THE JUMA SUSTAINABLE DEVELOPMENT RESERVE PROJECT: REDUCING GREENHOUSE GAS EMISSIONS FROM DEFORESTATION IN THE STATE OF AMAZONAS, BRAZIL

FUNDAÇÃO AMAZONAS SUSTENTÁVEL

Document Prepared By FAS and C$_3$Floresta

victor.salviati@fas-amazonas.org and c3floresta@gmail.com

Project Title	The Juma Sustainable Development Reserve Project: Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation *plus* forest management in the State of Amazonas, Brazil
Version	1.0
Date of Issue	22 November 2019
Prepared By	Fundação Amazonas Sustentável - FAS and C3-Floresta, Meio Ambiente & Energia
Contact	Rua Álvaro Braga, 351 - Parque 10 de Novembro - CEP 69.055-660, Manaus (AM), + 55 92 4009-8900, victor.salviati@fas-amazonas.org, www.fas-amazonas.org

CONTENTS

1 PROJECT DETAILS

1.1 Summary Description of the Project

The Juma Sustainable Development Reserve Project for Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation *plus* forest management (“Juma REDD+ Project”) aims to address deforestation and its resulting emission of greenhouse gases (GHG) in an area of the State of Amazonas, which is under great land use pressure. Its implementation is part of a wide strategy planned and initiated in 2003 by the current Government of the State of Amazonas to halt deforestation and promote sustainable development in Amazonas, based on giving value to the environmental services provided by its standing forests. (BRAGA & VIANA et al., 2003; AMAZONAS, 2002).

The region in which the Novo Aripuanã municipality is located is in an area under high risk for deforestation. Under the “business as usual” scenario, the paving of large highways (BR-319 and AM-174) will result in the loss of large areas of forest in the next decades. The objectives of creating the reserve were to protect forests with high conservation value. The reserve seeks to protect species in risk of extinction while also preserving the quality of life of the hundreds of families that live in these areas. The main activities are:

1. **Strengthening of environmental monitoring and control**
2. **Income Generation Through the Promotion of Sustainable Businesses and Entrepreneurship** [1]
3. **Community Development, Social Protection, Scientific Research and Education**[2]
4. **Cash reward for Environmental Services (“Bolsa Floresta” Program)**

The Juma Reserve RED Project involves the establishment of a Protected Area for Sustainable Use (Unidade de Conservação de Uso Sustentável) in a region that would be almost completely deforested under the “business as usual” scenario if the current land use practices in the Amazon region continue. The Juma Sustainable Development Reserve (SDR) was created, in 2006, covering 581,655.6 hectares of Amazonian forest located alongside the BR-319 highway and crossed by the AM-174 highway. Its creation and effective implementation was only possible

---

[1] Marginalized communities are more likely to participate in the illegal exploitation of natural resources. The lack of training in natural resources management results in the use of destructive practices that produce low quality products with limited market demand.

[2] Because the influence and deforestation pressure normally comes from outside the protected areas, it is essential to help the communities living inside these areas, especially helping the future generations of decision makers understand the importance of Forest conservation

due to the perspective of the Government of the State of Amazonas' plan to create a financial mechanism for generating a financial compensation from activities reducing emissions from deforestation and degradation *plus* forest management (REDD+). The resources raised from the sale of certified emission reductions will permit the State Government to implement all of the measures necessary to control and monitor deforestation within the project site and its surroundings, enforce the law, and improve the welfare of local communities.

Based on the baseline scenario for the project area, the project expects to prevent the deforestation of about 6,900 hectares of tropical forests that would release **3,407,566 tons of CO_2** into the atmosphere, in the first 10 years **or 340,757 tCO2e/year**

1.2 Sectoral Scope and Project Type

The Juma REDD+ Project is within the Agriculture, Forestry and Other Land Use (AFOLU) sectoral scope and consist in a Reduced Emissions from Deforestation and Degradation (REDD) project, under the category of Avoiding Unplanned Deforestation and/or Degradation (AUDD).

It is not a grouped project.

1.3 Project Eligibility

According to the eligible AFOLU project categories stated in VCS v.4, REDD is an eligible category, as follow: "*Eligible REDD activities are those that reduce net GHG emissions by reducing deforestation and/or degradation of forests. In addition, the project area shall meet an internationally accepted definition of forest, such as those based on UNFCCC hostcountry thresholds or FAO definitions*[3]*, and shall qualify as forest for a minimum of 10 years before the project start date*".

All the above-mentioned criteria are meet by the Juma RED project, turning this eligible under VCS v.4. for additional information, please refer to section 1.11 and 1.13, below.

1.4 Project Design

The Juma REDD+ project is a single project that consists of several activities in a specific area, the Juma SDR, as presented in section 3.3.

Eligibility Criteria

Not applicable.

1.5 Project Proponent

Organization name	Fundação Amazonas Sustentável - FAS

[3] in Brazil a forest is defined as an area of land greater than 1 hectare, with more than 30% canopy cover and a minimum tree height of 5 metres.

Contact person	Victor Salviati (FAS)
Title	Institutional Development & Innovation Director at FAS
Address	Rua Álvaro Braga, 351 - Parque 10 de Novembro - CEP 69.055-660, Manaus (AM)
Telephone	+ 55 92 4009-8900
Email	victor.salviati@fas-amazonas.org

1.6 Other Entities Involved in the Project

Organization name	Amazonas State Secretary of Environment (SEMA)
Role in the project	Supervising programs and action within the reserve
Contact person	Luis Henrique Piva
Title	Deputy Secretary of Enviroment
Address	Avenida Mário Ipiranga Monteiro, 3280 Parque Dez – Manaus – CEP: 69050-030.
Telephone	+55 92 3659-1820/1822/1828
Email	

Organization name	C_3-Floresta, Meio Ambiente & Energia
Role in the project	VCS Project Document and Monitoring Report development
Contact person	Diego Serrano
Title	Director
Address	Alameda Rio Claro, 137, conj. 22, Bela Vista, São Paulo - SP, CEP: 01332-010
Telephone	+55 75 99828-3988 and +55 11 3288-7959
Email	c3floresta@gmail.com

1.7 Ownership

The Sustainable Development Reserves (SDRs) are public domain areas that allow living with traditional populations, however, the particular areas included in their boundaries should be expropriated when necessary. The use of areas occupied by traditional populations is regulated by a concession agreement and a commitment term, which must be in accordance with the unit's Management Plan.

They are managed by a Deliberative Council that is chaired by the responsible government institutions (State body in the case of state-created SDR and ICMBio in federal SDR) and composed by representatives of public institutions, civil society organizations and the traditional population residents in the area.

Once the REDD project area is within a SDR, the land tenure is public (State of Amazonas), while the land use is done by the traditional population and regulated by a concession agreement and a commitment term, in accordance with the unit's Management Plan (AMAZONAS, 2010). According to the VCS Standard v.4, the project ownership and right of use fits to the definition stated in item 1 of section 3.6.1: “A right of use arising or granted under statute, regulation or decree by a competent authority” it is also in accordance to the definition of **Project Ownership** stated in the VCS document *Program Definitions* v.4: “The legal right to control and operate the project activities”.

Despite of the Juma Reserve allows private areas inside its boundaries, it was verified during the socio-environmental survey prior to the Reserve creation, that there are no people living within these private lands and only 15.038 hectares (less than 3% of the project area) are being claimed as private property.

A full analysis of the documents related to these land claims will permit the State Government to determine which of these title claims are legal - and should be recognized - and which are not. This analysis include a detailed review of the relevant documents at the Land Tenure Secretary (SPF), the National Institute for Colonization and Land Reform (INCRA), and registry offices in the municipalities of Novo Aripuanã and Manicoré.

The certified emission reductions belong to SEMA and, as a result of the environmental services management through Law n° 3,135 and the Decree n° 27,600 (AMAZONAS, 2008c), it was legally transferred to FAS. Article 6 of the Climate Changes Law (AMAZONAS, 2007b) authorized the participation of the Amazonas Government in a sole non-profit Private Foundation whose purpose and objective are the development and administration of Climate Change, Environmental Conservation, and Sustainable Development, as well as the management of environmental services and products.

1.8 Project Start Date

The project start date is 3rd July 2006, the date when the Decree n° 26.010 of the Creation of the Juma Sustainable Development Reserve, was signed (Annex 3). This milestone is when the Juma REDD+ Project started being implemented “on the ground”.

It´s worth mentioning that the Juma RED project has started under an "approved GHG program" (Climate Community and Biodiversity Standard - CCBS), thus the section 3.19.5 of VCS standard v.4 applies.

As per section 3.19.5 of VCS standard v.4:

"The following applies with respect to projects registered under an approved GHG program which are seeking registration with the VCS Program: The approved GHG program validation or VCS validation shall be completed within the relevant validation deadline as set out in Section 3.7".

According to the VCS standard v.4, section 3.7: *"The project start date of an AFOLU project is the date on which activities that led to the generation of GHG emission reductions or removals are implemented"* in addition, *"AFOLU projects shall complete validation within five years of the project start date".*

The Juma RED project has started in 3rd July 2006 and was validated under the CCBA standard in 30th September 2008[4], thus in line with the VCS v.4 requirements.

1.9 Project Crediting Period

The project start date is 3rd July 2006, however the baseline deforestation model (SimAmazonia I), used as the project baseline by the time of CCBA standard validation is from 23rd March 2006 (the date when the SimAmazonia I was published at Nature Journal).

According to the methodology that is being used to register the Juma project in the VCS system (VM0015), the baseline of a REDD project expires after ten years and must be renewed. Based on this, the Juma VCS baseline starts on 1st January 2016 and must be renewed after 31th December 2025. The **project crediting period starts on 1st January 2016 and ends in 01st January 2116, in a total of 100 years**, the maximum granted by the VCS v.4,

Finally, it's important to highlight that no credits will be required under VCS system for the period that precedes the above mentioned crediting period, also it´s worth mentioning that in the ambit of CCB standard, no credits will be verified or required under the VCS crediting period.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	X
Large project	

[4] https://www.vcsprojectdatabase.org/#/ccb-all-project-details/CCB1596

Year	Estimated GHG emission reductions or removals (tCO_2e)
2016	327.390
2017	174.096
2018	214.810
2019	576.109
2020	-48.083
2021	37.917
2022	661.733
2023	-40.076
2024	42.765
2025	438.636
Total estimated ERs	2.385.296
Total number of crediting years	**10**
Average annual ERs	238.530

1.11 Description of the Project Activity

The Juma Reserve REDD+ Project aims to control deforestation and forest degradation and their GHG emissions in an area under great land use pressure in southern State of Amazonas. Its implementation was part of a broader strategy, planned and initiated in 2003 by the Government of the State of Amazonas, to halt deforestation and to promote sustainable development based on valuing the environmental services provided by its forests (BRAGA & VIANA *et al.,* 2003; AMAZONAS, 2002).

The project is characterized by the creation and implementation of a State-owned Sustainable Development Reserve (SDR) in an area where the deforestation pressure has increased significantly in a "business as usual" scenario. The Juma SDR creation and implementation was only possible due to the prospect of implementing a financial mechanism to generate certified emission reductions from REDD+ activities. This strategy was certified, under the CCB standard, within the gold level, in 30th September 2008. Its baseline and carbon accounting were validated until 2016.

Financial resources got from emission reduction commercialization in the voluntary market has allowed FAS and the Government of Amazonas to effectively implement actions to control and monitor the deforestation inside the project's boundaries by supporting sustainable income activities, providing social protection, capacity-building and education, as well as supporting law enforcement in order to improve people's livelihood. The certification has expired in the 13th September 2013.

The creation and implementation of the Juma Sustainable Development Reserve was the first step in realizing this project. This process began with several studies in the project area conducted by different institutions between April and May of 2005 towards the diagnosis of biological and socio-economic aspects, the ethno-characterization of the landscape and the mapping of natural resources, archeological sites and land tenure surveys. Public consultation meetings followed these studies with local stakeholders and the publication of the Decree of the Creation of the Juma Sustainable Development Reserve in April 2006. For more detailed information on the project's start date and additionality, see Annex III.

The development and implementation of the Reserve Management Plan includes identifying demands and implementing all the necessary measures to promote the conservation of natural resources and biodiversity and to promote sustainable development within the limits of the reserve and its buffer area.

Combining the reserve's management plan and the project's theory of change, there are four major activities, as aforementioned:

a. Investments and capacity-building on sustainable production: through participatory on-the-ground workshops, communities will decide jointly what type of sustainable production activity ('bioeconomy') they are able to implement within the period (1-3 years). Therefore, FAS provides productive infrastructure, equipment and specific training on natural resources management and business management. This creates an enabling environment for local entrepreneurship and increases capacity to manage forest products, promotion and support of forest management, research and development of new technologies for product innovation and the development of markets for sustainable products and services. Increasing bioeconomy activities will optimize forest production chains and then decreasing pressure on forest resources, as well as increasing families' income.

b. Investment in social capital through leadership training and formalization of grassroots organizations: FAS has a people-centered approach that combines economic development with social capital investments: training people to empowering them for territorial management. Through on-the-ground workshops, training sessions, and leadership training (focusing on youngsters), FAS and partners support the creation, formalization and licensing of grassroots organizations run by local leaders. Educational background is key for long-lasting results. Therefore FAS has built, in partnership with private partners, two Conservation and Sustainability Centers[5] that provides relevant and high-level schooling to 200+ students from 10 to 45 years-old at the project's area. Well-training and aware, these students are becoming leaders of their communities and qualifying the decision-making processes within the Juma SDR. This enables better decisions on natural resources management, stronger institutions and a greater involvement of Juma's inhabitants on territorial management and the implementation of the reserve's management plan.

[5] Facilities compounded by classrooms, students' lodges, teachers' house, R&D base, office, garden, forest management plots etc aiming at holistic and relevant educational content to Amazonian public schooling students.

c. Provide sustainable solutions on community infrastructure: Juma SDR has more than 2 thousand people living within, thereby it is essential to consider the provision of basic services (e.g. water, energy, education etc.). Such services, mostly provided public institutions, need significant investments to allow a better livelihood for the reserve's inhabitants. Such services are deeply connected with natural resources management and, therefore, with emission reduction. By providing clean water, sustainable energy and education, for instance, people will have better lives and will take care better of the forest. Happier and healthier people will also increase bioeconomy's outputs and then promoting a positive feedback on forest resources pressure – halting deforestation and GHG emissions; and,

d. Cash reward to mothers of families committed to zero deforestation in pristine forests (Bolsa Floresta): families receive, since 2009, cash reward of BRL 50 per month, for their contributions to conservation by avoiding the deforestation of pristine forests. This reward for environmental services scheme is a key component of the REDD+ rationale as it is a direct incentive for those who are engaged in forest conservation and decrease GHG emissions.

Jurisdictional REDD

The project is not located within a jurisdiction covered by a jurisdictional REDD+ program.

1.12 Project Location

The Juma REDD+ Project (540,444.5 ha) is within the Juma Reserve (581,655.6 ha), figure 1 and appendix III and their area is approximately 93% of the State Reserve. All the forest areas mapped by the PRODES and located inside of the protected area in 2015, were considered as project area. The Juma RED project is located in the municipality of Novo Aripuanã, in the southern region of the State of Amazonas.

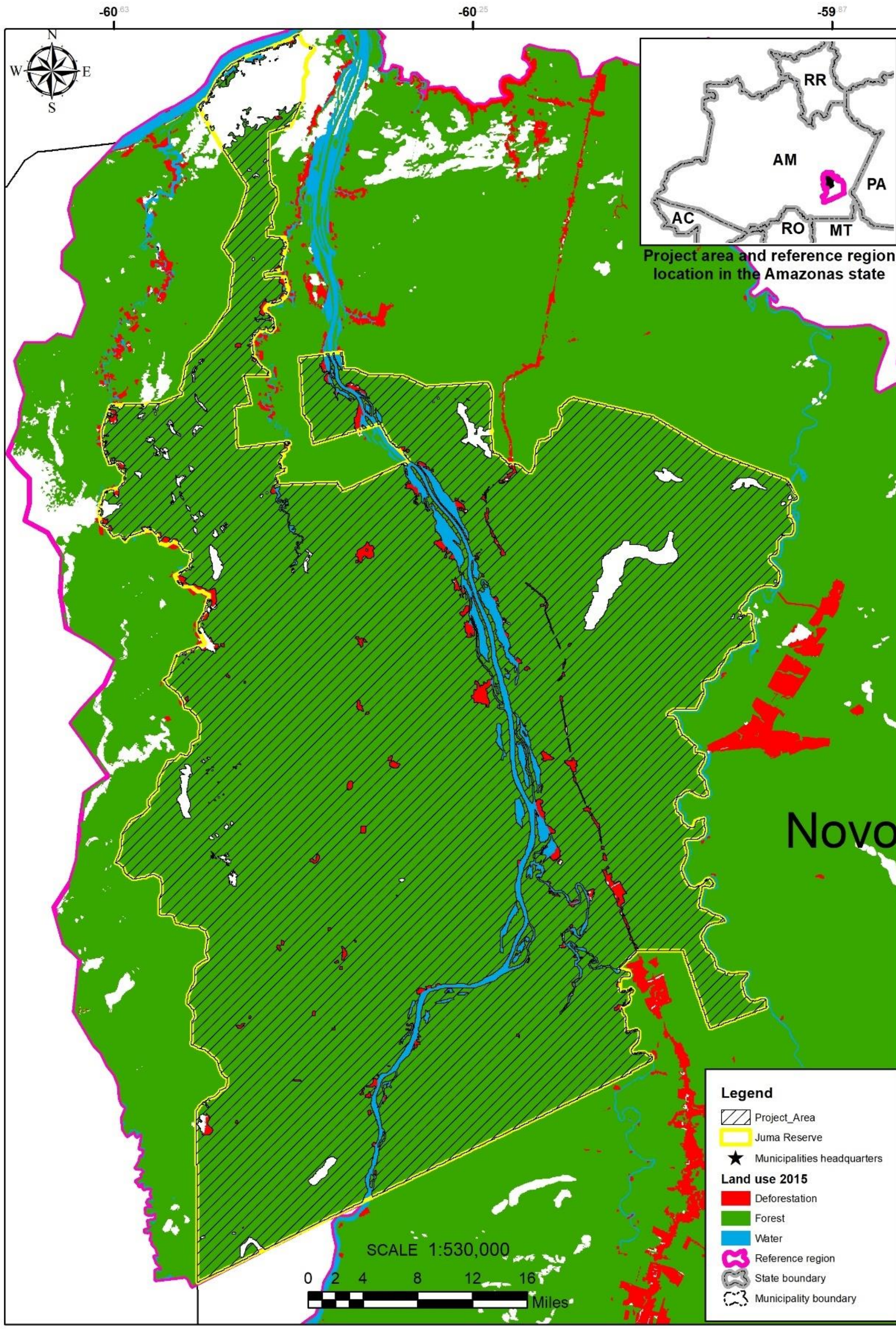


Figure 1. The project area and the Juma reserve location map.

1.13 Conditions Prior to Project Initiation

The conditions existing in the project area prior to VCS project initiation is of a homologated Sustainable Development Reserve (Juma SDR) created in 2006 that has being contemplated since than by financial support from a previous carbon program[6]

Its implementation was part of a wide strategy planned and initiated in 2003 by the current Government of the State of Amazonas to halt deforestation and promote sustainable development in Amazonas, based on giving value to the environmental services provided by its standing forests. (BRAGA & VIANA et al., 2003; AMAZONAS, 2002).

Considering that the project area is a SDR, where the main objective is to promote the environmental and social welfare, as well the sustainable income generation for the resident communities. One of the main goals of the reserve is, with or without the REDD project, to maintain the stand forest and its environmental services. Thus the VCS project has not been implemented to generate GHG emissions for the purpose of their subsequent reduction, removal or destruction, once this is not a legal option as per the applicable regulation. Notwithstanding, the land use business as usual in the region goes in a different direction, as presented in the sections 3.4 and 3.5. Thus the payment for environmental services through the VCS platform (carbon assets as the VCUs), was the most efficiently strategy found to guarantee the SDR goals to be meet.

Hydrology

The Juma Reserve RED Project is located in one of the two most important interfluvial regions in Amazonas, between the Madeira and Purus Rivers. Its area is drained by a complex system of rivers and streams, including both banks of the lower region of the Aripuanã River, the main tributary of the Madeira River. The main tributaries of the Aripuanã River in the region of the Reserve are the Acari River (the left bank of which defines the eastern boundary of the Reserve), the Mariepauá River (the right bank of which defines the western boundary of the Reserve) and the Juma River (which defines the southern limit of the Juma Reserve), Figure 2.

[6] https://www.vcsprojectdatabase.org/#/ccb-all-project-details/CCB1596

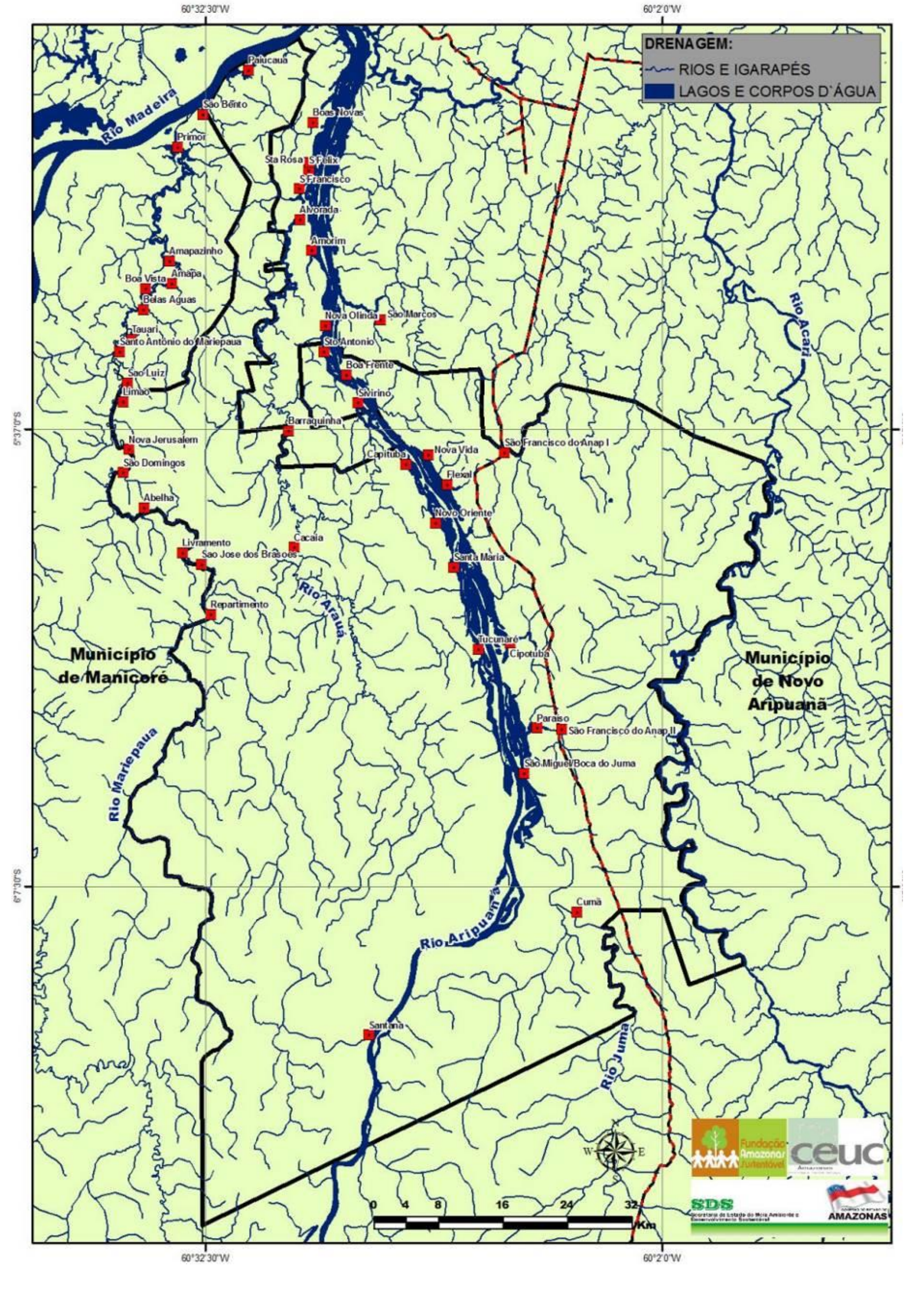


Figure 2. Juma and surrounding hydrology.

Geomorphology

Most of the geomorphological formations of the Juma RDS are composed by depressions with 91.8% of occurrences, dividing between 74.1% of Madeira Canumã depression and 17.7% composed by Roosevelt depression. The Amazon Plain presents 5.2% of the formations in the Reserve (Figure 3 and Figure 4). The formations of the Amazon plain are located near the main river channels. There is also in the area the presence of Planalto Juma formation, but these values were less than 0.1% of the area (AMAZONAS, 2010).

The depression formation of Madeira is a sedimentary basin area formed mainly by Cretaceous sandstones, siltites and argilites, that were truncated by pleistocene pediplanation and subsequently dissected under conditions of greater humidity. Contacts usually gradual and eventually defined by slope breaks. The changes in sandstones, siltites and argilites originated mainly Alicos Yellow Latosols sometimes of medium texture average, on the other hand, from clayey to very clayey textures (SIPAM 2001).

The Roosevelt Depression is a Pleistocene pediplane interspersed with lithology of the crystalline basement, leveling it, and the current climate has promoted its dissection. Gradual contact with neighboring depression and abrupt contact with the various residual plateaus that permeate the recessed surface. The alternation of long stretches of soft dissection with several slightly more dissected ones. However, to the northwest, the relief has flat tops. Alteration of different lithologies of the basement generated a pedological diversity where Podzolic soils predominate, also occurring Oxisols and Plinthosol (SIPAM, 2001).

The formation with the lowest occurrence in the area of RDS Juma is the Amazon Plain. It is presented as an adjustment-oriented plains and tectonics terraces construction and accelerated by meander evolution. In general gradual but with clear bumps contact between the plains with the most intense dissection forms of the neighboring units. Contacts with older terraces can be disguised. Several levels of terraces and recent floodplains contain dykes and paleochannels, meander lakes, decantation basins, holes, anastomosed canals and sections of talveges rectilinized by structural factors. Clay, silt and very thin to coarse sands levels, stratified, locally interspersed with irony concretions, and organic concentrations, resulting in Alluvial, Hydromorphic, Gleyzy and Organic (SIPAM, 2001)

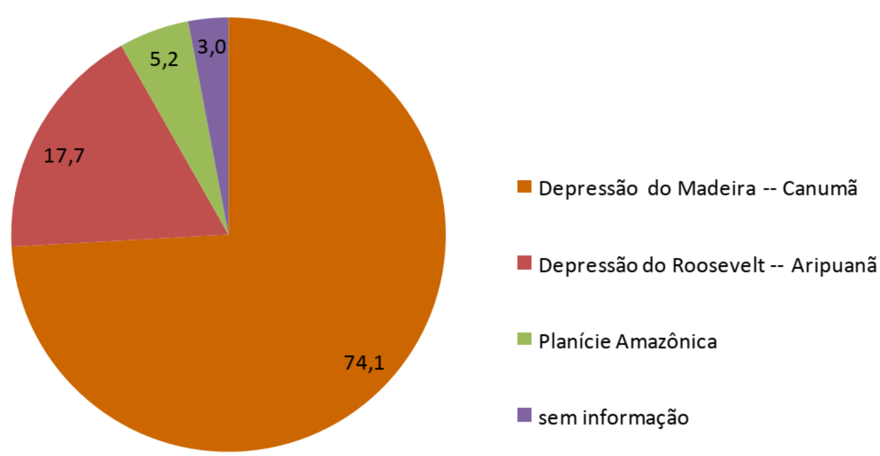


Figure 3. Percentage of area occupied by different geomorphological features in Juma RDS

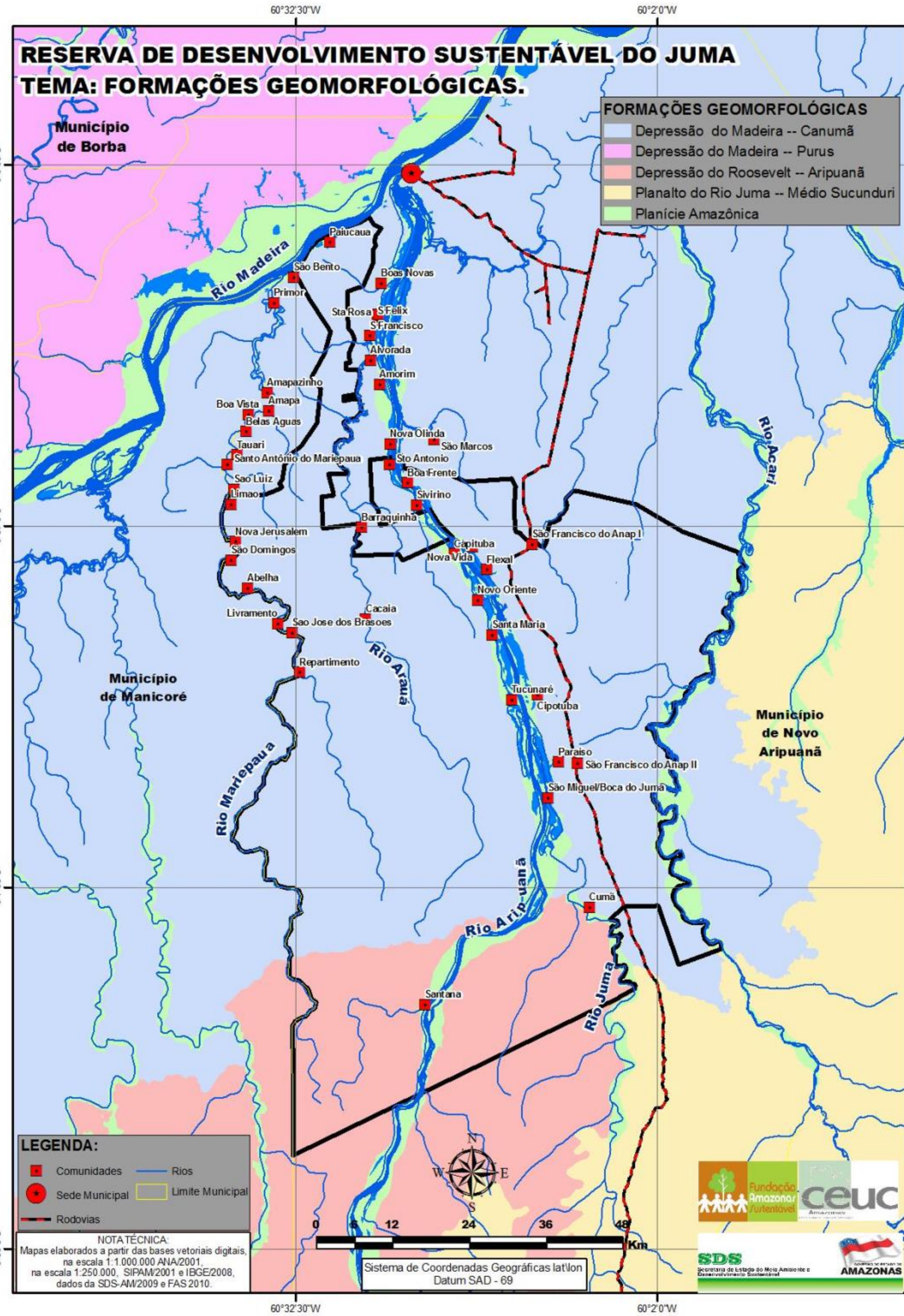


Figure 4. Juma SDR geomorphological formations (SIPAM, 2001)

Soils

In general, the soils of the Amazon pedagogical domain, proposed and described by Resende et al (1999), are Alic Yellow Latosols and Yellow Podzolic (high aluminum saturation), low in iron and very low cationic exchange capacity. In the areas of elevation rupture, Plintite soils are common. There are rich soils related to river alluviums that are influenced by Andean sediments. Oxisols are typically kaolinitic and goethitic and have a thin A horizon. The chemical richness, according to the author, is linked to vegetation (AMAZONAS, 2010).

Corroborating with the one described by Resende et al. (1999), the soils of the RDS Juma are predominantly Oxisols, occurring in 91.2% of the Reserve. These divide in Yellow Latosols (70.1%) and Red - Yellow Podzolic Latosols (21.1%). The rest of the occurrences of divide in Plintosoil, Gleisoil and Quartz sands, as seen in Figure 5 and Figure 6.

