	36.37	39,895.66	1,016,083.89
2049	771.04	25,867.86	12,303.76	738.99	102.95	26.90	39,811.50	1,055,895.39
2050	718.88	25,908.72	12,116.38	822.23	98.67	24.30	39,689.18	1,095,584.57

Table 21 Annual areas of baseline deforestation in the project area

Project year t	Stratum i in the project area (ha)			Total (ha)	
	$ABSLPA_1$ Dense Alluvial Tropical Rainforest	$ABSLPA_2$ Dense Submontane Tropical Rainforest	$ABSLPA_3$ Open Submontane Tropical Rainforest	annual $ABSLPA_t$	cumulative ABSLPA
2020	0.00	38.58	19.28	57.86	57.86
2021	0.00	120.97	26.47	147.44	205.30
2022	0.00	169.96	67.21	237.17	442.47
2023	0.00	222.13	122.09	344.22	786.69
2024	0.00	283.13	167.97	451.10	1,237.79
2025	0.00	317.78	196.75	514.53	1,752.32
2026	0.00	345.22	245.12	590.34	2,342.66
2027	0.00	404.86	288.77	693.63	3,036.29
2028	0.00	506.67	321.35	828.02	3,864.31
2029	0.00	591.17	365.64	956.81	4,821.12
2030	0.00	716.75	444.41	1,161.16	5,982.28
2031	2.46	964.21	507.46	1,474.13	7,456.41
2032	20.06	1,155.30	583.06	1,758.42	9,214.83
2033	55.04	1,390.56	645.58	2,091.18	11,306.01
2034	78.59	1,586.05	759.20	2,423.84	13,729.85
2035	89.90	1,830.49	773.98	2,694.37	16,424.22
2036	117.69	2,023.09	821.17	2,961.95	19,386.17
2037	157.69	2,370.72	869.16	3,397.57	22,783.74
2038	157.59	2,858.90	845.66	3,862.15	26,645.89
2039	166.47	3,677.86	899.60	4,743.93	31,389.82
2040	159.05	4,122.46	1,026.42	5,307.93	36,697.75
2041	173.88	4,570.18	1,078.32	5,822.38	42,520.13
2042	164.27	4,818.58	1,097.45	6,080.30	48,600.43
2043	179.25	5,243.12	1,035.54	6,457.91	55,058.34
2044	164.65	5,392.31	1,054.27	6,611.23	61,669.57
2045	157.85	5,644.53	1,039.44	6,841.82	68,511.39
2046	154.86	5,802.83	1,016.02	6,973.71	75,485.10
2047	211.11	6,023.08	1,111.66	7,345.85	82,830.95
2048	215.61	6,266.17	1,024.80	7,506.58	90,337.53
2049	185.64	6,381.75	1,015.34	7,582.73	97,920.26
2050	193.18	6,327.19	1,100.32	7,620.69	105,540.95

Table 22 Annual areas of baseline deforestation in the leakage belt

Project year t	Stratum i in the leakage belt (ha)			Total (ha)	
	$ABSLLK_1$ Dense Alluvial Tropical Rainforest	$ABSLLK_2$ Dense Submontane Tropical Rainforest	$ABSLLK_3$ Open Submontane Tropical Rainforest	annual $ABSLLK_t$	cumulative ABSLLK
2020	0.08	92.39	0.06	92.53	92.53
2021	0.00	177.48	0.27	177.75	270.28
2022	0.00	218.70	0.14	218.84	489.12
2023	0.59	312.67	0.00	313.26	802.38
2024	1.56	310.43	0.04	312.03	1,114.41
2025	3.51	380.32	0.00	383.83	1,498.24
2026	9.73	375.13	0.25	385.11	1,883.35
2027	17.08	402.12	0.51	419.71	2,303.06
2028	12.36	514.55	2.49	529.40	2,832.46
2029	33.03	604.69	3.04	640.76	3,473.22
2030	37.56	778.63	12.13	828.32	4,301.54
2031	85.09	964.71	21.97	1,071.77	5,373.31
2032	104.81	1,104.93	30.20	1,239.94	6,613.25
2033	128.19	1,349.04	38.65	1,515.88	8,129.13
2034	146.12	1,522.69	75.22	1,744.03	9,873.16
2035	170.27	1,735.54	137.68	2,043.49	11,916.65
2036	164.35	1,972.48	217.60	2,354.43	14,271.08
2037	157.01	1,965.26	280.21	2,402.48	16,673.56
2038	173.83	2,072.77	306.02	2,552.62	19,226.18
2039	185.38	2,067.50	372.80	2,625.68	21,851.86
2040	153.89	2,183.21	453.33	2,790.43	24,642.29
2041	162.52	2,122.69	511.35	2,796.56	27,438.85
2042	145.59	2,129.19	605.20	2,879.98	30,318.83
2043	138.78	2,152.44	688.03	2,979.25	33,298.08
2044	143.50	2,252.04	824.04	3,219.58	36,517.66
2045	104.41	2,325.92	889.22	3,319.55	39,837.21
2046	107.29	2,299.88	952.46	3,359.63	43,196.84
2047	154.92	2,398.91	964.82	3,518.65	46,715.49
2048	145.27	2,536.20	985.06	3,666.53	50,382.02
2049	166.71	2,535.64	999.35	3,701.70	54,083.72
2050	142.52	2,566.81	1,041.32	3,750.65	57,834.37

- Projection of the location of future deforestation

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

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

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

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

(iv) Development of scenarios, which is the creation of future scenarios using historical trends (2009 to 2019) through the Business-as-usual scenario.

Assigning weights to change agents

The predictive variables considered to have the potential to influence the risk of deforestation in the region are the proximity to roads, proximity to cities, slope, altitude, presence of settlements, presence of fully protected and sustainable use protection areas, presence of indigenous lands, proximity to small rivers and the proximity to large rivers.

Regarding the proximity factor of roads, in addition to the official roads of the IBGE database, the most recent Imazon mappings were used, which contains the new roads that are being opened in the region, roads visibly opened by satellite images and information obtained in field (Figure 56).

In addition, for future projection, the construction project of the Ramal Marcelino extension was considered, for the disposal of wood. This project already has the economic and environmental feasibility certificate issued by SEMA in Novo Aripuanã, the municipal authorization and the licensing at IPAAM. For this reason, the extension of the branch was considered an important vector of future deforestation within the project area (Figure 52).

Figure 52 Access roads in the reference region by Landsat images

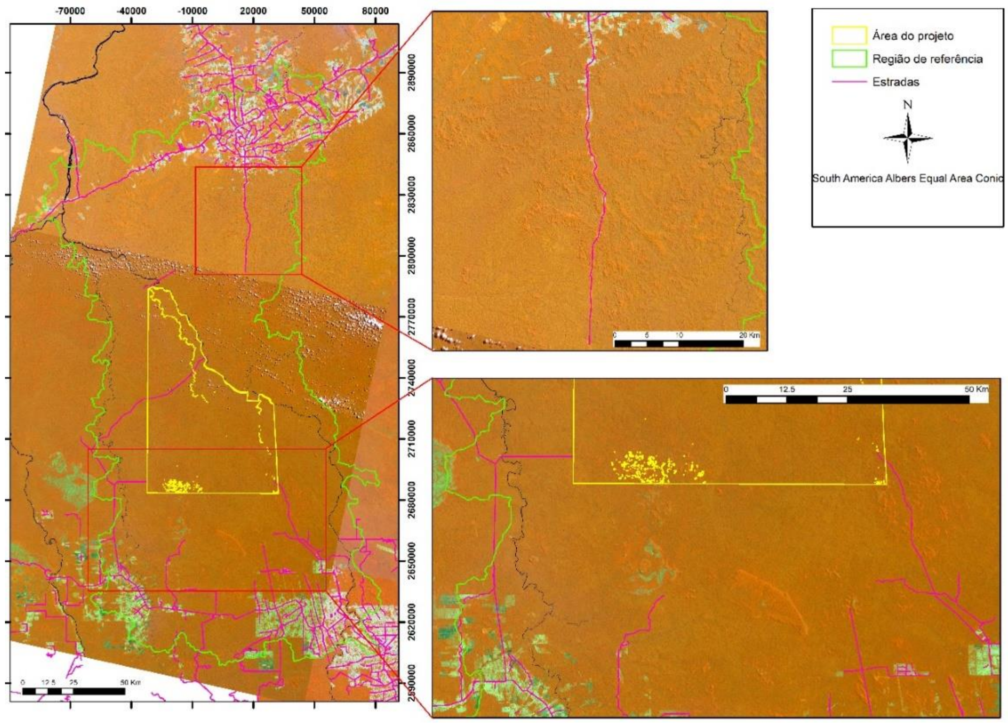
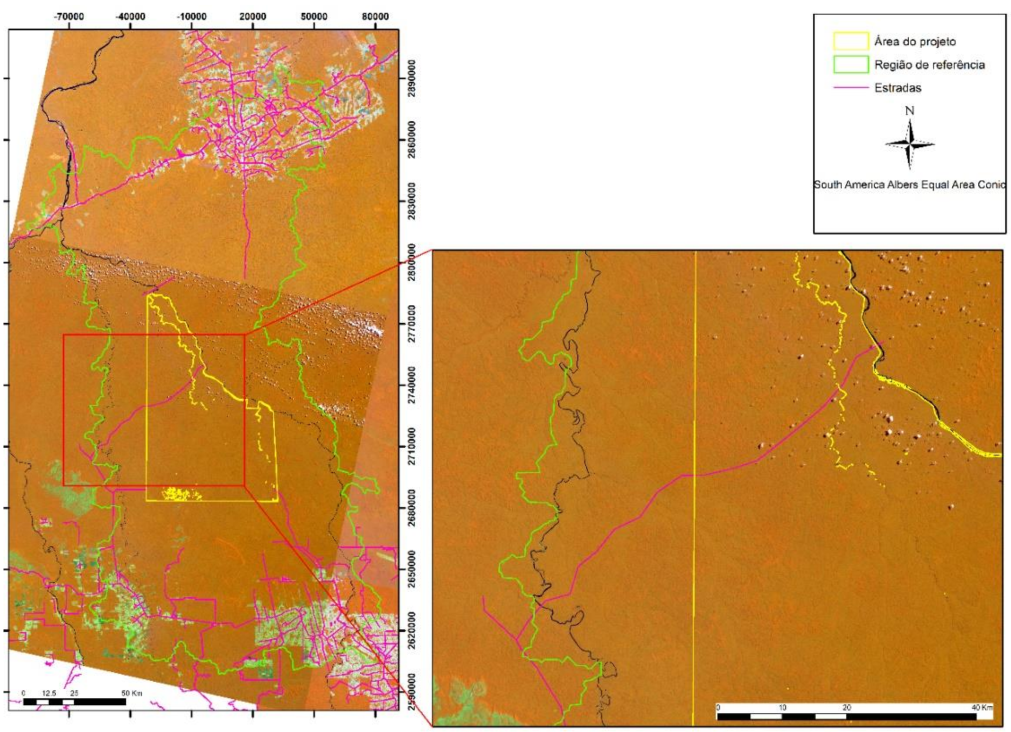


Figure 53 Location of the Marcelino RAMAL expansion project



Deforestation risk maps show regions with the highest (risk = 1) or lowest (risk = 0) conditions for deforestation to occur. The risk map was created using Dinamica EGO Software[163], which modeling techniques are used for calibrating, running and validating space-time models.

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

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

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

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

However, due to the current situation in which Indigenous Lands (ILs) and Protected Areas (PAs) are showing an increase in the deforestation rate, it was necessary to adjust the weights of evidences for these areas according to the following proportion: 0.092 in full protection PAs, 1,216 in sustainable use PAs and 0.409 in ILs. The statistical treatment is detailed below:

The presence of protected areas (PAs) and indigenous lands (ILs) within the reference region was an important component to tackle deforestation during the last years before the project start date. However, as of 2019, there were important changes in the Brazilian Government regarding the importance of these areas, putting a negative pressure on their extent and existence in the country[164,165]. In fact, the Federal

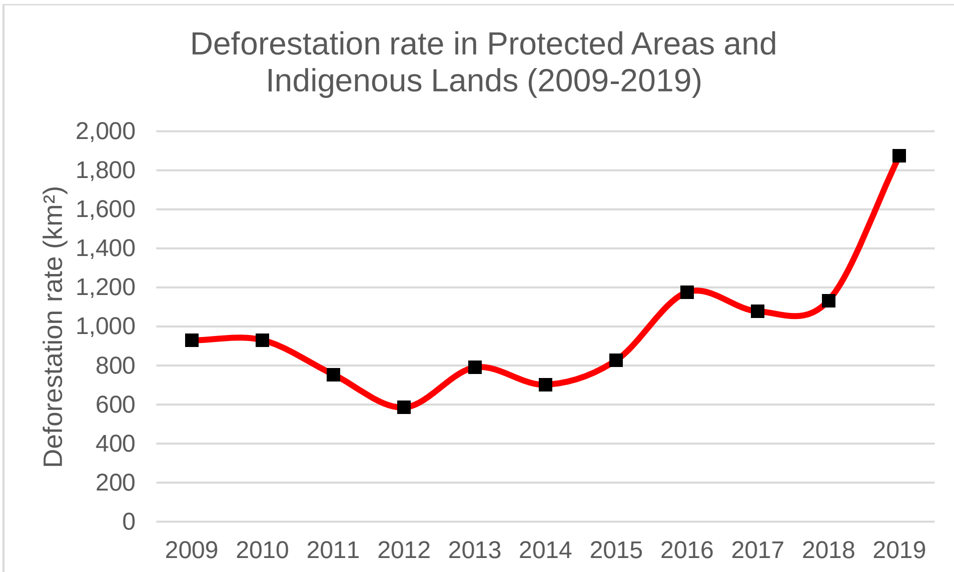
[163] Dinamica Ego Software. Available at: <https://csr.ufmg.br/dinamica/>. Last visited on 29/12/2020

[164] Available at: <https://www.terradedireitos.org.br/acervo/artigos/ameacas-concretas-do-governo-bolsonaro-sobre-unidades-de-conservacao/23231>. Last visited on March 21st, 2021.

[165] Available at: <https://brasil.elpais.com/brasil/2020-02-04/governo-bolsonaro-manobra-para-travar-a-demarcacao-de-terras-indigenas-no-brasil.html>. Last visited on March 21st, 2021.

Government weakened the National Indigenous Foundation (FUNAI) in the first hours after starting the new mandate[166].

Deforestation rate has significantly increased in Brazil since 2019, however it almost doubled inside PAs and ILs, as can be seen in the figures below, which analyzes the historical deforestation over the last 10 years. According to several studies, this increase in deforestation was a direct result from the new Government measures for protected areas and indigenous lands in Brazil[167,168,169,170].



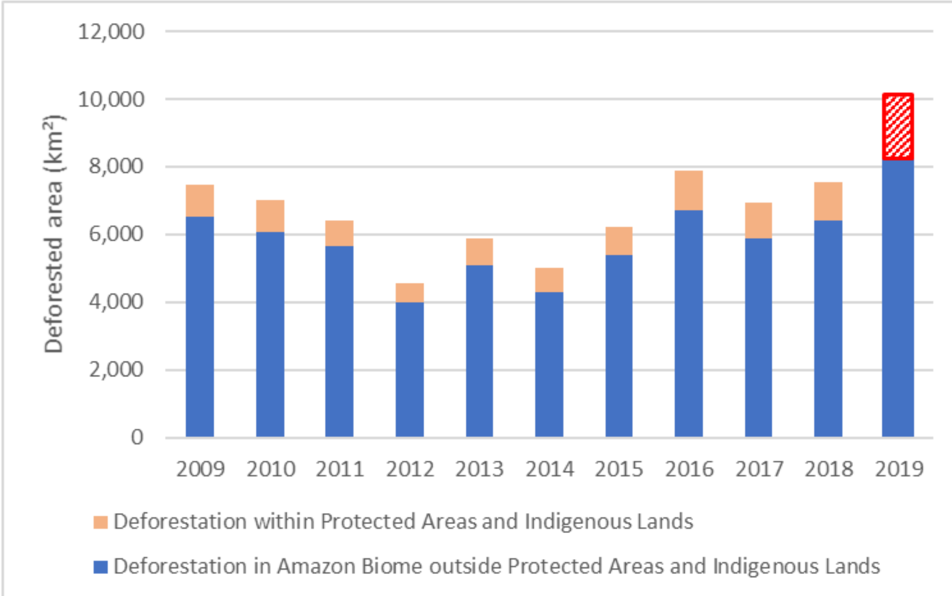
[166] Available at: <https://www.bbc.com/portuguese/brasil-46749222>. Last visited on March 21st, 2021.

[167] Available at: <https://www.oeco.org.br/reportagens/desmatamento-em-unidades-de-conservacao-atinge-maior-indice-dos-ultimos-10-anos/>. Last visited on March 21st, 2021.

[168] Available at: <https://exame.com/brasil/desmatamento-em-unidades-de-conservacao-cresce-40-em-12-meses/>. Last visited on March 21st, 2021.

[169] Available at: <https://noticias.uol.com.br/colunas/rubens-valente/2020/09/30/indigenas-relatorio-violencia-brasil-governo-bolsonaro.htm>. Last visited on March 21st, 2021.

[170] Available at: <https://www.oeco.org.br/reportagens/desmatamento-em-terras-indigenas-sobe-65-e-alcanca-maior-cifra-em-10-anos/>. Last visited on March 21st, 2021.



Therefore, the deforestation rate analysis was separated for each of those categories, based on data from PRODES[171]. As of 2019, there was a 95% increase in deforestation rates within Protected Areas and Indigenous Lands compared to the average historical deforestation rate (2008-2018). Meanwhile, the increase in the deforestation rate in areas outside PAs and ILs during the same analyzed period was about 35%. Therefore, comparing these rates, it was possible to conclude that the increase in deforestation in PAs and ILs was 172% higher than in other areas without any level of protection.

In addition, according to PRODES, from the total deforestation inside PAs and ILs, 70.8% occurred in PAs from the category "sustainable use", 23.8% in ILs, and 5.3% in PAs from the category "full protection". Thus, the 172% deforestation increase could be divided in each category as follows:

- 9.2% in PAs from the category "full protection"
- 121.6% in PAs from the category "sustainable use"
- 40.9% in indigenous lands

Therefore, the weight of evidence for these land uses were adjusted according to the figures described above.

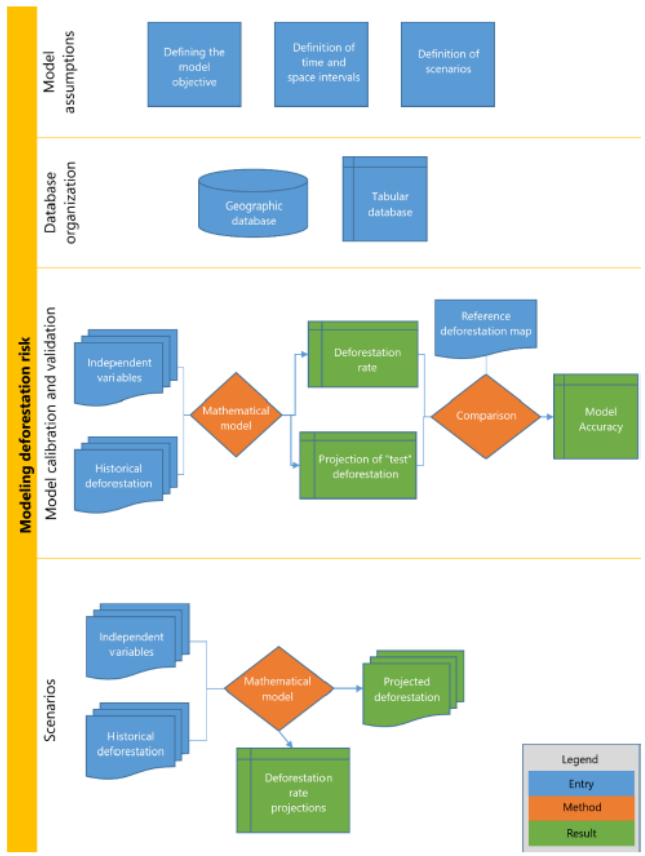
Regarding the settlements factor, it was verified that the deforestation patterns within the area begin to occur after a period of time of their creation. Thus, in older settlements it is possible to clearly see the deforestation related to its installation, while in newer settlements its impact is not yet perceptible. Thus, the old settlements were considered as predictive variables and in the future projection the most recent settlements were included.

[171] Available at: <http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes>. Last visited on: March 21st, 2021.

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

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

Figure 54 Modelling steps focusing on the creation of the deforestation risk map and the projection of future deforestation



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

Table 23 List of variables, maps and factor maps

Factor Map		Source	Variable represented		Meaning of categories or pixel value		Other maps or variables used to create the Factor Map		Algorithm or equation used	Comments
ID	File Name		Unit	Description	Range	Meaning	ID	File Name		
1	d_estradas_v4_paraBL.tif	IBGE	Meter	Euclidean Distance from paved and unpaved roads	0-56229.7	Lower values mean more proximity		Rodovias_IBGE_edit_c_EstradasIlegais	Euclidean Distance (ArcGis 10.6)	
2	UCs.tif	MMA		Sustainable Use Protected Areas						
3	UCs.tif	MMA		Full protection Protected Areas						
4	TIs.tif	FUNAI		Indigenous land						
5	Assentamentos.tif	INCRA		Rural Settlements						
6	d_rios_g.tif	ANA	Meter	Euclidean Distance from water bodies	0 – 95.845,8	Lower values mean more proximity		RiosGrandes_ANA	Euclidean Distance (ArcGis10.6)	
7	d_rios_g_mbiomas.tif	MapBiomas	Meter	Euclidean distance from rivers	0 – 37,067.7	Lower values mean more proximity		rios_MBiomas	Euclidean Distance (ArcGis10.6)	
8	d_rios.tif	ANA	Meter	Distance from rivers	0-17,571	Lower values mean more proximity		Rios_ANA	Euclidean Distance (ArcGis10.6)	
9	d_urbana.tif	IBGE	Degree	Average slope variation	0-171169	Lower values mean lower slope		AreasUrbanas_IBGE	Euclidean Distance (ArcGis10.6)	
10	dem.tif	SRTM	Meter	Average altitude variation	22-504	Lower values mean lower altitude		BoaFe_SRTM_Mosaic		
11	slope.tif	SRTM	Degree	Variação média da declividade do terreno	0-543.468	Lower values mean lower slope		slope	Slope (ArcGIS 10.6)	

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

Table 24 Variation of the weights of evidence according to deforestation distance ranges

Distância ao desmatamento		Peso de evidência	Distância ao desmatamento		Peso de evidência
0	100	2.96	5000	5300	-3.36
100	200	2.37	5300	5600	-3.50
200	300	2.13	5600	5900	-3.82
300	400	1.90	5900	6200	-3.97
400	500	1.68	6200	6500	-4.90
500	700	1.37	6500	6800	-5.15
700	800	1.06	6800	7200	-5.97
800	900	0.84	7200	7600	-5.50
900	1000	0.61	7600	8000	-7.67
1000	1100	0.39	8000	8400	-8.48
1100	1200	0.21	8400	8900	-7.37
1200	1300	0.06	8900	9400	-8.12
1300	1400	-0.11	9400	9900	-7.32
1400	1600	-0.34	9900	10400	-6.38
1600	1700	-0.62	10400	10900	-7.51
1700	1900	-0.83	10900	11500	-6.35
1900	2100	-1.02	11500	12100	-6.13
2100	2300	-1.32	12100	12800	-6.44
2300	2500	-1.57	12800	13500	-6.36
2500	2700	-1.88	13500	14300	-6.32

2700	2900	-2.14	14300	15100	-6.59
2900	3100	-2.49	15100	16000	-6.39
3100	3300	-2.73	16000	17000	-6.75
3300	3500	-2.96	17000	18200	-6.86
3500	3800	-3.24	18200	19600	-6.82
3800	4100	-3.24	19600	21300	-5.90
4100	4400	-3.39	21300	23300	-6.54
4400	4700	-3.19	23300	26500	-9.39
4700	5000	-3.19	26500	31500	0.00

Table 25 Variation of the weights of evidence according to the distance from roads

Distância às estradas		Peso de evidência	Distância às estradas		Peso de evidência
0	100	2.04	11200	11900	-2.51
100	400	1.97	11900	12600	-3.44
400	600	1.97	12600	13300	-3.71
600	800	1.88	13300	14000	-4.15
800	1000	1.78	14000	14800	-4.65
1000	1200	1.68	14800	15600	-4.37
1200	1400	1.55	15600	16400	-4.16
1400	1600	1.42	16400	17200	-3.67
1600	1900	1.25	17200	18000	-3.60
1900	2200	1.03	18000	18900	-3.50
2200	2400	0.83	18900	19800	-4.26
2400	2500	0.66	19800	20700	-4.86
2500	2700	0.53	20700	21700	-4.13

2700	3000	0.39
3000	3400	0.31
3400	3800	0.20
3800	3900	0.01
3900	4200	-0.15
4200	4300	-0.46
4300	4600	-0.62
4600	5100	-0.83
5100	5600	-0.99
5600	6100	-1.19
6100	6500	-1.00
6500	6600	-0.73
6600	7100	-0.87
7100	7300	-1.14
7300	7900	-1.42
7900	8500	-1.72
8500	9100	-1.83
9100	9800	-2.13
9800	10500	-1.97
10500	11200	-2.05
21700	22700	-4.87
22700	23700	-5.31
23700	24700	-5.45
24700	25800	-4.65
25800	27100	-4.91
27100	28600	-5.14
28600	30300	-4.92
30300	32200	-7.39
32200	34200	-5.87
34200	36300	-5.40
36300	38300	-8.00
38300	40200	-7.76
40200	42200	-7.47
42200	44300	-6.13
44300	46500	-6.06
46500	49100	-6.73
49100	54100	-5.77
54100	56300	0.00

Table 26 Variation of the weights of evidence according to the distance from rivers

Distância aos rios		Peso de evidência
0	100	-0.34
100	200	-0.29
2900	3100	-0.03
3100	3300	-0.07

200	300	-0.23
300	400	-0.16
400	500	-0.10
500	600	-0.06
600	700	-0.04
700	800	-0.03
800	900	-0.04
900	1000	-0.06
1000	1100	-0.07
1100	1200	-0.09
1200	1300	-0.08
1300	1400	-0.08
1400	1500	-0.08
1500	1600	-0.04
1600	1700	-0.03
1700	1800	-0.04
1800	1900	-0.03
1900	2000	-0.05
2000	2100	-0.05
2100	2200	0.00
2200	2300	-0.01
2300	2500	-0.01
2500	2700	-0.01
2700	2900	-0.01

3300	3500	-0.12
3500	3700	-0.14
3700	3900	-0.09
3900	4100	-0.02
4100	4300	-0.05
4300	4500	-0.03
4500	4700	-0.06
4700	4900	-0.03
4900	5200	0.02
5200	5500	0.13
5500	5800	0.24
5800	6100	0.17
6100	6400	0.11
6400	6800	0.21
6800	7200	0.24
7200	7700	0.33
7700	8300	0.25
8300	9000	0.23
9000	9800	0.13
9800	11000	0.16
11000	12100	0.37
12100	12200	0.59
12200	12500	0.83
12500	17600	0.76

Table 27 Variation of the weights of evidence according to the distance from large rivers

Distância aos rios grandes		Peso de evidência	Distância aos rios grandes		Peso de evidência
1	100	-0.87	8200	8600	-0.17
100	200	-0.53	8600	8900	-0.36
200	300	-0.31	8900	9300	-0.39
300	500	-0.08	9300	9700	-0.44
500	700	0.14	9700	10100	-0.45
700	900	0.30	10100	10600	-0.39
900	1100	0.36	10600	11100	-0.24
1100	1300	0.46	11100	11600	-0.38
1300	1600	0.54	11600	12100	-0.32
1600	1900	0.57	12100	12700	-0.40
1900	2200	0.61	12700	13300	-0.34
2200	2500	0.67	13300	13600	-0.54
2500	2800	0.72	13600	13700	-0.76
2800	3100	0.77	13700	14200	-1.00
3100	3400	0.70	14200	14900	-1.28
3400	3700	0.56	14900	15700	-1.41
3700	4000	0.53	15700	16500	-1.26
4000	4300	0.46	16500	17400	-1.61
4300	4600	0.44	17400	17600	-2.21
4600	4900	0.48	17600	18600	-2.79
4900	5200	0.42	18600	19700	-3.65
5200	5500	0.43	19700	20900	-2.96
5500	5800	0.40	20900	22100	-3.42

5800	6100	0.33
6100	6400	0.25
6400	6700	0.32
6700	7000	0.31
7000	7300	0.29
7300	7700	0.23
7700	8100	0.14
8100	8200	-0.05

22100	23400	-3.70
23400	24800	-2.96
24800	26400	-3.39
26400	28500	-3.33
28500	28700	-2.11
28700	32700	-3.18
32700	37100	0.00

Table 28 Variation of the weights of evidence according to slope

Declividade		Peso de evidência
0	2	0.07
2	3	0.09
3	4	0.09
4	5	0.08
5	6	0.03
6	7	-0.04
7	8	-0.11
8	9	-0.16
9	10	-0.21
10	11	-0.23
11	12	-0.23
12	13	-0.21
13	15	-0.22
15	18	-0.19
18	55	-0.35

Table 29 Variation of the weights of evidence according to altitude

Altitude		Peso de evidência
0	31	-1.69
31	32	-1.10
32	33	-0.34
33	34	0.88
34	35	0.03
35	36	0.60
36	37	0.28
37	38	-0.09
38	39	0.22
39	40	-0.52
40	41	-0.78
41	42	-0.29
42	49	-0.51
49	50	-0.81
50	57	-1.07
57	58	-1.57
58	76	-1.60
76	82	-1.21
82	88	-1.10
88	89	-0.82
89	93	-0.64
93	96	-0.66
96	99	-0.96

99	100	-1.36
100	103	-1.61
103	105	-1.67
105	107	-1.50
107	109	-1.30
109	111	-1.10
111	113	-0.92
113	115	-0.76
115	117	-0.66
117	119	-0.60
119	121	-0.52
121	123	-0.42

Table 30 Variation of the weights of evidence according to the Conservation Unit

Unidades de Conservação	Peso de evidência
Fora de UCs	0.43
Uso Sustentável	-2.98
Proteção Integral	-5.92

Table 31 Variation of the weights of evidence according to Indigenous lands

Território Indígenas	Peso de evidência
Fora de TIs	0.16
Dentro de Tis	-3.55

Table 32 Variation of the weights of evidence according to the presence of settlements

Assentamentos	Peso de evidência
Dentro de assentamentos	-0.29
Fora de assentamentos	1.85

Table 33 Variation of the weights of evidence according to distance from urban areas

Distância às áreas urbanas		Peso de evidência	Distância às áreas urbanas		Peso de evidência	Distância às áreas urbanas		Peso de evidência
1	100	2.65	70000	72000	-3.12	113000	115000	-2.88
500	1000	0.83	72000	72500	-1.78	115000	115500	-1.35
1000	1500	2.18	72500	74500	-2.38	115500	116000	-0.76
1500	16500	1.96	74500	76500	-4.40	116000	117000	-0.42
16500	22500	1.70	76500	77000	-1.80	117000	119000	-0.30
22500	26500	1.39	77000	77500	-1.23	119000	119500	0.02
26500	30000	1.47	77500	78000	-1.67	119500	121500	0.14
30000	33500	1.58	78000	78500	-3.00	121500	123500	0.00
33500	36500	1.49	78500	80500	-4.16	123500	124000	-0.31
36500	39500	1.41	80500	82000	-2.34	124000	126000	-0.27
39500	42500	1.12	82000	82500	-1.15	126000	126500	-0.04
42500	43000	0.86	82500	83000	-1.46	126500	128500	-0.02
43000	44000	1.11	83000	83500	-2.46	128500	130500	-0.19
44000	46000	0.89	83500	85500	-2.15	130500	131000	-0.69
46000	46500	0.62	85500	86000	-3.42	131000	132500	-0.44
46500	47000	0.82	86000	88000	-4.31	132500	135000	-0.37
47000	50000	0.90	88000	88500	-1.99	135000	136000	-0.65
50000	50500	0.64	88500	90500	-2.20	136000	138500	-0.63

50500	51500	0.47
51500	52000	0.29
52000	52500	0.07
52500	53000	-0.18
53000	53500	0.24
53500	56500	0.33
56500	59500	0.27
59500	60000	0.40
60000	62500	0.31
62500	63000	0.11
63000	63500	-0.33
63500	65000	-0.50
65000	65500	-0.67
65500	67000	-1.10
67000	67500	-2.02
67500	70000	-2.22
90500	92500	-3.35
92500	94500	-2.95
94500	96000	-1.97
96000	98000	-1.54
98000	100000	-1.32
100000	100500	-0.80
100500	101500	-0.55
101500	102000	-0.26
102000	103000	-0.44
103000	103500	-1.02
103500	105000	-1.40
105000	107000	-1.32
107000	107500	-1.79
107500	109000	-2.55
109000	111000	-2.88
111000	113000	-2.73
138500	140500	-0.84
140500	141000	-1.37
141000	142500	-0.98
142500	143000	-0.40
143000	143500	-0.73
143500	144000	-1.36
144000	145000	-1.04
145000	145500	-0.70
145500	147500	-0.99
147500	148000	-1.54
148000	148500	-4.32
148500	154000	-4.51
154000	163000	-5.15
163000	171500	-4.81

Furthermore, the factor maps used to create the deforestation risk map are presented below.