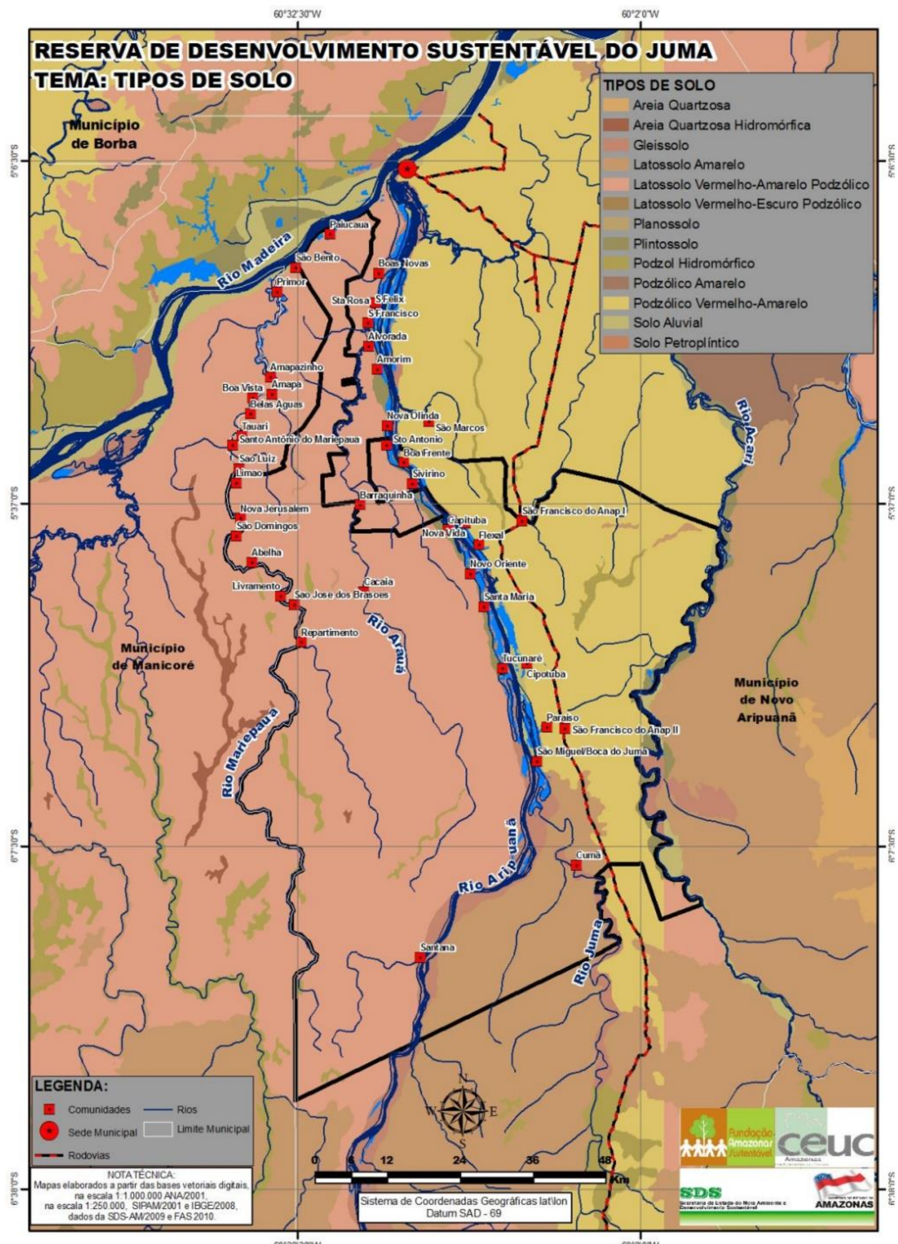


Figure 5. Juma Reserve Soil Types

According to Resende The Yellow Latosol that typically occurs in coastal trays and to a large extent in the Amazon, has low Fe_2O_3, yellowish color and is typically kaolinitic and goethitic. It is almost always alic. The Yellow Red Latosol is quite broad in color and Fe_2O_3.

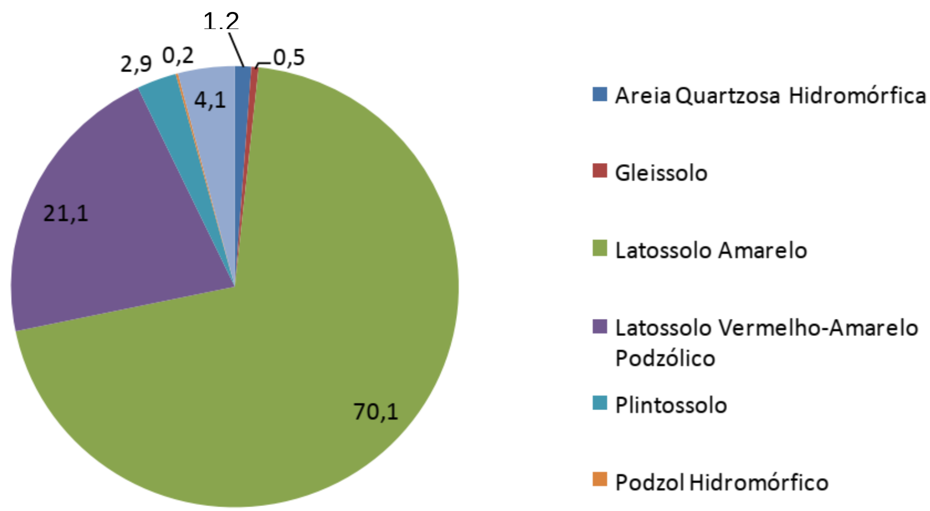


Figure 6. Percentage of area occupied by different soil types in the Juma SDR.

Climate

According to World Map of Köppen-Geiger Climate Classification, the climate of the region of Nova Aripuanã is equatorial (Am) (Figure 7). The average temperature is about 25º C with a minimum temperature of 21º C and a maximum temperature of 32º C. The average annual rainfall is about 2,000 mm with 70% of the region's precipitation being concentrated between the months of October and April. The region's average relative humidity is about 85%. Novo Aripuanã receives 2,000 hours of sun per year (SEMA, 2007).

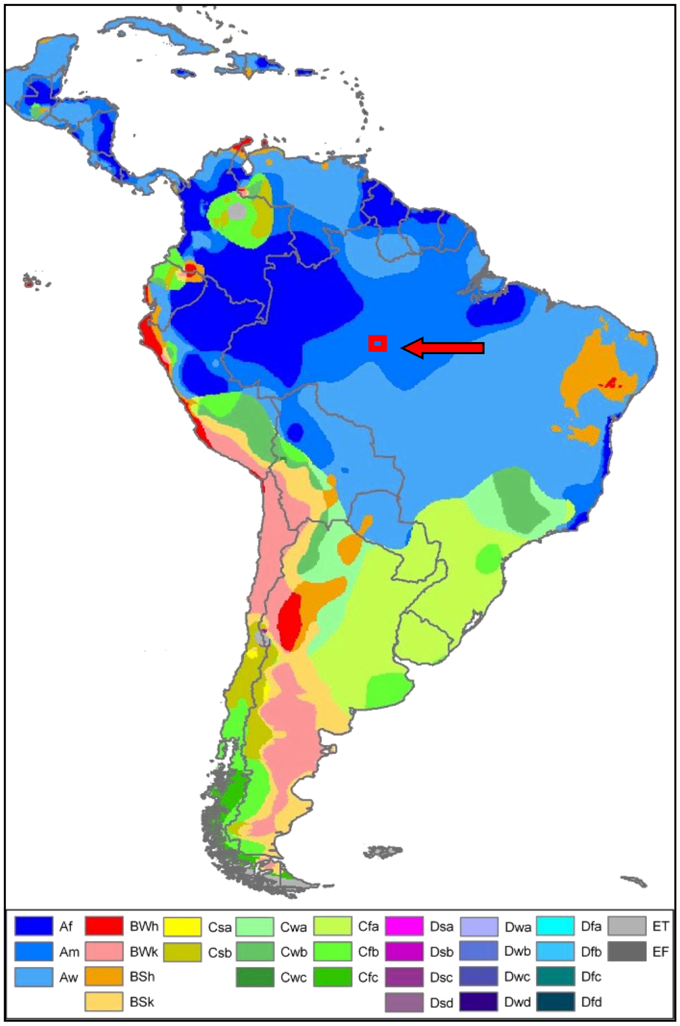


Figure 7. Climate Classification at the project location (Am), according to the KöppenGeiger Climate Classification

Between 1950 and 2000, data from average air temperature for the Juma RDS region showed little variation ranging from 26 to 27.2ºC (Figure 8). Throughout the period the temperature oscillated around 25ºC, corroborating the pattern described by (Nimer, 1979) for the Wet Equatorial regime. The highest maximum temperature value was observed for the August, with 32.9 ºC and the highest minimum for July with 20.3ºC.

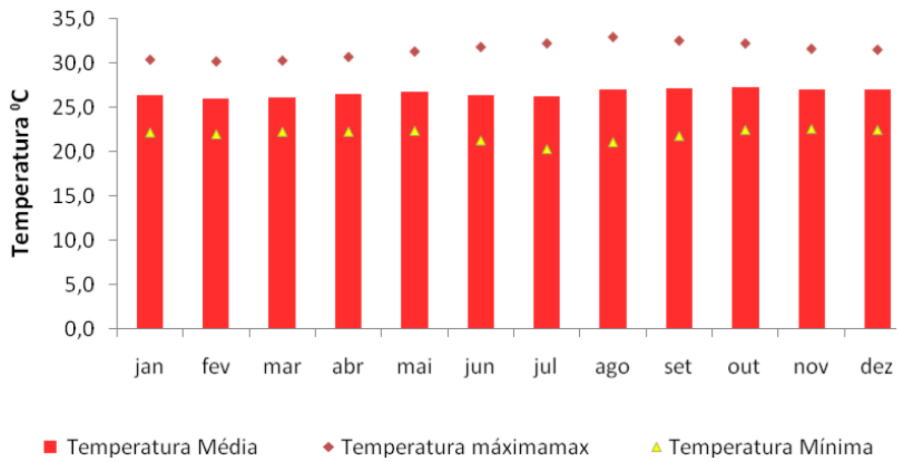
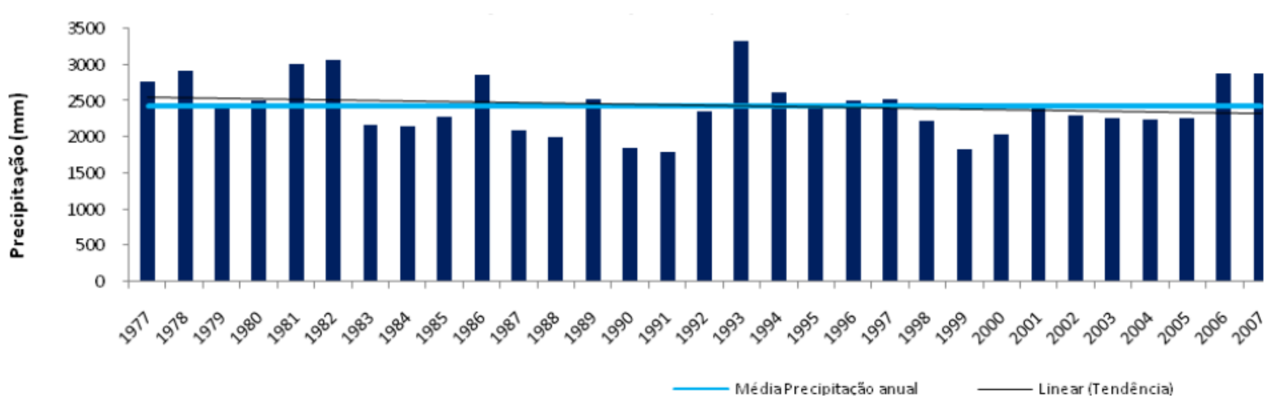


Figure 8. Average monthly temperature, maximum and minimum monthly rainfall of the RDS area of Juma from 1950 to 2000 (source: www.worldclim.org[7])

In a more detailed study it was possible to better analyze the series precipitation periods of the Juma SDR through station located at municipality of Nova Aripuanã. The data is managed and made available by the National Water Agency - ANA.

Average rainfall data for the Nova Aripuanã station shows a value of average annual cumulative rainfall of 2,435 mm for the period 1977 to 2007. This rainy season has shown that this is an area with an average of very high annual precipitation. The annual cumulative precipitation values in a occasion were greater than 3,300mm. The least rainy year was 1991 with annual accumulated precipitation of 1,792 mm as observed in Figure 9. Slight downward trend over the 30-year observed the trend line for the entire period. (AMAZONAS, 2010).



[7] Extracted from annex III

Figure 9. Annual Cumulative Rainfall, Annual Average, and Rainfall Trend Line from the municipality of Nova Aripuanã for the period 1977 to 2007 (Source: http://hidroweb.ana.gov.br)

The average monthly precipitation values pointed to rainy periods of October to May with January as the wettest month (Figure 10). In this period the values exceeded 300 mm. The dry season runs from June to December, reaching occasions in July and August with no precipitation. The highest value monthly rainfall was 746.1 mm in January 1982. The month of January also had the highest average monthly rainfall with 331.5mm. Already the month of July presented lower average values for precipitation, with 72.5mm for the whole period (AMAZONAS, 2010).

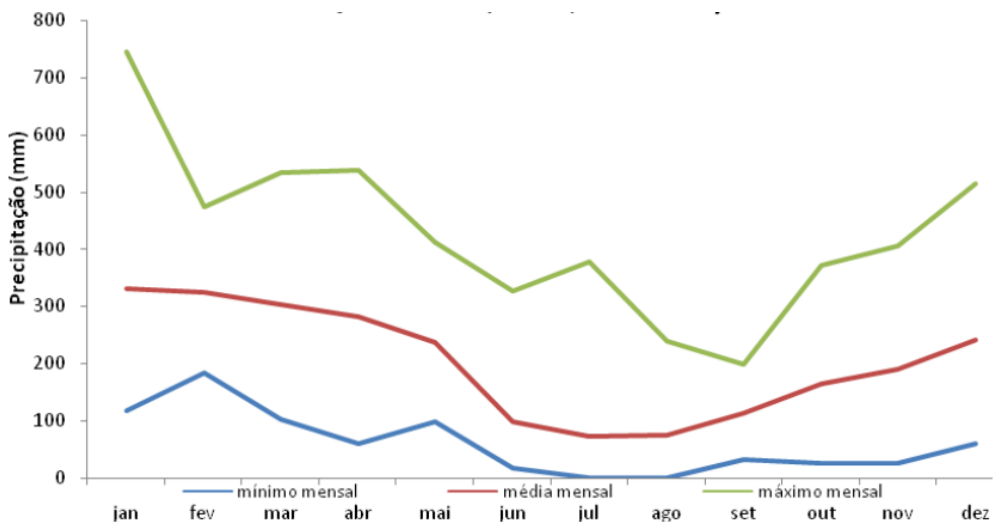


Figure 10. Average monthly, maximum and minimum monthly precipitation of the rainy season of the municipality of Nova Aripuanã between 1977 and 2007 (Source: http://hidroweb.ana.gov.br)

Types and condition of vegetation at the project site:

Analysis of vegetation cover showed predominance of Submontane Ombrophilous Dense Forest of Emerging Canopy that occupies 59% of the RDS area. Other significant formation is the Lowland Ombrophilous Dense Forest of Emerging Canopy with 31% of the area. The rest of the area is occupied by the Alluvial Ombrophilous Dense Forest of Emerging Canopy with 4.7%, pioneering formations with fluvial and / or lake influence with 1.4% and the Alluvial Ombrophilous Open Forest with Palm trees with 1% (Figure 11 and 12). The forest inventory carried out in the Reserve sampled 358 species (AMAZONIA, 2010 - annex 14.1), 61 of which have potential for furniture and joinery. "Breu vermelho" (Protium sp.) - Burseraceae was the most common, followed by yellow matamatá (Eschweilera sp.) - Lecythidaceae. This default is found throughout the Amazon (Higuchi et al., 2010).

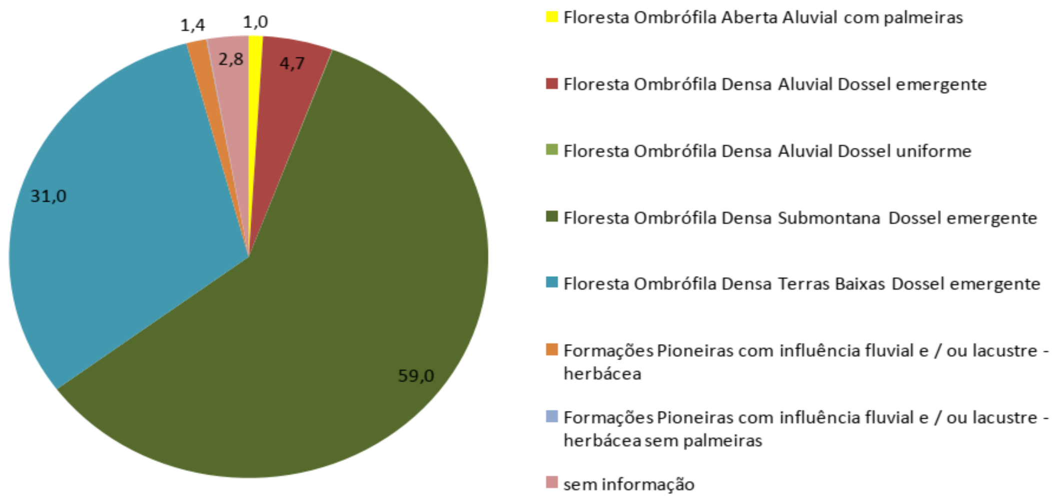


Figure 11. Percentage of area occupied by different types of vegetation cover in the Juma RDS.

A brief description of the main phytophysiognomies is given below:

Submontane Ombrophyllous Dense Forest – *Floresta Ombrófila Densa Submontana* (Ds)

Dense forests cover both the plateaus of the Precambrian platform and the dissected terrain in hillocks and hills. This is the dominant vegetative phyto-physiognomy in the southern region of the Juma Sustainable Development Reserve. In the plateaus, the forests have a uniform structure, with wide, tall trees (over 40 m), with or without palm trees and lianas. It is also characterized by a large number of emergent trees. This forest does not have an herbaceous stratum, but rather an intense secondary regeneration of tree species. On the hillocks and hills, the forest structure varies with the degree of dissection of the terrain. The presence of emergent trees decreases in proportion to the declivity of the terrain. This vegetation represents 59% of the project area and has an estimated average carbon stock of 135.77 tons of carbon per hectare (MCT, 2006)[8] to 184.71 tons of carbon per hectare (NOGUEIRA *et al* 2008a,b, c), varying according to the two main estimates existent in the literature. However, for the *Ex-ante* and *Ex-post* calculation, a TIER 3 value of **155.1 tons of carbon per hectare** (above and below ground and dead wood biomass) was assumed (Please refer to Annex 4 and section 3.1).

Lowland Ombrophyllous Dense Forest – *Floresta Ombrófila Densa de Terras Baixas* (Db)

This forest type is the dominate type found in the northern area of the Juma Reserve, replacing Submontane Ombrophyllous Dense Forests as one moves north in the Reserve area. These

[8] The presented values from MCT have already the addition off 21% for belowground biomass

forests have groupings of emerging trees at the highest interfluvial elevations. Significant densities of palm trees are found, which compete for light in the upper strata of the forest. This vegetation represents 31% of the project area and has an estimated average carbon stock of 139.49 tons of carbon per hectare (MCT, 2006)[9] to 184.31 tons of carbon per hectare (NOGUEIRA *et al* 2008a,b, c), varying according to the two main estimates existent in the literature. However, for the *Ex-ante* and *Ex-post* calculation, a TIER 3 value of **155.1 tons of carbon per hectare** (above and below ground and dead wood biomass) was assumed (Please refer to Annex 4 and section 3.1).

Ombrophyllous Dense Alluvial Forest – *Floresta Ombrófila Densa Aluvial* (Da).

This type of arboreal forest is characteristically found along the banks of the Aripuanã River and part of the Acari River region along the eastern limit of the Juma Reserve. This forest type is found in areas that are subject to seasonal flooding, and is ecologically adapted to the associated intense variations in the water level. These forests benefit from the regular renewal of the soils from seasonal floods. It is not a climax environment. During the flood periods, a certain decrease in biological activity occurs, which can decline to the point of dormancy if the flooding season is abnormally extended. This vegetation represents 4,7% of the project area and has an estimated average carbon stock of 139.49 tons of carbon per hectare (MCT, 2006)[10] to 172.95 tons of carbon per hectare (NOGUEIRA *et al* 2008a,b, c), varying according to the two main estimates existent in the literature. However, for the *Ex-ante* and *Ex-post* calculation, a TIER 3 value of **155.1 tons of carbon per hectare** (above and below ground and dead wood biomass) was assumed (Please refer to Annex 4 and section 3.1).

Since the RADAMBRASIL classification was made for the scale of the entire Amazon Basin (5.4 million km2), it was needed a “remote sensed” flyover to validate its classification for the project scale (4,2776 km2). The flyover was made with a GPS tracking system that collected points and was connected to a video camera attached below the plane, simultaneously sending images to a monitor where the project area was re-classified. During the flyover it was established that some areas were not in accordance with those presented on the RADAMBRASIL vegetation map[11].

Thus, the boundaries of the original vegetation classes from RADAMBRASIL were appropriately adjusted to the on-site conditions of the project. It was also decided to re-classify two of the vegetation classes to simplify the ex-ante carbon estimates. The **Submontane Ombrophyllous Dense Forest** and **Lowland Ombrophyllous Dense Forest** were grouped into a new class called **Dense Forest.** This grouping was made because no clear difference was detected in the vegetations during the flyover, and because the carbon stocks presented in the literature for the two vegetation classes, (submontane = 186.8 tC/ha; lowland = 184.3 tC/ha) are not significantly different. The corrected map is shown in Figure 12, and the methodology used to classify the vegetation is presented in Annex 6, pg 173.

[9] The presented values from MCT have already the addition off 21% for belowground biomass

[10] The presented values from MCT have already the addition off 21% for belowground biomass

[11] Some vegetation classes were larger than those presented on the RADAMBRASIL vegetation map, and others were displaced from the exact point as mapped by remote sensing.

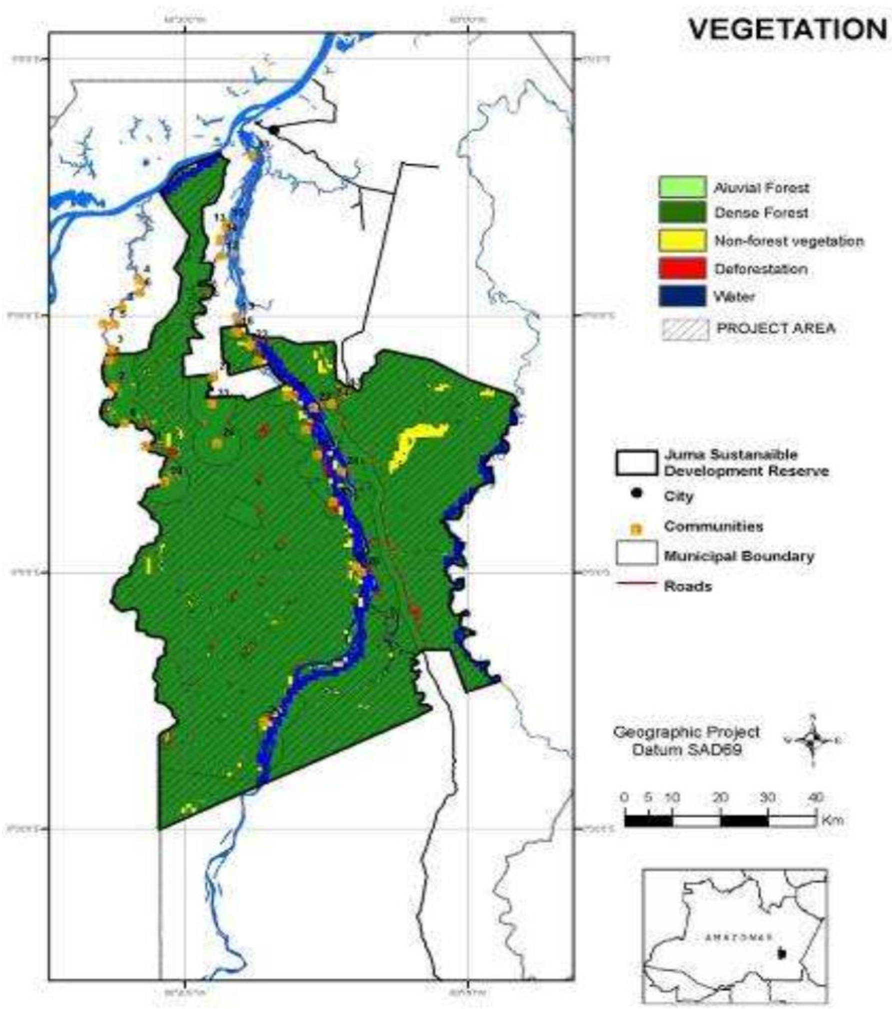


Figure 12. The two main types of vegetation found within the boundaries of the Juma Reserve RED Project

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

In a major legal aspects, the project observes the principles established in the Federal Constitution, as per article 225, by contribution towards achievement of an ecologically well-balanced environment and article 224, paragraph 1 (I) and (III) by contribution to conservation and restoration of the essential ecological processes, while supporting the preservation of attributes that justify protection of the specially-protected territorial space (RDS).

The Project also falls under the principles established by the National Environmental Policy - Law No. 6938 of August 31, 1981, which declares the objectives of conservation, improvement and recovery of environmental quality that is conducive to life, having among its principles the protection of ecosystems with the conservation of relevant areas (article 2, IV) and the protection of areas threatened by degradation (item IX).

The Juma RED Project was created under the auspices of the Amazonas State Policy on Climate Change (PEMC-AM, Law 3135 of June 2007) and its implementation occurred in accordance with existing legal requirements, including those related to the operation of a mechanism for financial compensation for environmental services based on the Reduction of Emissions from Avoided Deforestation (AMAZONAS, 2007b).

The Governor of the State of Amazonas signed Decree no. 26.010, which created the Juma Sustainable Development Reserve on July 3, 2006 (AMAZONAS, 2006). Its implementation has followed the rules of the State System of Protected Areas (*Sistema Estadual de Unidades de Conservação*, SEUC) (ASSEMBLÉIA LEGISLATIVA DO ESTADO DO AMAZONAS, 2007), as well as the requirements established in the National System of Protected Areas (*Sistema Nacional de Unidades de Conservação*, SNUC - Federal Law no, 9,985 of July 18, 2000).

More recently, due to the approval of the State-level Environmental Services Law (No 4,266 of 2015)[12], this project is also following the sub-program of Climate Change and REDD+ -- still under regulation process.

According to the above-mentioned legal framework, applicable to the project, during the process of creating the Juma REDD+ Project, a process of consultation was undertaken to consult all of the relevant legal institutions in the project area. The entities consulted included the State Secretary of Enviroment (SEMA), the State Secretary for Planning, Economic Development, Science, Technology and Innovation (SEPLANCTi),, The State Public Prosecutor (*Ministério Público Estadual*, MPE) and other entities within the Government for the State of Amazonas. In addition to these consultations, an independent legal analysis was commissioned to determine if there were any potential conflicts between the State Legislation, and other State and Federal rules and regulations. The conclusion of this analysis determined that there was no conflict between the Juma REDD+ Project and the relevant State and Federal regulations (LOPES, 2007). Finally considering that the project was proposed in partnership with the Government of the State of Amazonas, guarantees the law compliance.

1.15 Participation under Other GHG Programs

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

The project was validated under the CCB Standards First Edition, on 30 September 2008, however it expired on 13 September 2013. The project registration number under CCB standard is CCB1596. Its carbon baseline and crediting, within CCB, was validated from 2006 to 2016 generating 3.6 million tons of CO2e.

The project is not seeking registration in other GHG program, than VCS.

[12] http://online.sefaz.am.gov.br/silt/Normas/Legisla%E7%E3o%20Estadual/Lei%20Estadual/Ano%202015/Arquivo/LE%204.266_15.htm

1.15.2 Projects Rejected by Other GHG Programs

Not applicable.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The project was validated under the CCB Standards First Edition, on 30th September 2008; however it expired on 13th September 2013[13]. Its carbon baseline and crediting, within CCB, was validated from 2006 to 2016 generating 3.6 million tons of CO2e.

The revenues from CCB reduction emission should had been critical for the implementation of all planned projects within Bolsa Floresta. Unfortunately, due to lack of national legislation and the deceleration of international carbon market, project's revenues were not enough. The average price of the forest carbon credit, within 2010-2015, was less than USD 2 per ton. FAS was able to collaborate with Brazilian companies and achieved a premium carbon price – in average USD 5 per ton. Nevertheless, the volume was not high – less than 600,000 tons against of 3.6 million tons available from 2006-2016.

The GHG emission reductions generated by the Juma REDD+ Project within the VCS will not be used for compliance under CCB standard. As VCS crediting period started on **1st January 2016**, that is the date when the baseline deforestation model (SimAmazonia I), used as the project baseline by the time of CCBA standard, has expired[14].

It is important to highlight that no credits will be required under VCS system for the period that precedes the mentioned crediting period. Also, within the CCB standard, no credits will be verified or required for the period after its expiration (13th September 2013), in a way to avoid standards overlapping, as well as emission reductions double counting.

1.16.2 Other Forms of Environmental Credit

Not applicable.

The Juma Project did not seek or receive another form of GHG-related environmental credit. The VCU´s are the only GHG credits that will be generated by the Juma REDD+ Project.

1.17 Additional Information Relevant to the Project

Leakage Management

The project activities to be carried out on the offsite project area will directly address the drivers and dynamics of deforestation in the region, as illegal logging and grazing, land grabbing, mining

[13] https://www.vcsprojectdatabase.org/#/ccb-all-project-details/CCB1596

[14] According to the VM0015 which states that the baseline of a REDD project expires after ten years and must be renewed.

etc, that could be considered as a leakage effect from the project implementation – even though they cannot be attributable to the project activities (i.e. will occur anyway).

These activities will directly address the drivers and dynamics of deforestation in the region, particularly in the "Juma Reserve Surrounding Zone." The Reserve's "surrounding zone" will be an area defined as a strip of lands surrounding the Reserve with specific geographical delimitation and in which land use will be subject to specific terms and conditions, established by law (as envisioned in SEUC, 2007).

The physical boundaries of the "surrounding zone" will be determined as part of the Reserve's management plan during the initial years of the project implementation. Usually this area is defined as at least a 10 km buffer surrounding the Reserve's perimeter (i.e., in the Juma Reserve the zone would be around 400,000 ha).

The entire surrounding area will be monitored as part of the project's monitoring plan. Migrations from the communities inside the Juma Reserve to other forest areas, will be monitored by the Bolsa Floresta Program annual activities.

If areas around the Reserve of Juma are deforested, this deforestation will be quickly identified and addressed by the project's monitoring and surveillance activities. led by the State Secretary of Environment of Amazonas.

If this occurs, any negative offsite impacts directly attributed to the project will be accounted for in the overall carbon balance of project, and may also be compensated by the credits put in buffer account.

In addition, the project promotes "positive leakage", i.e. its activities, mainly on governance and social empowerment, enable positive impact on decreasing deforestation in project's surrounding areas (Reimer, Börner & Wunder, 2012[15]; Yanai et al; 2011[16]).

Commercially Sensitive Information

Not applicable. No commercially sensitive information had to be excluded from the public version.

Sustainable Development

According to the Brazilian NDC to decisions 1/CP.19 and 1/CP.20, the Government of the Federative Republic of Brazil commits to reduce greenhouse gas emissions by 37% below 2005 levels in 2025, with a subsequent indicative contribution of reducing greenhouse gas emissions by 43% below 2005 levels in 2030.

[15] https://pdfs.semanticscholar.org/dcc8/27c5aa0e2d4dad820624b999f0ad36c269bb.pdf?_ga=2.158427967.422780913.1572126356-1594150802.1570572645

[16] https://www.researchgate.net/profile/Philip_Fearnside/publication/266462372_Desmatamento_no_sul_do_Amazonas_Simulacao_do_efeito_da_criacao_da_Reserva_de_Desenvolvimento_Sustentavel_do_Juma/links/54b3c4ee0cf2318f0f9589fa/Desmatamento-no-sul-do-Amazonas-Simulacao-do-efeito-da-criacao-da-Reserva-de-Desenvolvimento-Sustentavel-do-Juma.pdf

The Brazilian iNDC document submitted to UNFCCC, states that: *"Specifically concerning the forest sector, the implementation of REDD+ activities and the permanence of results achieved require the provision, on a continuous basis, of adequate and predictable results-based payments in accordance with the relevant COP decisions. The document also highlights "Brazil is a developing country with several challenges regarding poverty eradication1, education, public health, employment, housing, infrastructure and energy access"*. It also important to highlight

- *"Strengthening and enforcing the implementation of the Forest Code, at federal, state and municipal levels;*
- *"Strengthening policies and measures with a view to achieve, in the Brazilian Amazonia, zero illegal deforestation by 2030 and compensating for greenhouse gas emissions from legal suppression of vegetation by 2030";*
- *"Enhancing sustainable native forest management systems, through georeferencing and tracking systems applicable to native forest management, with a view to curbing illegal and unsustainable practices"*

In this sense, the Juma REDD+ Project is very much in line with the national sustainable development priorities, once encompasses not only the climate change mitigation through emission reductions by reducing deforestation, but also promotes the climate change adaptation by providing alternatives of sustainable income generation for the forest population..

Further Information

The current strategy, within a VCS-certified project, is to reach the heating-up economy of OECD countries, multilateral funds and both national and international corporations. The average forest carbon price within 2016-2018 has increased to USD 4.5 per ton. Moreover, due to political arrangement and current institutional opportunities, FAS has been engaging with OECD countries and multilateral funds, which are willing to acquire *top* certified emission reductions (e.g., Norway, Sweden, Ireland, World Bank's FCPF). Within the Brazilian scheme, there are solid signs that companies will start to implement a more robust carbon offset program (e.g. implementation of the Brazilian Climate Change Policy's domestic carbon market, climate and environmental criteria under the EU-Mercosur scheme).

Following the Juma SDR's management plan and the UN's Sustainable Development Goals[17], it was developed a theory of change that encompasses two axis: poverty eradication and conserved ecosystems (figure 12).