Figure 55 Distance from roads risk map

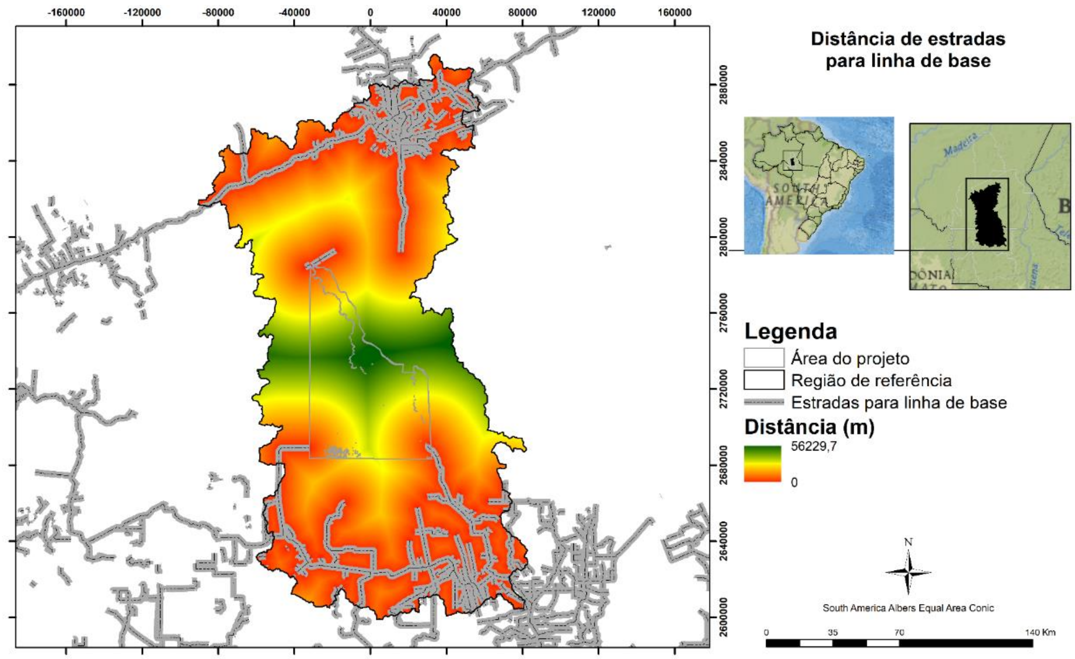


Figure 56 Distance from urban areas risk map

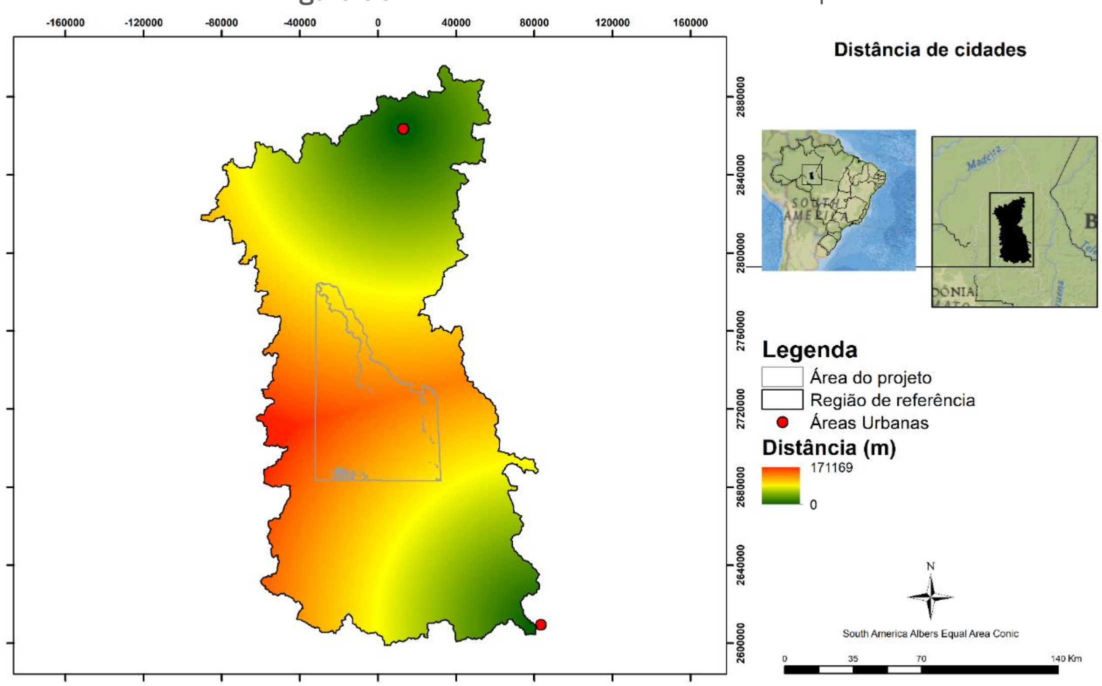


Figure 57 Presence of settlements (baseline)

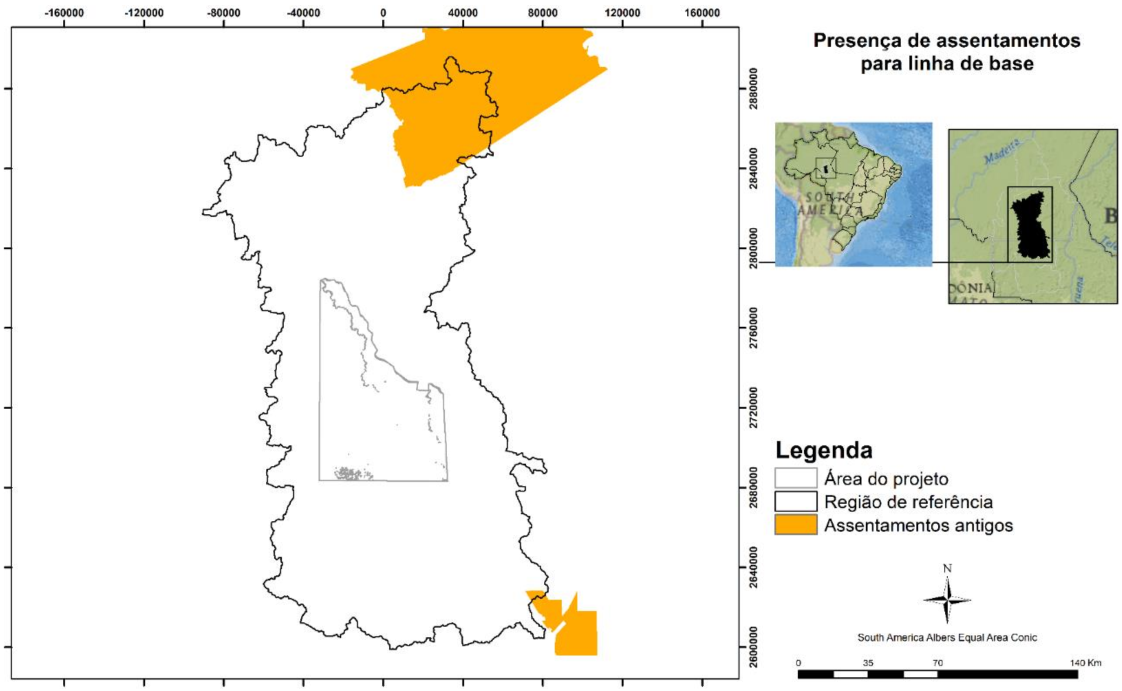


Figure 58 Presence of indigenous lands risk map

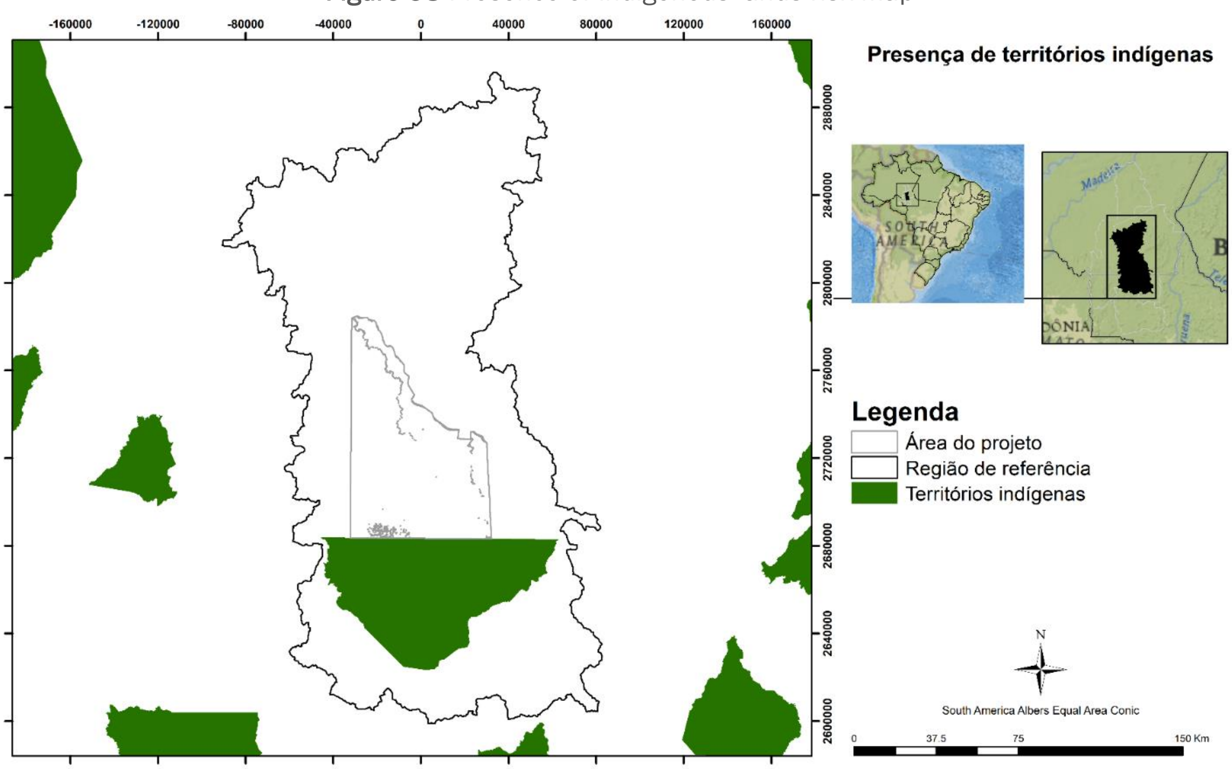


Figure 59 Proximity to conservation units

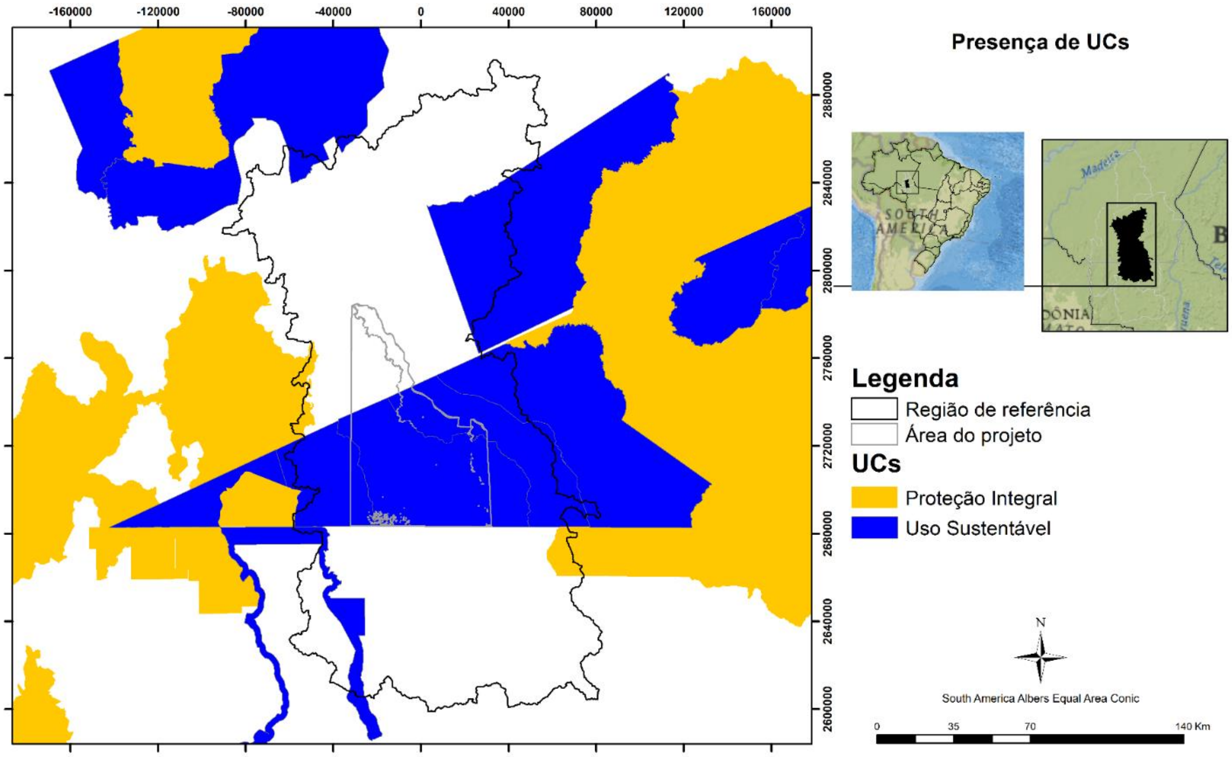


Figure 60 Proximity to small rivers

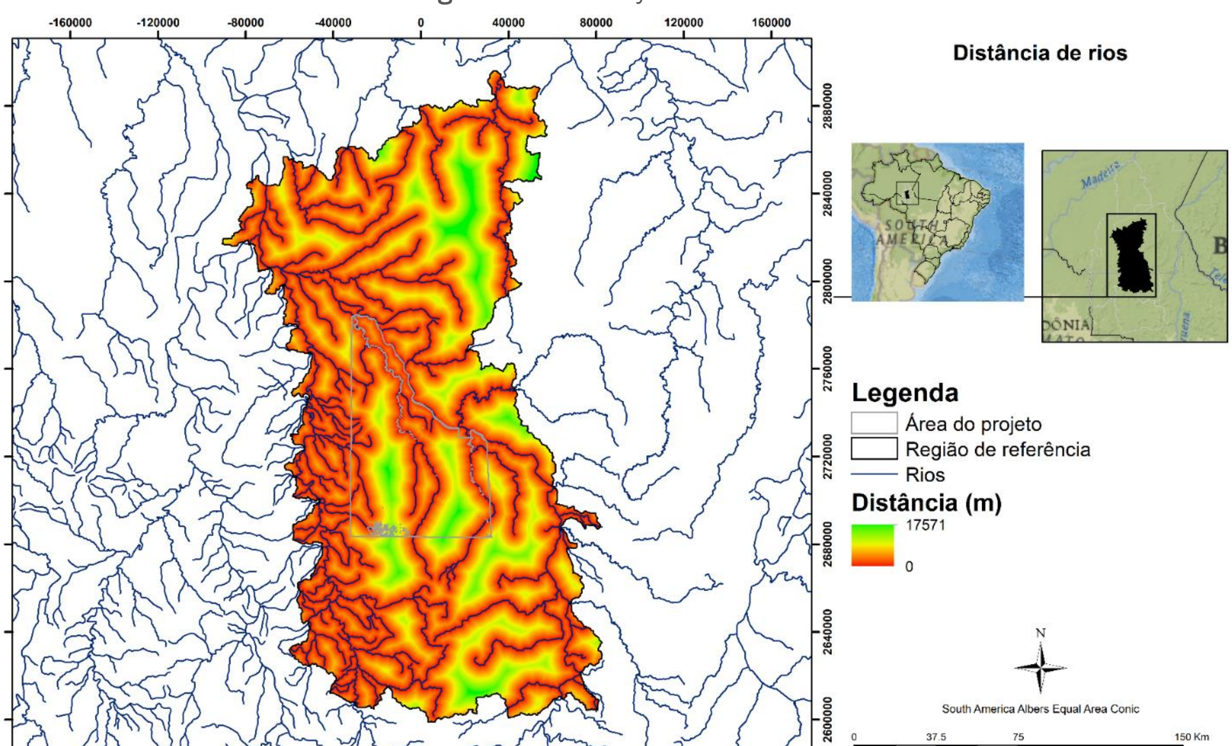


Figure 61 Proximity to large rivers

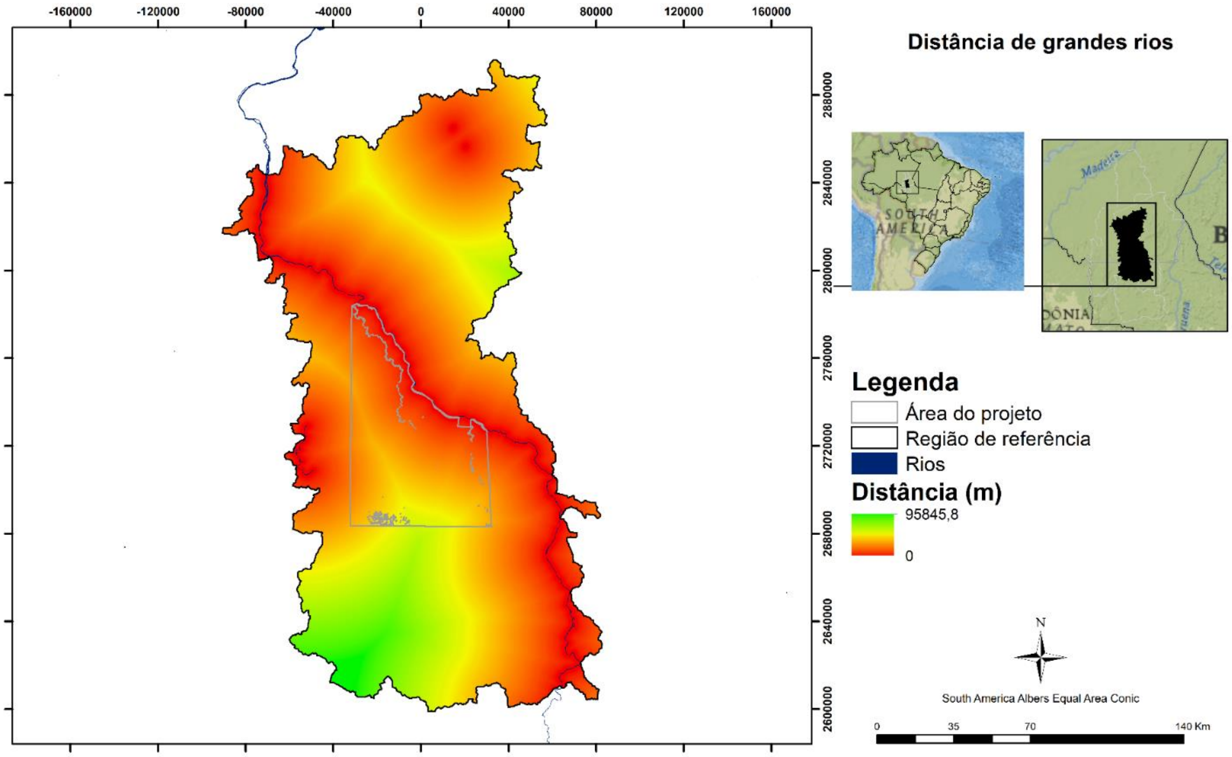
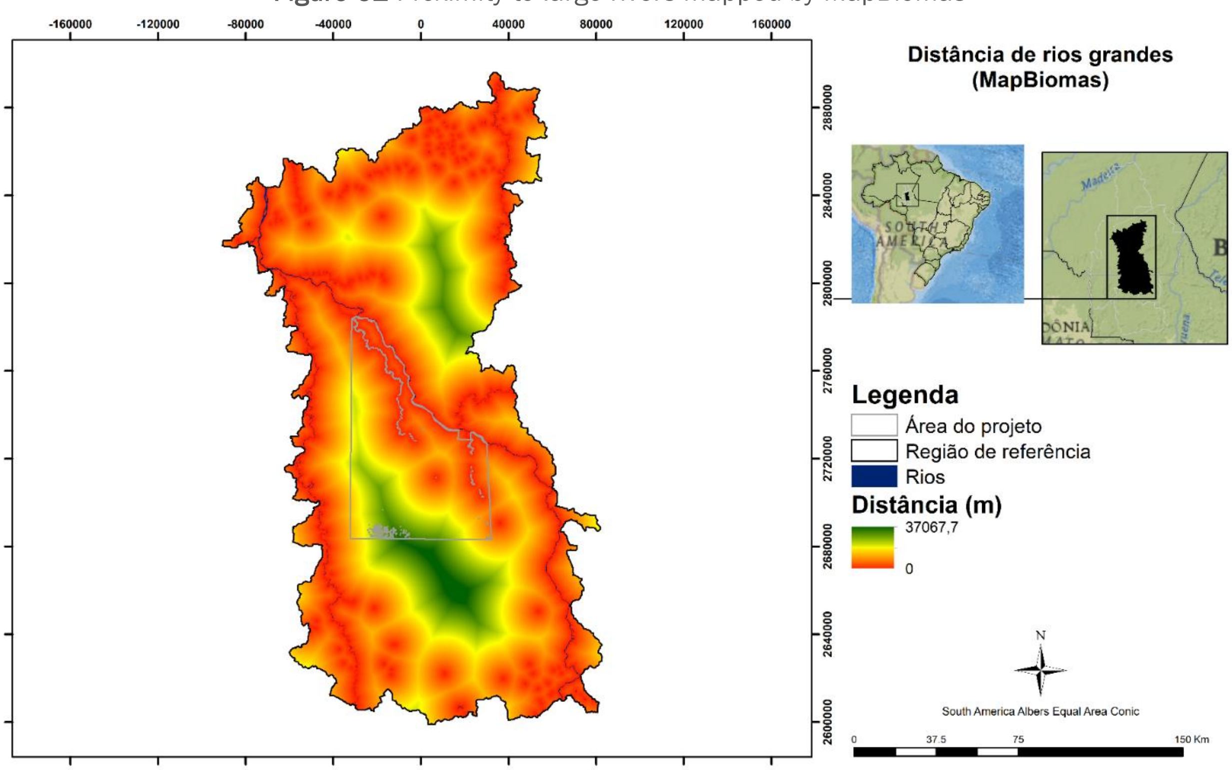


Figure 62 Proximity to large rivers mapped by MapBiomas



Selection of most accurate deforestation risk map

As previously noted, the time function approach was chosen to project the quantity of future deforestation, given the tendency to increase over time. In addition, to validate which are the best models to allocate where these deforestations tend to happen, it was used the calibration and confirmation methodology, dividing the dynamics of deforestation into two periods: 2009-2014 and 2014-2019.

The period from 2009 to 2019 was used to generate the existing correlations between the deforested areas and the predictor variables, calculating the adjustment parameters of the models. Then a projection was made from 2014 to 2019, generating a scenario of the reference region for that date. Thus, there is the deforestation risk maps for the period from 2014 to 2019 and two scenarios for 2019, the real and the projected.

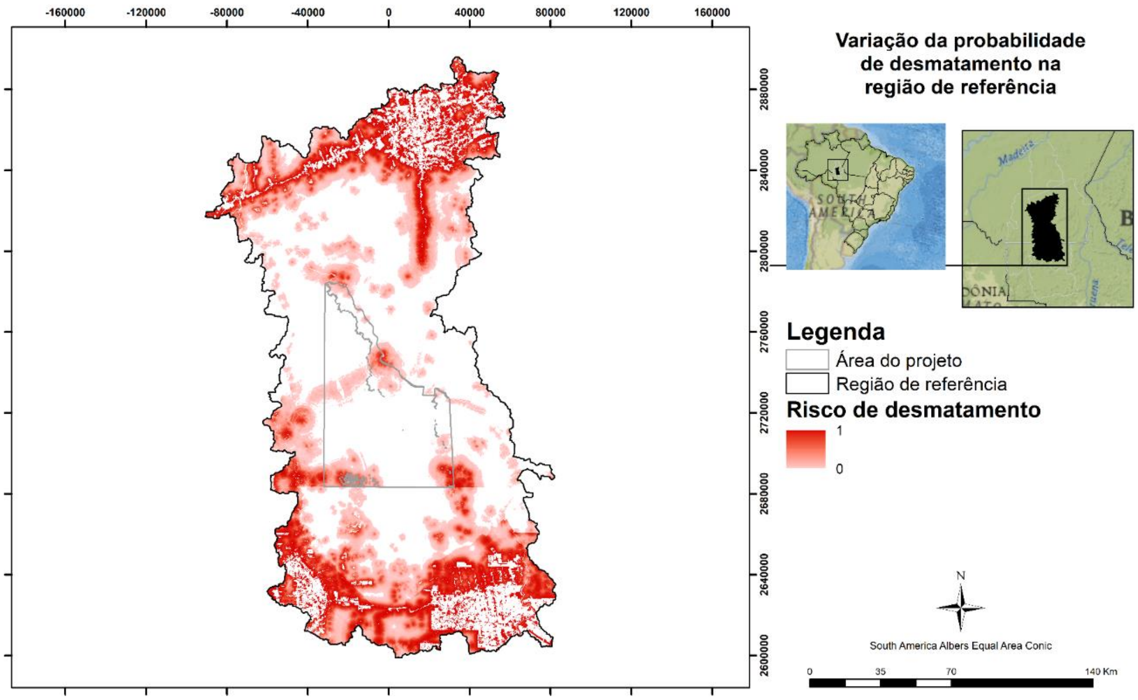
For validation, the simulated scenarios for 2019 were compared to the actual deforestation that happened in the area, using the method of similarity with exponential decay due to the distance. This index ranges from 0 (no overlapping) to 1 (totally overlapped), and the closer to 1, the more similar is the simulated scenario in relation to the real. Two values are calculated for the indices, the comparison of the simulated map in relation to the real map of deforestation and, conversely, the real map in relation to the simulated map. The average similarity values of the models ranged between 0.39 and 0.42. The results of this analysis are shown in table below.

Figure 63. Best deforestation projection models from 2009 to 2019. Each line corresponds to a model and was evaluated by the degree of similarity

Modelo	Similaridade 01	Similaridade 02	Média	Assentamento	TIs	Distância às estradas	Distância aos rios	Distâncias aos rios maiores	Distância às áreas urbanas	Declividade	Altitude	UCs
m14	0.474	0.370	0.422	0	1	1	0	0	0	1	1	1
m16	0.469	0.369	0.419	0	1	1	1	1	0	1	1	1
m15	0.469	0.370	0.419	0	1	1	0	1	0	1	1	1
m06	0.465	0.370	0.417	1	1	1	1	1	0	1	1	1
m01	0.462	0.369	0.415	0	1	1	1	1	1	1	1	1
m04	0.454	0.366	0.410	1	1	1	0	1	1	1	1	1
m05	0.452	0.364	0.408	1	1	1	1	0	1	1	1	1
m02	0.450	0.361	0.406	1	0	1	1	1	1	1	1	1
m09	0.450	0.361	0.406	1	1	1	1	1	1	1	1	0
m13	0.456	0.355	0.406	0	0	1	0	0	0	1	1	1
m00	0.450	0.361	0.405	1	1	1	1	1	1	1	1	1
m07	0.445	0.360	0.402	1	1	1	1	1	1	0	1	1
m10	0.444	0.360	0.402	0	0	1	0	0	0	0	0	0
m08	0.444	0.358	0.401	1	1	1	1	1	1	1	0	1
m12	0.445	0.345	0.395	0	0	1	0	0	0	1	1	0
m11	0.442	0.349	0.395	0	0	1	0	0	0	0	1	0
m03	0.434	0.345	0.390	1	1	0	1	1	1	1	1	1

Therefore, all the variables and deforestation patterns were analysed together to produce the risk map, which is illustrated in the figure below. Thus, the deforestation risk map was produced based on the information above, in accordance with the steps required by the methodology VM0015 v1.1.

Figure 64 Potential risk map for the occurrence of deforestation in the reference region, using Dinâmica Ego Software



Mapping of the location of future deforestation

The mapping of the location of future deforestation until 2050 was carried out through Dinamica Ego. Figures below show the results in the reference region, project area and leakage belt.

Figure 65 Projection of deforestation in the reference region, using Dinamica EGO

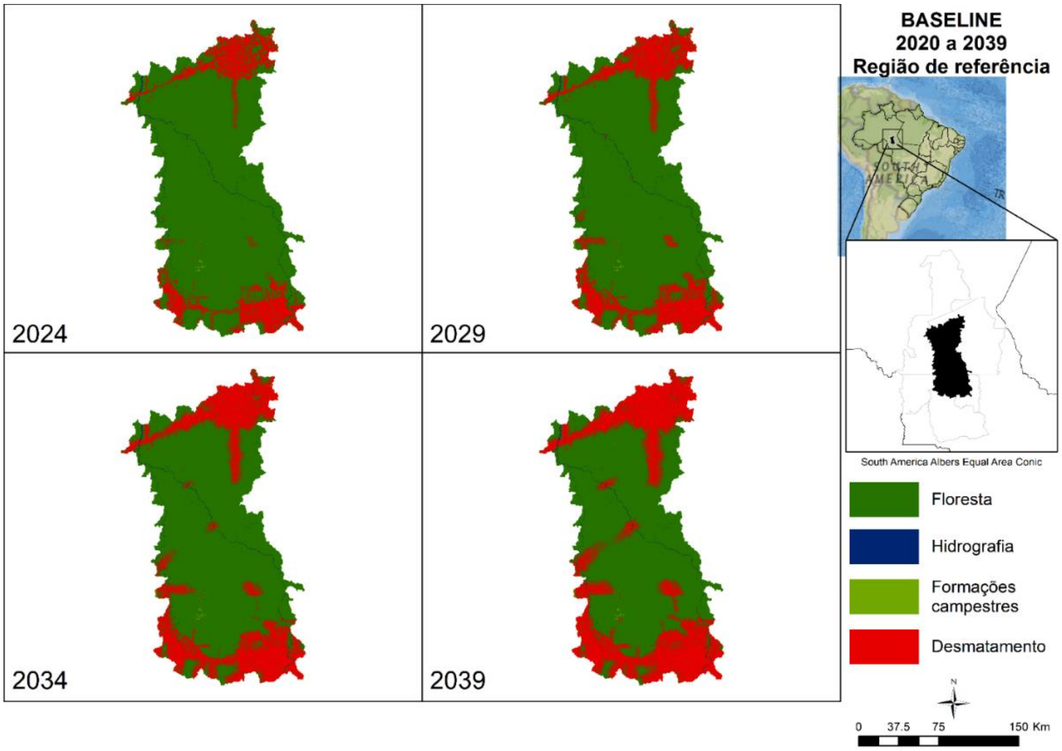


Figure 66 Projection of deforestation in the reference region, using Dinamica EGO