[17] More at https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

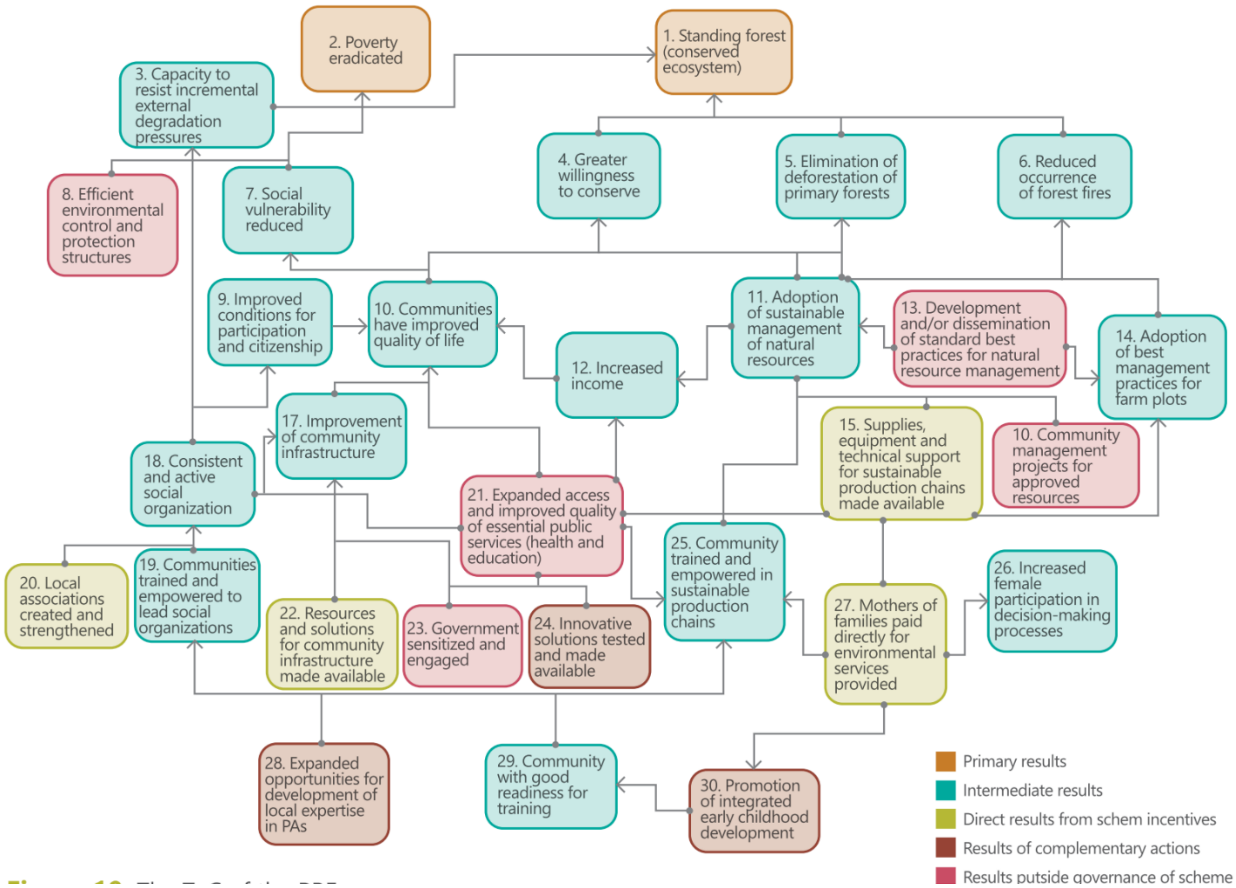


Figure 12: The ToC of the PBF

Therefore, it is necessary to implement five major activities (or 'direct results from scheme initiatives'):

(a) provide investments and capacity-building programs for sustainable production;

(b) invest in social capital through leadership training and formalization of grassroots organizations;

(c) provide sustainable solutions on community infrastructure (e.g., access to clean water, sustainable energy, education, transportation, communication); and

(d) cash reward to mothers of families committed to zero deforestation in pristine forests.

As a result of such activities, there are five 'intermediary results[18]': (i) social resilience (or capacity to resist incremental external degradation pressures), (ii) will to conserve (or greater willingness to conserve), (iii) stop deforest pristine forests (or elimination of deforestation of primary forests), (iv) reducing occurrence of forest fires, and (v) reducing social vulnerability. All these will enable to reach both poverty eradication and conserved ecosystems within project's area.

[18] The project's Theory of Change has 29 'intermediary results'. For the sake of priority and importance, it was highlighted the most important ones.

The generation and commercialization of certified emission reduction will feedback and fund aforementioned activities and results. Therefore, considering this financial scheme, funding through carbon financing is essential to implement Theory of Change's rationale.

2 SAFEGUARDS

2.1 No Net Harm

Not applicable.

2.2 Local Stakeholder Consultation

Before the Juma VCS project start date, previous activities related to climate change mitigations were in place[19]. This first initiative was based manly in the creation of the Juma Sustainable Development Reserve. The conversation regarding the creation of the SDR had the participation of residents involved in several types of work (fishermen, extractivists, farmers, ranchers, etc.). The process also included informal community associations (mothers, professors, artisans). Public hearings were also carried out in Novo Aripuanã and in the communities on March 15, 2006 (SEMA, 2006), bringing together the community leaders and major local stakeholders, with representatives from City Hall, the City Council, local churches, and the local civil society organizations in attendance. Inhabitants of all communities within the Reserve were interviewed to obtain their perspectives on the social, economic and environmental context of the Reserve.

The project updating is done periodically to the community, stakeholders and partners. In practice no significant changes is supposed to occur for local population due to the transition from CCB standard to the VCS, regarding the mechanism for on-going communication with local stakeholders. This mechanism will remain the same and fully operational.

By the time of the first carbon project initiative, the stakeholders were informed verbally and, the FAS website, announced that the Project Document was available with the Head of the Reserve, for reading and commenting. During all the process, the stakeholders had the opportunity to express their concerns about the project, and to support some actions and decisions. The meetings held with the communities were also a moment when the community, as the main stakeholder, could better understand and opine about the REDD project (see table 1). It is worth mentioning that even after the VCS project validation the communication channel between project proponent and communities keeps open in order to address any doubt or comment. All comments from any stakeholder were taken into consideration and when applicable, incorporated into the project. In addition, comments can be made and incorporated into the project during its implementation stages by the process described in the figure 13, below.

[19] Please refer to annex 6 regarding the Juma CCB Project, in place before the VCS Project start date

Table 1. local stakeholder consultation conducted prior to validation

Event	Description	Relevancy	Responsible Institution	Date
Public Consultation Meeting	Discussion on the creation of the Reserve and choice of name “RDS do Juma” in the Municipality of Novo Aripuanã	Disseminate information to some of the main stakeholders of the project and collect information and gain support	SEMA/IPAAM, SEMA/SEAPE	Mar 15, 2006
Meeting with the City Council	Discuss the creation of the Reserve	Disseminate information to some of the main stakeholders of the project and collect information and gain support	SEMA/IPAAM, SEMA/SEAPE	Mar 15, 2006
Community Meeting	Elect the Council Representative and the First and Second Substitutes	Definition needed to proceed with the activities	CEUC	Jun 18, 2008
Community Meeting	Operational costs to elect the Council Representative and the First and Second Substitutes	Definition needed to proceed with the activities	FAS	Jun 18, 2008
Community Meeting	Locate 3 schools to be implemented by the Juma RED Project	Determine the community’s needs and priorities to proceed with the project activities	DEMUC	Jun 28, 2008
Community Meeting	Locate 3 schools to be implemented by the Juma RED Project	Determine the community’s needs and priorities to proceed with the project activities	FAS	Jun 28, 2008
Juma Reserve Management Council creation	Meetings with the community representatives to form the team and design the	The council will be an important member of the project. It will help with decision making, as an information resource and	CEUC	Jul - Nov 2008

	activities to be done by them	in achieving the project goals		

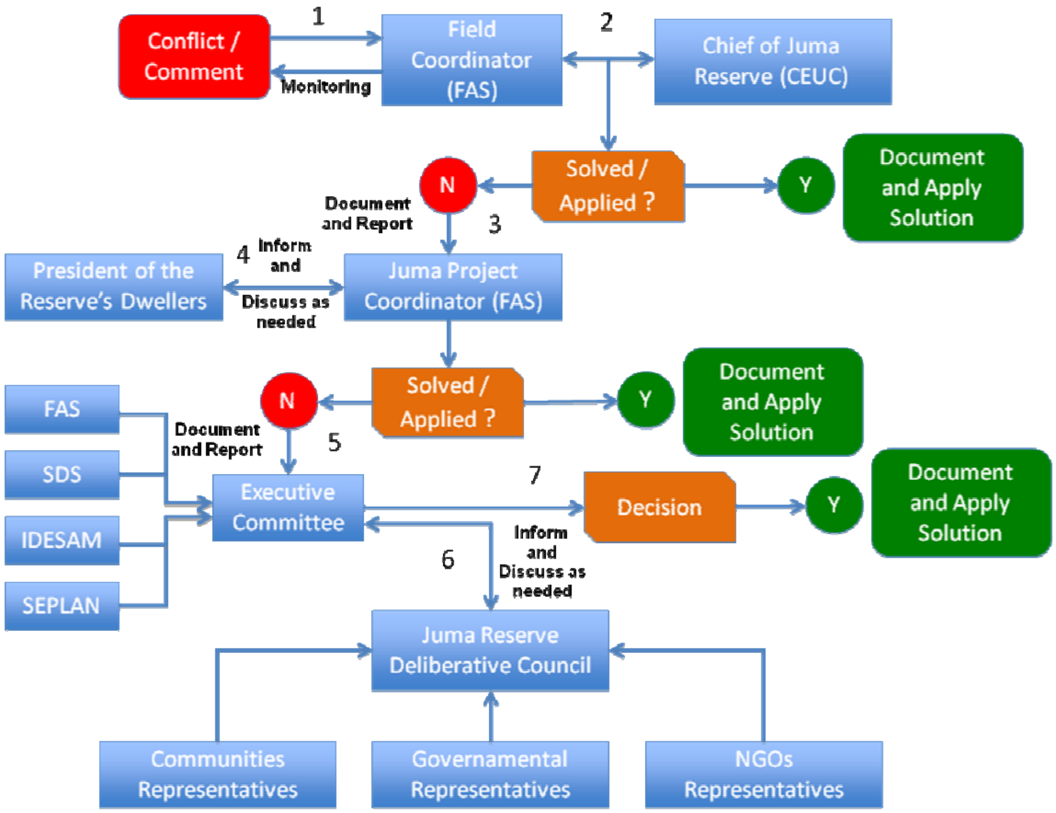


Figure 13. Process for handling unresolved conflicts, grievances and comments that may arise during project planning and implementation

Figure 13 illustrates how the grievances, conflicts or comments will be resolved once they reach the Field Coordinator, who will be the first person responsible for receiving any complaints. A best effort will be made done to provide a written response within 30 days after the complaint/comment is documented. It is important to point out that some actions involved in this process may have logistical constraints.

2.3 Environmental Impact

Considering the project activities is based in forest conservation and sustainable management of non-timber forest products[20], negative impacts inside or outside the project area due to project activities are not expected. Actually, the project is supposed to have positive environmental impact not only on the areas within the project boundary, but also in the adjacent to the Juma

[20] Please refer to annex 5

Reserve, due to the significant reduction in deforestation that is associated with an actively managed protected area. This effect was observed in the great majority of the protected areas created in the Brazilian Amazon, and the offsite "reduction of deforestation" that was generated varied from 1 to 3% of the size of the PA (IPAM, 2008).

2.4 Public Comments

Please refer the section 2.5 below.

2.5 AFOLU-Specific Safeguards

The Juma Sustainable Development Reserve was created through a participatory process. This process included meetings and public hearings; interviews were performed with broad participation by local communities and stakeholders. The management plan is also developed by a participatory process, considering that community people and other local stakeholders know their environment and understand their conditions and needs better than anyone else.

In addition to public consultation, FAS also hired an independent poll research company to carried out a survey with the dwellers of Juma in 2010 and 2015. There were 97 questions regarding their perception on public services, FAS' activities, and general impact on forest conservation.

Any negative impacts can be reported by the communities through the process for dealing with unresolved conflicts, grievances and comments, as explained in section 2.2.

The Local stakeholder identification process, how the project will mitigate eventual risks to local stakeholders and processes to ensure ongoing communication and consultation with local stakeholders, including procedure to resolve any conflicts which may arise between the project proponent and local stakeholders, are described in section 2.2. Addition information regarding stakeholder's communication, decision making in the SDR, as well as property rights, are presented in annex 5.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

- VCS Methodology VM0015, - Methodology for Avoided Unplanned Deforestation, version 1.1, 3 December 2012
- VT0001 - Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities, version 3.1, February 2012
- AFOLU Non-Permanence Risk Tool, version 3, 19 October 2016

3.2 Applicability of Methodology

According to the applicability conditions stated in the **VM0015 v.1.1,** the methodology has no geographic restrictions and is applicable globally under the following conditions:

a) Baseline activities may include planned or unplanned logging for timber, fuel-wood collection, charcoal production, agricultural and grazing activities as long as the category is unplanned deforestation according to the most recent VCS AFOLU requirements.

Juma REDD+ Project's baseline scenario encompasses unplanned deforestation for cattle and agriculture purposes, as well as timber and fuel-wood. For more information, refer to sections 2.4 and 2.5 of this document.

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 of the VM0015*).*

According to the table 1 of the VM0015, the project activities fit in scenario "D" as follow:

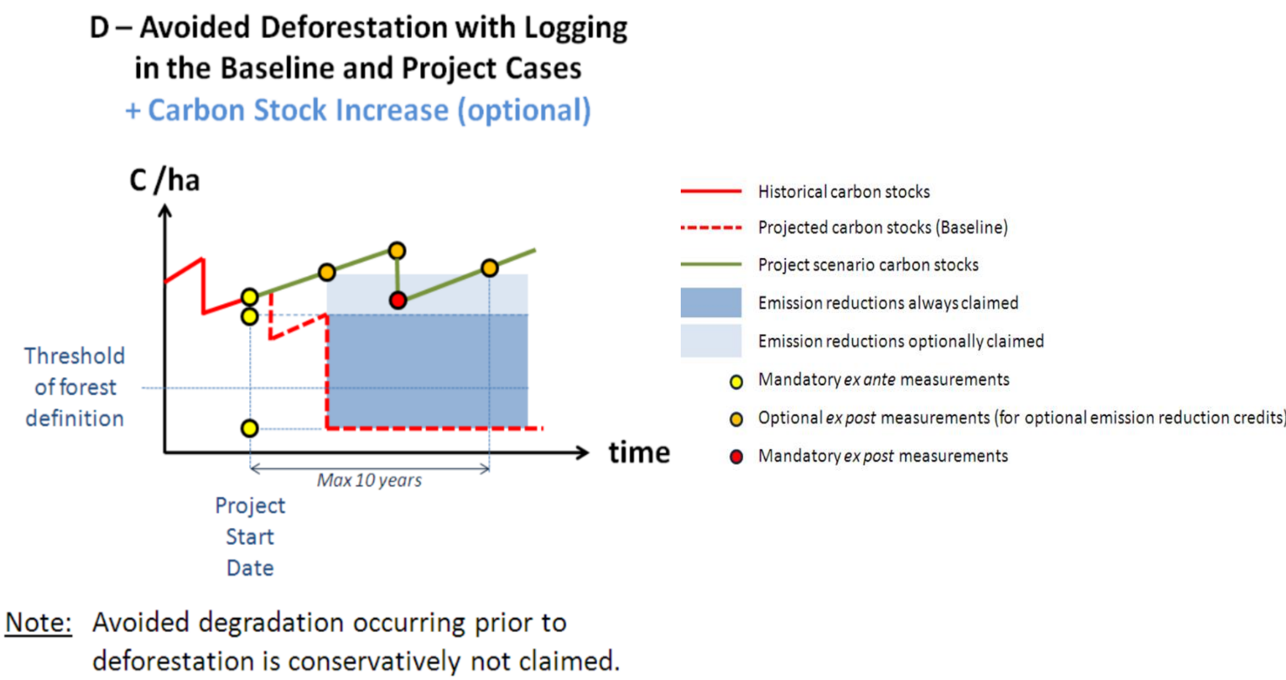


Figure 14. Project category according to the applied methodology.

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 project area encompasses three types of old-growth forest:

1. **Submontane Ombrophyllous Dense Forest** (59% of the area)

2. **Lowland Ombrophyllous Dense Forest** (31% of the area)

3. **Ombrophyllous Dense Alluvial Forest** (4.7% of the area)

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.

For baseline modelling and climate benefits (VCUs) it is considered land categorized as "forest" for a minimum of 10 years prior to the project start date. For more information refer to section 2.4, below.

e) The project area can include forested wetlands (such as bottomland forests, floodplain forests, mangrove forests) as long as they do not grow on peat. Peat shall be defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm. If the project area includes a forested wetlands growing on peat (e.g. peat swamp forests), this methodology is not applicable.

The project does not include peat forest in its baseline, neither in the project activities, only the Ombrophyllous Dense Alluvial Forest, that is a floodplain forests.

According to the applicability conditions stated in the **VT0001 v.3**, the tool is applicable under the following conditions:

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

The project activities are based in conservation strategies that include monitoring against forest degradation and deforestation and sustainable income generation, as sustainable fishing and non-timber forest production. Neither of these activities has lead to violation of any applicable law.

b) The use of this tool to determine additionality requires the baseline methodology to provide for a stepwise approach justifying the determination of the most plausible baseline scenario. Project proponent(s) proposing new baseline methodologies shall ensure consistency between the determination of a baseline scenario and the determination of additionality of a project activity.

The Juma REDD+ Project made use of the approved VCS Methodology VM0015, - Methodology for Avoided Unplanned Deforestation, version 1.1. This methodology includes all the steps to define the most plausible baseline scenario.

3.3 Project Boundary

According to the VM0015, four types of boundary must be defined, as follow:

1. Spatial boundaries;
2. Temporal boundaries;
3. Carbon pools, and
4. Sources of GHG emissions

Spatial boundary

The spatial boundaries are divided in: Reference region, Project area; Leakage belt; Leakage management areas; and Forest.

Reference region

The reference region of the Juma Project was defined considering Brown's rule of thumb[21] (BROWN et al., 2007): 5-7 times the size of the project's area. The Juma Project has an area of 540,444.5 hectares, according to BROWN et al (2007) the reference region should be about 5-7 times larger than the project area

Based on this methodology suggestion, it was calculated a buffer zone of the project area, using a buffer distance of 47km, this initial reference region was 6.88 times larger than the project area. But this reference region needed to be adjusted to reflect the land use and the land use change specially to meet the likelihood of deforestation within the project area.

Southern Amazonas is one of the last deforestation frontiers in the Amazon. All municipalities within Amazonas-Pará-Mato Grosso-Rondônia border are in a high risk of forest loss due to lack of governance, sustainable income alternatives and weak surveillance practices. According to official data, in August, the peak of forest fires in the Amazon, there were two municipalities in southern Amazonas out of top 10 in the Amazon[22].

Within the project's area and its reference region, there are three main deforestation agents and drivers: (a) land grabbling due to ranching activities (Carrero & Fearnside, 2011[23]), (b) illegal

[21] See VM0015's footnote number 5.

[22] https://g1.globo.com/natureza/noticia/2019/08/22/municipios-com-maior-numero-de-queimadas-tiveram-as-maiores-taxas-de-desmatamento-em-2019-diz-ipam.ghtml

[23] https://www.ecologyandsociety.org/vol16/iss2/art26/

timber extraction (Fearnside, 2008[24]) both large and small scales (Kalamandeen et al., 2018[25]), and (c) roads (Piontekowski et al., 2011[26]).

In a broader analysis, covering Mato Grosso, Rondônia and Pará, it should be included (i) soy production (Silva Junior & Lima, 2018[27]), (ii) mining (both legal and illegal) (Souza et al., 2018[28]), (iii) big dams (Souza Jr et al., 2019[29]).

In regards of land grabbing and cattle ranching, they are very connected. Due to lack of governance and proper surveillance by both National and State-level institutions, several big ranchers do not pay for lands in the Amazon (Brito et al., 2019[30]). Through land grabbing (*grilagem*), these agents steal public lands mostly to cattle ranching (Conscieme et al., 2018[31]). Thus, cattle raising, as a means for land speculation, contributes to the advance of deforestation (Brito et al., 2019). Besides cattle ranching is highly profitable, unsustainable ranching causes huge environmental impact with low social return (Azevedo-Ramos & Moutinho, 2018[32]), mostly due to low-productivity pasture management (Hansen et al., 2019[33]; Silva et al., 2018[34]). The ranchers thus seeks new areas for pasture, increasing pressure on pristine forests and raising deforestation (Silva et al., 2018).

It is worth mentioning that the ranchers' decision-making process of expanding pasture to primary forest is based on a disturbed economic rationale (Hansen et al., 2019), which it does not account for costs of losses of environmental services. On the top of it, big ranchers push medium- and smallholders to other areas – also increasing pressure on primary forests.

[24] ftp://ftp.iluci.org/Evan/GEOG415/Reading_Assignments/Reading%2016%20-%20LCLUC%20Deforestation%20Focus/Fearnside%20-%20The%20Roles%20and%20Movements%20of%20Actors%20in%20the%20Deforestation%20of%20Brazilian%20Amazonia.pdf

[25] https://www.nature.com/articles/s41598-018-19358-2

[26] http://marte.sid.inpe.br/col/dpi.inpe.br/marte/2011/07.15.13.22/doc/p1430.pdf

[27] https://www.sciencedirect.com/science/article/abs/pii/S0264837717312413

[28] https://ieeexplore.ieee.org/abstract/document/8518495

[29] https://www.mdpi.com/2073-4441/11/3/566

[30] https://ieeexplore.ieee.org/abstract/document/8518495

[31] https://www.mdpi.com/2079-9276/7/3/44

[32] https://www.sciencedirect.com/science/article/abs/pii/S0264837717314527

[33] https://www.sciencedirect.com/science/article/pii/S0921800918304130

[34] https://onlinelibrary.wiley.com/doi/abs/10.1002/ldr.3087

Another worth mentioning deforestation driver is road (Godar et al., 2012[35]; Lima et al., 2006[36]; Fearnside, 1987[37]). The project's area has two main (and official) roads: one federal BR-230 (Transamazon road) and other State-owned AM-174. The first was built in 1972 and it is the largest Federal road in Brazil: 5,662 km connecting Labrea-AM and Cabedelo-PB. The State-owned connects Novo Aripuanã-AM to Apuí-AM, and it is one of the biggest drivers of deforestation in southern Amazonas (Yanai et al., 2012[38]). Therefore, the reference region was adjusted to include the southern border of AM-174 and BR-230 up to the Madeira river.

The reference region also includes the Madeira river basin, as it is a driver of deforestation. Thus, the western border is within the Aripuanã river and the Uruá river; the eastern border was within the Sucunduri river and its main affluent; the northern border was within the Madeira river.

Both ecological and biological aspects are similar between the project's area and its reference region. These aspects enable to consider that deforestation drivers and agents are also similar (more details Appendix VI):

- Forest/vegetation classes: All the tree forest classes that exists in the project area, exists in 90,9% of the reference region;

- Elevation: All the tree geomorphology classes that characterizes the elevation and that exists in the project area, exists in 95,8% of the reference region;

- Slope: All the slope classes that exists in the project area from 0 degrees to 37 degrees exists in the in 100% of the reference region;

- Rainfall: Due the fact that the climate classification of Koppen is direct dependent from the amount of rain in certain area, the Koppen classification was utilized to characterize the rainfall in the project area and reference region and both areas were mapped as the same two Koppen classes.

In regards of the socio-economic and cultural conditions, following VM0015, the project's area is also alike of the reference region, e.g. legal status of the land, land tenure, land use, enforced policies and regulations.

---

[35] https://www.sciencedirect.com/science/article/abs/pii/S0378112711007316

[36] https://www.tandfonline.com/doi/abs/10.3200/ENVT.48.1.26-38

[37] https://s3.amazonaws.com/academia.edu.documents/7370178/Causes%20of%20Deforestation%20in.pdf?response-content-disposition=inline%3B%20filename%3DCauses_of_Deforestation_in_the_Brazilian.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20191027%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20191027T152354Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=9b59b1bcc7e5e86762d078c46d5b03a05ab52ee11a637b2eb5acc00ffa9055a3

[38] https://www.sciencedirect.com/science/article/pii/S0921800918304130

- Legal status of the land: the project area is located inside of a State-owned protected area within a category called sustainable development reserve (SDR). The reference region has *circa* 70% covered by public and protected area and 45% of SDR. See the analysis in the Appendix VI – sheet “RR analysis”.

- Land tenure: Juma SDR allows the use of the natural resources by the communities in a sustainable way, following the area’s management plan, and also people living within the area. In the reference region, 45% of the areas enables sustainable use of natural resources (e.g., National Forest of Aripuanã and Rio Madeira SDR) with traditional communities living inside of the protected area with the same characteristics. See Appendix VI – sheet “RR analysis”.

- Land use: official Brazilian data[39] qualifies the project’s area with "forest" as major land category. The reference region has also “forest” as a category and also “low-productive pasture.” This pasture is due to the progress of the deforestation threshold. Due to ecological, social and economic similarities, the drivers of deforestation are also the same. Therefore, within a BAU scenario, the project’s area is expected to be converted from forests to pasture.

- Enforced policies and regulations: The project area is located in the Novo Aripunã municipality which is located in the Amazonas state and all policies, legislation and regulations that applies to the project area are the same elsewhere in the reference region.

After all the analysis it was generated a boundary of the reference region of the Juma REDD+ Project (figure 15), the reference region area is 3,200,443.44 hectares, which is 5.89 times bigger than the project area, so also meeting the BROWN et al. (2007) suggestion.

[39] Brazilian National Space Agency and its PRODES program: responsible to monitor Amazon’s land-use changes yearly.

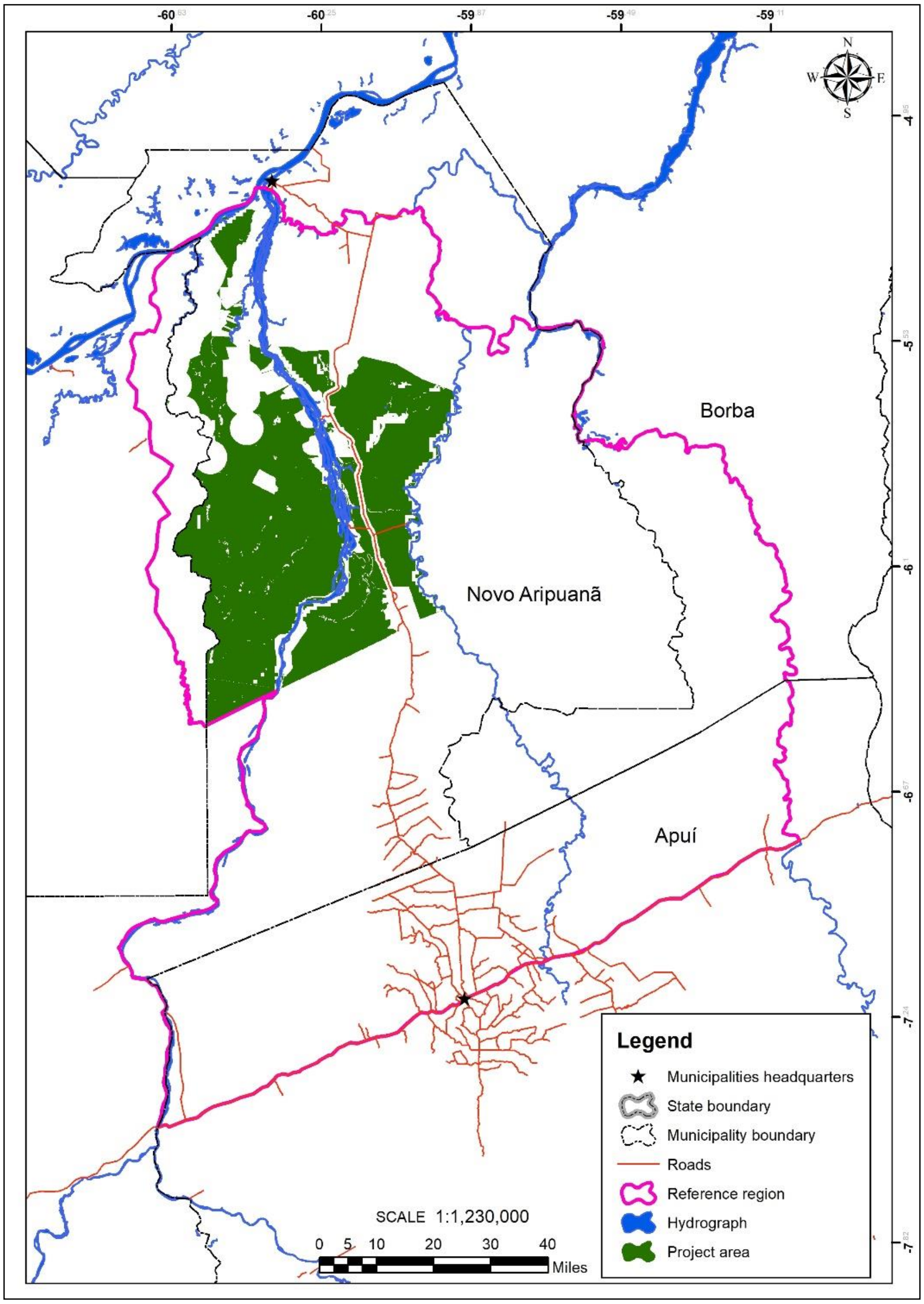


Figure 15. The reference region of the Juma RED Project.

Project area;

The Juma RED project area is located in the State Sustainable Development Reserve Juma, all the areas located within the state reserve are under control of the Environmental State Secretary of the Amazonas state which is a project partner and is directly involved in the reserve management and is also cited in the section 1.6 of these VCS PD.

At the project start date of the reviewed baseline (2016) the project area only included forest land; the project area boundary was defined using GIS software. It was used the 2015 PRODES data and it was selected only the forest class inside of the Juma Reserve.

After this initial step, it was merged all the clouds, shadows and residues from all data of the baseline reference period (2009, 2012 and 2015) and excluded from the 2015 forest land mapped by the PRODES to generate the project area (figure 15) with 540,444.5 hectares.

Leakage belt;

The leakage belt boundary definition followed the guidelines of the VM0015 methodology and used the methodological option I, Opportunity Cost Analysis. This approach is applied to the project, because there is economic profit or its perspective for the beef cattle production chain in the reference region. Currently the conventional practices adopted by this activity make it the main vector of deforestation in the reference region and in the historical reference period of the baseline (2009-2015).

Historically, local farmers have been encouraged to clear and plant pasture in the region. Farmers and ranchers were instructed by the colonization government institutions to suppress forest areas and thus obtain title to the land. This occupation strategy even had subsidy policies without any concern regarding the sustainability of economic activity.

In the Apuí municipality that is located in the south portion of the reference region and where the deforestation frontier is already a reality, there is an underuse of pastures which is directly linked to environmental problems related to the activity, according to data from SIDRA / IBGE (2017) the average density of cattle heads per hectare is 1.01 in the municipality, while the national average is 1.15 heads / hectare.

The main cause of underuse of pastures is due to a large number of factors, such as pasture formation in poor soils, lack of technical assistance and rural extension. This scenario generates a high level of environmental degradation in productive areas, especially regarding nutrient depletion, soil compaction, erosion, weed invasion, “dirty” pasture, among others. This scenario contributes to the reduction of the cattle herd per hectare and, consequently, influences the opening of new areas for pasture formation to supply the market demand.

With the low productivity, the rancher seeks new areas for pasture formation, bearing an additional cost in his production, to convert a new forest area to pasture. The agrarian dynamics of land accumulation and formation of large estates, also influenced the deforestation dynamic, because small farmers are “pushed” to other regions and with low investment capital, open new areas and with the revenue from illegal sale of wood make pasture formation possible.

It is also known that a large part of ranchers in the Amazon do not pay for the public lands in which they take possession or makes "grilagem". They illegally exploit the wood which contributes to accumulate capital to invest in livestock. Thus, cattle raising, as a means for land speculation, contributes to the advance of deforestation. The result is high environmental impact with low productivity and social return. However, cattle are considered a highly liquid product and are considered as an investment for small and medium producers, as they can be transported alive and quickly sold when needed.

The pressure for the forest tends to continue in the coming years, considering the growing demand from the markets for Amazonian commodities (especially meat). In addition to this, there is the question of paving BR-319, which will facilitate the logistics of meat flow from Apuí to Manaus, the state capital is the largest consumer market to the meat produced in the reference region. The reconstruction of this highway may also indirectly result in a considerable increase in migration to the region.

According to IBGE data, the municipality of Apuí has a prominent role with respect to the municipal cattle herd, in relation to the total herd of Amazonas the municipality owns about 10.9% of the total state (table 2) and with a cattle herd 6x larger than the municipality of Novo Aripuanã. However, there is a clear trend of increase in herds in the different territorial units, with emphasis on Novo Aripuanã, with an increase in the cattle herd in the period 2006-2017 of 205%, which shows that Novo Aripunã, due to its proximity to Apuí and the AM-174 ground connection with the municipal headquarters of Apuí, located on the banks of the federal highway BR-230 (Transamazônica) it´s the next deforestation frontier in the south of Amazonas..

Table 2. The number of animals in the Amazonas state and in the main municipalities of the reference region

Cattle herd (number of animals)	2017		2006		Increase in the period, 2006-2017 (%)
Amazonas	1,252,835		916,811		37%
Apuí (AM)	136,801	10.9%	91,138	9.9%	50%
Novo Aripuanã (AM)	22,492	1.8%	7,386	0.8%	205%
Source: IBGE – Agricultural census					

According to RAZERA (2005), practically all cattle raised in Apuí and region are slaughtered in Iranduba-AM to supply part of the Manaus market and a small portion ends up being slaughtered locally for the consumption of the local population. The cattle that will be consumed in Manaus are transported by truck to some river port, where live cattle are taken by water transport, the preferred route is by the BR-230 in the region known as “prainha”, shortly before “Matá -matá ”, according to Razera, the transportation cost of one animal is R$ 3/km in a truck. According to a study by CARRERO *et al.* (2015) the average profit per animal in the Apuí region is R$ 212, however the IDESAM data considers in the calculation the production costs as a function of the number of heads, if it is considered in terms of units of production. area the average profit per animal is R$ 159/ha.