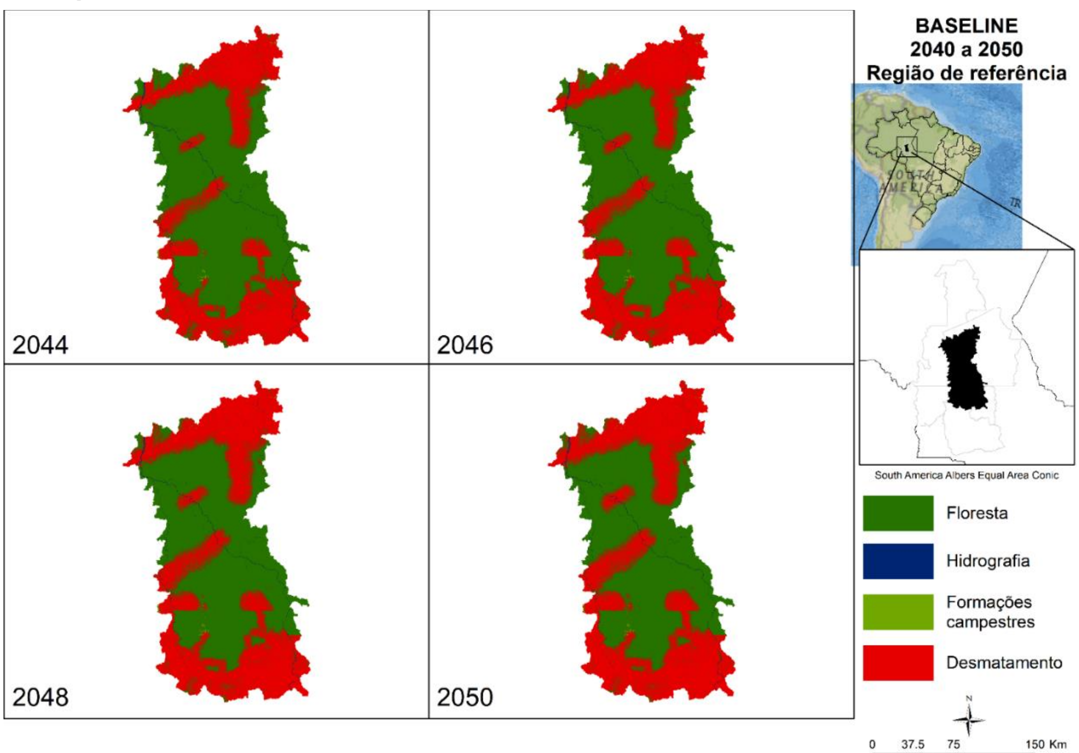


Figure 67 Projection of deforestation in the project area, using Dinamica EGO

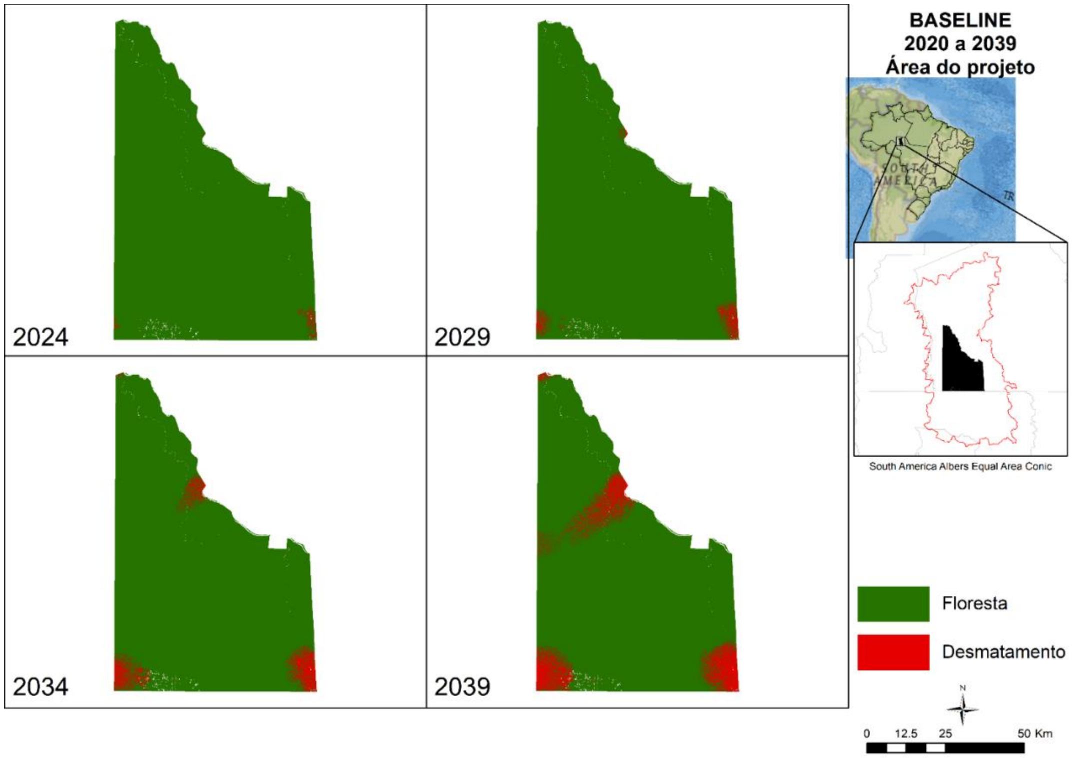


Figure 68 Projection of deforestation in the project area, using Dinamica EGO

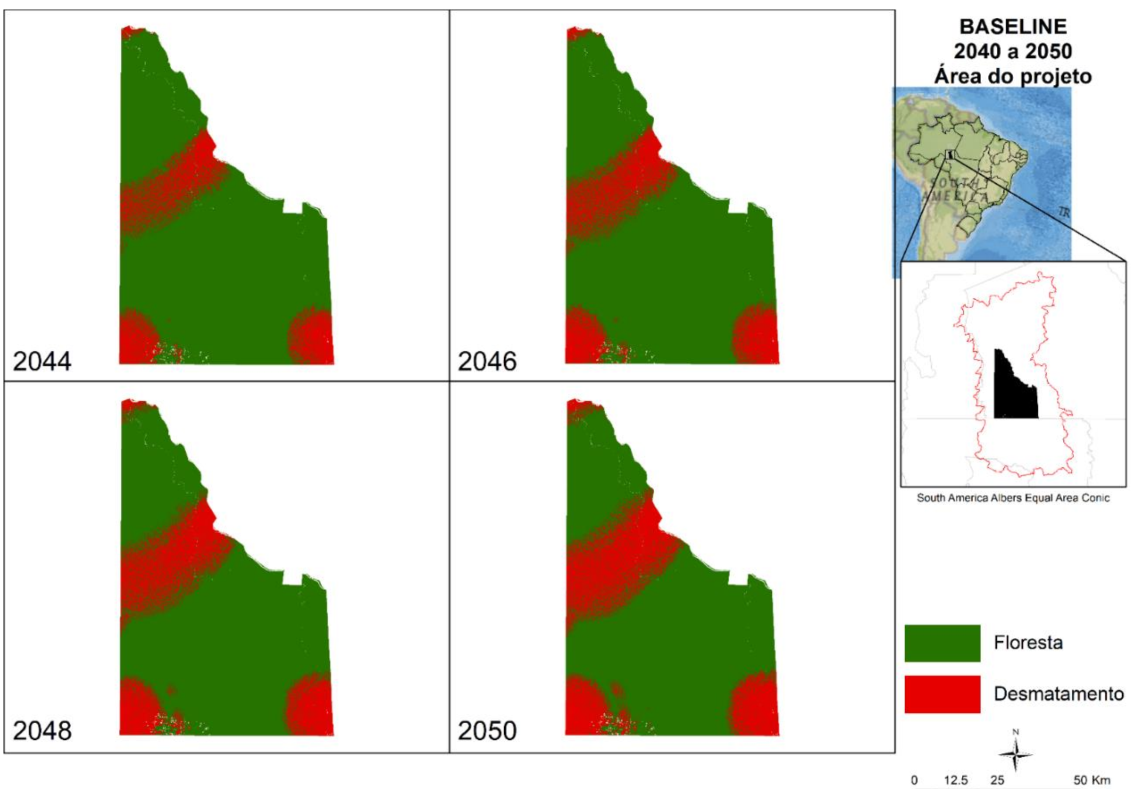


Figure 69 Projection of deforestation in the leakage belt, using Dinâmica EGO

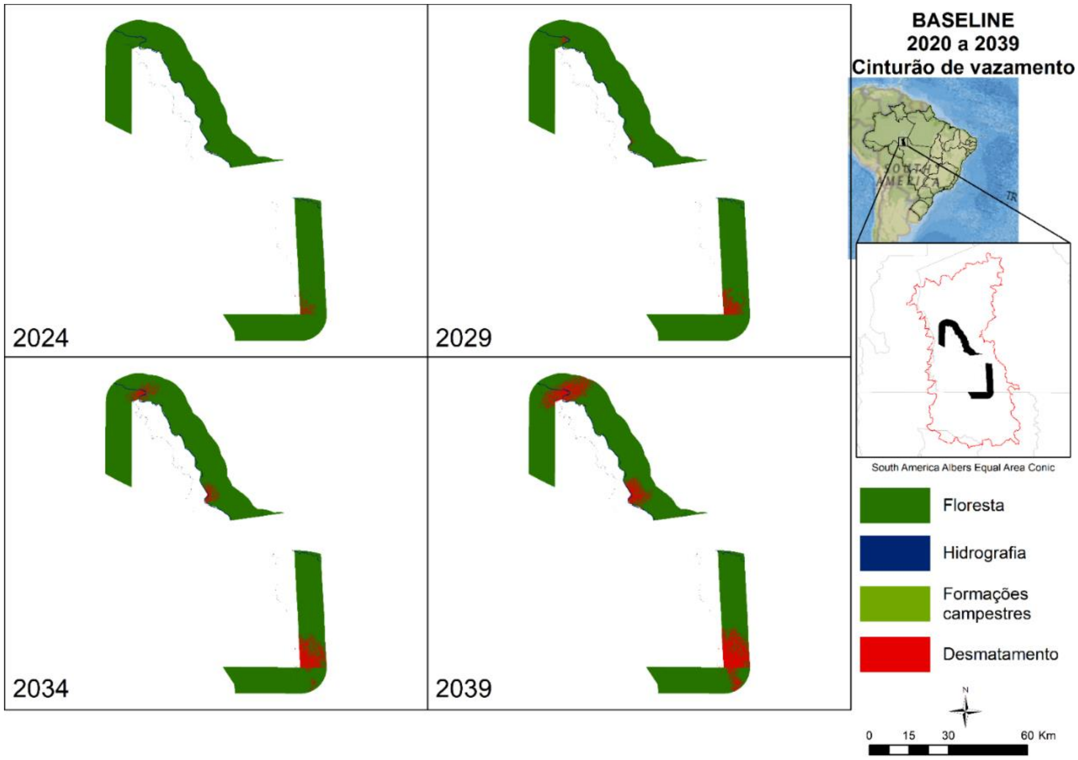


Figure 70 Projection of deforestation in the leakage belt, using Dinâmica EGO

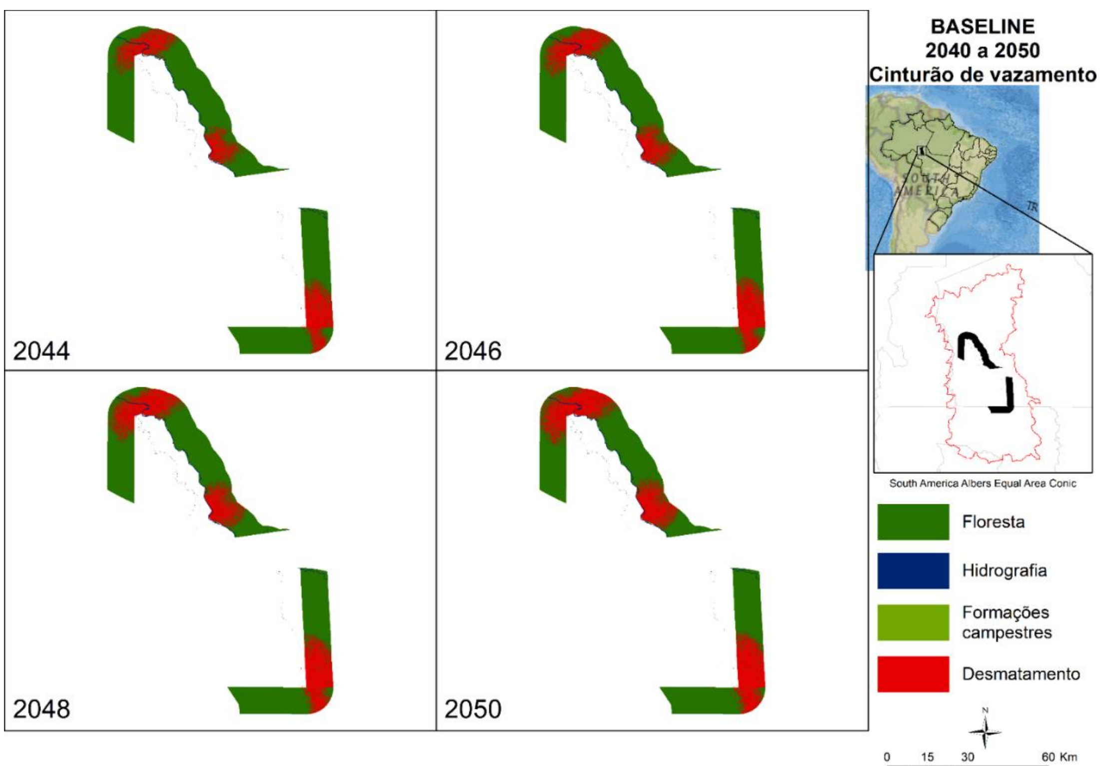


Figure 71. Deforestation projection in the reference region, year by year

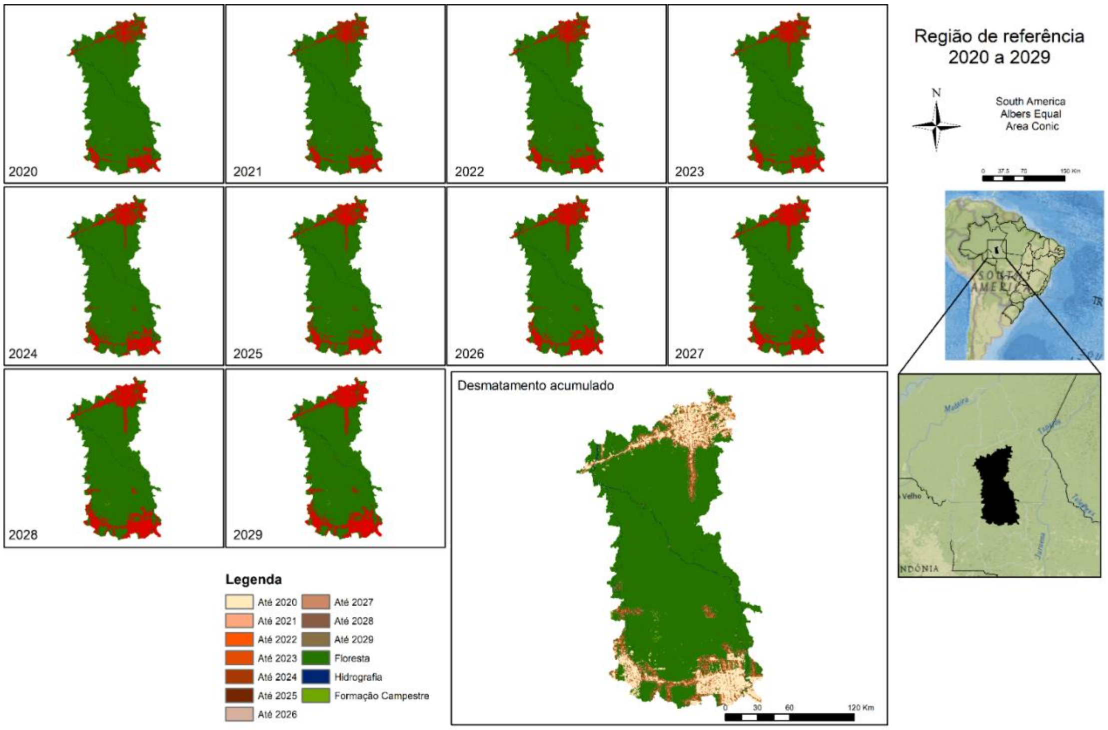


Figure 72 Deforestation projection in the reference region, year by year

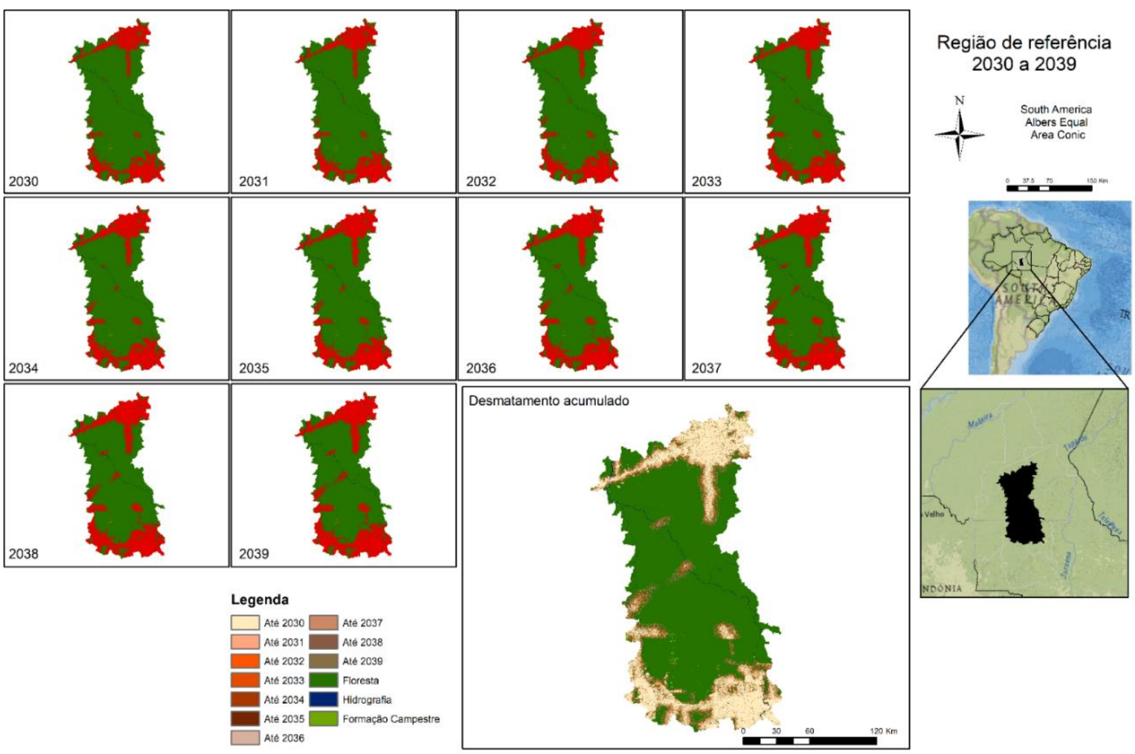


Figure 73 Deforestation projection in the reference region, year by year

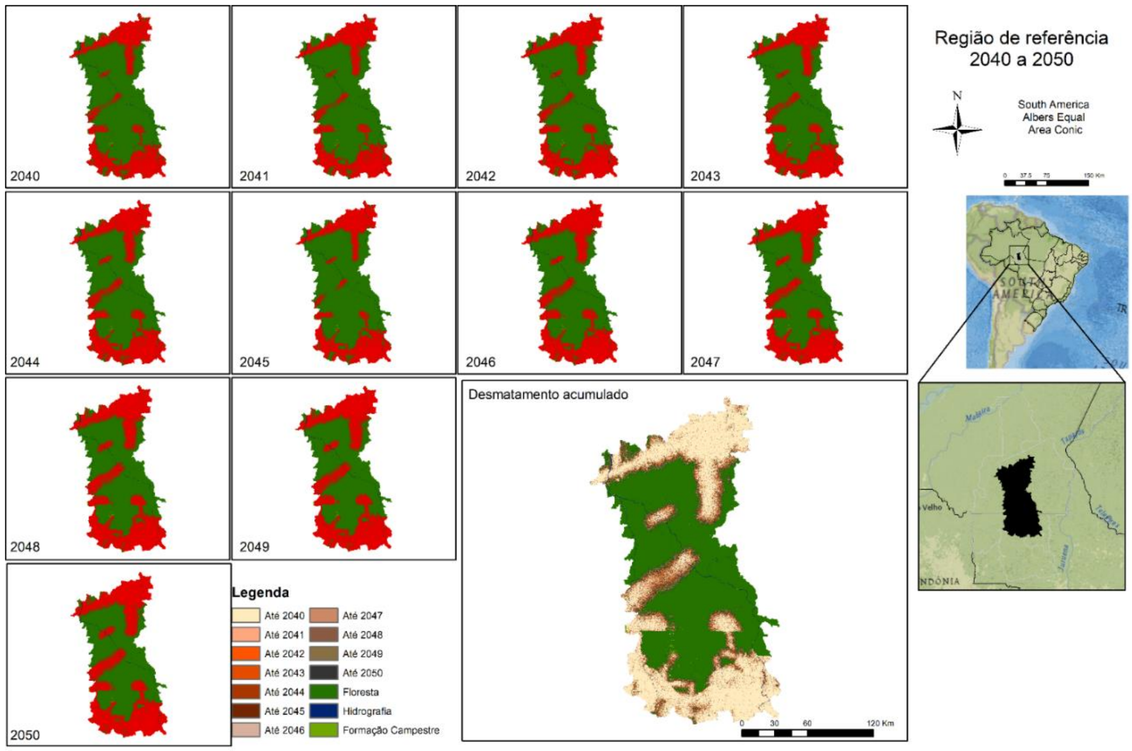


Figure 74 Deforestation projection in the project area, year by year

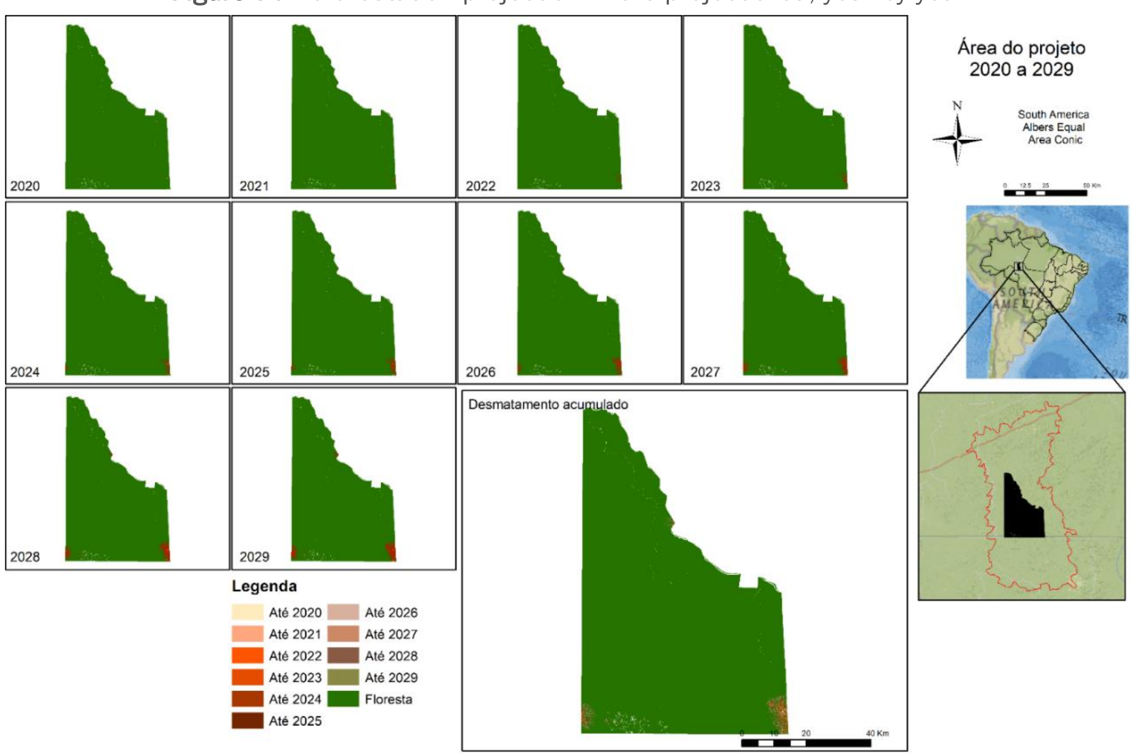


Figure 75 Deforestation projection in the project area, year by year

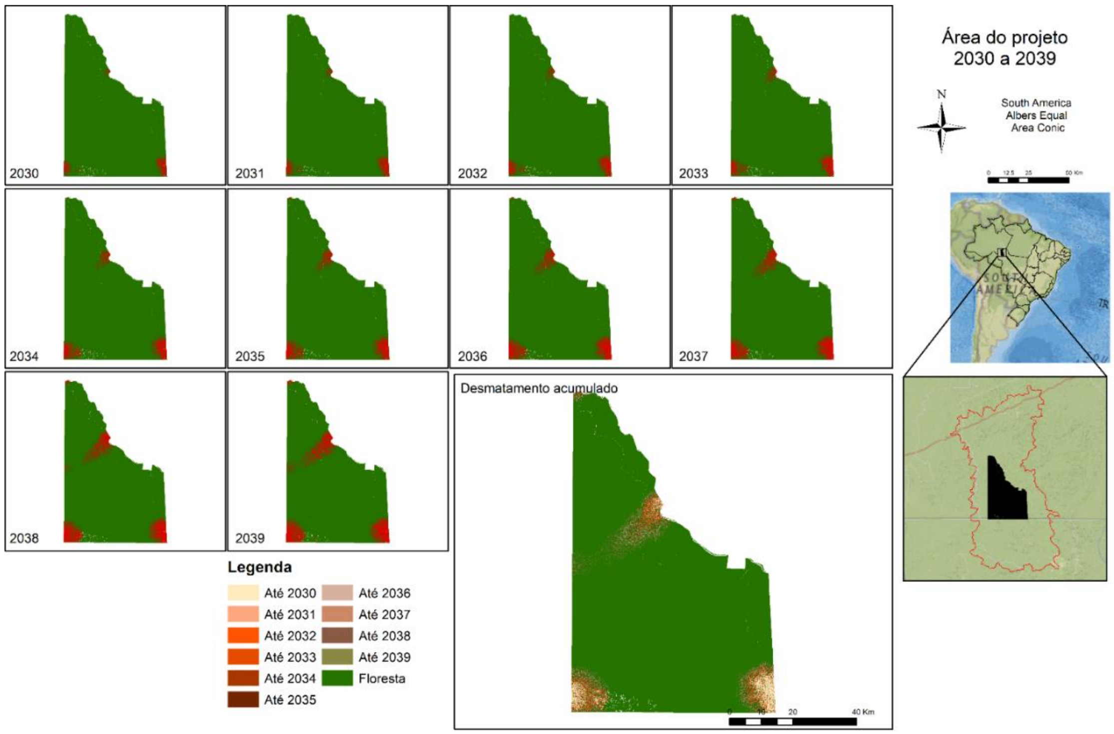


Figure 76 Deforestation projection in the project area, year by year

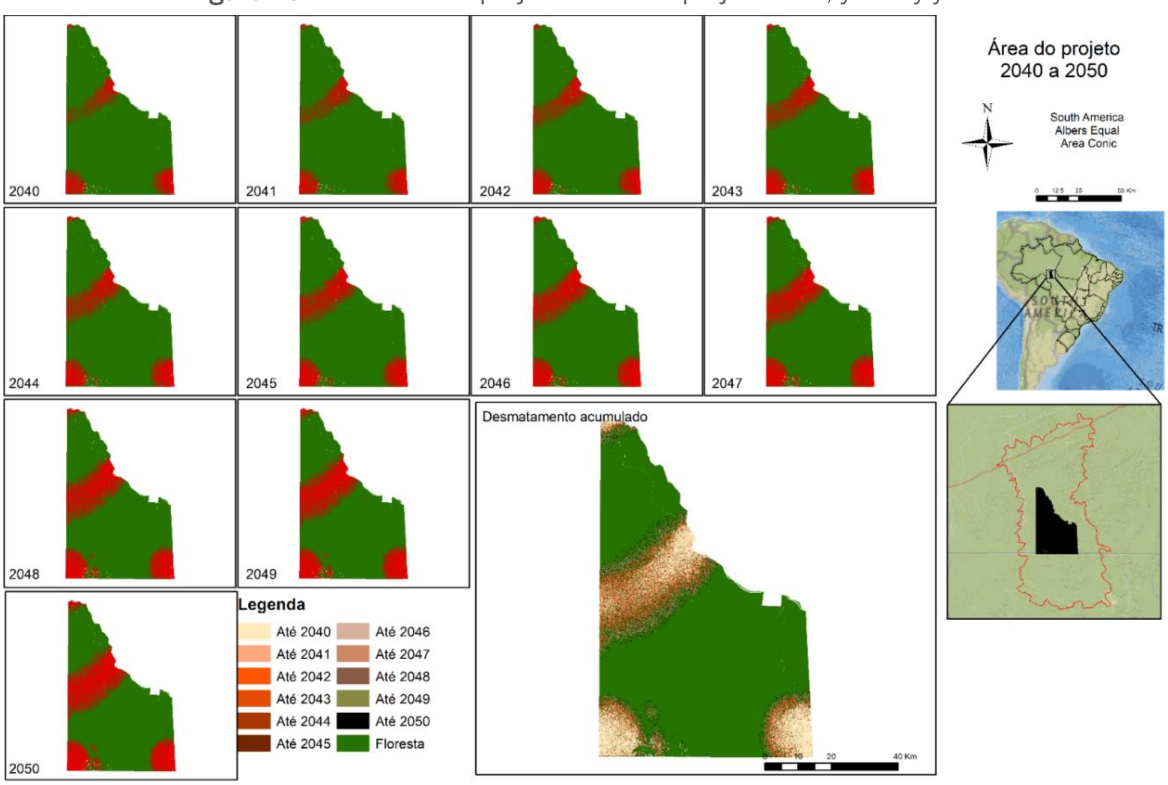


Figure 77 Deforestation projection in the leakage belt, year by year

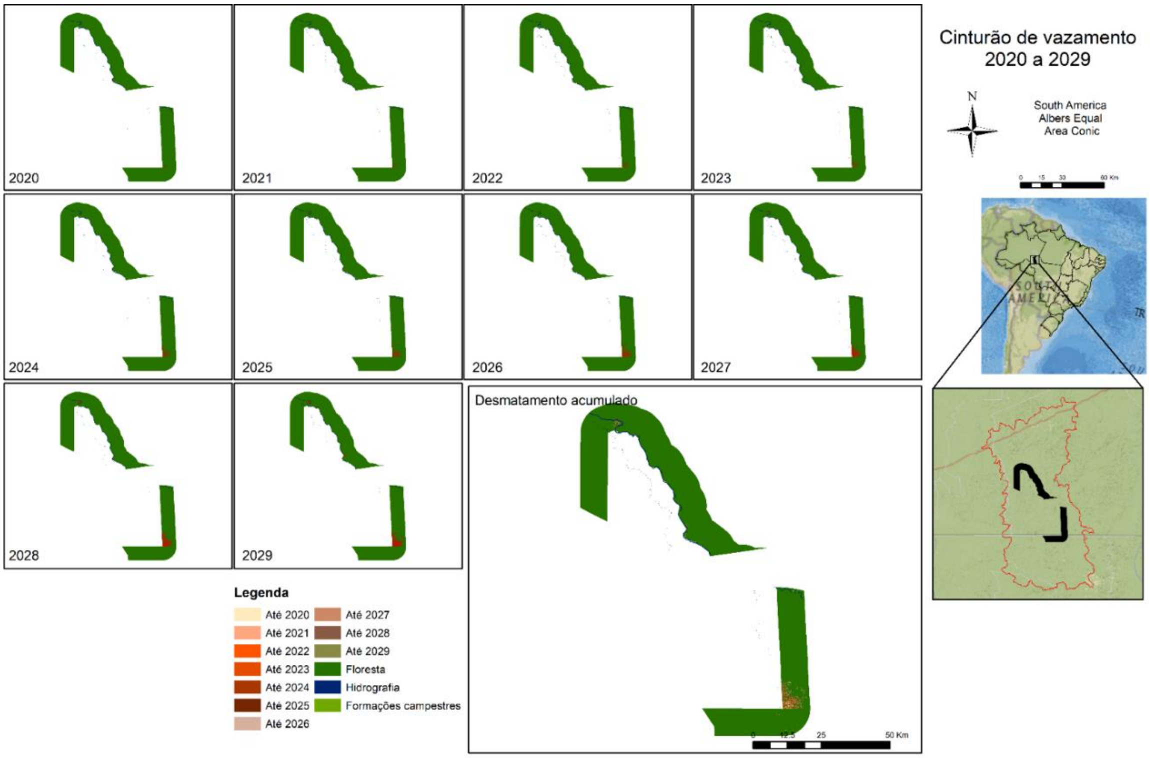


Figure 78 Deforestation projection in the leakage belt, year by year

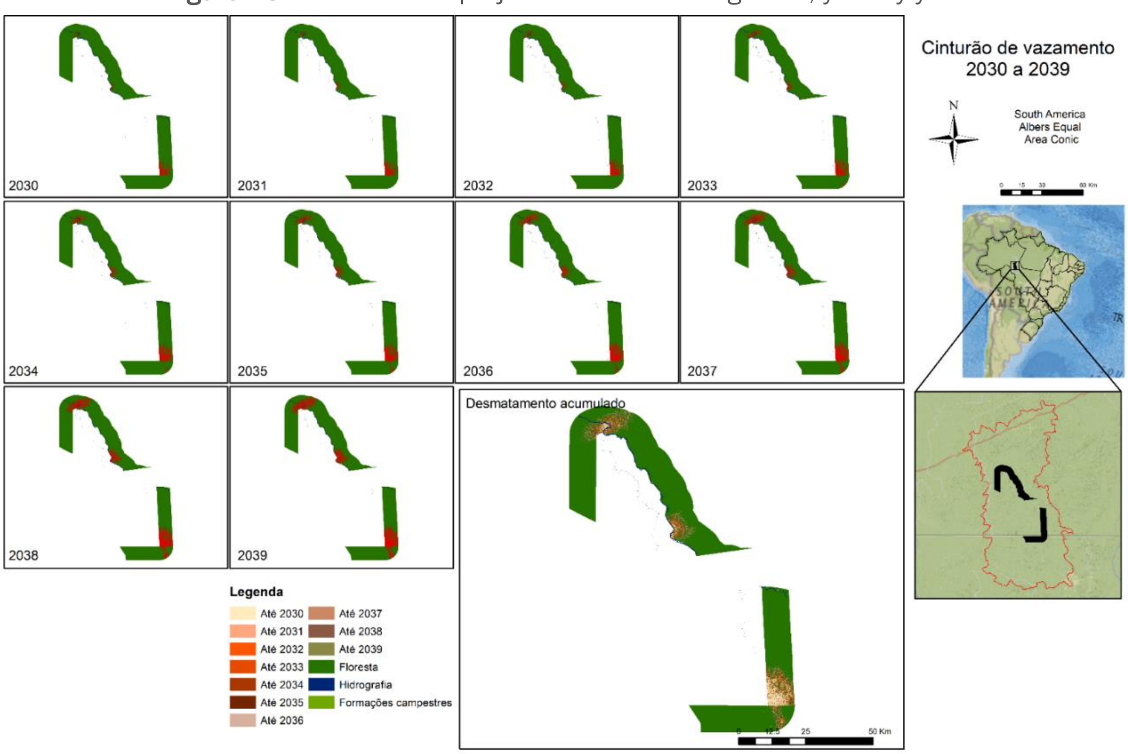
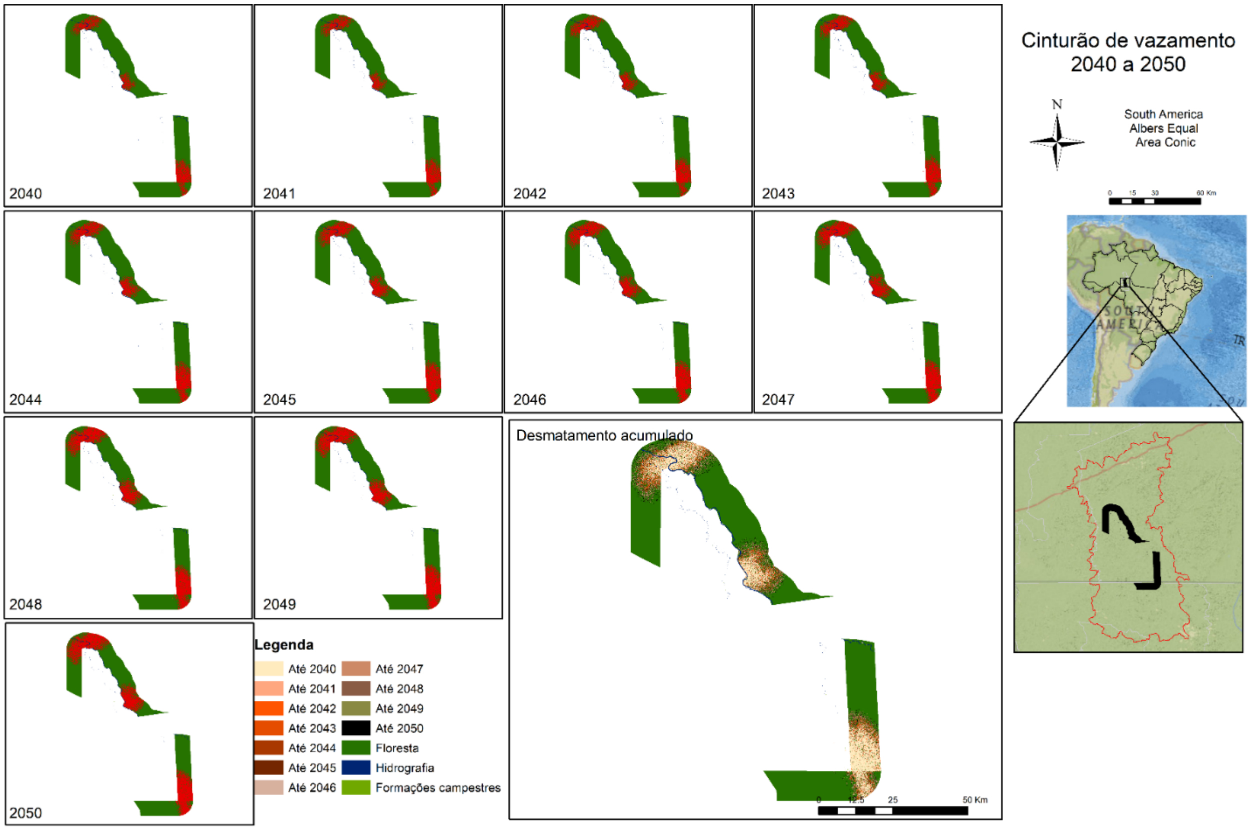


Figure 79 Deforestation projection in the leakage belt, year by year



Definition of the Land-Use and Land-Cover Change Component of the Baseline

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

In accordance with analysis achieved through the procedure described above, the quantity of baseline LU/LC-change was projected throughout the 1st baseline period, in the reference region, project area and leakage belt in each stratum. This is in accordance with step 5 of the methodology "Definition of the land-use and land-cover change component of the baseline"

Calculation of baseline activity data per forest class

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

The LU/LC-change within the project crediting period, caused by baseline deforestation consisted of initial forest classes being converted to the final LU/LC class of 'non-forest'. The number of hectares deforested in each forest class, within the reference region, project area and leakage belt are found in tables below.

Table 34 Annual areas deforested per forest class icl within the reference region in the baseline case (baseline activity data per forest class)

Area deforested per florest class *icl* within the reference region							Total baseline deforestation in the reference region	
IDicl	**1**	**2**	**3**	**4**	**5**	**6**	**annual ABSLRRt (ha)**	**ABSLRR cumulative (ha)**
Name	**Dense Alluvial Tropical Rainforest**	**Dense Submontane Tropical Rainforest**	**Open Submontane Tropical Rainforest**	**Dense Lowland Tropical Rainforest**	**Savannah Forest**	**Pioneer vegetation in areas with riverine influence**		
Project year *t*	**ha**	**ha**	**ha**	**ha**	**ha**	**ha**		
2020	266.85	7,029.51	16,976.71	232.68	103.00	13.01	24,621.76	24,621.76
2021	217.11	8,119.60	17,098.55	186.14	100.54	18.96	25,740.90	50,362.66
2022	210.96	8,893.71	17,415.85	178.39	113.30	11.64	26,823.85	77,186.51
2023	212.57	9,767.35	17,580.76	187.89	104.47	16.36	27,869.40	105,055.91
2024	222.10	10,360.34	17,967.40	189.98	111.57	24.67	28,876.06	133,931.97
2025	307.88	10,995.68	18,179.13	238.10	103.81	18.23	29,842.83	163,774.80
2026	303.65	11,669.37	18,379.48	276.72	96.80	42.72	30,768.74	194,543.54
2027	324.09	12,350.59	18,554.11	309.20	84.57	30.26	31,652.82	226,196.36
2028	365.18	13,045.62	18,610.70	342.95	91.40	38.39	32,494.24	258,690.60
2029	397.97	13,673.75	18,736.55	337.40	87.98	58.53	33,292.18	291,982.78
2030	419.89	14,382.15	18,784.44	351.42	54.65	53.53	34,046.08	326,028.86
2031	504.22	15,125.62	18,609.99	396.85	60.62	58.03	34,755.33	360,784.19
2032	535.28	16,048.08	18,342.91	397.84	47.07	48.04	35,419.22	396,203.41
2033	566.10	16,710.24	18,225.87	423.64	61.23	50.71	36,037.79	432,241.20
2034	636.01	17,433.65	18,014.25	420.32	52.58	53.84	36,610.65	468,851.85
2035	700.67	18,200.96	17,747.48	395.02	46.23	47.23	37,137.59	505,989.44
2036	694.98	18,923.08	17,499.04	397.70	52.89	50.69	37,618.38	543,607.82
2037	804.40	19,644.34	17,114.52	381.29	59.20	49.61	38,053.36	581,661.18
2038	810.98	20,523.80	16,661.01	356.82	48.88	40.84	38,442.33	620,103.51
2039	827.26	21,157.46	16,360.39	353.86	45.11	41.52	38,785.60	658,889.11
2040	793.21	21,766.34	16,116.70	301.51	50.00	55.80	39,083.56	697,972.67
2041	813.94	22,301.47	15,807.37	312.20	56.15	45.45	39,336.58	737,309.25
2042	774.61	23,059.17	15,261.06	310.63	75.09	64.37	39,544.93	776,854.18
2043	779.22	23,558.70	14,892.70	363.46	72.22	43.03	39,709.33	816,563.51
2044	779.59	23,951.28	14,648.04	340.74	57.81	52.96	39,830.42	856,393.93
2045	807.74	24,543.20	14,008.74	422.52	89.54	36.95	39,908.69	896,302.62
2046	754.98	24,825.99	13,769.26	489.65	77.30	27.96	39,945.14	936,247.76
2047	803.93	25,268.53	13,165.23	586.61	81.23	34.94	39,940.47	976,188.23
2048	796.84	25,551.38	12,768.97	649.34	92.76	36.37	39,895.66	1,016,083.89
2049	771.04	25,867.86	12,303.76	738.99	102.95	26.90	39,811.50	1,055,895.39
2050	718.88	25,908.72	12,116.38	822.23	98.67	24.30	39,689.18	1,095,584.57

Table 35 Annual areas deforested per forest class icl within the project area in the baseline case (baseline activity data per forest class)

Area deforested per florest class icl within the project area				Total baseline deforestation in the project area	
IDicl	1	2	3	annual ABSLPAt (ha)	ABSLPA cumulative (ha)
Name	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest		
Project year *t*	ha	ha	ha		
2020	0.00	38.58	19.28	57.86	57.86
2021	0.00	120.97	26.47	147.44	205.30
2022	0.00	169.96	67.21	237.17	442.47
2023	0.00	222.13	122.09	344.22	786.69
2024	0.00	283.13	167.97	451.10	1,237.79
2025	0.00	317.78	196.75	514.53	1,752.32
2026	0.00	345.22	245.12	590.34	2,342.66
2027	0.00	404.86	288.77	693.63	3,036.29
2028	0.00	506.67	321.35	828.02	3,864.31
2029	0.00	591.17	365.64	956.81	4,821.12
2030	0.00	716.75	444.41	1,161.16	5,982.28
2031	2.46	964.21	507.46	1,474.13	7,456.41
2032	20.06	1,155.30	583.06	1,758.42	9,214.83