The GIS software Idrisi Taiga edition was used to calculate the Euclidean distance from Apuí municipality headquarters to the rest of the reference region, considering that the main economic driver of the region is responsible for deforestation as it was discussed above, a fact that reinforces this aspect is the information from Mapbiomas (figure 18, section 3.4), which mapped that most deforested areas in the region is grasslands to the cattle. Thus, the headquarters of the municipality of Apuí ends up being a warehouse for the commercialization of cattle and subsequent disposal of it to Manaus.

Based on the values raised in the studies by RAZERA (2005) and IDESAM (2015), it was possible to follow the guidelines of the VM0015 for the delimitation of the leakage belt. Initially, using the GIS was created a surface of the cost of transportation of a cattle head (13 arrobas) within the reference zone to the municipal headquarters of Apuí and, also, was considered the most common means of transport in the region. After this step, the total cost for the production of a head of cattle (13 arrobas) was added to this surface, this surface contains information on the total cost for the production, plus the cost of freight to the Apuí municipality headquarter to “prainha”. Then the average resale price of a head of cattle (13 arrobas) was subtracted resulting in the surface representing the potential profit of the product.

After mapping the surface area representing the potential profit for livestock production, the areas in which profit from livestock production is positive within the region were selected according to section 1.1.3, letter “c”. as shown in figure 16 below, the total area of the leakage belt is 428,963.7 hectares.

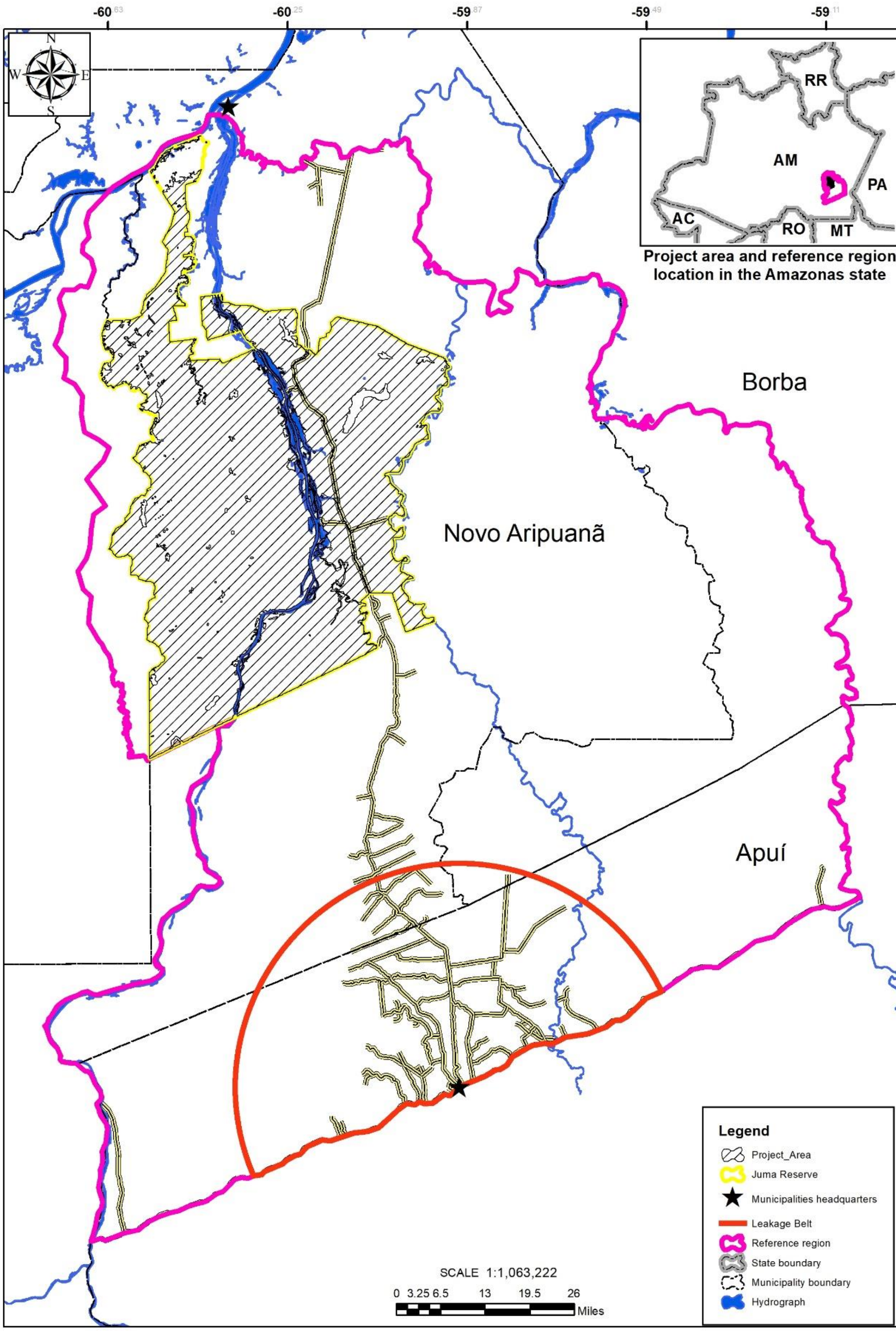


Figura 16. The leakage belt boundary of the Juma REDD+ project.

Forest.

The definition of the forest boundaries was based on PRODES data from 2015, the same information that allowed the delimitation of the project area. Only features mapped as forest were selected, see figure 1.

Remote sensing, as well as field data and other types of data from Forest inventories, plays an important role in addressing these issues. In Brazil, for example, the PRODES Project has been used as an indicator for proposing public policies and for evaluating the effectiveness of their implementations. PRODES spatial data are used in: (a) Certification of agribusiness production chains such as the Soy Moratorium and the Beef Cattle TAC Conduct Adjustment Term; (b) Intergovernmental agreements such as the United Nations Conference on Climate Change (COP 21) and National Inventory Reports on Greenhouse Gas Emissions; and (c) Monetary Donations from the Amazon Fund, which use PRODES as a reference to deforestation activity in the Legal Amazon.

The forest monitoring data transparency policy adopted by INPE and the federal government since 2004 allows full access to all data generated by the monitoring systems, allowing for independent assessments by the user community, including the government at its spheres and levels, Brazilian academia, citizens and civil society in their various institutional arrangements.

PRODES data has been used to monitor numerous REDC + projects in Brazil under the VCS standard, with efficiency, effectiveness and low costs. The product provided by INPE monitoring is the result of a selection of images with lower cloud coverage and adequate radiometric quality. The images are all georeferenced using 1: 100,000 scale topographic maps, and a spectral mixture model of the percentage of vegetation, soil and shadow for each pixel of the image is also created. Segmentation techniques are applied to identify the following categories: forest, non-forest, vegetation, water and deforestation.

In addition to the use of PRODES data in voluntary projects, the National REDD + Commission (CONAREDD +) in its Resolution No. 06 of 06 July 2017 which defines the distribution of payment capping by emission reductions from deforestation in the Amazon biome, cites in Articles 6 and 7 the use of PRODES data to monitor results and distribute benefits.

Therefore, due to the quality of PRODES data and being an international reference in remote forest monitoring, the Juma REDD + project will use its own to monitor the project's forest area, thus maintaining the integration and adherence of a REDD + project in the territory with related initiatives at the federal and state levels. See more information, section 3.6, methodology deviation.

Temporal boundaries

Starting date and end date of the historical reference period

The historical reference period used for the model calibration is from 2009 until 2012, while for the model validation, the year of 2015 was used.

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

The VCS project crediting period starts on 1st January 2016 and ends in 01st January 2116, in a total of 100 years, the maximum granted by the VCS v.4,

Starting date and end date of the first fixed baseline period

The fixed baseline period starts on 01st January 2016 and ends in 31th December 2025, in a total of 10 years as stated in the VM0015.

Monitoring period

The minimum duration of a monitoring period will be one year and the maximum duration should not exceed one fixed baseline period of ten years. The monitoring period will depend on the VCU´s demand, project budget, as well as the deforestation monitored for the reference region.

Carbon pools and sources of GHG emission

Table 3. Carbon pools and sources of GHG included or excluded within the boundary of the project activity

Carbon pools/Sources		Gas	Included?	Justification/Explanation
Baseline	Above-ground tree biomass	CO_2	Yes	Main source of project emissions, through deforestation. Carbon stock change in this pool is always significant
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Below-ground tree biomass	CO_2	Yes	Deemed significant by the PP
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Dead wood biomasss	CO_2	Yes	Deemed significant by the PP
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Non-tree biomass,	CO_2	No	Conservatively excluded

Carbon pools/Sources		Gas	Included?	Justification/Explanation
	litter and soil organic carbon	CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Biomass burning	CO_2	Yes	Counted as carbon stock change
		CH_4	No	Conservatively excluded
		N_2O	No	Considered insignificant according to VCS Program Update of May 24th, 2010
	Livestock emissions	CO_2	No	Not a significant source
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
Project	Above-ground tree biomass	CO_2	Yes	Main source of project emissions, through deforestation. Carbon stock change in this pool is always significant
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Below-ground tree biomass	CO_2	Yes	Deemed significant by the PP
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Dead wood biomass	CO_2	Yes	Deemed significant by the PP
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded
		Other	No	-
	Non-tree biomass, litter and soil organic carbon	CO_2	No	Conservatively excluded
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded

Carbon pools/Sources		Gas	Included?	Justification/Explanation
		Other	No	-
	Biomass burning	CO_2	Yes	Counted as carbon stock change
		CH_4	No	Conservatively excluded
		N_2O	No	Considered insignificant according to VCS Program Update of May 24th, 2010
	Livestock emissions	CO_2	No	Not a significant source
		CH_4	No	Conservatively excluded
		N_2O	No	Conservatively excluded

The map with the project physical boundaries is presented in figure 1, above.

3.4 Baseline Scenario

The baseline scenario development of the Juma REDD+ Project was based in the VM0015 methodology and was divided in 4 steps (step 2-5 of the methodology):

- Step 2 (VM0015): Analysis of historical land-use and land-cover change;
- Step 3 (VM0015): Analysis of agents, drivers and underlying causes of deforestation and their likely future development;
- Step 4 (VM0015): Projection of future deforestation;
- Step 5 (VM0015): Definition of the land-use and land-cover change component of the baseline

Step 2: Analysis of historical land-use and land-cover change

In the Amazon region there are initiatives in the federal, state, municipal and also third sector organizations to monitoring the forest. The main forest cover monitoring initiative is that undertaken annually by the Space Research Institute (INPE) within the PRODES project.

The spatial land use data, collected to development the temporal analysis of the land use and land use change from the Juma Project was the PRODES project data from the federal government produced by the INPE and aims to systematically measure, map and quantify annual deforestation rates in order to guide the government in establishing strategies to prevent and combat deforestation.

The PRODES Project has been used as an indicator for proposing public policies and for evaluating the effectiveness of their implementations. PRODES spatial data are used in: (a) Certification of agribusiness production chains such as the Soy Moratorium and the Beef Cattle TAC Conduct Adjustment Term; (b) Intergovernmental agreements such as the United Nations Conference on Climate Change (COP 21) and the National Inventory Reports on Greenhouse Gas

Emissions and (c) Monetary Donations from the Amazon Fund, which use PRODES as a reference to deforestation activity in the Legal Amazon.

The forest monitoring data transparency policy adopted by INPE and the federal government since 2004 allows full access to all data generated by the monitoring systems, allowing for independent assessments by the user community, including the government at its spheres and levels, Brazilian academia, citizens and civil society in their various institutional arrangements.

PRODES data has been used to monitor numerous voluntary REDD + projects in Brazil with efficiency, effectiveness and low costs. The product provided by INPE monitoring is the result of a selection of images with lower cloud coverage and adequate radiometric quality. The images are all georeferenced using 1: 100,000 scale topographic maps, and a spectral mixture model of the percentage of vegetation, soil and shadow is created for each pixel of the image. Segmentation techniques are applied to identify the following categories: forest, non-forest, vegetation, water and deforestation. The minimum mapping unit is 6.25 hectares.

In addition to the use of PRODES data in voluntary projects, the National REDD + Commission (CONAREDD +) in its Resolution No. 06 of 06 July 2017 which defines the distribution of payment capping limits by emission reductions from deforestation in the Amazon biome, cites in Articles 6 and 7 the use of PRODES data to monitor results and distribute benefits.

Therefore, due to the quality of PRODES data and because it is an international reference in remote forest monitoring, the Juma Project will use as the main data source for forest area monitoring, thus maintaining the integration and adherence of a REDD project in the territory with the correlated initiatives at the federal and state levels.

The land use data was downloaded in the INPE website[40], it was obtained spatial information from the reference period (2009, 2012, 2015). Also, the PRODES data complies with the VM0015 criteria of land use classes. Because of the use of classified PRODES data, the table 5, of the VM0015 doesn´t apply to the Juma Project, since it wasn´t collected any kind of satellite or airplane images to the temporal analysis of the reference period.

Since, the focus of the baseline analysis is the transition between forest and deforested areas, the other classes such (clouds, shadows, old residues and non-forest) were merged separately first for the two first years of the reference period (2009 and 2012, calibration period of the model) and after to the confirmation period (2009 and 2015) and used as a mask to excluded this information from the land use data of 2009, 2012 and 2015, respectively, the exception was the hydrograph class which had been maintained in the project database only for presentation purposes.

The results of the forestry inventory conducted in Juma RDS (Annex 4), inventory showed that there is not any significative difference between the biomass and carbon stocks in the different forestry physiognomies within the project area. Thus, there is not necessity to stratify the forest land, according to the VM0015, section 2.2, but, nevertheless, it was produced a forest classes map (figure 17) using the vegetation mapping product from SIPAM which showed three different physiognomies, which are: alluvial, submontana and lowlands dense ombrophilous forestry.

[40] http://www.dpi.inpe.br/prodesdigital/dadosn/

The figure 17 shows the forest classes inside of the project area at the project start date, it´s important to highlight that at the project start date, the project area includes only forest land as it is set as a criterion in the section 1.1.2 of the VM0015.

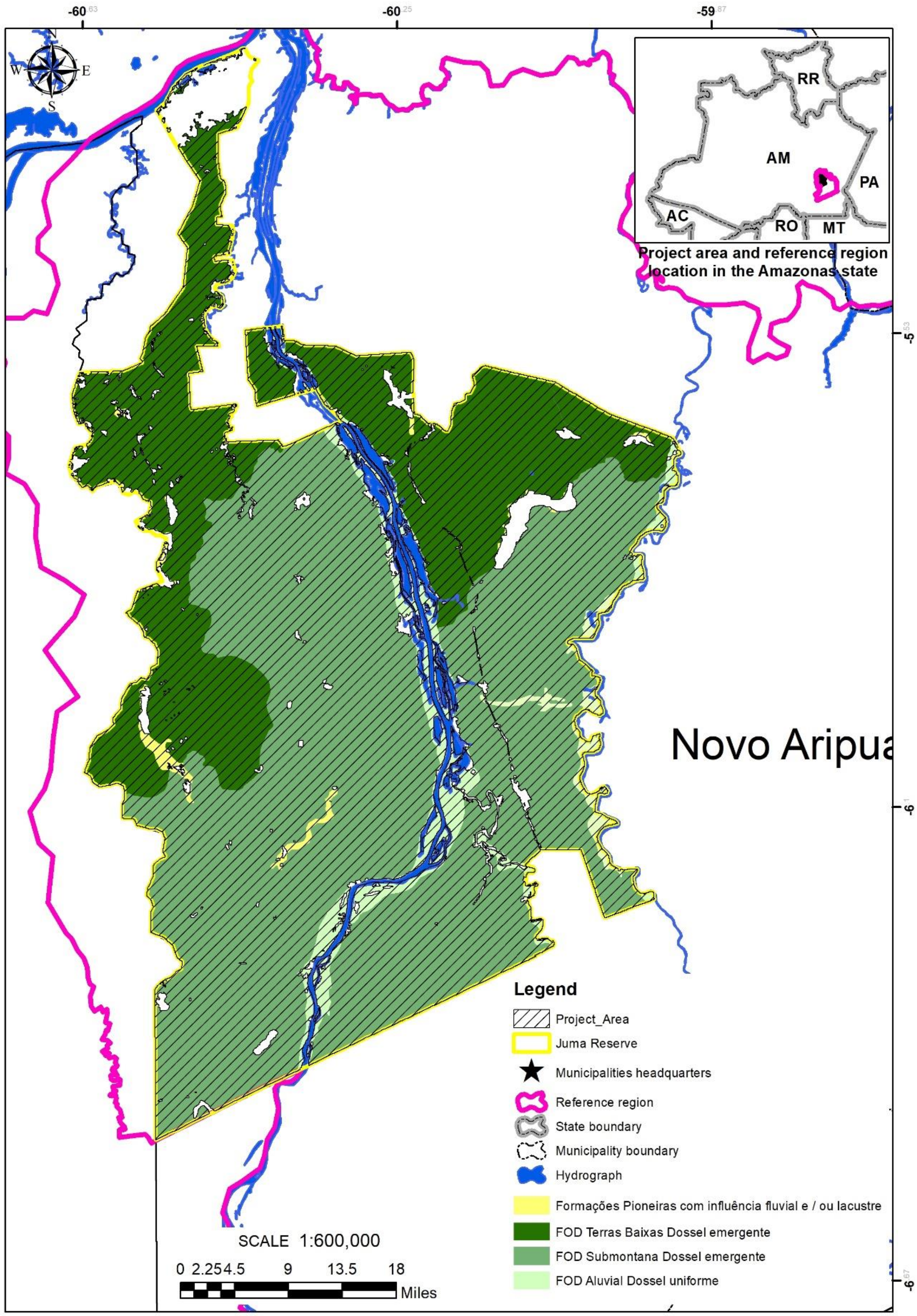


Figure 16. The forest classes located within the Juma Project.

The MapBiomas[41], another monitoring Amazon forest source, was utilized in this methodology step to characterize the land use at the project start date, and helping to qualify the land cover of the deforestation areas. The MapBiomas is an initiative of the third sector to monitoring the vegetation in Brazil in all biomes. All the land cover classes from 2017 that exists in the MapBiomas data, in the reference region are presented in the table 4 and in the figure 18.

Table 4. List of all land use and land cover classes existing at the project start date within the reference region.

Class identifier		Trend in carbon stock	Presence in	Baseline activity			Description
IDcl	Name			LG	FW	CP	
1	Forest	Constant	RR, PA, LK.	Yes	Yes	Yes	Remaining forest
2	Other natural formations	Constant	RR	No	Yes	Yes	Natural cover of non-forest vegetation
3	Pasture	Constant	RR, LK, LM	No	No	No	Deforestation areas to cattle ranching
4	Settlements	Constant	RR, LK	No	No	No	Urban areas and infrastructure
5	Water	Constant	RR, LK, LM.	No	No	No	Bodies of water

[41] http://mapbiomas.org/

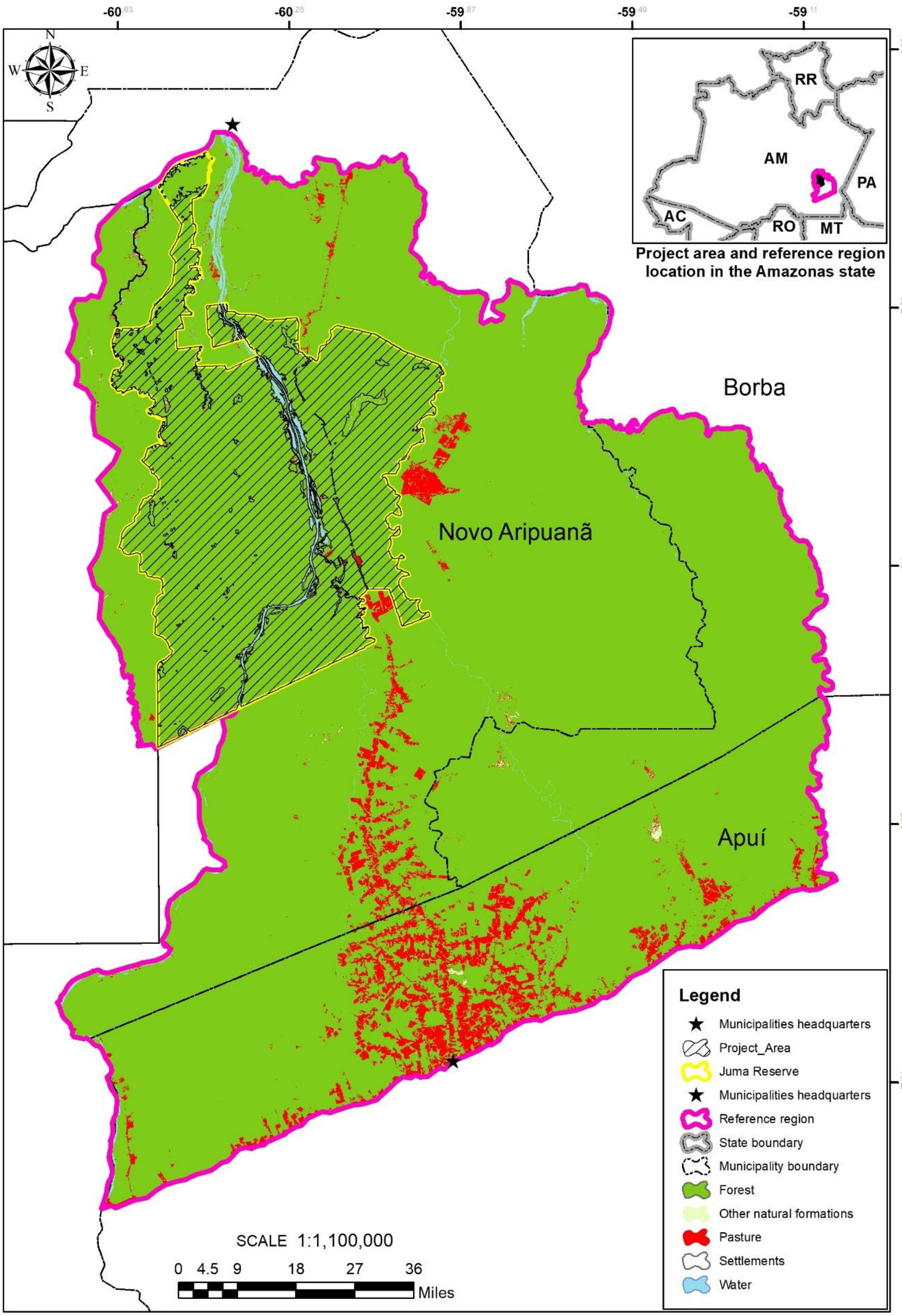


Figure 17. Land use and land cover in the reference region of the Juma Project.

The definition of categories of land-use and land-cover change was made identifying all LU/LC-change categories that could occur within the project area, reference region and leakage belt (table 4) during the project crediting period in both, the baseline and project case. This was done by analysing a land-use change matrix that combines all LU/LC-classes previously defined (table 5).

Table 5. Potential land-use and land-cover change matrix

ID$_{cl}$			**Initial LU/LC Class**				
		Name	Forest	Other natural formations	Pasture	Settlements	Water
			I1	I2	I3	I4	I5
Final LU/LC class	F1	Forest	Forest/Forest	Other natural formations/Forest	Pasture/Forest	Settlements/Forest	Water/Forest
	F2	Other natural formations	Forest/Other natural formations	Other natural formations/Other natural formations	Pasture/Other natural formations	Settlements/Other natural formations	Water/Other natural formations
	F3	Pasture	Forest/Pasture	Other natural formations/Pasture	Pasture/Pasture	Settlements/Pasture	Water/Pasture
	F4	Settlements	Forest/ Settlements	Other natural formations/ Settlements	Pasture/Settlements	Settlements/ Settlements	Water/ Settlements
	F5	Water	Forest/Water	Other natural formations/Water	Pasture/Water	Settlements/Water	Water/Water

Table 6. List of land-use and land-cover change categories

ID$_{cl}$	**Name**	**Trend in Carbon Stock**	**Present in**	**Activity in case of baseline**			**Name**	**Trend in Carbon Stock**	**Present in**	**Activity in case of Projetc**		
				LG	**FW**	**CP**				**LG**	**FW**	**CP**
I1/F3	Forest	Constant	RR, PA, LK.	Yes	Yes	Yes	Pasture	Constant	RR, LK, LM	No	No	No

I1/F4	Forest	Constant	RR, LK, PA	Yes	Yes	Yes	Settlements	Constant	RR, LK	No	No	No

Analysis of historical land-use and land-cover change

Deforestation mapping data provided by PRODES were used to analyses the temporal land use change. The main methodological[42] steps undertaken by PRODES to map deforestation in the Brazilian Amazon are, as follows:

• Pre-processing: according to CÂMARA et al. (2006) the main image pre-processing procedures performed by PRODES consist of the steps of image selection with lower cloud cover, with date of acquisition closest to the dry season in the Amazon and with adequate radiometric quality; georeferencing of images with spatial resolution of 30 meters with 1: 100,000 scale topographic maps and orthorectified MrSID format images from NASA.

• Interpretation and classification: The satellite image classification method used by PRODES follows four main steps. First, a spectral mixture model is generated identifying in the images the components of vegetation, soil and shade. This technique is known as the linear spectral mixture model (MLME), which aims to estimate the percentage of vegetation, soil and shadow components for each cell (pixel) of the image. The second step is the application of the segmentation technique, which identifies spatially adjacent regions (segments) with similar spectral characteristics in the satellite image. After segmentation, the segments are individually classified to identify the classes forest, non-forest vegetation, hydrography and deforestation (anthropized vegetation). Finally, the result of classified segmentation is submitted to the process of editing, or audit of classification, performed by an expert, ending with the creation of state mosaics.

• Postprocessing: The result of the classification is then submitted to an audit process of a geoprocessing analyst.

• Map accuracy check: Mapping check available from PRODES was performed by comparing each class of the land cover map from the reference period (2009, 2012 and 2015) with a set of 34 points randomly distributed over the reference region for each year. The reference data used for this step comes from the visual interpretation of high spatial resolution images available in Google Earth. The global accuracy of the mapping for the different classes of land cover presented values above 80% for all three classes in each year analyzed. The overall accuracy of the forest cover reference map (2015) was 100%. See more details in the Appendix VI (spredshet PRODES data accuracy analysis).

Preparation of a methodology annex to the PD

As LU/LC-change analysis is an evolving field and will be performed several times during the project crediting period. A consistent time-series of LU/LC-change data must emerge from this process.

The VM0015 guides the project proponent to use the same source of remotely sensed data and data analysis techniques within a period for which the baseline is fixed (fixed baseline period).

[42] http://www.obt.inpe.br/prodes/metodologia.pdf

However, if remotely sensed data have become available from new and higher resolution sources (e.g. from a different sensor system) during this period, these can only be used if the images based on interpretation of the new data overlap the images based on interpretation of the old data by at least 1 year and they cross calibrate to acceptable levels based on commonly used methods in the remote sensing community.

So, as this PD used the PRODES data from the federal government produced by the INPE to make the temporal analysis of the land use and land use change of the reference period, the data that will be used in the monitoring period and in the renewal of the baseline is going to be the PRODES unless appear others data with better resolution and more efficient.

Initially the PRODES data will be download from the INPE database in the web, after all the classes that are not in the focus of avoidance the deforestation (such as non-forest areas, clouds, shadow and residues) of the Juma Project will be excluded from the database and the analysis of the PRODES data will have only the classes of interesting, such as forest, deforestation and water.

After that procedure, the PRODES data will have to has an accuracy assessment as the VM0015 give the guidelines in the section 2.5, in summary a minimum of 104 randomly distributed points (34 points for each class) in a high spatial resolution (≤5 meters) satellite images will be used. The minimum accuracy of classification mapping should be 80%.

Step 3: Analysis of agents, drivers and underlying causes of deforestation and their likely future development

Identification of agents of deforestation

Southern Amazonas is one of the last deforestation frontiers in the Amazon. All municipalities within Amazonas-Pará-Mato Grosso-Rondônia border are in a high risk of forest loss due to lack of governance, sustainable income alternatives and weak surveillance practices. According to official data, in August, the peak of forest fires in the Amazon, there were two municipalities in southern Amazonas out of top 10 in the Amazon[43].

Within the project's area and its reference region, there are two main deforestation agents: (a) land grabbling due to ranching activities (Carrero & Fearnside, 2011[44]) and (b) illegal timber extraction (Fearnside, 2008[45]) both large and small scales (Kalamandeen et al., 2018[46]).

[43] https://g1.globo.com/natureza/noticia/2019/08/22/municipios-com-maior-numero-de-queimadas-tiveram-as-maiores-taxas-de-desmatamento-em-2019-diz-ipam.ghtml

[44] https://www.ecologyandsociety.org/vol16/iss2/art26/

[45] ftp://ftp.iluci.org/Evan/GEOG415/Reading_Assignments/Reading%2016%20-%20LCLUC%20Deforestation%20Focus/Fearnside%20-%20The%20Roles%20and%20Movements%20of%20Actors%20in%20the%20Deforestation%20of%20Brazilian%20Amazonia.pdf

[46] https://www.nature.com/articles/s41598-018-19358-2

In a broader analysis, covering Mato Grosso, Rondônia and Pará, it should be included (i) soy production (Silva Junior & Lima, 2018[47]), (ii) mining (both legal and illegal) (Souza et al., 2018[48]), (iii) big dams (Souza Jr et al., 2019[49]).

In regards of land grabbing and cattle ranching, they are very connected. Due to lack of governance and proper surveillance by both National and State-level institutions, several big ranchers do not pay for lands in the Amazon (Brito et al., 2019[50]). Through land grabbing (*grilagem*), these agents steal public lands mostly to cattle ranching (Conscieme et al., 2018[51]). Thus, cattle raising, as a means for land speculation, contributes to the advance of deforestation (Brito et al., 2019).

It is also known that a large part of ranchers in the Amazon do not pay for the public lands in which they take possession or makes "grilagem". They illegally exploit the wood which contributes to accumulate capital to invest in livestock. Thus, cattle raising, as a means for land speculation, contributes to the advance of deforestation. The result is high environmental impact with low productivity and social return. However, cattle are considered a highly liquid product and are considered as an investment for small and medium producers, as they can be transported alive and quickly sold when needed.

Besides cattle ranching is highly profitable, unsustainable ranching causes huge environmental impact with low social return (Azevedo-Ramos & Moutinho, 2018[52]), mostly due to low-productivity pasture management (Hansen et al., 2019[53]; Silva et al., 2018[54]). The ranchers thus seek new areas for pasture, increasing pressure on pristine forests and raising deforestation (Silva et al., 2018).

Name of the deforestation agent	land grabbling due to ranching activities and illegal timber extraction
Brief description of the main social, economic, cultural and other relevant features	The dynamics of deforestation in this region have historical roots due to the promotion of colonization that occurred during the dictatorship. At this time the federal government supported the occupation of land by settlers who after the opening of forest areas received the title of the area.

47 https://www.sciencedirect.com/science/article/abs/pii/S0264837717312413

48 https://ieeexplore.ieee.org/abstract/document/8518495

49 https://www.mdpi.com/2073-4441/11/3/566

50 https://ieeexplore.ieee.org/abstract/document/8518495

51 https://www.mdpi.com/2079-9276/7/3/44

52 https://www.sciencedirect.com/science/article/abs/pii/S0264837717314527

53 https://www.sciencedirect.com/science/article/pii/S0921800918304130

54 https://onlinelibrary.wiley.com/doi/abs/10.1002/ldr.3087

	Thus, the current context of deforestation in the reference region originates from the creation of the Settlement Project where the current headquarters of the municipality of Apuí is located. The dynamics of deforestation occur mainly due to the integrated action of the three main agents (logger, land grabber and rancher) that in most situations the same stakeholder assumes the role of the three agents of deforestation. For example, by extracting timber from public areas and with revenue from illegal logging, irregular documentation of the area is made possible through notorious fraud and also investing in grazing and buying cattle. After the degradation of the pasture that results in a low productivity of the economic activity, the rancher looks for new areas to maintain the deforestation dynamics.
Brief assessment of the most likely development of the population size	In the continuity of the baseline and the common practice of land use and occupation it is expected that in areas where the opportunity cost, especially of the livestock economic activity, an increase in forest pressure will be attractive due to the joint action of the three agents. deforestation in the region and, consequently, an increase in population size. In other regions with lower transition potential, but with a likelihood of change, where the dynamics of deforestation stem from the motivation of land speculation and land grabbing, an increase in population size is not expected.
Statistics on historical deforestation attributable	According with the Mapbiomas data all the land use after the deforestation in the reference region is the pasture, figure 17. So, all the deforestation that occurred in the reference period in the reference region can be attributable to the deforestation dynamics of the three main deforestation agents, as it was described above.

Identification of deforestation drivers

Deforestation driver	Evidence that the identified variables have been a driver for deforestation during the historical reference period	Driver variables will impact on each agent group's decision to deforest.
Distance of the accumulated deforestation in 2009	The reason for choosing this variable is the characteristic of deforestation in the region known as border deforestation (the reference region is located in the "arc of deforestation"). In these locations, forest cover in the vicinity of an agricultural / urban	Illegal timber and Cattle ranching

	landscape matrix has a higher opportunity cost for conservation than in isolated and / or hard to reach regions. Thus, productive areas tend to increase, following the logic of "puxadinho" over conserved areas.	
Distance of main and secondary roads	Roads are known and consolidated deforestation vectors on a global scale and are responsible for deforestation in "fishbone" format.	Illegal timber and Cattle ranching
Distance of National Department of Mineral Prospecting (DNPM) process	Mining activity in general can be considered a deforestation vector, both legal and illegal. From the mineral exploration begins a migratory flow to an isolated region establishing services to supply a mining, for example, which results in the suppression of vegetation in and around the exploited areas.	miners
Distance of the rivers	This variable was chosen because the areas close to the watercourses are areas most used for various agricultural activities. Mainly for the easy accessibility to the resource and also for being in the riparian zone where are more fertile soils, with high presence of organic material. They are also a common means of transport in the Amazon region, facilitating the flow of illegal timber products and access to remote regions.	Illegal timber
Distance of municipalities headquarters	Locations with clustering of people, with little infrastructure and poor access to public policy, find themselves in a state of neglect by public governance, especially with regard to environmental command / control. Forested areas have a great vulnerability around the localities that demand wood (energy, construction and commercialization), which initially selectively extract, then cut and burn for the implantation of low productivity and low value pastures. aggregate.	Cattle ranching

Identification of underlying causes of deforestation

In regards of land grabbing and cattle ranching, they are very connected. Due to lack of governance and proper surveillance by both National and State-level institutions, several big ranchers do not pay for lands in the Amazon (Brito et al., 2019[55]). Through land grabbing (*grilagem*), these agents steal public lands mostly to cattle ranching (Conscieme et al., 2018[56]). Thus, cattle raising, as a means for land speculation, contributes to the advance of deforestation (Brito et al., 2019). Besides cattle ranching is highly profitable, unsustainable ranching causes huge environmental impact with low social return (Azevedo-Ramos & Moutinho, 2018[57]), mostly due to low-productivity pasture management (Hansen et al., 2019[58]; Silva et al., 2018[59]). The ranchers thus seeks new areas for pasture, increasing pressure on pristine forests and raising deforestation (Silva et al., 2018).

It is worth mentioning that the ranchers' decision-making process of expanding pasture to primary forest is based on a disturbed economic rationale (Hansen et al., 2019), which it does not account for costs of losses of environmental services. On the top of it, big ranchers push medium- and smallholders to other areas – also increasing pressure on primary forests.

Another worth mentioning deforestation driver is road (Godar et al., 2012[60]; Lima et al., 2006[61]; Fearnside, 1987[62]). The project's area has two main (and official) roads: one federal BR-230 (Transamazon road) and other State-owned AM-174. The first was built in 1972 and it is the largest Federal road in Brazil: 5,662 km connecting Labrea-AM and Cabedelo-PB. The State-owned connects Novo Aripuanã-AM to Apuí-AM, and it is one of the biggest drivers of deforestation in southern Amazonas (Yanai et al., 2012[63]).

[55] https://ieeexplore.ieee.org/abstract/document/8518495

[56] https://www.mdpi.com/2079-9276/7/3/44

[57] https://www.sciencedirect.com/science/article/abs/pii/S0264837717314527

[58] https://www.sciencedirect.com/science/article/pii/S0921800918304130

[59] https://onlinelibrary.wiley.com/doi/abs/10.1002/ldr.3087

[60] https://www.sciencedirect.com/science/article/abs/pii/S0378112711007316

[61] https://www.tandfonline.com/doi/abs/10.3200/ENVT.48.1.26-38

[62] https://s3.amazonaws.com/academia.edu.documents/7370178/Causes%20of%20Deforestation%20in.pdf?response-content-disposition=inline%3B%20filename%3DCauses_of_Deforestation_in_the_Brazilian.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=AKIAIWOWYYGZ2Y53UL3A%2F20191027%2Fus-east-1%2Fs3%2Faws4_request&X-Amz-Date=20191027T152354Z&X-Amz-Expires=3600&X-Amz-SignedHeaders=host&X-Amz-Signature=9b59b1bcc7e5e86762d078c46d5b03a05ab52ee11a637b2eb5acc00ffa9055a3

[63] https://www.sciencedirect.com/science/article/pii/S0921800918304130

Analysis of chain of events leading to deforestation

Since mid-2000, the start of activities for logging companies from the states of Rondônia and Mato Grosso began in the reference region, which led to the opening and maintenance of unofficial roads (branches). In 2008, Novo Aripuanã featured five sawmills near its urban headquarters north of the Juma RDS. PA Juma and Acari and its surroundings concentrate most of the accumulated deforestation of the municipalities of the reference region together.

According with CENAMO *et al.* (2011) In Novo Aripuanã, land grabbing and forest clearing in the Acari River region, east of the Juma RDS, there are records that areas of about 4,000 ha were cleared between 2008-2010 in a hard-to-reach region. Low governance also contributes to land grabbing in isolated regions bordering other states, especially Mato Grosso. There is a highly capitalized and organized land grabbing process within the Apuí PA mosaic. From the municipality of Colniza (MT), there is the attempt of demarcation and occupation by employees of businessmen, doctors and lawyers who live in Cuiabá or in cities of southern and southeastern Brazil.

The migration of people who inhabited Rondônia to the village of km 180 and Apuí is quite significant (Fearnside 2008, Carrero 2009). These families, together with immigrants from the southeastern and southern regions of Brazil since the 1980s, are the main agents of deforestation in the reference region - mainly focused on livestock activity.

Conclusion

As explained in the subsections of step 3, it was possible to conclude based on the evidences presented that the most probable scenario of the deforestation trend is the continuity of the common practice in the place, where the deforestation agents act in an integrated manner in the same area, with distinct temporalities.

These three agents seek areas close to old deforestation, surrounding roads, proximity to consumer centers and rivers, where they can run from illegally harvested timber and cattle production, these same agents (loggers and ranchers) use land grabbing techniques. to obtain illegal documentation from public and / or vacant areas or to associate with land grabbers for low value land.

Thus, it is expected that the situation related to the dynamics of deforestation agents and vectors in the reference region in the reference period will continue, thus being a potential scenario of the project baseline.

As shown in figure 18, it is expected that the deforestation trend will be fluctuating characterized by increases in deforestation rate due to macroeconomic aspects (demand for commodities, especially soybeans) that put pressure on pasture areas for productive conversion and, consequently, put pressure on cheaper forest areas for conversion to pasture, thereby shifting the arc of deforestation north of the state of Amazonas.

STEP 4: Projection of future deforestation

Projection of the quantity of future deforestation

The reference region was not stratified because present a level of similarity in different aspects with the project area, as analyzed in section 3.3. The adopted RR has basically the same phytophysiognomies as the project area, with 91.6% of its vegetation area covered by dense ombrophilous forest. According to the forest inventory conducted in the Juma RDS (Annex 4), the carbon stock in the phytophysiognomies (lowland, submontane and alluvial lands) do not present statistically significant differences, so the same value can be considered for both phytophysiognomies.

Selection of the baseline approach

The baseline approach selected to project the future deforestation of the project was the letter “c” (step 4.1.1 of the VM0015), the modelling approach. The deforestation rates measured in the reference period in the Novo Aripuanã, which is the main municipality of the reference region and where is located the project area didn´t reveal any trend (decreasing, constant or increasing deforestation), as is it possible to see in figure 18, below. Also, conclusive evidence emerged from the analysis of agents and drivers (step 3) explaining the different historical deforestation rates and there is at least one explanatory variable can be used to project the deforestation rate.

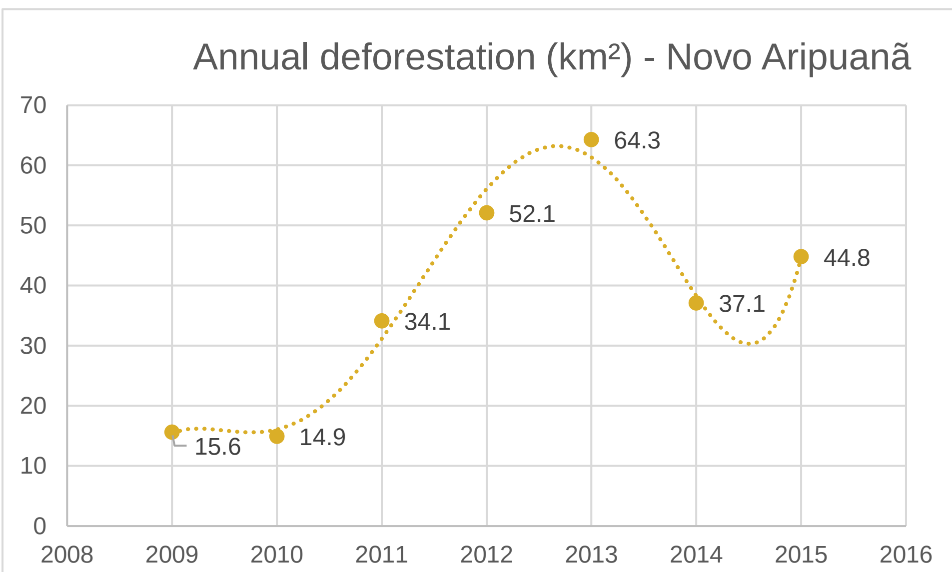


Figure 18. The annual deforestation (km²) in the Novo Aripuanã, PRODES data.

Quantitative projection of future deforestation

Approach “c”: Modeling

Land use changes can be modeled empirically by relating historical changes to their explanatory variables (vectors) so that it is possible to extract a set of rules that can be extrapolated to the future (SANGERMANO et al. 2012).

According to MATTA (2015), the most common methods for extracting these relationships are neural networks (PIJANOWSKI et al. 2002), logistic regression (PONTIUS & SCHNEIDER 2001) and evidence weights (SOARES-FILHO et al. 2006).

AMUCHASTEGUI and FORREST (2013) evaluated six different tools with potential for modeling land use changes: LCM, GEOMOD, DYNAMIC EGO, MAXENT / ZONATION, CLUE and InVEST. The study concluded that the best land use modeling tool is LCM, and is considered a successful project.

MATTA (2015) pointed out in his study that within the scope of REDD + projects validated to the VCS standard, the Land Change Modeler (LCM) was used in three projects in Brazil and one project in Peru, in Cordilheira Azul National Park (CIMA, 2012). It is worth mentioning another study that used MLP to simulate the impact of major works, such as the Belo Monte Hydroelectric Deforestation Risk (IMAZON, 2011).

For this reason, the tool chosen for the baseline analysis of the Juma REDD+ project was the Land Change Modeler, LCM module (EASTMAN, 2009), present in the IDRISI 16.0 Taiga Edition software.

Algorithm used: Neural Networks

Artificial neural networks are important tools that use a computational learning approach to quantify and model complex behaviors and patterns. Among them, Multi-Layer Perception (MLP) stands out as the most used neural network. MLP consists of one input data (the explanatory variables) and one output data (the modeled transitions) and one or more hidden data. Each hidden data has a node (or neuron) that is connected by weights to the input and output data. (PIJANOWSKI et al. 2002).

HU AND WENG (2009) pointed out that neural networks have been widely used due to their advantages over other statistical methods, such as: it does not need to assume assumptions for input data; It is robust in noisy environments and assimilates complex patterns. Although there are several robust neural network models, the MLP neural network is the most commonly used, according to the authors.

Weights in a neural network are determined using a training algorithm that randomly selects the initial weights and then compares the calculated output data with the expected observation value. The difference between the calculated and expected values in all observations is summarized using the mean of squared errors. After all observations are analyzed by the neural network, the weights are modified so that the total error is distributed across the various nodes of the network. This process of looking forward and backward to propagate the inaccuracy is repeated until the error assumes its lowest value. (PIJANOWSKI et al. 2002).

In the analysis of the deforestation dynamics of the JUMA REDD+ Project Reference Region, the input data (factor maps) of the neural network model were all analyzed, even though there is a possibility of correlation and redundancy of information between them. As SANGERMANO, et al. (2012) demonstrated that MLP is nonparametric and allows to associate complex relationships regardless of the presence or absence of multicollinearity or inclusion of insignificant variables.

Location analysis of future deforestation within reference region is required to determine the annual areas of deforestation within the project area and leakage belt. Once location analysis was completed, the portion of annual areas of baseline deforestation within the project area and leakage belt was determined using a GIS software (table 7).

Table 7. Annual areas of baseline deforestation in the reference region (RR), project area (PA) e leakage belt (LB).

Year	Project year	Total - RR		Total - PA		Total - LB	
		Annual *ABSLRR* ha	Cummulative ABSLRR ha	Annual *ABSLPA* ha	Cummulative ABSLPA ha	Annual *ABSLLB* ha	Cummulative ABSLLB ha
2015	0	-	153,622.67	-	-		90,877.75
2016	1	11,977.29	165,599.96	942.66	942.66	6,219.30	97,097.04
2017	2	7,345.05	172,945.01	604.36	1,547.03	3,716.68	100,813.72
2018	3	7,078.94	180,023.95	664.44	2,211.47	3,625.18	104,438.90
2019	4	6,820.29	186,844.25	1,698.39	3,909.86	729.32	105,168.22
2020	5	6,542.62	193,386.86	-	3,909.86	3,580.63	108,748.85
2021	6	6,272.58	199,659.45	25.59	3,935.46	5,453.84	114,202.70
2022	7	8,283.06	207,942.51	1,824.56	5,760.02	348.85	114,551.55
2023	8	5,125.10	213,067.60	-	5,760.02	4,161.19	118,712.74
2024	9	4,938.55	218,006.15	-	5,760.02	4,666.20	123,378.94
2025	10	4,767.49	222,773.64	1,139.84	6,899.86	16.16	123,395.10
TOTAL		**69,150.97**		**6,899.86**		**32,517.35**	

Projection of the location of future deforestation

Preparation of factor maps

All factor maps that were generated is presented below, see (table 8), it was obtained all the spatial data related to each 5 variables analyzed, and it was created digital maps representing the Spatial Features of each variable. The LCM requires producing Distance Maps from the mapped features (e.g. distance to roads or distance to already deforested lands) and this data were created using the Empirical approach which is suggested by the VM0015 (section 4.2.1).

Preparation of deforestation risk maps

The preparation of all risk maps follows the figure 19, this flowchart illustrates how the deforestation risk maps were generated and for evaluate the model and the factor maps (table 8) that best explain the dynamics of deforestation was used, according to SANGERMANO, et al. (2012) and MATTA (2015), the sensitivity analysis “Jacknife”. In the analysis two classes are created: “ROC with only” and “ROC without”. “ROC with only” indicates that in the 2015 transition potential map, modelled from 2009 to 2012, only the focus deforestation driver of the analysis was used. “ROC without” means that all other deforestation drivers were used and the focus driver was excluded from the analysis. So, it was produced 12 twelve different deforestation risk maps to determine the most accurate one, comparing the transition potential maps modelled to 2015 with the actual deforestation that happened from 2009-2015 (see the details in the Appendix VI).

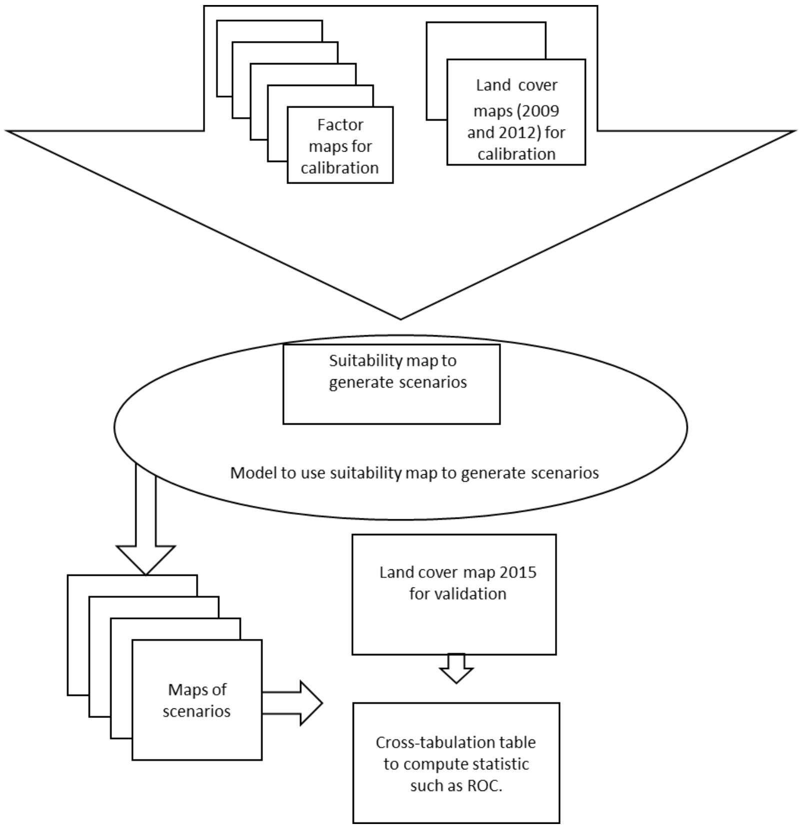


Figure 19. flow-chart diagram illustrating how the Risk Map was generated

ROC is the Relative Operating Characteristic, a method widely used to evaluate the accuracy of a model in predicting the occurrence locations of a class by comparing a susceptibility (transition potential) image or risk map that depicts the likely occurrence locations of the class, with a boolean image (values of 0 - non-existence and 1 - existence) showing where the class really exists. In the operation using the ROC was adopted as amplitude threshold the standard value equal to 10 (PONTIUS and SCHNEIDER, 2001). According to SANGERMANO, et al. (2012), variables that usefully contribute to the model will have a high ROC value when used separately ("ROC with only"). Variables that contribute unique information will have a lower ROC value when excluded from the model ("ROC without").

For each susceptibility value within the adopted threshold, points called false and true positives are generated (CLARK LABS, 2009). A real positive is a pixel that is categorized as change in the actual scenario (in the case of 2009-2015) and also in the modeled susceptibility scenario. A false positive is a pixel categorized as not changing in the real scenario, but as changing in the modeled scenario. These points are then connected in a computational environment creating a curve whose area (Area Under the Curve - AUC) represents the value of the ROC (dimensionless) statistic. The modeling software, IDRISI Taiga, calculated the area over the curve using the trapezoidal rule of differential and integral calculus.

Table 8. List of variables, maps and factor maps.

Factor Map		Source	Variable represented		Meaning of the categories or pixel value		Other Maps and Variables used to create factor map		Algorithm or Equation used	Comments
ID	***File Name***		**Unit**	**Description**	**Range**	**Meaning**	**ID**	**File name**		
1	dist_desmat09clip.rst	The cartographic base used was generated with the 2009 data from the PRODES / INPE Amazon Monitoring System.	degrees	Distance of the accumulated deforestation in 2009 (figure 2).	0 - 0.42	Values close to 0 are closer to the deforestation	1A	Prodes2009_RR.shp	The classes accumulated deforestation, forests and hydrography in shapefile format were selected in the ArcGIS 10.5 software. This land cover file was imported into Idrisi Taiga software. Subsequently, the file was converted from a vector format to an image, a Boolean file of the deforestation class 2009 was created and its Euclidean distance was calculated.	The reason for choosing this variable is the characteristic of deforestation in the region known as border deforestation (the reference region is located in the “arc of deforestation”). In these locations, forest cover in the vicinity of an agricultural / urban landscape matrix has a higher opportunity cost for conservation than in isolated and / or hard to reach regions. Thus, productive areas tend to increase, following the logic of "*puxadinho*" over conserved areas.
2	dist_estradas_cut.rst	The cartographic base used was provided by Imazon, and refers to the systematic mapping of branches, secondary and primary roads, in a 1: 50000 scale.	degrees	Distance of main and secondary roads (figure 3)	0 - 0.846	Values close to 0 are closer to main roads	2A	estradas_amazonas_imazon.shp	The data was clipped to the reference region using ArcGIS 10.5 software. The information was imported into the Idrisi Taiga software and converted to raster, then the Euclidean road distances within the reference region were calculated.	Roads are known and consolidated deforestation vectors on a global scale and are responsible for deforestation in "fishbone" format.

3	dist_dnpm_cut.rst	The cartographic base used was generated based on information available to the Amazonas state in the Sigmine database[1], in 1:250000 scale.	degrees	Distance of National Department of Mineral Prospecting (DNPM) process (figure 5)	0 - 0.506	Values close to 0 are closer to the mining areas	3A	am.shp	It was clipped to the reference region using ArcGIS 10.5 software. The information was imported into the Idrisi Taiga software, converted to raster and then the Euclidean distances from the areas declared in the licensed process within the reference region were calculated.	Mining activity in general can be considered a deforestation vector, both legal and illegal. From the mineral exploration begins a migratory flow to an isolated region establishing services to supply a mining, for example, which results in the suppression of vegetation in and around the exploited areas.
4	dist_hidro_cut.rst	The cartographic base used was generated with the hydrographic data of the Amazon Protection System (SIPAM), on a scale of 1: 250,000.	degrees	Distance of the rivers (figure 1).	0 - 0.041	Values close to 0 are closer to hidrography	4A	hidrografia_sipam.shp	The spatial information of the hydrography was grouped and cut to the study area using ArcGIS 10.5 software. The information was imported into the Idrisi Taiga software, where such vectors were converted to matrix format and the Euclidean hydrographic distances within the RR were calculated.	This variable was chosen because the areas close to the watercourses are areas most used for various agricultural activities. Mainly for the easy accessibility to the resource and also for being in the riparian zone where are more fertile soils, with high presence of organic material. They are also a common means of transport in the Amazon region, facilitating the flow of illegal timber products and access to remote regions.

5	dist_sedes_cut.rst	The cartographic base used was generated based on IBGE (2014) spatial information, in 1: 250000 scale.	degrees	Distance of municipalities headquarters (figure 4)	0 - 2.12	Values close to 0 are closer to municipalities headquarters	5A	localidades_ibge.shp	It was clipped to the reference region using ArcGIS 10.5 software. The information was imported into the Idrisi Taiga software, converted to raster and then the Euclidean distances from the localities within the reference region were calculated.	Locations with clustering of people, with little infrastructure and poor access to public policy, find themselves in a state of neglect by public governance, especially with regard to environmental command / control. Forested areas have a great vulnerability around the localities that demand wood (energy, construction and commercialization), which initially selectively extract, then cut and burn for the implantation of low productivity and low value pastures. aggregate.

1[1] http://sigmine.dnpm.gov.br/webmap/

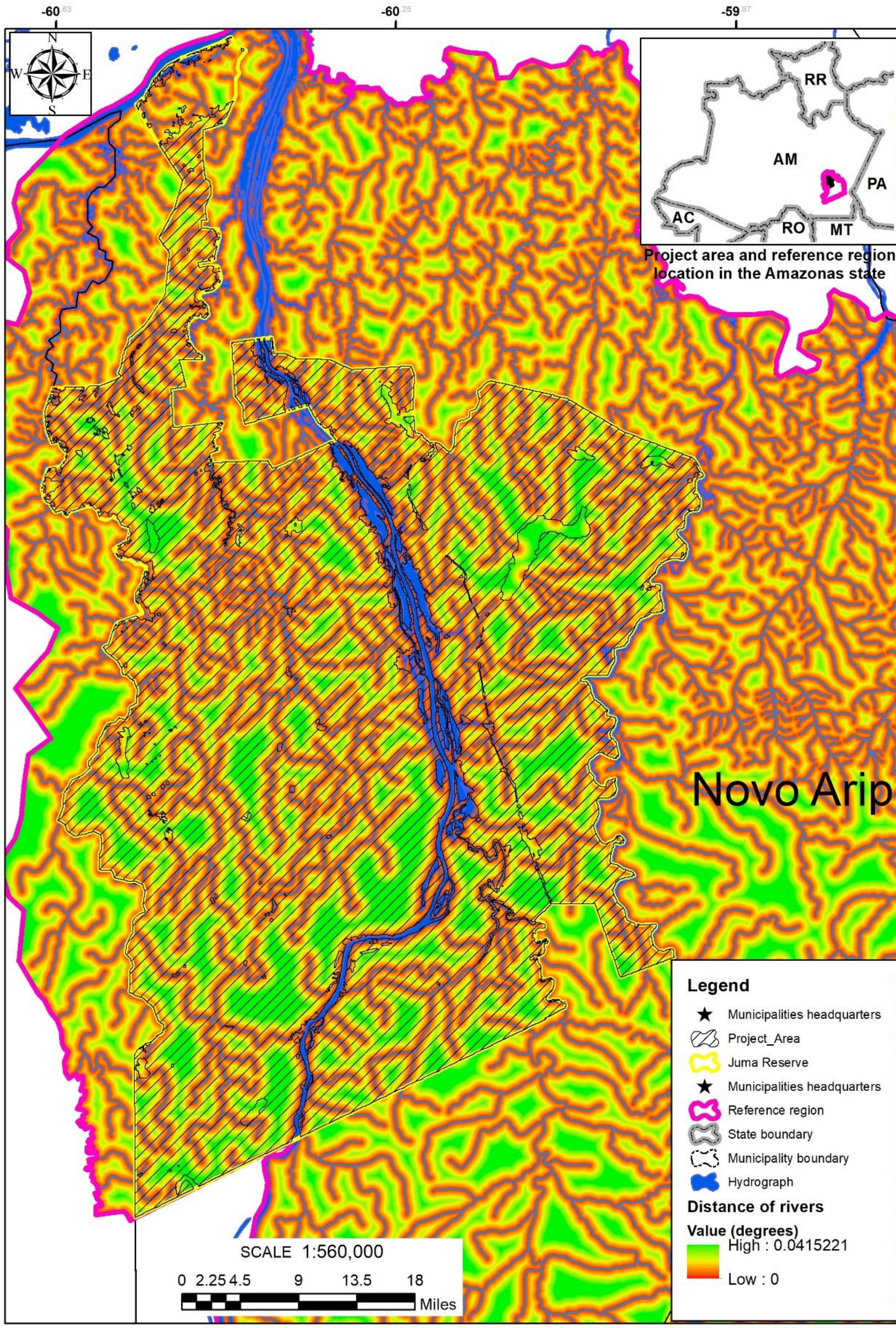


Figure 20. Distance of the rivers.map.

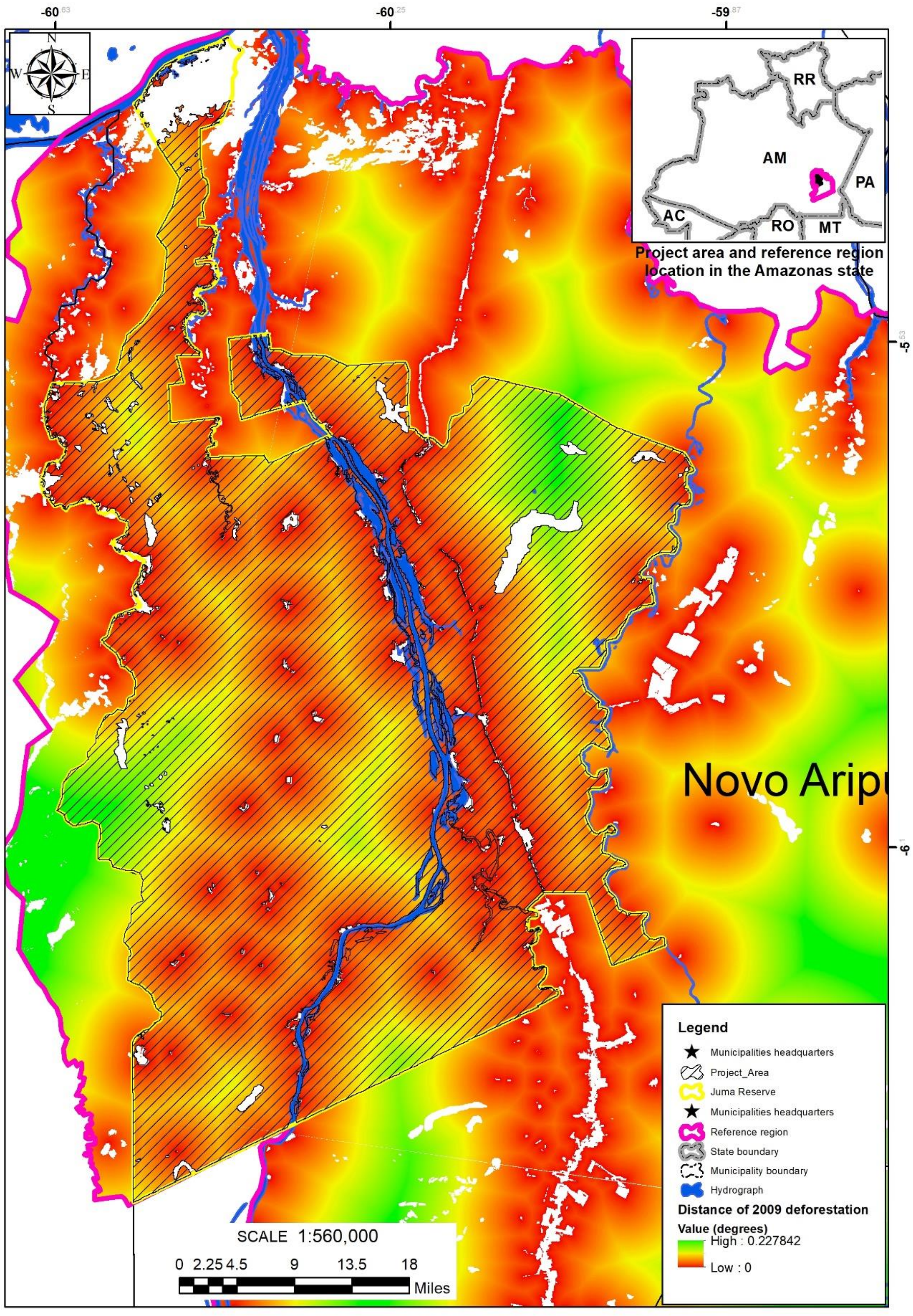


Figure 21. Distance of the accumulated deforestation in 2009 map.

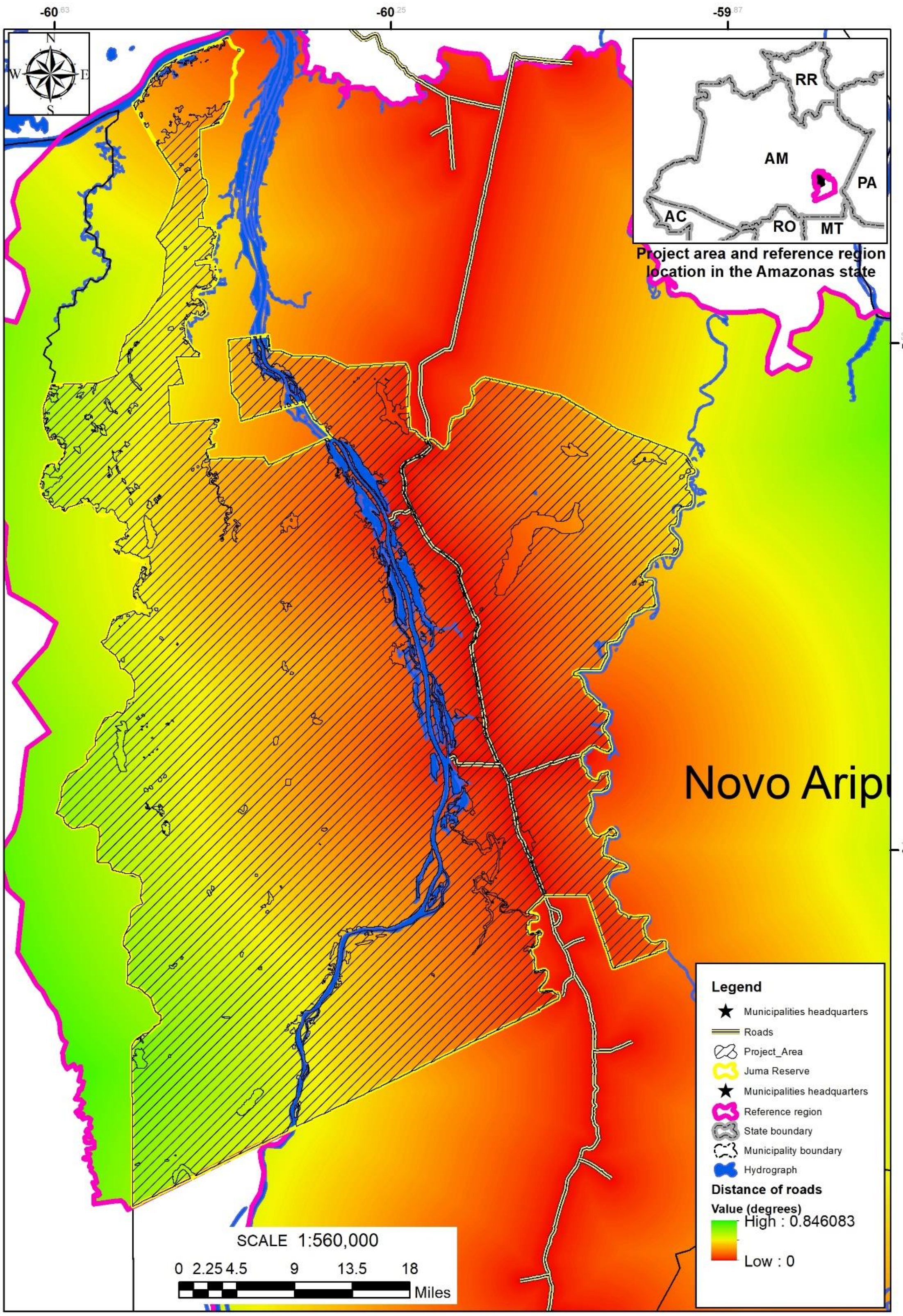


Figure 22. Distance of roads map.