2033	55.04	1,390.56	645.58	2,091.18	11,306.01
2034	78.59	1,586.05	759.20	2,423.84	13,729.85
2035	89.90	1,830.49	773.98	2,694.37	16,424.22
2036	117.69	2,023.09	821.17	2,961.95	19,386.17
2037	157.69	2,370.72	869.16	3,397.57	22,783.74
2038	157.59	2,858.90	845.66	3,862.15	26,645.89
2039	166.47	3,677.86	899.60	4,743.93	31,389.82
2040	159.05	4,122.46	1,026.42	5,307.93	36,697.75
2041	173.88	4,570.18	1,078.32	5,822.38	42,520.13
2042	164.27	4,818.58	1,097.45	6,080.30	48,600.43
2043	179.25	5,243.12	1,035.54	6,457.91	55,058.34
2044	164.65	5,392.31	1,054.27	6,611.23	61,669.57
2045	157.85	5,644.53	1,039.44	6,841.82	68,511.39
2046	154.86	5,802.83	1,016.02	6,973.71	75,485.10
2047	211.11	6,023.08	1,111.66	7,345.85	82,830.95
2048	215.61	6,266.17	1,024.80	7,506.58	90,337.53
2049	185.64	6,381.75	1,015.34	7,582.73	97,920.26
2050	193.18	6,327.19	1,100.32	7,620.69	105,540.95

Table 36 Annual areas deforested per forest class icl within the leakage belt in the baseline case (baseline activity data per forest class)

Leakage Belt					
Area deforested per florest class icl within the leakage belt				Total baseline deforestation in the leakage belt	
IDicl	1	2	3	annual ABSLLKt (ha)	ABSLLK cumulative (ha)
Name	Dense Alluvial Tropical Rainforest	Dense Submontane Tropical Rainforest	Open Submontane Tropical Rainforest		
Project year *t*	ha	ha	ha		
2020	0.08	92.39	0.06	92.53	92.53
2021	0.00	177.48	0.27	177.75	270.28
2022	0.00	218.70	0.14	218.84	489.12
2023	0.59	312.67	0.00	313.26	802.38
2024	1.56	310.43	0.04	312.03	1,114.41
2025	3.51	380.32	0.00	383.83	1,498.24
2026	9.73	375.13	0.25	385.11	1,883.35
2027	17.08	402.12	0.51	419.71	2,303.06
2028	12.36	514.55	2.49	529.40	2,832.46
2029	33.03	604.69	3.04	640.76	3,473.22
2030	37.56	778.63	12.13	828.32	4,301.54
2031	85.09	964.71	21.97	1,071.77	5,373.31
2032	104.81	1,104.93	30.20	1,239.94	6,613.25
2033	128.19	1,349.04	38.65	1,515.88	8,129.13
2034	146.12	1,522.69	75.22	1,744.03	9,873.16
2035	170.27	1,735.54	137.68	2,043.49	11,916.65
2036	164.35	1,972.48	217.60	2,354.43	14,271.08
2037	157.01	1,965.26	280.21	2,402.48	16,673.56
2038	173.83	2,072.77	306.02	2,552.62	19,226.18
2039	185.38	2,067.50	372.80	2,625.68	21,851.86
2040	153.89	2,183.21	453.33	2,790.43	24,642.29
2041	162.52	2,122.69	511.35	2,796.56	27,438.85
2042	145.59	2,129.19	605.20	2,879.98	30,318.83
2043	138.78	2,152.44	688.03	2,979.25	33,298.08
2044	143.50	2,252.04	824.04	3,219.58	36,517.66
2045	104.41	2,325.92	889.22	3,319.55	39,837.21
2046	107.29	2,299.88	952.46	3,359.63	43,196.84
2047	154.92	2,398.91	964.82	3,518.65	46,715.49
2048	145.27	2,536.20	985.06	3,666.53	50,382.02
2049	166.71	2,535.64	999.35	3,701.70	54,083.72
2050	142.52	2,566.81	1,041.32	3,750.65	57,834.37

Calculation of baseline activity data per post-deforestation forest class

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

According to the methodology VM00145, the Historical LU/LC-change (Method 1) was used to calculate the LU/LC class that will replace the forest cover in the baseline scenario. The table below shows the area of Zone 1 that encompasses areas of possible post-deforestation LU/LC-class within the reference region.