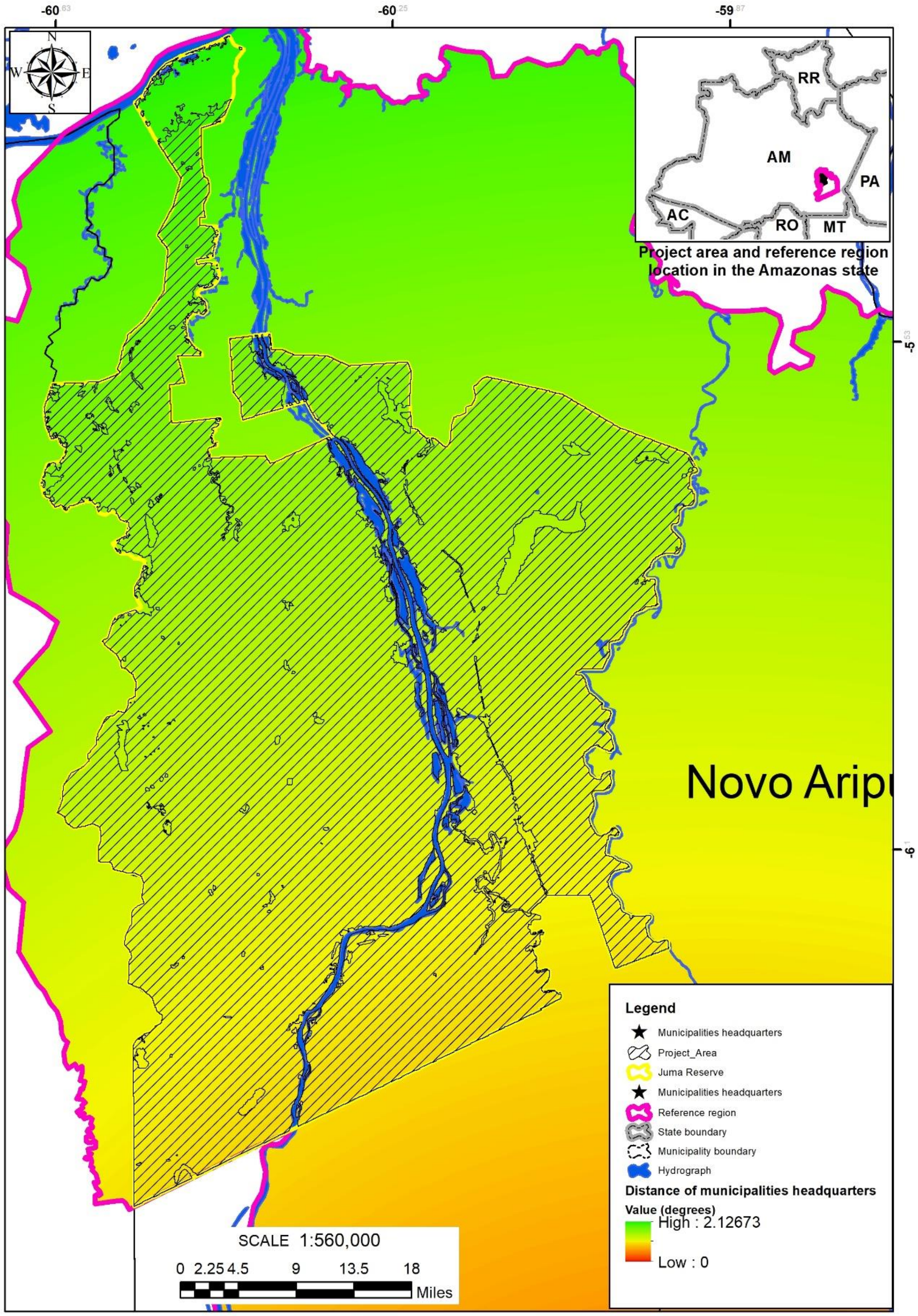


Figure 23. Distance of municipalities headquarters map.

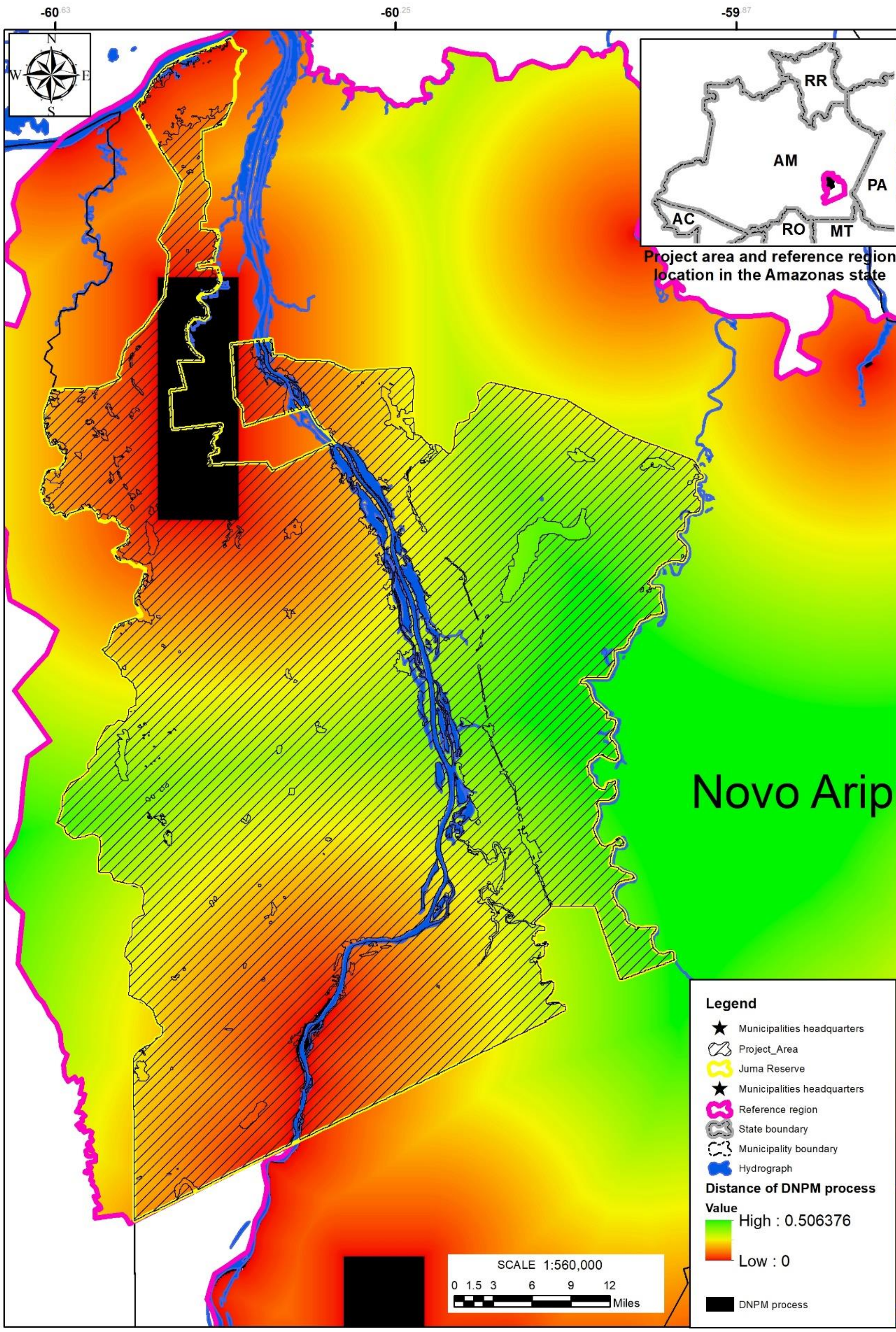


Figure 24. Distance of DNPM process map

Selection of the most accurate deforestation risk map

To evaluate the accuracy of the model it was necessary to compare the map obtained through the prediction with real data. For this analysis we compared the land use maps: estimated / modeled map for 2015, with the actual map observed in 2015 (confirmation period).

The model prediction results were analyzed in two ways. Firstly, a total of 12 different combinations of variables were simulated in MLP for 2015 (land use change models, with the calibration period between 2009 and 2012). The soft prediction output data, vulnerability map, generated for each of the twelve models was compared with the actual deforestation map (forest class changes to deforestation class) from the same period of the models; through ROC Statistics.

The deforestation risk map with the best fit according to the ROC statistic value was the model that only used one factor map that is the distance from the accumulated deforestation with a value of 0,788 (see Appendix VI – Jacknife analysis and figure 21). This variable represents the main characteristic of deforestation in the region, known as border deforestation (the reference region is located in the “arc of deforestation”). In these locations, forest cover in the vicinity of an agricultural/urban landscape matrix has a higher opportunity cost for conservation than in isolated and/or hard to reach regions. Thus, productive areas tend to increase, following the logic of "puxadinho" over conserved areas.

The ROC obtained to the Juma reference region is value that can be comparable with others studies, for example the values obtained by PONTIUS and SCHNEIDER (2001). In this study, in a land cover change model validated with the ROC method it was obtained two different values of ROC according with the model used, in the logistic regression produced a ROC of 0,65 and in the Multi-criteria Evaluation (MCE) produced a suitability map with a ROC of 0,70.

The model that obtained the highest value for the ROC statistics was evaluated in another test. Through the generation of two histograms: one with the vulnerability values within the areas that showed real change (figure 25) and the other with the vulnerability values within the areas that did not (persistence) (figure 26). According to SANGERMANO et al. (2012), a perfect model presents vulnerability values equal to one in all areas that showed change and vulnerability values equal to 0 in areas that did not change.

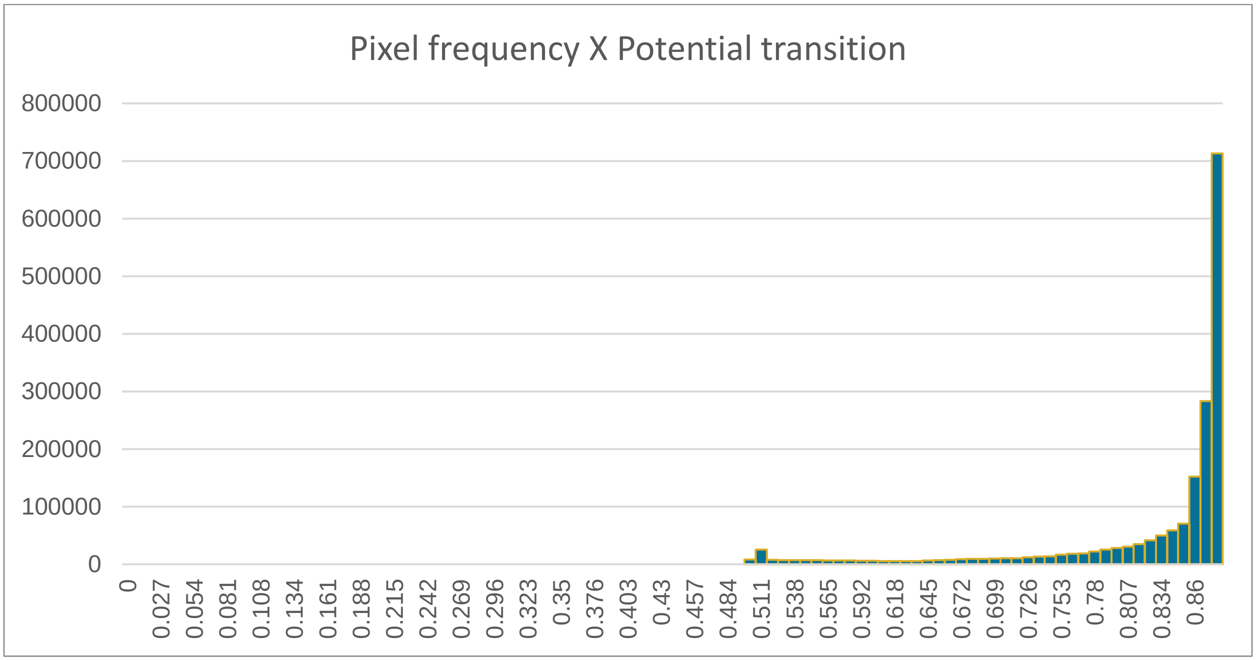


Figure 25. Histogram of the frequency of vulnerability values (deforestation risk) in the period 2009-2015, in relation to the frequency of areas (pixels) that actual were deforested in the same period analyzed.

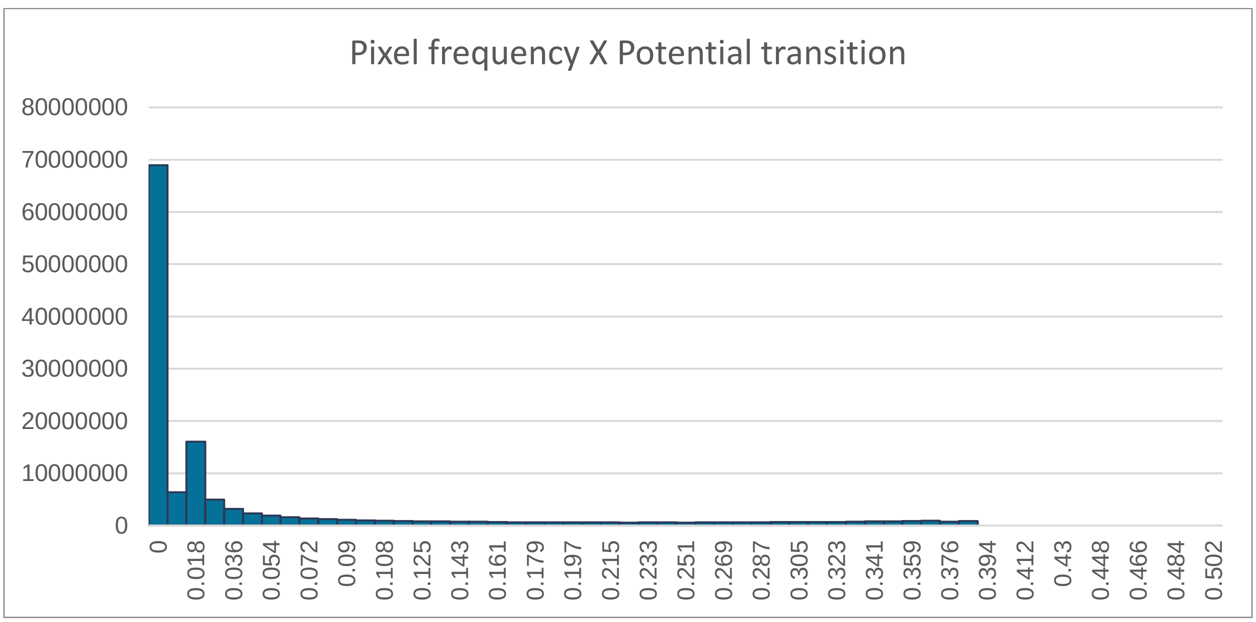


Figure 26. Histogram of the frequency of vulnerability values (deforestation risk) in the period 2009-2015, in relation to the frequency of areas (pixels) that persisted in the same period analyzed.

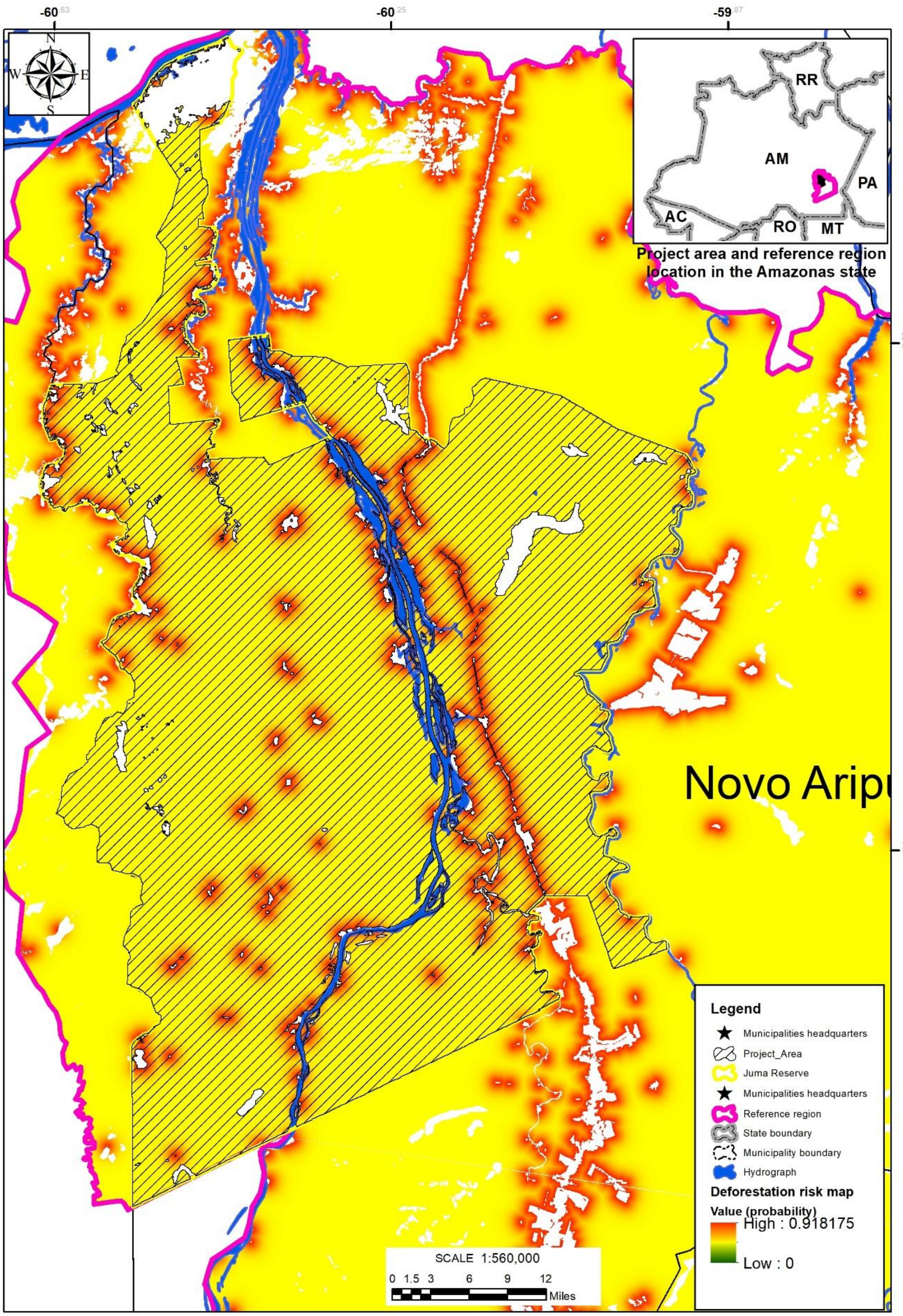


Figure 27. The most accurate deforestation risk map.

Mapping of the locations of future deforestation

Change predictions were estimated and mapped using Markov Chains. According to MATTA (2015) apud BACA (2002), Markov chains are a system modeling formalization that describes the whole system as a stochastic process. Thus, the system is characterized by its states and the way in which they alternate. Markov's processes are based on the premise that there is a dependence between an event and its previous one.

The first order Markovian Chain model depends only on its present state and on the possibilities of transition (SOARES FILHO, 1998). The transition probabilities do not change over time, which characterizes it as a stationary process (LIU, 2006).

According to MATTA (2015), LCM output data related to change prediction are: the estimated land use map for a specific time period, containing the same classes as the hard prediction data. In addition to the estimated land use map, the soft prediction map is also generated, which is a continuous Boolean map with values ranging from 0 to 1. As the focus of the analysis is the transition between the Forest and Deforestation classes, the vulnerability map is equivalent to the transition potential map developed by neural networks (figure 27).

STEP 5: Definition of the land-use and land-cover change component of the baseline

Calculation of baseline activity data per forest class

It was combined the Maps of Annual Baseline Deforestation of each future year produced in the previous step with the forest class map showing the polygons that would be deforested each year in absence of the AUD project activity. It was extracted from these maps the number of hectares of each forest class that would be deforested and present the results in tables 9, 10 (for the reference region, for the project area and for the leakage belt area).

It was used the Maps of Annual Baseline Deforestation of each future year produced in the previous step with the forest class map showing the polygons that would be deforested each year in absence of the AUD project activity. It was extracted from these maps the number of hectares of the forest class that would be deforested and present the results in tables 9, 10 (for the reference region, for the project area and for the leakage belt area).

Since the forest inventory from the Juma Reserve (annex 4) showed that there is a significant statistical similarity between each forest class located in terms of carbon stock per hectare, so it was calculated the Project area baseline activity data for the forest class which aggregates: the Lowland dense Ombrophile's Forest, Sub mountain dense Ombrophile's Forest, Alluvial dense. The same approach was used to the reference region and leakage belt where more than 90% of the forest cover is similar from the project area, so it was possible to adopt the carbon stock value obtained in the forest inventory in the Juma Reserve to the RR and LB.

Table 9. Annual areas deforested per forest class icl within the reference region in the fixed baseline period (baseline activity data per forest class)

Area deforested per forest class *icl* within the reference region		Total baseline deforestation in the reference region	Total baseline deforestation in the reference region
ID_{icl}>	icl1	$ABSLRR_t$	$ABSLRR_t$
Name>	Forest	annual	cumulative
Project $year_t$	ha	ha	ha
2016	11,977.29	11,977.29	11,977.29
2017	7,345.05	7,345.05	19,322.34
2018	7,078.94	7,078.94	26,401.28
2019	6,820.29	6,820.29	33,221.58
2020	6,542.62	6,542.62	39,764.19
2021	6,272.58	6,272.58	46,036.78
2022	8,283.06	8,283.06	54,319.83
2023	5,125.10	5,125.10	59,444.93
2024	4,938.55	4,938.55	64,383.48
2025	4,767.49	4,767.49	69,150.97
Total	69,150.97		

Table 10. Annual areas deforested per forest class icl within the project area in the baseline case (baseline activity data per forest class)

Area deforested per forest class *icl* within the project area		Total baseline deforestation in the project area	Total baseline deforestation in the project area
ID_{icl}>	icl1	$ABSLPA_t$	$ABSLPA_t$
Name>	Forest	annual	cummulative
Project $year_t$	ha	ha	ha
2016	942.66	942.66	942.66
2017	604.36	604.36	1,547.03
2018	664.44	664.44	2,211.47
2019	1,698.39	1,698.39	3,909.86
2020	-	-	3,909.86
2021	25.59	25.59	3,935.46
2022	1,824.56	1,824.56	5,760.02
2023	-	-	5,760.02
2024	-	-	5,760.02
2025	1,139.84	1,139.84	6,899.86
Total	6,899.86		

Table 11. Annual areas deforested per forest class *icl* within the leakage belt area in the baseline case (baseline activity data per forest class)

Area deforested per forest class *icl* within the leakage belt		Total baseline deforestation in the leakage belt	Total baseline deforestation in the leakage belt
ID$_{icl}$>	**icl1**	**ABSLPA$_t$**	**ABSLPA$_t$**
Name>	**Forest**	**annual**	**cummulative**
Project year$_t$	**ha**	**ha**	**ha**
2016	6,219.30	6,219.30	6,219.30
2017	3,716.68	3,716.68	9,935.97
2018	3,625.18	3,625.18	13,561.16
2019	729.32	729.32	14,290.47
2020	3,580.63	3,580.63	17,871.10
2021	5,453.84	5,453.84	23,324.95
2022	348.85	348.85	23,673.80
2023	4,161.19	4,161.19	27,834.99
2024	4,666.20	4,666.20	32,501.19
2025	16.16	16.16	32,517.35
Total	**32,517.35**		

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

As described in step 4 of this section, the method used to design the post-deforestation land use class in the baseline scenario was that of modeling.

The land change modeler (LCM) through neural networks projected the transitions between forest and deforested area for the reference period (figure 28) below and the model was calibrated and validated for the first baseline cycle.

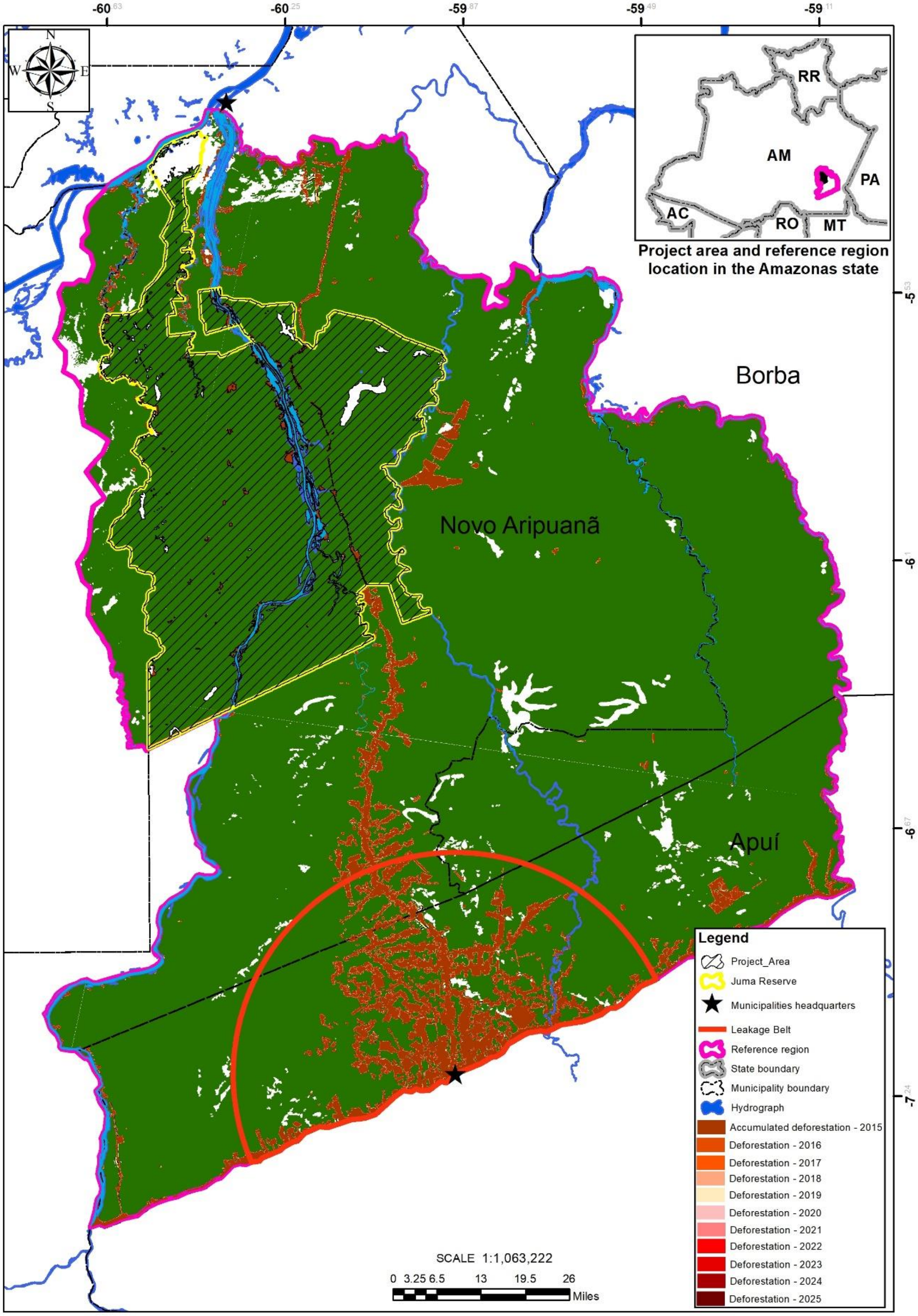


Figure 28. The future spatial distribution of the deforestation in the reference region in the baseline scenario.

3.5 Additionality

According to the VM0015: "Additionality of the proposed AUD project activity must be demonstrated using either the most recent VCS-approved VT0001Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities"

Based on that, the following four steps were assessed:

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

b) STEP 2. Investment analysis to determine that the proposed project activity is not the most economically or financially attractive of the identified land use scenarios; or

c) STEP 3. Barriers analysis; and

d) STEP 4. Common practice analysis.

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:

Based in the economic and political trends and regional business as usual, three credible alternative land use scenarios were identified for the project area, as follow:

1) Forest cover maintenance, i.e.: through conservation activities resulting from incentives other than the REDD project

2) Legal deforestation for pasture (cattle raising) and agriculture

3) Illegal deforestation for pasture (cattle raising) and agriculture purposes or simply for land grabbing and real estate speculation.

The three land use scenarios identified above occur in the project municipality as well as in the surrounding municipalities, In addition, they are also credible and in line with historical land uses, practices and economic trends in the region.

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

According to this section, the following step must be applied:

Demonstrate that all land use scenarios identified in the sub-step 1a are in compliance with all mandatory applicable legal and regulatory requirements;

Considering the project activities will be developed in a Sustainable Development Reserve (Juma SDR), only scenario 1 is in accordance to current laws and regulations.

Despite of the common practice of deforestation for cattle and agriculture purpose in the region, once the project area is a SDR, deforestation permits is not a legal option, thus the scenario 2 is not a credible scenario and must be excluded from the analysis.

In the other hand, most of the deforestation observed in the region are illegal and despite of the creation of Juma SDR, there scenario 3 is credible and very much in line with the currently business as usual observed in the region. Therefore, the uncontrolled occupation of the land by land-grabbers and independent producers, followed by illegal deforestation, even not being in line with the mandatory applicable legislation and regulations, is a credible scenario. This assumption is based in the land use “business as usual” (BAU) for the municipality of Novo Aripuanã, as well as the region as a whole, once applicable mandatory legal or regulatory requirements are systematically not enforced and non-compliance with those requirements is widespread[64]

According to a broad study carried out by IMAZON (2008), the Brazilian government does not have control over the land in a great part of the Amazon territory. The research indicated that **only 12% of the land “supposedly” under private control or tenure is officially registered** and has up to date land titles at the government’s central office.

According to GREENPEACE (2008), only 10% of the deforestation that took place in the Amazon in 2006/2007 was legally authorized (i.e., happened in properties legally entitled and respecting the limits of deforestation permits[65]). The lack of law enforcement is also a key factor for the common practice of deforestation: in 2007 only 3,4% of the illegal deforestation detected by the National System of Deforestation Monitoring (DETER) was processed and fined by the legal authorities GREENPEACE (2008).

Not even the legally protected areas stay safe of deforestation. In the period between July 2007 and August 2008, it was registered that 5,4% (14,9 km2) of the total deforestation occurred in the Legal Amazon happened inside protected areas (IMAZON, 2008).

Based in the above mentioned, only Scenarios 1 and 3 are plausible alternative land use to the VCS AFOLU project activity, where scenario 1 is deemed plausible by being in compliance with all mandatory legislation and regulations, while scenario 3 is deemed plausible considering the widespread BAU of non-enforcement and non-compliance with the land use legislation and regulations. It´s worth mentioning that incompliance with environmental laws and legal requirements for land use is common in the Amazon and can be found in many relevant writings and studies about the region. Refer to Appendix I

Sub-step 1c. Selection of the baseline scenario:

The historical trends regarding land use and land occupation in the Amazon indicate that deforestation would be the most likely scenario for the forest land within the project’s boundary. According to the Brazilian National Space Agency, over the last 50 years, 17% of the Amazon’s

[64] Please refer to appendix I

[65] The Brazilian Forest Law Nº 12.651/2012 sets that private lands in the Amazon Basin should keep 80% of the original forest cover protected as “legal reserve”.

original forest cover has been destroyed (INPE, 2008). Only between 2000 and 2007, about 150,000 km², or 3.7% of its forests cover area, was lost.

Although the State of Amazonas has had a historical low rate of deforestation, with 96% of the State's original forest cover still intact, the rates have been increasing for the last five years: reaching 1,400 km2 in 2019 (INPE, 2019). In addition, land-use modeling[66] shows deforestation rate will increase fast in the coming years (SOARES-FILHO et. Al, 2006):

in a BAU scenario, there will be an intense deforestation trend that will result in a loss of up to 30 percent of the Amazon's forest cover by 2050 – mostly in the project's area and reference region (figure 29).

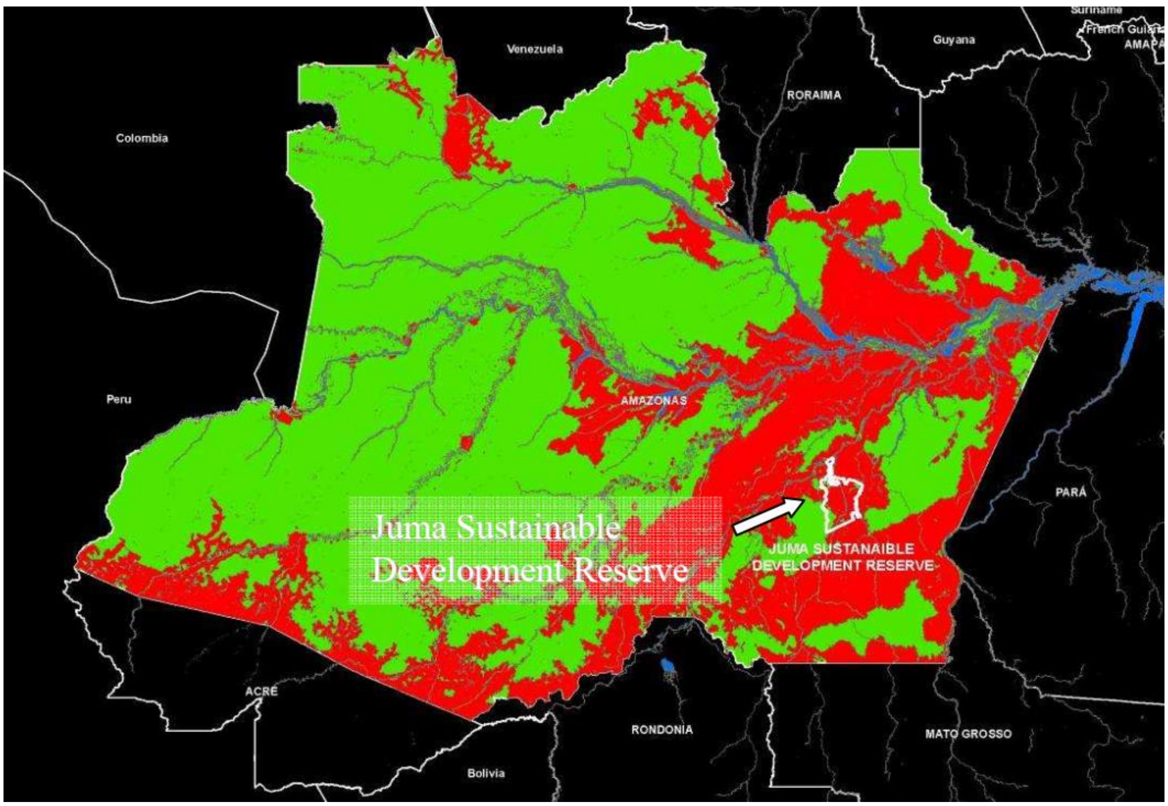


Figure 29: Projected Deforestation for the State of Amazonas by 2050 according to the projections of SimAmazonia I model under the "business as usual" scenario. (SOARES-FILHO et. Al, 2006),

According to the most recent data, after one decade of drop in the deforestation rates in Amazon biome, it was observed a shifting in this trend from 2015 on, where the annual deforested area and fire outbreaks have shown a significant increasing (figure 30). This new trend has become more evident in 2019 where the deforestation and fire events have boosted up by changes in the

[66] SimAmazonia I was designed by program "Amazon Scenarios", lead by the Institute for Environmental Research in the Amazon (IPAM), The Federal University of Minas Gerais, and the Woods Hole Research Center. The model is also available for public use online on the website (in English): http://www.csr.ufmg.br/simamazonia/

Brazilian government environmental policy, after election in 2018[67]. The new government has shown very little commitment to environmental agenda and a strong alignment with cattle ranchers, miners and agribusiness. In addition the president, as well as the environment minister has promoting severe cuts in the budget of IBAMA, the main institution in charge of inspection and controlling environmental crimes[68]

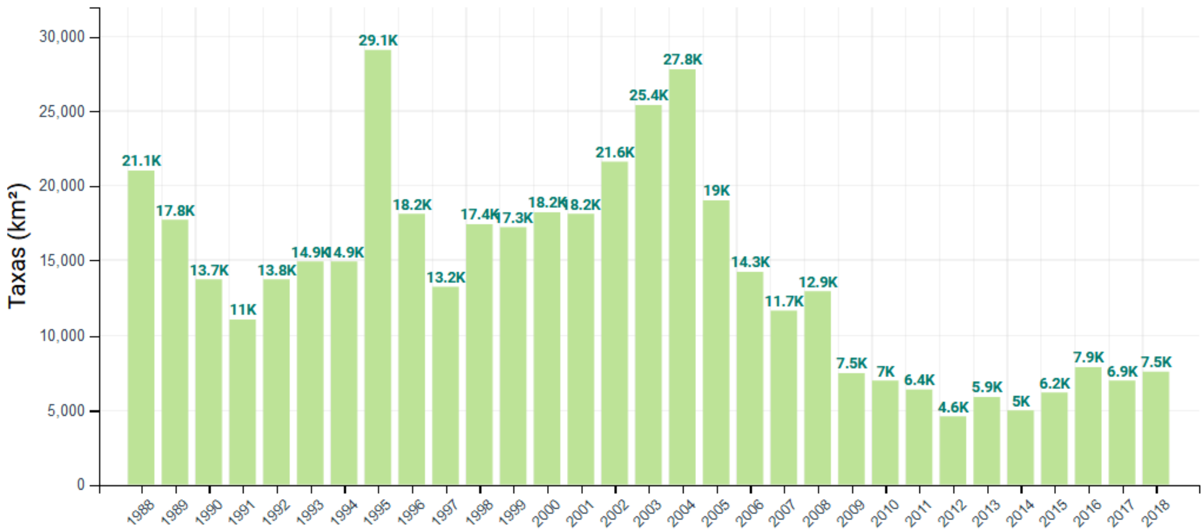


Figure 30: Deforestation rate for Amazon biome from 1988 until 2018 (INPE, 2019)

Cattle ranching and soy farming accounts for some 82 % of the deforestation in the Amazon (GREENPEACE, 2008). Regionally, according to the Institute for the Agriculture and Livestock Development of Amazonas (IDAM, 2007), in the municipality of Apuí – the closest and most developed municipality in the south of Novo Aripuanã – 88% of the "productive lands" are occupied by cattle raising. This correlation pattern between deforestation and cattle activity is also observed in most regions of Amazon forest frontier.

In the period from 1990 to 2003, prior to the great expansion of livestock in the state of Amazonas, the herd´s growth rates in the state were 4.4% / year, higher than the national average of 0.7% / year (IMAZON, 2015). The infrastructure investments planned for the Amazon - such as the highway BR-163 (Cuiabá-Santarém), a stretch of BR-364 in Acre and BR-319 (Manaus - Porto Velho) - will make livestock in these regions even more attractive.

According to the IDESAM: "The southern region of Amazon is a front for agricultural expansion in the Amazon, receiving enormous pressure from the states of Mato Grosso and Rondônia. In the five Amazonian municipalities on the list of critical deforestation municipalities, Apuí, Lábrea and Novo Aripuanã have shown a peak of deforestation in 2019, and remain among the most deforested municipalities annually in the Amazon"[69] (figures 32 and 33, below)

[67] Please refer to appendix I

[68] Please refer to appendix I

[69] https://idesam.org/propostas-emergenciais-apui/

Therefore, the most likely scenario for the project area, in the absence of the project activities, is options 3 (Illegal deforestation for cattle raising and agriculture purposes or simply for land grabbing and real estate speculation). Even considering several applicable laws mandate forest conservation, the currently political and economic context, as mentioned above, suggest a systematic lack of enforcement of applicable laws and regulations.

Step 2. Investment analysis

Sub-step 2a. Determine appropriate analysis method

Sub-step 2b. – Option II. Apply investment comparison analysis

Considering that project activity and baseline activities can be associated to financial revenues, the investment comparison analysis (option II) was chosen, and the financial indicators used for comparison were the IRR (investment rate of return) and NPV-10% (net present value with 10% of interest).

Sub-step 2c. Calculation and comparison of financial indicators (option II)

The profitability comparison between project and baseline scenario was done based in the IRR and NPV (10% of discount rate of return). For the project scenario, eight sources of revenues were considered: Seven non-timber forest products and community based timber forest management[70]. For the baseline scenario (logging, followed by deforestation for cattle rising), the analysis has considered beyond the revenues from logging and livestock, the land sale after 10 years[71]. Aquiculture was excluded, as it is supposed to occur in both scenarios and it has not significant link with land-use changes. The IRR and NPV-10% under the project scenario and baseline scenario are presented in table 12.

Table 12: comparison of financial indicators between project and baseline scenario

	IRR	NPV-10%
Project scenario	-8%	R$ 37.71
Baseline scenario	16%	R$ 429.61

For more details regarding the investment comparison analysis, please refer to appendix 2.

Sub-step 2d. Sensitivity analysis (only applicable to options II and III)

[70] To be conservative, the logging profitability assumption for both scenarios was the same (USD 28,50/ha), even considering that illegal logging is more profitable, in the short term, than logging under sustainable forest management.

[71] Considering the BAU cattle rise system, with low productivity and complete exploitation of soil fertility (organic matter) after 10 years, what is deemed conservative.

Four stress tests were applied to the financial analysys in order to assess the sensitivity of its indicators, two in the project scenario as follow:

1. 30% drop in implementation costs

2. 100% rise in price of cassava flour

For the baseline scenario the assumptions under analysis are:

Logging price, despite of relevant, did not participate in the analysis once has the same income for both scenarios and any rise would affect better the baseline than the scenario with project activities, thus don't assume rise on this is deemed conservative.

The sensitivity analysis is presented in tables 13 and 14:

Tables 13: Financial indicators of the project scenario in the sensitivity analysis

	30% drop in implementation costs	100% rise in price of cassava flour
IRR	-15%	-13%
NPV 10%	R$ 56.12	R$49.17

Tables 14: Financial indicators of the baseline scenario in the sensitivity analysis

	30% drop in livestock price	50% rise in pasture inputs
IRR	12%	11%
NPV 10%	R$ 158.38	R$43.68

As presented in tables above, even when the investment analyses is submitted to a stress test, the sensitivity analysis shows that market fluctuations are not able to affect significantly the economic indicators. In all the four models, the baseline activities are far more profitable than project remuneration, confirming the project activities remain additional through the investment perspective, regardless the market flu

Step 3. Barrier analysis

As stated in the VT0001, barrier analysis maybe performed instead of or as an extension of investment analysis. If this step is used, determine whether the proposed project activity faces barriers that:

a) Prevent the implementation of this type of proposed project activity without the revenue from the sale of GHG credits; and

b) Do not prevent the implementation of at least one of the alternative land use scenarios. Use the following sub-steps:

2.3.1 ***Sub-step 3a. Identify barriers that would prevent the implementation of the type of proposed project activity***

The following barriers were identified, as those able to prevent the project activities in a scenario without any kind of PES mechanism, as carbon credits (VCUs). If not alone, at least in conjunction with others these barriers can a reinforce of the projects

Institutional barriers, as the risk related to changes in government policies or laws, as well as the lack of enforcement of forest and land-use-related legislation, for financial or political purposes, as presented in the appendix I.

Also, the Implantation difficulty related to board changes, which take place every 2 years, and depending on who enters, engagement work has to be restarted. bi-annual change also hampers the ongoing management process.

Technological barriers, as the lack of equipment and infrastructure for implementation of the technology, as laboratories, biofactories, fruit dryers, warehouses, frezzers, etc.

Barriers due to local ecological conditions, as seasonality and climate changes, that hinder production (eg.: banana and cocoa, which is planted in a lowland area, and in large floods are affected).

Barriers related to local tradition: Despite of some local people still keeps some etnobotanical knowledge, most of communities face significant level of technical assistance restriction and does not practice most of this knowledge, as it has not been taught to new generations in a systematic way.

Communities have a different timeframe for project start-ups (eg.: if agreed to build a flour house, a community responsibility is to remove the wood and built it, the PP is in charge to get materials and inputs not available in the community and equipments, besides the regiment of goods).

Barriers due to social conditions and land-use practices, once the illegal practices are widespread (e.g. illegal logging, deforestation, cattle rising, besides crimes related to land disputes and land grabbing).

Barriers relating to markets, transport and storage; due to:

- Distance of project activities and undeveloped road and infrastructure that incur large transportation expenditures until the final costumer[72], eroding the competitiveness and profitability of timber and non-timber products from the project area;
- The most profitable product of the project area (*manioc flour*) is subject to large price fluctuations, due to absence of efficient markets and insurance mechanisms.

[72] Considering that most of the NFTP produced in the Project has its final costumer in big cities out of Amazonas state. (e.G vegetal oils, cocoa, nuts and açaí)

- Absence of facilities to convert, store and add value to production.

For documented evidences regarding the above-mentioned barriers, please refer to Appendix I and IV

Step 4. Common practice analysis

According to step 4, the project proponent must provide an analysis to which extent similar activities to the one proposed as the VCS AFOLU project activity have been implemented previously or are currently underway.

Similar activities are defined as that which are of similar scale, take place in a comparable environment, inter alia, with respect to the regulatory framework and are undertaken in the relevant geographical area, subject to further guidance by the underlying methodology. Other registered VCS AFOLU project activities shall not be included in this analysis.

Considering the above-mentioned criteria of "similar scale", "comparable environment" and "regulatory framework", four similar cases were identified. They refer to SDR situated in the State of Amazonas with an area between 50% and 200% the project area, this means that all the SDR within the State of Amazonas between 294,806 and 1,179,224 hectares were considered for the common practice analysis, as presented in table 15:

Table 15: List of similar activities (SDRs between 294,806 and 1,179,224ha)

Ref.	Unit name	Municipality	Area (in hectares)
1	Reserva de Desenvolvimento Sustentável de Uacari	Carauari	632.949,02
2	Reserva de Desenvolvimento Sustentável do Uatumã	São Sebastião do Uatumã e Itapiranga	424.430,00
3	Reserva de Desenvolvimento Sustentável Igapó-Açú	Beruri, Borba e Manicoré	397.557,32
4	Reserva de Desenvolvimento Sustentável Mamirauá	Fonte Boa, Japurá, Maraã, Uarini, Japurá e Tonantins	1.124.000,00

As can be seen in the figure 30, the SDRs Uacari, Uatumã and Mamirauá have one important difference between SDR Juma, none of them is crossed by highways. Considering that roads are the main deforestation drivers in Amazon forest - enabling the access and expansion of livestock activity and herd trading - these three SDRs cannot be considered similar cases, once they are under less deforestation threat. The Juma SD is crossed by the highway AM 174, that connects Apuí to Novo Aripuanã, two of the most high deforestation rates among all the municipalities of Amazonas, 11th and 19th position respectively (Figure 32 and 33).

Another important diference between the project area and the similar cases is the proximity of SDR Juma from the "deforestation arc" (Figure 31 in grey).

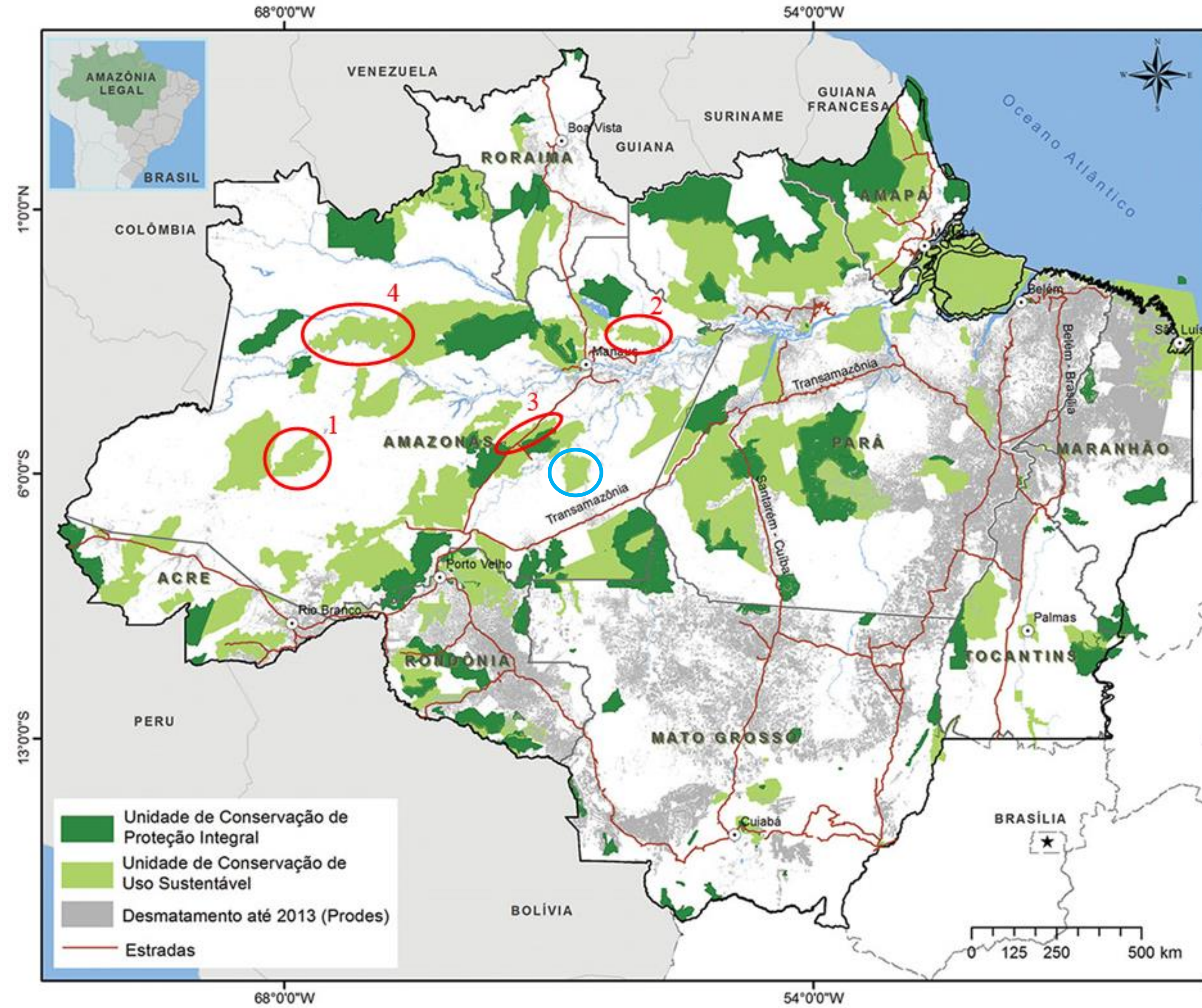


Figure 31: Similar activities that can be compared to the VCS Juma project in terms of scale, environment and regulatory framework. Similar activities marked in red, Juma SDR marked in blue (IMAZON, 2015b)

Figure 32: Deforestation in Apuí from 2008 until 2018 and the ranking of municipalities with highest increment in the deforestation rate in Legal Amazon (INPE/PRODES 2019).

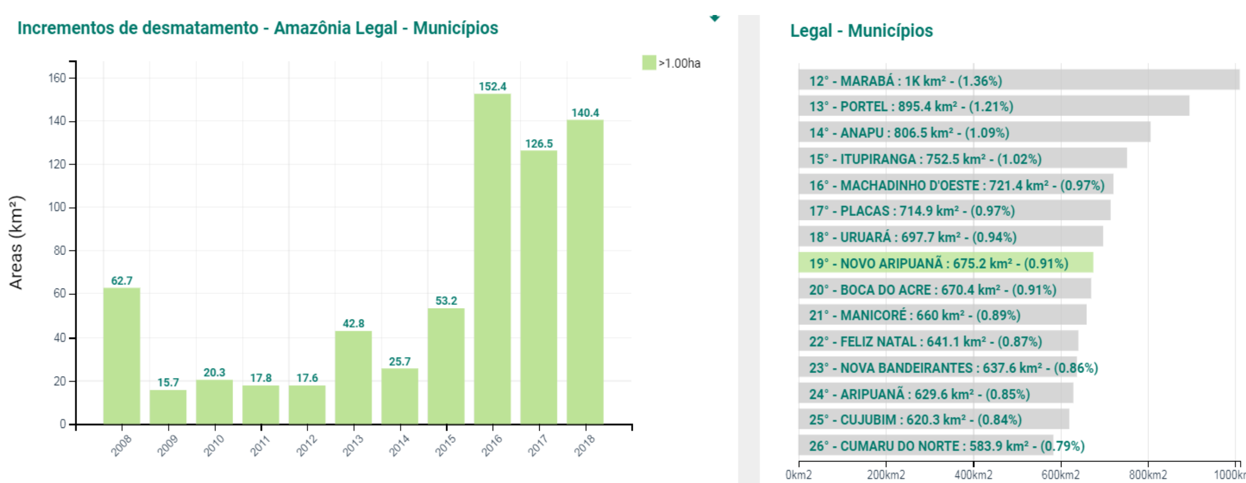


Figure 33: Deforestation in Nova Aripuanã from 2008 until 2018 and the ranking of municipalities with highest increment in the deforestation rate in Legal Amazon (INPE/PRODES 2019).

In the other hand, the Igapó-Açú SDR, can be compared to Juma SDR, once it is also crossed by an important highway (BR 319 Manaus – Porto Velho). However, the deforestation rate of its municipality (Beruri – AM) is lower than that observed for Apuí and Novo Aripuanã, not only in terms of increment but especially because of its stable trend in the last decade, with slightly reduction after 2014 (figure 34)

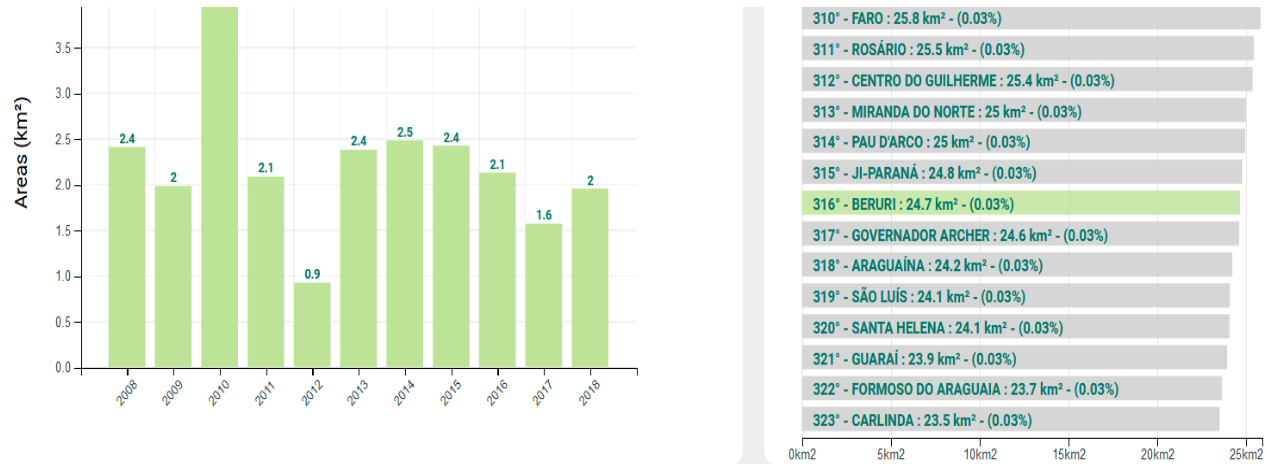


Figure 34: Deforestation in Beruri from 2008 until 2018 and the ranking of deforestation rate increment, in the Legal Amazon municipalities (INPE 2019).

Based in the assessment presented above, there are essential distinctions between the project activity and the similar activities identified, thus the proposed VCS AFOLU project activity is not the baseline scenario and, hence, it is additional.

3.6 Methodology Deviations

The only deviation from the methodology that occurred was related to the use of PRODES data for forest mapping. According to VM0015, section 1.1.5, the minimum mapping unit is 1hectare for LULUCF mappings.

The PRODES data, on the other hand, have a minimum mapping unit superior, with 6.25 ha, however they are reliable and widely used data, even for validated and verified VCS projects, serving as the main reference for forest monitoring in the Brazilian Amazon, see more section 3.3 (project boundary), definition of forest area.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The baseline emission calculations are intrinsically connected to the baseline scenario (deforestation model) defined by the steps 2 to 5 of VM0015 methodology. For more information regarding the baseline scenario and the methodological steps application to the project area, please refer above section 3.4.

The section 6 of the VM0015 refers to Estimation of baseline carbon stock changes and non-CO2 emissions and is divided in two subsections, as follow:

- 6.1 - Estimation of baseline carbon stock changes, and
- 6.2 -Baseline non-CO2 emissions from forest fires

According to the section 6.1.1 - Estimation of the average carbon stocks of each LU/LC class, "*Average carbon stocks must be estimated for the forest classes existing within the project area. This information must be collected from* existing carbon-stock data for these classes from local published studies and existing forest and carbon, according to the following criteria":

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

According to the forest inventory undertaken in the Juma SDR in 2010 (annex 4), all the above mentioned criteria were fulfilled.

The forest inventory did not find statistic distinction between the biomass of the three main forest phytophysiognomies present in the project. It is important to highlight that all these three types of vegetation are characterized as "Ombrophyllous Dense Forest" and represent 95% of the project area[73]. Their average carbon stocks were estimated in 161.3 (+/- 6.2) tons of elementary carbon per hectare, including above and below ground and dead wood biomass. For conservativeness[74], the value assumed for *Ex-ante* and *Ex-post* calculations is **155.1 tons of elementary carbon per hectare (tC/ha).** It's worth mentioning that the value adopted is a TIER 3 data (project specific), that is more conservative than the Amazon biome default data presented by Nogueira et. al. and MCT (TIER 2), and more accurate than the tropical rain forests default data available in the IPCC GPG for LULUCF (TIER 1), as presented in the table 16.

Table 16. Comparison of the different carbon stocks for above and below ground biomass in the vegetation types found within the Juma Reserve

[73] Submontane Ombrophyllous Dense Forest (59%), Lowland Ombrophyllous Dense Forest (31%), Ombrophyllous Dense Alluvial Forest (4,7%)

[74] Assuming the Lower limit of the confidence interval

Author	Forest type	Above Ground Biomass		Below Ground Biomass Tons of C/ha	Total Biomass Tons of C/ha
		Live Biomass Tons of C/ha	Dead Biomass Tons of C/ha		
Nogueira *et al* *(TIER 2)*	Ombrophyllous Dense Alluvial Forest	127,71	15,69	29,55	*172,95*
	Lowland Ombrophyllous Dense Forest	136,09	16,72	31,49	*184,30*
	Submontane Ombrophyllous Dense Forest	136,39	16,76	31,56	*184,71*
MCT (*TIER 2*)	Ombrophyllous Dense Alluvial Forest	115,28	0,00	24,21	*139,49*
	Lowland Ombrophyllous Dense Forest	115,28	0,00	24,21	*139,49*
	Submontane Ombrophyllous Dense Forest	112,21	0,00	23,56	*135,77*
IPCC Default Value for Tropical Forests (*TIER 1)*		131,00			

Although the IPCC can be considered the most conservative data among the four compared sources, these values underestimate the carbon stock values for the Amazon forests, as they were generated through an average of different tropical forests in many regions of the world.

The same can be said for the MCTIC[75] data, however this source did not consider the dead wood biomass. For the MCTIC biomass and carbon estimates, the sum of the carbon from all trees was divided by the area of the sample plot. Then, a correction was applied for the carbon content to include the trees with a Diameter at breast height (DBH) less than 31.7 cm, according to a Meira-Filho personal communication of a circumference histogram. For the below ground biomass, an expansion factor of 21% was then applied, as suggested by the authors.

[75] Ministério da Ciência Tecnologia inovações e Comunicações

Finally Nogueira *et al.* used the allometric equation from Higuchi *et al.* (1998) from the Central Amazon, to calculate bole biomass of tree datasets from the RADAMBRASIL Project (the trees inventoried had a circumference at breast height (CBH) greater than 100 cm, or 31.7 cm of diameter at breast height (DBH)).

However, the carbon stocks considered in the biomass estimates of Nogueira *et al.* (nd) combined allometric equations and inventoried wood volume in order to adjust the biomass estimates for different types of Amazonian forests. A new biomass equation was developed from trees harvested on relatively fertile soils in the Southern Amazon and new bole-volume equations were developed from trees in dense and open forests. These allometric relationships were used to assess uncertainties in previous estimates of wood volume and biomass. Finally, all corrections were applied to generate a new biomass map for forests in the Brazilian Amazon from the RADAMBRASIL plots, and the biomass stocks by forest type were calculated for each of the nine states in the Brazilian Legal Amazon.

Calculation of carbon stock change factors

According to the VM0015, section 6.1.2 - Calculation of carbon stock change factors, default linear functions are applied to account for the decay of carbon stock in initial forest classes (*icl*) and increase in carbon stock in post-deforestation classes, when applicable. Considering the three project carbon pools and the methodology requirements, the following approach was assumed:

<u>Above-ground biomass:</u>

According to the VM0015, Initial forest classes (*icl*) immediate release 100% of the carbon stock (as estimated in Table 17). It is assumed to happen at the end of year $t = t*$ (= year in which deforestation occurs).

The VM 0015 also states that post-deforestation classes (*fcl*) is supposed to present a linear increase from 0 tCO2-e/ha in year $t = t*$ to 100% of the long-term (20-years) average carbon stock in year $t = t*+9$ is assumed to happen in the 10-years period following deforestation (i.e. 1/10th of the final carbon stock is accumulated each year). However, considering that all the deforested area under the baseline or project scenario are supposed to became pasture and no forest regeneration is expected to occur, the post-deforestation classes (*fcl*) has considered only the below-ground and dead wood carbon stocks decay, as well as the above-ground and below-ground carbon stocks of grassland (pasture)..

<u>Below-ground biomass:</u>

As per VM0015, for initial forest classes (*icl*), an annual release of 1/10th of the initial carbon stock (as estimated in Table 17) is assumed to happen each year between $t = t*$ and $t = t*+9$.

The VM 0015 also states that post-deforestation classes (*fcl*) is supposed to present a linear increase from 0 tCO2-e/ha in year $t = t*$ to 100% of the long-term (20-years) average carbon stock in year $t = t*+9$ is assumed to happen in the 10-years period following deforestation (i.e. 1/10th of the final carbon stock is accumulated each year). However, considering that all the deforested area under the baseline or project scenario are supposed to became pasture and no forest regeneration is expected to occur, the post-deforestation classes (*fcl*) has considered only the below-ground and dead wood carbon stocks decay, as well as the above-ground and below-ground carbon stocks of grassland (pasture).

Dead wood:

According to VM0015, for initial forest classes (*icl*), an annual release of 1/10th of the initial carbon stock (as estimated in Table 17) is assumed to happen each year between $t = t^*$ and $t = t^*+9$.

The VM 0015 also states that post-deforestation classes (*fcl*) is supposed to present a linear increase from 0 tCO2-e/ha in year $t = t^*$ to 100% of the long-term (20-years) average carbon stock in year $t = t^*+9$ is assumed to happen in the 10-years period following deforestation (i.e. 1/10th of the final carbon stock is accumulated each year). However, considering that all the deforested area under the baseline or project scenario are supposed to became pasture and no forest regeneration is expected to occur, the post-deforestation classes (*fcl*) has considered only the below-ground and dead wood carbon stocks decay, as well as the above-ground and below-ground carbon stocks of grassland (pasture).

Table 17. Carbon stocks per hectare of initial forest classes *icl* existing in the project area and leakage belt

Project year t	Initial forest class *icl* Name: Dense Forest; ID_{icl} 1; Average carbon stock per hectare ± 90% CI							
	Cab_{icl}		Cbb_{icl}		Cdw_{icl}		$Ctot_{icl}$	
	C *stock*	± 90% CI	C *stock*	± 90% CI	C *stock*	± 90% CI	C *stock*	± 90% CI
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
0								
1		534		84		33		651
2	486		76		30		592	
3								
...		437		69		27		532
30								

Where:

Cab_{icl}	Average carbon stock per hectare in the above-ground biomass carbon pool of class *icl*; tCO2-e ha-1
Cbb_{icl}	Average carbon stock per hectare in the below-ground biomass carbon pool of class *icl*; tCO2-e ha-1
Cdw_{icl}	Average carbon stock per hectare in the dead wood biomass carbon pool of class *icl*; tCO2-e ha-1

After defined the carbon stocks per hectare of initial forest classes, the VM0015 requires calculating the long-term (20-years) average carbon stocks of post-deforestation classes.

According to VM0015, these classes often do not have a stable carbon stock because different land uses may be implemented in a time sequence or because the land use after deforestation implies carbon stocks changes over time (e.g. in case of tree plantations). The carbon stock of post-deforestation classes must be estimated as the long-term (20 years) average carbon stock and can be determined from measurements in plots of known age, long-term studies and other verifiable sources. For each post-deforestation LU/LC class, report the calculation of the long-term (20-year) average carbon stock, please refer to Table 18.

Table 18: Long-term (20-years) average carbon stocks per hectare of post-deforestation LU/LC classes present in the reference region[76]

[76] Following the most conservative approach provided by the VM0015 for carbono stock, the upper confidence interval (90%) was used for post-deforestation classes, please refer to Appendix VI.

Project year t	Post deforestation class *fcl* Name: Pasture ID $_{fcl}$ 1 Average carbon stock per hectare ± 90% CI							
	Cab $_{fcl}$		Cbb $_{fcl}$		*Cdw* $_{fcl}$		Ctot $_{fcl}$	
	average stock	± 90% CI	*average stock*	± 90% CI	C *stock*	± 90% CI	*average stock*	± 90% CI
	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
t*	0	0,00	76,34	83,97	29,73	32,70	106,06	116,67
t*+1	11,38	12,51	98,25	108,07	26,75	29,43	136,38	150,01
t*+2	11,38	12,51	90,61	99,67	23,78	26,16	125,77	138,35
t*+3	11,38	12,51	82,98	91,28	20,81	22,89	115,16	126,68
t*+4	11,38	12,51	75,35	82,88	17,84	19,62	104,56	115,01
t*+5	11,38	12,51	67,71	74,48	14,86	16,35	93,95	103,35
t*+6	11,38	12,51	60,08	66,09	11,89	13,08	83,35	91,68
t*+7	11,38	12,51	52,44	57,69	8,92	9,81	72,74	80,01
t*+8	11,38	12,51	44,81	49,29	5,95	6,54	62,13	68,35
t*+9	11,38	12,51	37,18	40,89	2,97	3,27	51,53	56,68
t*+10	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+11	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+12	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+13	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+14	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+15	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+16	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+17	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+18	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+19	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+20	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
...	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
t*+30	11,38	12,51	29,54	32,50	0,00	0,00	40,92	45,01
Average	10,84	11,92	48,13	52,94	7,79	8,56	66,75	73,43
Average to be used in calculations	**10,84**	**11,92**	**48,13**	**52,94**	**7,79**	**8,56**	**66,75**	**73,43**

As mentioned above, considering that all the deforested area under the baseline or project scenario are supposed to became pasture and no forest regeneration is expected to occur, the post-deforestation classes (*fcl*) has considered only the below-ground and dead wood carbon stocks decay, as well as the above-ground and below-ground carbon stocks of grassland (pasture). For the grassland biomass increment (above and below ground) it was assumed, as a conservative approach, that the full carbon stock is reached in one year after deforestation (please refer to appendix VI and table 20).

After calculation of average carbon stocks per hectare of post-deforestation the VM0015 requires to calculate the Long-term (20-years) area-weighted average carbon stocks of the post-deforestation LU/LC classes existing within each zone. Its worth mentioning that, according to the VM0015, once the project has used Method 2 in step 5.2, then each zone will have only one post-deforestation class fcl, thus the area weighted average carbon stock per zone Table 19, has the same value of average carbon stocks per hectare, presented in table 18

Table 19: Long-term (20-years) area weighted average carbon stock per zone

Zone		Post -deforestation LU/LC-class *fcl* Name: Pasture ID $_{fcl}$ 1			Area weighted long-term (20 years) average carbon stocks per zone *z*			
		Cab $_{fcl}$	Cbb $_{fcl}$	Cdw_{icl}	Cab $_z$	Cbb $_z$	Cdw_{icl}	Ctot $_z$
		C stock	*C stock*	*C stock*	*C stock*	*C stock*	*C stock*	*C stock*
IDz	Name	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}	t CO_2e ha^{-1}
1	RR	11,92	52,94	8,56	11,92	52,94	8,56	**73,43**

Following the VM0015, the section 6.1.3 states that regarding to the calculation of baseline carbon stock changes, the choice of the method to calculate carbon stock changes depends on whether activity data are available for classes or for categories. Considering that method 2 was used Table 20 summarizes how carbon stock change factors were calculated.