Table 37 Zone of the reference region encompassing potential post-deforestation LU/LC class.

<table>
<tr><th colspan="2" rowspan="4">Zone</th><th colspan="2">Name</th><th colspan="2" rowspan="3">Total area of each zone</th></tr>
<tr><th colspan="2">Non-forest</th></tr>
<tr><th>ID fcl</th><th>1</th></tr>
<tr><th>Area</th><th>% of zone</th><th>Area</th><th>% of zone</th></tr>
<tr><th>IDz</th><th>Name</th><th>ha</th><th>%</th><th>ha</th><th>%</th></tr>
<tr><td>1</td><td>Reference region</td><td>1,095,584.57</td><td>37%</td><td>1,095,584.57</td><td>37%</td></tr>
<tr><td colspan="2">Total area of each class fcl</td><td>1,095,584.57</td><td>37%</td><td>1,095,584.57</td><td>37%</td></tr>
</table>

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

Table 38 Annual areas deforested in each zone within the reference region in the baseline case (baseline activity data per zone)

Area established after deforestation per zone within the reference region		Total baseline deforestation in the reference region	
ID_{fcl}	1	$ABSLRR_t$	ABSLRR
Name	No forest	annual	cumulative
Project year	ha	ha	ha
2020	24,621.76	24,621.76	24,621.76
2021	25,740.90	25,740.90	50,362.66
2022	26,823.85	26,823.85	77,186.51
2023	27,869.40	27,869.40	105,055.91
2024	28,876.06	28,876.06	133,931.97
2025	29,842.83	29,842.83	163,774.80
2026	30,768.74	30,768.74	194,543.54
2027	31,652.82	31,652.82	226,196.36
2028	32,494.24	32,494.24	258,690.60
2029	33,292.18	33,292.18	291,982.78
2030	34,046.08	34,046.08	326,028.86
2031	34,755.33	34,755.33	360,784.19
2032	35,419.22	35,419.22	396,203.41
2033	36,037.79	36,037.79	432,241.20
2034	36,610.65	36,610.65	468,851.85
2035	37,137.59	37,137.59	505,989.44
2036	37,618.38	37,618.38	543,607.82
2037	38,053.36	38,053.36	581,661.18
2038	38,442.33	38,442.33	620,103.51
2039	38,785.60	38,785.60	658,889.11
2040	39,083.56	39,083.56	697,972.67
2041	39,336.58	39,336.58	737,309.25
2042	39,544.93	39,544.93	776,854.18
2043	39,709.33	39,709.33	816,563.51
2044	39,830.42	39,830.42	856,393.93
2045	39,908.69	39,908.69	896,302.62
2046	39,945.14	39,945.14	936,247.76
2047	39,940.47	39,940.47	976,188.23
2048	39,895.66	39,895.66	1,016,083.89
2049	39,811.50	39,811.50	1,055,895.39
2050	39,689.18	39,689.18	1,095,584.57

Table 39 Annual areas deforested in each zone within the project area in the baseline case (baseline activity data per zone)

Area established after deforestation per zone within the project area		Total baseline deforestation in the project area	
ID_{fcl}	1	$ABSLPA_t$	ABSLPA
Name	No forest	annual	cumulative
Project year	ha	ha	ha
2020	57.86	57.86	57.86
2021	147.44	147.44	205.30
2022	237.17	237.17	442.47
2023	344.22	344.22	786.69
2024	451.10	451.10	1,237.79
2025	514.53	514.53	1,752.32
2026	590.34	590.34	2,342.66
2027	693.63	693.63	3,036.29
2028	828.02	828.02	3,864.31
2029	956.81	956.81	4,821.12
2030	1,161.16	1,161.16	5,982.28
2031	1,474.13	1,474.13	7,456.41
2032	1,758.42	1,758.42	9,214.83
2033	2,091.18	2,091.18	11,306.01
2034	2,423.84	2,423.84	13,729.85
2035	2,694.37	2,694.37	16,424.22
2036	2,961.95	2,961.95	19,386.17
2037	3,397.57	3,397.57	22,783.74
2038	3,862.15	3,862.15	26,645.89
2039	4,743.93	4,743.93	31,389.82
2040	5,307.93	5,307.93	36,697.75
2041	5,822.38	5,822.38	42,520.13
2042	6,080.30	6,080.30	48,600.43
2043	6,457.91	6,457.91	55,058.34
2044	6,611.23	6,611.23	61,669.57
2045	6,841.82	6,841.82	68,511.39
2046	6,973.71	6,973.71	75,485.10
2047	7,345.85	7,345.85	82,830.95
2048	7,506.58	7,506.58	90,337.53
2049	7,582.73	7,582.73	97,920.26
2050	7,620.69	7,620.69	105,540.95

Table 40 Annual areas deforested in each zone within the leakage belt in the baseline case (baseline activity data per zone)

Leakage Belt			
Area established after deforestation per zone within the leakage belt		Total baseline deforestation in the leakage belt	
ID_{fcl}	1	$ABSLLK_t$	$ABSLLK$
Name	Non forest	annual	cumulative
Project year	ha	ha	ha
2020	92.53	92.53	92.53
2021	177.75	177.75	270.28
2022	218.84	218.84	489.12
2023	313.26	313.26	802.38
2024	312.03	312.03	1,114.41
2025	383.83	383.83	1,498.24
2026	385.11	385.11	1,883.35
2027	419.71	419.71	2,303.06
2028	529.40	529.40	2,832.46
2029	640.76	640.76	3,473.22
2030	828.32	828.32	4,301.54
2031	1,071.77	1,071.77	5,373.31
2032	1,239.94	1,239.94	6,613.25
2033	1,515.88	1,515.88	8,129.13
2034	1,744.03	1,744.03	9,873.16
2035	2,043.49	2,043.49	11,916.65
2036	2,354.43	2,354.43	14,271.08
2037	2,402.48	2,402.48	16,673.56
2038	2,552.62	2,552.62	19,226.18
2039	2,625.68	2,625.68	21,851.86
2040	2,790.43	2,790.43	24,642.29
2041	2,796.56	2,796.56	27,438.85
2042	2,879.98	2,879.98	30,318.83
2043	2,979.25	2,979.25	33,298.08
2044	3,219.58	3,219.58	36,517.66
2045	3,319.55	3,319.55	39,837.21
2046	3,359.63	3,359.63	43,196.84
2047	3,518.65	3,518.65	46,715.49
2048	3,666.53	3,666.53	50,382.02
2049	3,701.70	3,701.70	54,083.72
2050	3,750.65	3,750.65	57,834.37

3.5 Additionality

For the purpose of the present analysis, the VT0001 VCS Tool for the demonstration and assessment of additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) project activities, version 3.0[172] was applied below for Boa Fé REDD project activity.

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

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

As described in section above of the present VCS PD, the considered alternatives to the project activity are:

- Timber production
- Cattle raising
- Continuation of pre-project land use

These activities are considered credible alternatives, as shown by official data[173]. Cattle raising is an important economic activity in Brazil, especially in the south of Amazon, where the project is located, being an expressive deforestation agent. It is important to note that firewood harvesting is also an important economic product within the reference region, mainly in Novo Aripuanã, representing more than 70% of the total extraction production value in this municipality. However, timber logging (roundwood) showed the highest production values within the reference region during the 2010-2019 period. Although wood harvesting represented by higher timber production was concentrated in the municipalities of Novo Aripuanã and Colniza, copaíba oil and resin from the trees of the genus Copaifera were predominant in Apuí.

The pre-project land use is the maintenance of the area as it is, without any activity and actions for conservation. Although no economic activities are carried out in the pre-project scenario, the area is exposed to invasions and illegal deforestation, as detailed in section 3.4.

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

Timber production:

Timber production may be authorized in the Amazon as long as the property has an approved Sustainable Forest Management Plan and an Exploration Authorization (AUTEX) issued by the Brazilian Environmental Agency. Furthermore, the land shall follow the Brazilian Federal Law 12,651/2012, that classifies at least 80% of the property located in the Amazon biome as Legal Reserve, which restricts the activities that

[172] Available in: <https://verra.org/wp-content/uploads/2017/11/VT0001v3.0.pdf> Last visited on 11/03/2021

[173] Sources: Instituto Brasileiro de Geografia e Estatística (IBGE) - IBGE Cidades - Censo Agropecuário. Available at <https://cidades.ibge.gov.br/brasil/am/novo-aripuana/pesquisa/24/76693> Last visited on 11/03/2021

could be developed in the area. In addition, there are other mandatory restriction regulations that limits the legal exploring area, such as the Permanent Preservation Areas.

The landowner of the project area has no timber production in the area but demonstrated interest in issuing an authorization in the absence of the present project activity.

However, Brazilian legislation and other legal restrictions are not enough to prevent the illegal deforestation of the Brazilian Amazon Rainforest, which is a common practice in the country. According to INPE[174], the estimated deforestation rate (complete removal of primary forest cover by clear cutting, regardless of the future use of these areas) between August 2018 and July 2019 was 9,762 km^2, an increase of 29.54% over the rate calculated during the previous annual period. The State of Amazonas was the third State with the highest deforestation rate within the biome, with 14.56% of the total.

IPAM estimates that 44% of the deforestation in the period was illegal, registered in non-designated lands or protected areas[175].

Thus, the Project area is exposed to legal and illegal timber activity, which is a common practice in the region; moreover, the related environmental legislation are systematically not enforced.

Cattle raising:

Cattle raising in the Amazon Forest is legal as long as the owner follows the 80% Legal Reserve and Permanent Preservation Areas restriction described in the Brazilian legislation, as explained above. The landowner must also provide a deforestation authorization for clearing the area for pasture. Therefore, livestock in the region is legalized.

According to IPAM[176], rural credit is the main funding for the Brazilian livestock production and is essential in the transition to sustainable land use, but in the Amazon area, it is used for conventional practices and activities, associated with deforestation. Despite the fact that, since 2014, the Brazilian Central Bank demands an assessment of socio-environmental risks from banks to approve public financing[177], and the existence of credit and financing opportunities for sustainable practices and producers in compliance with environmental laws, conventional livestock still represents 20% of the conversion of forest coverage to pasture and other agricultural crops[178]. These practices are still used mainly due to its low implementation costs and maintenance, along with non-intensive use of labor, and as long as it's held in

[174] Available at <http://www.inpe.br/noticias/noticia.php?Cod_Noticia=5294> Last visited on 11/03/2021

[175] Available at <https://ipam.org.br/35-do-desmatamento-na-amazonia-e-grilagem-indica-analise-do-ipam/> Last visited on 11/03/2021

[176] Available at < https://ipam.org.br/wp-content/uploads/2020/01/Fluxos-financeiros-pecu%C3%A1ria.pdf> Last visited on 11/03/2021

[177] Available at < https://www.bcb.gov.br/pre/normativos/res/2014/pdf/res_4327_v1_O.pdf> Last visited on 11/03/2021

[178] Available at <https://idesam.org/viabilidade-pecuaria-sustentavel-leite/> Last visited on 11/03/2021

areas with legal authorization, are legal, although inefficient, with low productivity and high environmental impact[179].

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

Thus, all the land uses listed under sub-step 1a are retained in 1b, being either in accordance with the law or a widespread illegal practice in respect to which the law is not enforced.

Outcome of substep 1b:

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

- Timber extraction;
- Cattle raising;
- No activities.

Sub-step 1c. Selection of the baseline scenario
The area held no activity in the baseline scenario. There are no economic activities implemented in the area, nor exploration of non-timber forest products (NTFPs) or other land use activities.

Therefore Therefore, the difficulty in monitoring the area makes it exposed to invasions and illegal deforestation, without any control of the activities carried out within the area.

As described in section above, between 2010 and 2019 the deforestation in the reference region was of 29,497.80 ha, with an average rate of 2,949.78 ha/year.

STEP 2. Investment analysis

Sub-step 2a. Determine appropriate analysis method

The present VCS AFOLU project generates no financial or economic benefits other than VCS related income, then it was applied the simple cost analysis (Option I).

Sub-step 2b. Simple Cost Analysis
The simple cost analysis was determined as the appropriate analysis method once the Project does not generate any financial or economic benefits other than VCUs related income. There is no for-profit sale of any products and there is no NTFPs or timber production in the area.

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

[179] Available at <https://idesam.org/publicacao/viabilidade-pecuaria-leite-apui.pdf> Last visited on 11/03/2021

Table 41 Estimated annual costs for the REDD Project[180]

	Estimated Annual Costs of Conservation (R$)
3 employees	R$ 108,000.00
Equipment and vehicles, including maintenance costs (1 boat and 3 motorbikes)	R$ 30,000.00
Accountancy and tax costs of property	R$ 20,000.00
Expenses related to forest conservation and property inspection / control	R$ 80,000.00
Proposed socio-environmental activities	R$ 14,640.00
TOTAL	**R$ 252,640.00**

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

STEP 4. Common practice analysis

Given that no financial benefits were found in the results of the simple cost analysis, the following step according to the VCS additionality tool is the common practice analysis.

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

In the Verra Registry[181], there are 25 REDD projects registered in Brazil, four of them located in the State of Amazonas. Despite being located in Novo Aripuanã, the "Juma REDD+ Project[182]" is a project in partnership with the Government of the State of Amazonas, characterized by the creation and implementation of a State-owned Sustainable Development Reserve, a type of Conservation Unit, thus, a public area.

180 Costs were estimated based on the quotes provided by the respective service providers, according to the available cashflow.

181 Available in: <https://registry.verra.org/> Last visited on 11/03/2021

182 Available in: <https://registry.verra.org/app/projectDetail/CCB/1596> Last visited on 11/03/2021

The "Amazon Rio REDD+ IFM Project"[183] involves the cessation of a legally authorized logging plan that was operational since 1999, and the implementation of a Management Plan in the area.

The Agrocortex REDD Project is an AUD project with a Sustainable Management Plan to maintain the logging activity, establishing a barrier against the advancement of illegal deforestation.

Lastly, the Yellow Ipê Grouped REDD Project is a grouped project which the primary objective is to avoid unplanned deforestation (AUD) of a specific region within the municipalities of Novo Aripuanã and Borba.

In conclusion, the development of a carbon project is not a common practice in the area, and those that exist have essential distinctions between them and the present VCS AFOLU activity.

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

- **Private Reserve of Natural Heritage (RPPN):** it is a category of conservation unit created voluntarily by the landowner. When the area is categorized as RPPN, the owner is committed to nature conservation, without land expropriation. The benefits of the private reserve are preference in the analysis of applications to acquire rural credit, tax benefits and the possibility of cooperation with private and public entities in the protection, and management of the land. In the Amazonas State, there are 14 registered RPPNs[184]. None of them is located in Novo Aripuanã, and they are much smaller properties compared to the project area.
- **Payment for Environmental Services (PSA):** PSA is a voluntary transaction, with the main objective of providing economic incentives to owners of rural or urban properties that have natural areas capable of providing environmental services. Many law projects are in discussion in Brazil's National Congress, and some federal laws mention the service, but currently there is no valid regulation in the entire country. The Amazon State created, with a state decree, in 2017, the Bolsa Floresta, a payment from the government to benefit traditional communities that live in State Conservation Units in Amazonas, to encourage the conservation and maintenance of the forest[185]. This program, however, does not benefit landowners of areas outside these protected areas. The search for investment and payment for these areas is up to the owners, usually being agreed with banks or private companies, without government participation.

For the aforementioned reasons of the essential difference between the present project and similar projects in the area, the proposed VCS AFOLU project activity is not the baseline scenario, and hence it is additional.

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183 Available in: <https://registry.verra.org/app/projectDetail/CCB/1147> Last visited on 11/03/2021

184 Available in: <http://sistemas.icmbio.gov.br/simrppn/publico/rppn/AM/> Last visited on 11/03/2021

185 More information available in: https://www.amazonia.org.br/wp-content/uploads/2012/07/Marco-Regulatorio-PSA.pdf

3.6 Methodology Deviations

This project activity does not apply any methodology deviations.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5 MONITORING

APPENDIX