Table 20 Carbon stock change factors for land-use change categories (*ct* or ctz) (Method 2)

Year after deforestation	$\Delta Cab_{ctz,t}$	$\Delta Cbb_{ctz,t}$	$\Delta Cdw_{ctz,t}$
t*	-486	-7,63	-2,97
t*+1	11,92	45,31	-2,97
t*+2	0	-7,63	-2,97
t*+3	0	-7,63	-2,97
t*+4	0	-7,63	-2,97
t*+5	0	-7,63	-2,97
t*+6	0	-7,63	-2,97
t*+7	0	-7,63	-2,97
t*+8	0	-7,63	-2,97
t*+9	0	-7,63	-2,97
t*+10	0	0	0
t*+11	0	0	0
t*+12	0	0	0
t*...	0	0	0
t*+30	0	0	0

According to Method 2, first calculate the carbon stock change factors of each category as shown in table 20 and then calculate the baseline carbon stock changes for the reference region (optional), project area and leakage belt area by multiplying activity data with their corresponding emission factors. Do this at least for the fixed baseline period and, optionally, for the entire project crediting period. The results of the **ex-ante** calculations are presented in Tables 21.a, 21.b, 21.c (for the project area); and 22.a, 22.b and 22.c (for the leakage belt area).

Table21.a. Baseline carbon stock change in the above-ground biomass in the project area

Project year t	Activity data per category x Carbon stock change factor for above-ground biomass in the project area		Total baseline carbon stock change in the project area	
	IDct = 1		annual	cumulative
	$ABSLPA_{ct,t}$	$\Delta Cab_{ct,t}$	$\Delta CabBSLPA_t$	$\Delta CabBSLPA$
	ha	tCO_2-e ha^{-1}	tCO_2-e	tCO_2-e
2016	942,7	-485,5	-457.701	-457.701
2017	604,4	11,9	-282.207	-739.909
2018	664,4	0,0	-315.412	-1.055.321
2019	1.698,4	0,0	-816.721	-1.872.041
2020	0,0	0,0	20.243	-1.851.799
2021	25,6	0,0	-12.427	-1.864.225
2022	1.824,6	0,0	-885.596	-2.749.821
2023	0,0	0,0	21.747	-2.728.074
2024	0,0	0,0	0	-2.728.074
2025	1.139,8	0,0	-553.441	-3.281.515

Table21.b. Baseline carbon stock change in the below-ground biomass in the project area

Project year t	Activity data per category x Carbon stock change factor for below-ground biomass		Total baseline carbon stock change in the project area	
	IDct = 1		annual	cumulative
	$BBSLPA_{ct,t}$	$\Delta Cbb_{ct,t}$	$\Delta CbbBSLPA_t$	$\Delta CbbBSLPA$
	ha	tCO_2-e ha^{-1}	tCO_2-e	tCO_2-e
2016	942,7	-7,6	-7.196	-7.196
2017	604,4	45,3	38.097	30.902
2018	664,4	-7,6	15.115	46.016
2019	1.698,4	-7,6	5.331	51.347
2020	0,0	-7,6	60.071	111.418
2021	25,6	-7,6	-30.042	81.376
2022	1.824,6	-7,6	-42.615	38.762
2023	0,0	-7,6	52.627	91.389
2024	0,0	-7,6	-43.970	47.419
2025	1.139,8	-7,6	-52.671	-5.252

Table21.c. Baseline carbon stock change in the dead wood biomass in the project area

Project year t	Activity data per category x Carbon stock change factor for dead wood biomass in the project area		Total baseline carbon stock change in the project area	
	$IDct$ = 1		annual	cumulative
	$BBSLPA_{ct,t}$	$\Delta Cbb_{ct,t}$	$\Delta CbbBSLPA_t$	$\Delta CbbBSLPA$
	ha	tCO_2-e ha^{-1}	tCO_2-e	tCO_2-e
2016	942,7	-2,97	-2.802	-2.802
2017	604,4	-2,97	-4.599	-7.401
2018	664,4	-2,97	-6.574	-13.975
2019	1.698,4	-2,97	-11.623	-25.598
2020	0,0	-2,97	-11.623	-37.221
2021	25,6	-2,97	-11.699	-48.920
2022	1.824,6	-2,97	-17.123	-66.043
2023	0,0	-2,97	-17.123	-83.165
2024	0,0	-2,97	-17.123	-100.288
2025	1.139,8	-2,97	-20.511	-120.799

Table 22.a. Baseline carbon stock change in the above-ground biomass in the leakage belt area

Project year t	Activity data per category x Carbon stock change factor for above-ground biomass in the leakage belt		Total baseline carbon stock change in the leakage belt	
	IDct = 1		annual	cumulative
	$ABSLLK_{ct,t}$	$\Delta Cab_{ct,t}$	$\Delta CabBSLLK_t$	$\Delta CabBSLLK$
	ha	$tCO_2\text{-e ha}^{-1}$	tCO_2-e	tCO_2-e
0	0,0	-485,5	0	0
1	6.219,3	11,9	-3.019.723	-3.019.723
2	3.716,7	0,0	-1.730.473	-4.750.196
3	3.625,2	0,0	-1.715.876	-6.466.072
4	729,3	0,0	-310.907	-6.776.979
5	3.580,6	0,0	-1.729.850	-8.506.829
6	5.453,8	0,0	-2.605.388	-11.112.217
7	348,9	0,0	-104.378	-11.216.596
8	4.161,2	0,0	-2.016.271	-13.232.867
9	4.666,2	0,0	-2.216.035	-15.448.902
10	16,2	0,0	47.769	-15.401.132

Table 22.b. Baseline carbon stock change in the below-ground biomass in the leakage belt area

Project year t	Activity data per category x Carbon stock change factor for below-ground biomass in the leakage belt		Total baseline carbon stock change in the leakage belt	
	IDct = 1		annual	cumulative
	$BBSLLK_{ct,t}$	$\Delta Cbb_{ct,t}$	$\Delta CbbBSLLK_t$	$\Delta CbbBSLLK$
	ha	tCO_2-e ha^{-1}	tCO_2-e	tCO_2-e
0	0,0	-7,6	0	0
1	6.219,3	45,3	-47.476	-47.476
2	3.716,7	-7,6	253.417	205.941
3	3.625,2	-7,6	93.249	299.191
4	729,3	-7,6	82.838	382.029
5	3.580,6	-7,6	-97.809	284.220
6	5.453,8	-7,6	11.514	295.733
7	348,9	-7,6	108.023	403.757
8	4.161,2	-7,6	-194.012	209.744
9	4.666,2	-7,6	-27.798	181.947
10	16,2	0,0	-1.185	180.762

Table 22.c. Baseline carbon stock change in the dead wood biomass in the leakage belt area

Project year t	Activity data per category x Carbon stock change factor for dead wood biomass in the leakage belt		Total baseline carbon stock change in the leakage belt	
	IDct = 1		annual	cumulative
	$BBSLLK_{ct,t}$	$\Delta Cbb_{ct,t}$	$\Delta CbbBSLLK_t$	$\Delta CbbBSLLK$
	ha	tCO_2-e ha^{-1}	tCO_2-e	tCO_2-e
0	0,0	-2,97	0	0
1	6.219,3	-2,97	-18.488	-18.488
2	3.716,7	-2,97	-29.537	-48.025
3	3.625,2	-2,97	-40.313	-88.338
4	729,3	-2,97	-42.481	-130.819
5	3.580,6	-2,97	-53.125	-183.945
6	5.453,8	-2,97	-69.338	-253.283
7	348,9	-2,97	-70.375	-323.658
8	4.161,2	-2,97	-82.745	-406.403
9	4.666,2	-2,97	-96.616	-503.019
10	16,2	0,00	-96.664	-599.684

Finlay according to the VM0015, non-CO2 emissions from fires used to clear forests in the baseline can always be omitted. In order to keep the conservativeness, this source of GHG will not be accounted.

4.2 Project Emissions

According to the VM0015, future carbon stock changes and non-CO2 emissions from forest fires under the project scenario must be estimated *ex-ante,* in order to assist in guiding optimal implementation of emission reduction measures, and to allow reasonable projections of revenue to be made. On this regarding, two approaches are listed in the methodology, as follow:

- Planned activities within the project area.

- Unplanned deforestation that cannot be avoided.

Ex ante estimation of actual carbon stock changes due to planned activities

As per this section of methodology, certain discrete areas of forest within the project area might be subject to project activities that will change the carbon stocks of these areas compared to the baseline, like:

- Planned deforestation to build project infrastructure,
- Planned degradation by timber logging, fuel-wood collection, etc
- Protection without harvesting leading to carbon sequestration in forest classes that at project start are below their carbon stock potential at maturity

In addition the methodology states that, if the project activity generates a significant decrease in carbon stocks during the fixed baseline period, the carbon stock change must be estimated *ex ante* and measured *ex post*. If the decrease is not significant, it must not be accounted, and *ex post* monitoring will not be required.

Despite of the Juma management plan (annex 5) allows the use of wood for houses construction, community centers, canoes, churches, hulls, schools and community boat building[77], none of this activities are supposed to exceed, in a project scenario, the demand that would occur under the baseline scenario. In fact, considering that the REDD+ project brings governance to the SDR, its expected that all the logging to supply the above mentioned demand, that would occur with or without the implementation of the REDD project, in a project scenario, must happen in a sustainable basis. This assumption is based in the fact that, if SDR does not receive the resources from the VCU´s commercialization, most of the environmental monitoring and projects of sustainable income generation, that are part of the REDD project, would not be implemented, resulting in more degradation for logging and deforestation for cattle rising and commercial agriculture.

It is worth mentioning that the management plan also allows commercial logging, but restricted to Juma SDR residents and the surrounding communities listed in volume I of the management plan. In addition, it is necessary to elaborate a Small-scale Sustainable Forest Management Plan, following SEMA-AM's Normative Instruction (002/2008) to be licensed by IPAAM. This situation is far different from that foreseen in the baseline scenario where the logging is done illegally through outsider loggers, followed by deforestation for livestock and land grabbing.

Considering the aforementioned scenarios, the PP understands that the project activity will not generate more deforestation or degradation, and thus GHG emission, if compared to the baseline scenario. Also REDD+ project does not consider any kind of forest disturbance in order to build infrastructure, thus the project emission due to planned activities within the project area does not need to be estimated *ex ante,* neither measured *ex post.*

[77] All of these activities must be notified and are regulated by the Resolution 003/2008 of the State Environmental Council of the Amazonas (CEMAAM).

In addition, the Juma REDD+ project has opted to does not account or monitor the carbon change in forest that was in a disturbed conditions prior to the project start date, (with the potential to remove carbon during the regeneration process), following a conservative approach.

***Ex ante* estimation of carbon stock changes due to unavoidable unplanned deforestation within the project area**

According to the VM0015, to allow *ex ante* projections to be made, the project proponent shall make a conservative assumption about the effectiveness of the proposed project activities and estimate an Effectiveness Index (*EI*) between 0 (no effectiveness) and 1 (maximum effectiveness). The estimated value of *EI* is used to multiply the baseline projections by the factor (1 - *EI*) and the result shall be considered the *ex ante* estimated emissions from unplanned deforestation in the project case

$$\Delta CUDdPA_t = \Delta CBSL_t * (1 - EI)| \quad (1)$$

Where:

ΔCUDdPAt	Total *ex ante* actual carbon stock change due to unavoided unplanned deforestation at year *t* in the project area; tCO2-e
ΔCBSLt	Total baseline carbon stock change at year *t* in the project area; tCO2-e
EI	*Ex ante* estimated Effectiveness Index; % **(70%)**
t	1, 2, 3 … *T,* a year of the proposed project crediting period; dimensionless

The project proponent believes that under the REDD project governance it will be possible to reduce in 70% the deforestation in the project area compared to the baseline scenario, therefore the *ex-ante* Effectiveness Index (*EI*) adopted for the first baseline period is 0.7.

Table 23: Ex ante estimated net carbon stock change in the project area under the project scenario

Project year	Total carbon stock decrease due to planned logging activities		Total carbon stock increase due to planned logging activities		Total carbon stock decrease due to unavoided unplanned deforestation		Total carbon stock change in the project case	
	annual	cumulative	annual	cumulative	annual	cumulative	annual	cumulative
	$\Delta CPLdPA_t$	$\Delta CPLdPA$	$\Delta CPLiPA_t$	$\Delta CPLiPA$	$\Delta CUDdPA_t$	$\Delta CUDdPA$	$\Delta CPSPA_t$	$\Delta CPSPA$
	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2016	0	0	0	0	-140.310	-140.310	-140.310	-140.310
2017	0	0	0	0	-74.613	-214.923	-74.613	-214.923
2018	0	0	0	0	-92.061	-306.984	-92.061	-306.984
2019	0	0	0	0	-246.904	-553.888	-246.904	-553.888
2020	0	0	0	0	20.607	-533.280	20.607	-533.280
2021	0	0	0	0	-16.250	-549.531	-16.250	-549.531
2022	0	0	0	0	-283.600	-833.131	-283.600	-833.131
2023	0	0	0	0	17.175	-815.955	17.175	-815.955
2024	0	0	0	0	-18.328	-834.283	-18.328	-834.283
2025	0	0	0	0	-187.987	-1.022.270	-187.987	-1.022.270

4.3 Leakage

According to the VM0015, two sources of leakage are considered in this methodology and must be addressed:

1. Decrease in carbon stocks and increase in GHG emissions associated with leakage prevention measures
2. Decrease in carbon stocks and increase in GHG emissions associated with activity displacement leakage

In the first case, the PP commits to invest part of the annual budget generated through the sales of VCU in mitigation measures to guarantee that the offsite carbon stocks will not decrease. Such investments will reinforce a holistic approach and strategy, e.g. rural technical assistance, leadership capacity-building, social empowerment, education etc. (Bolsa Floresta), focusing on supporting leakage management areas through the intensification of sustainable territorial management and monitoring[78] illegal practices (logging, grazing, land grabbing and mining) in the leakage belt.

The second source of leakage considered by the methodology refers to activities that cause deforestation within the project area in the baseline scenario and could be displaced outside the project boundary due to the implementation of the AUD project activity. VM0015 states that if carbon stocks in the leakage belt area decrease more during project implementation than

[78] The only source of GHG that is suposed to increase due to mitigation leakage activities is the consumption of fossil fuels for patrols, however as per VM0015, section 8.1, this kind of source is always considered insignificant in AUD project activities and must not be considered.

projected in the baseline case, this will be an indication that leakage due to displacement of baseline activities has occurred.

Notwithstanding, it is not expected that the implementation of project activities will generate any offsite decreases in carbon stocks. In fact, the project implementation is expected to additionally reduce deforestation outside the project boundaries, as compared to the baseline scenario. Specific studies on deforestation dynamics indicate that the single measure of creating a Protected Area promotes reduction of deforestation in the surrounding areas. This effect was observed in the great majority of the protected areas created in the Brazilian Amazon, and the offsite "reduction of deforestation" that was generated varied from 1 to 3% of the size of the PA (IPAM, 2008). For this reason, it was assumed that the implementation of the Juma REDD+ Project will not result in negative leakage, but rather a "positive leakage" since there will be a reduction in deforestation rates outside of the Reserve. This offsite positive effect is also expected due to the intensification of non-timber forest products management in the project area, which is supposed to strength the sustainable business chain.

4.4 Net GHG Emission Reductions and Removals

According to the VM0015 v1.1 net anthropogenic GHG emission reduction of the proposed AUD project activity is calculated as follows:

$$\Delta REDD_t = (\Delta CBSLPA_t + EBBBSLPA_t) - (\Delta CPSPA_t + EBBPSPA_t) - (\Delta CLK_t + ELK_t) \qquad (2)$$

$\Delta REDD_t$ — *Ex ante* estimated net anthropogenic greenhouse gas emission reduction attributable to the AUD project activity at year t; tCO_2e

$\Delta CBSLPA_t$ — Sum of baseline carbon stock changes in the project area at year t; tCO_2e

Note: The absolute values of $CBSLPA_t$ shall be used in equation 19.

$EBBBSLPA_t$ — Sum of baseline emissions from biomass burning in the project area at year t; tCO_2e

$\Delta CPSPA_t$ — Sum of *ex ante* estimated actual carbon stock changes in the project area at year t; tCO_2e

Note: If $CPSPA_t$ represents a net increase in carbon stocks, a negative sign before the absolute value of $CPSPA_t$ shall be used. If $CPSPA_t$ represents a net decrease, the positive sign shall be used

.

$EBBPSPA_t$ — Sum of (*ex ante* estimated) actual emissions from biomass burning in the project area at year t; tCO_2e

CLK_t — Sum of *ex ante* estimated leakage net carbon stock changes at year t; tCO_2e

Note: If the cumulative sum of CLK_t within a fixed baseline period is > *0,* CLK_t shall be set to zero.

ELK_t t — Sum of *ex ante* estimated leakage emissions at year t; tCO_2e 1, 2, 3 … *T,* a year of the proposed project crediting period; dimensionless

The project emission reduction is calculated based in the baseline land use change model and biomass carbon stock per hectare. For additional information, please refer to Appendix VI, section 3.4 and 4.1, above. For project emission, please refer to section 4.2. for information regarding leakage emission and leakage management please refer to section 4.3.

Table 24: Ex ante estimated net GHG emission reduction in the project area under the project scenario for the first baseline period (10 years)

Year	Estimated baseline emissions (tCO_2e)	Estimated project emissions (tCO_2e)	Estimated leakage emissions (tCO_2e)	Estimated net GHG emission reductions (tCO_2e)
2016	467.699	140.310	0	327.390
2017	248.709	74.613	0	174.096
2018	306.871	92.061	0	214.810
2019	823.013	246.904	0	576.109
2020	-68.691	-20.607	0	-48.083
2021	54.167	16.250	0	37.917
2022	945.333	283.600	0	661.733
2023	-57.251	-17.175	0	-40.076
2024	61.093	18.328	0	42.765
2025	626.623	187.987	0	438.636
Total	3.407.566	1.022.270	0	**2.385.296**

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	Temporal land Use data
Data unit	hectares
Description	Annual land use data from the Brazilian Amazon, with 4 main classes: forest, cumulative and annual deforestation, water and non-forest class

Source of data	PRODES project INPE
Value applied	It is the official government data from monitoring the Amazon forest, it´s a well-recognized monitoring system and very useful to monitoring the trends and deforestation in the north of Brazil. The PRODES data were used to establish the baseline scenario of deforestation in the reference region and this spatial data will be used to monitoring the project emissions reductions during the project lifetime.
Justification of choice of data or description of measurement methods and procedures applied	See the detailed PRODES mapping methodology: http://www.obt.inpe.br/prodes/metodologia.pdf
Purpose of Data	Determination of baseline scenario (AFOLU projects only)
Comments	No comments.

5.2 Data and Parameters Monitored

Data / Parameter	Temporal land Use data
Data unit	hectares
Description	Annual land use data from the Brazilian Amazon, with 4 main classes: forest, cumulative and annual deforestation, water and non-forest class
Source of data	PRODES project INPE
Description of measurement methods and procedures to be applied	It is the official government data from monitoring the Amazon forest, it´s a well-recognized monitoring system and very useful to monitoring the trends and deforestation in the north of Brazil. The PRODES data were used to establish the baseline scenario of deforestation in the reference region and this spatial data will be used to monitoring the project emissions reductions during the project lifetime. See the detailed PRODES mapping methodology: http://www.obt.inpe.br/prodes/metodologia.pdf
Frequency of monitoring/recording	Annual

Value applied	NA
Monitoring equipment	GIS software and PRODES data.
QA/QC procedures to be applied	All the PRODES data will have an accuracy assessment according to the procedures established in the VM0015.
Purpose of Data	Determination of avoided deforestation due the project activities
Calculation method	In the GIS platform will be calculated the actual deforestation in hectares, in the reference region, project area and leakage belt.
Comments	No comments.

5.3 Monitoring Plan

The monitoring plan follows all the part of the VM0015, which is divided in two main tasks:

1. Monitoring of carbon stock changes and GHG emissions for periodical verifications within the fixed baseline period; and

2. Monitoring of key baseline parameters for revisiting the baseline at the end of the fixed baseline period.

Monitoring of carbon stock changes and GHG emissions for periodical verifications

<u>Monitoring of actual carbon stock changes and GHG emissions within the project area;</u>

Monitoring of land-use and land-cover change;

Deforestation mapping data that will be use by the project will be provided by PRODES, due the fact that all the reference period use this same data source to analyses the temporal land use change and it´s a good practice in the remote sensing field to maintain the same methodology to compare and to evaluate the land use change.

The main methodological[79] steps undertaken by PRODES to map deforestation in the Brazilian Amazon are, as follows:

• Pre-processing: according to CÂMARA et al. (2006) the main image pre-processing procedures performed by PRODES consist of the steps of image selection with lower cloud cover, with date of acquisition closest to the dry season in the Amazon and with adequate radiometric quality;

[79] http://www.obt.inpe.br/prodes/metodologia.pdf

georeferencing of images with spatial resolution of 30 meters with 1: 100,000 scale topographic maps and orthorectified MrSID format images from NASA.

• Interpretation and classification: The satellite image classification method used by PRODES follows four main steps. First, a spectral mixture model is generated identifying in the images the components of vegetation, soil and shade. This technique is known as the linear spectral mixture model (MLME), which aims to estimate the percentage of vegetation, soil and shadow components for each cell (pixel) of the image. The second step is the application of the segmentation technique, which identifies spatially adjacent regions (segments) with similar spectral characteristics in the satellite image. After segmentation, the segments are individually classified to identify the classes forest, non-forest vegetation, hydrography and deforestation (anthropized vegetation). Finally, the result of classified segmentation is submitted to the process of editing, or audit of classification, performed by an expert, ending with the creation of state mosaics.

• Postprocessing: The result of the classification is then submitted to an audit process of a geoprocessing analyst.

• Map accuracy check: Mapping check available from PRODES was performed by comparing each class of each year of the monitoring period with at least a set of 34 points for each class randomly distributed over the reference region for each year. The reference data used for this step comes from the visual interpretation of high spatial resolution images available in Google Earth. The global accuracy of the mapping for the different classes of land cover presented needs to have values above 80% for all classes analyzed.

As LU/LC-change analysis is an evolving field and will be performed several times during the project crediting period. A consistent time-series of LU/LC-change data must emerge from this process.

The VM0015 guides the project proponent to use the same source of remotely sensed data and data analysis techniques within a period for which the baseline is fixed (fixed baseline period). However, if remotely sensed data have become available from new and higher resolution sources (e.g. from a different sensor system) during this period, these can only be used if the images based on interpretation of the new data overlap the images based on interpretation of the old data by at least 1 year and they cross calibrate to acceptable levels based on commonly used methods in the remote sensing community.

So, as this PD used the PRODES data from the federal government produced by the INPE to make the temporal analysis of the land use and land use change of the reference period, the data that will be used in the monitoring period and in the renewal of the baseline is going to be the PRODES unless appear other data with better resolution and more efficient.

Initially the PRODES data will be download from the INPE database in the web, after all the classes that are not in the focus of avoidance the deforestation (such as non-forest areas, clouds, shadow and residues) of the Juma Project will be excluded from the database and the analysis of the PRODES data will have only the classes of interesting, such as forest, deforestation and water.

After that procedure, the PRODES data will have to has an accuracy assessment as the VM0015 give the guidelines in the section 2.5. The minimum accuracy of classification mapping should be 80%.

Monitoring of carbon stocks and non-CO2 emissions; and

Monitoring of impacts of natural disturbances and other catastrophic events.

Monitoring of leakage;

Ex post calculation of net anthropogenic GHG emission reduction

Bibliography

AMAZONAS, Governo do Estado. 2002. Programa de Governo. Manaus, 75p, Agosto, 2002

AMAZONAS, Governo do Estado. 2006. Decreto n° 26.010, de 03 de julho de 2006: "Cria a Reserva de Desenvolvimento Sustentável do Juma, no Município de Novo Aripuanã, e dá outras providências", published in the Diário Oficial do Estado do Amazonas in July 03rd, 2006.

AMAZONAS, Governo do Estado. 2007b. Lei no. 3.135, de 05 de junho de 2007: "Institui a Política Estadual sobre Mudanças Climáticas, Conservação Ambiental e Desenvolvimento Sustentável do Amazonas". 16p.

AMAZONAS, Governo do Estado, 2008c. Decreto n° 27.600, de 30 de abril de 2008: "Dispões sobre a doação do valor que especifica à Fundação Amazonas Sustentável-FAS, e dá outras providências", published in the Diário Oficial do Estado do Amazonas in April 30th, 2008

AMAZONAS, Governo do Estado. 2010. "Plano de Gestão da Reserva de Desenvolvimento Sustentável do Juma". volumes I e II, Série Técnica Planos de Gestão. Novo Aripuanã – AM. 281p.

AMEND, M.R.; REID, J. & GASCON C. 2006. *Benefícios Econômicos Locais de Áreas Protegidas na Região de Manaus, Amazonas.* Revista Megadiversidade, Conservação Internacional, Belo Horizonte, volume 2, número 1-2, pp. 60-70

AMUCHASTEGUI, N. A.; FORREST, J. Assessing Risks to Forest Cover and Carbon Stocks: A review of tools and approaches to compare business-as-usual to REDD+ scenarios. Forest and Climate Initiative, WWF Report, 2013.

ASSEMBLÉIA LEGISLATIVA DO ESTADO DO AMAZONAS. 2007. Lei complementar No. 53, de 05 junho de 2007. Institui o Sistema Estadual de Unidades de Conservação – SEUC. 62 p.

BRAGA, C. E.; VIANA, V. M. "Establishing Frameworks for ecosystems service markets: creating political support". Amazonas, 2003.

BRASIL. Lei Federal Nº 9.985, de 18 de julho de 2000. Regulamenta o art. 225, § 1o, incisos I, II, III e VII da Constituição Federal, institui o Sistema Nacional de Unidades de Conservação da Natureza e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil/leis/L9985.htm

CARRERO, G. C.. Dinâmica do desmatamento e consolidação de propriedades rurais na fronteira de expansão agropecuária no Sudeste do Amazonas. Dissertação de Mestrado em Ecologia, Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas, Brasil, 2009.

CARRERO, G. C. 2014. Viabilidade econômica da pecuária semi-intensiva no sul do Amazonas: uma oportunidade para reduzir o avanço do desmatamento / Gabriel C. Carrero; Gabriela Ibuja; Mariano C. Cenamo; Murilo Bettarello; Adalberto Vicente. - Manaus: IDESAM. Available in: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiijsma0OfkAhXcKrkGHd2iCykQFjAAegQIABAC&url=http%3A%2F%2Fwww.idesam.org.br%2Fpublicacao%2Frelatorio-viabilidade-pecuaria.pdf&usg=AOvVaw3x-4vJ0pGk4fs2LQuGkA-u

CARRERO, GABRIEL CARDOSO; ALBUJA, GABRIELA; FRIZO, PEDRO; HOFFMANN, EVANDO KONRAD; BEZERRA, CRISTIANO ALVES; CAROLINE DE SOUZA. A Cadeia Produtiva da Carne Bovina no Amazonas. - Manaus: IDESAM, 2015.

CENAMO, MARIANO COLINI; CARRERO, GABRIEL CARDOSO; SOARES, PEDRO GANDOLFO. Redução de Emissões do Desmatamento e Degradação Florestal (REDD+): Estudo de Oportunidades para o Sul do Amazonas. –vol 1. Manaus, 2011.

CIMA- CENTRO DE CONSERVACIÓN, INVESTIGACIÓN Y MANEJO DE ÁREAS NATURALES – CORDILLERA AZUL (CIMA-CORDILLERA AZUL). Cordillera Azul National Park REDD Project. Peru: 2012.

CLARK LABS. Idrisi Help. MA, USA: Clark University. Idrisi Taiga Edition, versão 16.05, 2009.

EASTMAN J. R. IDRISI Taiga guide to GIS and image processing. USA: Clark University, Clark Labs, IDRISI Productions, Worcester, 2009.

FEARNSIDE, P. M. 2008. The roles and movements of actors in the deforestation of Brazilian Amazonia. Ecology and Society 13(1): 23. Disponível em: http://www.ecologyandsociety.org/vol13/iss1/art23/

FÉRES. J. 2003. Desafios da pecuária de corte no Brasil: Pecuária na Amazônia IPEA. 25p.

GREENPEACE, 2008. Financiando a Destruição. Brasil, March 2008.

Higuchi, N.; Lima, A. J. N. & Soares, L. 2010. *Inventário Florestal da Reserva de Desenvolvimento Sustentável do Juma (Novo Aripuanã) – Estrada AM-174*. Relatório Técnico. 47p.

HU, X.; WENG, Q. Estimating impervious surfaces from medium spatial resolution imagery using the self-organizing map and multi-layer perceptron neural networks. USA: Remote Sensing of Environment 113, 2089-2102, 2009.

IDAM- INSTITUTO DE DESENVOLVIMENTO AGROPECUÁRIO DO AMAZONAS. *Plano Operativo Anual – 2007. Comunicação pessoal*. Apuí-AM, setembro de 2007

IMAZON, 2008. Transparência Florestal da Amazônia Legal nº04. July, 2008. Available at: http://www.imazon.org.br/publicacoes/publicacao.asp?id=578

INSTITUTO DO HOMEM E MEIO AMBIENTE DA AMAZÔNIA (IMAZON). Risco de desmatamento associado a hidrelétrica de Belo Monte. Belém, Pará: 2011.

IMAZON, 2015. Pecuária na Amazônia: Tendências e Implicações para a Conservação Ambiental. Available at: https://imazon.org.br/pecuaria-na-amazonia-tendencias-e-implicacoes-para-a-conservacao-ambiental/

IMAZON, 2015b. Estratégias e fontes de recursos para proteger as Unidades de Conservação da Amazônia. Available at: https://imazon.org.br/estrategias-e-fontes-de-recursos-para-proteger-as-unidades-de-conservacao-da-amazonia/

INPE - NATIONAL INSTITUTE FOR SPACE RESEARCH, 2019. Terra Brasilis - PRODES (Desmatamento). Available at:

http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/increments

INPE - NATIONAL INSTITUTE FOR SPACE RESEARCH, 2008. Projeto PRODES – Monitoramento da Floresta Amazônica por Satélite. www.obt.inpe.br/prodes/

IPAM, 2008. “Redução de emissões de carbono associadas ao desmatamento no Brasil: O papel do Programa Áreas Protegidas da Amazônia (ARPA). Brasilia.

LIU, WILLIAM TSE HORNG. Aplicações de Sensoriamento Remoto. Campo Grande: Cap. 10. Ed. UNIDERP, 908 p, 2006.

LOPES, L. 2007. Nota Técnica elaborada sobre o respaldo legal da Lei 3135/2007 – AM e seu relacionamento com a Lei 11.284/2006 – DF.

MOTTA, R. S 2002. Estimativa do Custo Econômico do Desmatamento na Amazônia* da Rio de Janeiro. IPEA. 27p.

NIMER, E. 1979. Climatologia do Brasil. Secretaria de Planejamento da Presidência da República, Fundação Instituto Brasileiro de Geografia e Estatística, Diretoria Técnica, Superintendência de Recursos Naturais e Meio Ambiente, Rio de Janeiro, RJ.

Nogueira, E.M., Nelson, B.W., Fearnside, P.M., França, M.B. & de Oliveira, A.C.A., 2008a. Tree height in Brazil's 'Arc of deforestation': Shorter trees in south and southwest Amazonia imply lower biomass. Forest Ecology and Management 255: 2963-2972.

Nogueira, E.M., P.M. Fearnside & B.W. Nelson. 2008b. Normalization of the wood density data used in estimates of above-ground live biomass in Amazon forests. Forest Ecology and Management 256(5): 990-996.

Nogueira, E.M., P.M. Fearnside, B.W. Nelson, R.I. Barbosa & E.W.H. Keizer. 2008c. Estimates of forest biomass in the Brazilian Amazon: New allometric equations and adjustments to biomass from wood-volume inventories. Forest Ecology and Management (no prelo) doi:10.1016/j.foreco.2008.07.022

PIJANOWSKI B. C.; BROWN D. G.; SHELLITO B. A.; MANIK G. A. Using neural networks and GIS to forecast land use changes: a Land Transformation Model. USA: Computers, Environment and Urban Systems 26(6):553-575, 2002.

PONTIUS JR., R. G.; SCHNEIDER, L. C. Land-cover change model validation by a ROC method for the Ipswich watershed, Massachusetts, USA. USA: Agriculture, Ecosystems and Environment 85, 239-248, 2001.

RADAMBRASIL Project. 1978. Folha no. SB 20 Purus: geologia, pedologia, vegetação e uso potencial da terra. Departamento Nacional de Produção Mineral, rio de Janeiro, RJ, Brasil. 566p.

RAZERA, A. Dinâmica do desmatamento em uma nova fronteira do sul do Amazonas: análise da pecuária de corte no município do Apuí. Dissertação de Mestrado em Ciências de Florestas Tropicais, Instituto Nacional de Pesquisas da Amazônia (INPA) e Universidade Federal do Amazonas (UFAM), Manaus, Amazonas, Brasil. 2005.

RESENDE, M.; Curi, N.; Rezende, S. B.; Correa, G. F. 1999. Pedologia. Base para distinção de ambientes.

SANGERMANO, F.; TOLEDANO, J.; EASTMAN, J. R. Land cover change in the Bolivian Amazon and its implications for REDD+ and endemic biodiversity. USA: Landscape Ecol (2012) 27:571–584, 2012.

SILVA a. S. L. 2015. Carta Insumos - Custo para formação de um hectare de pasto. Scot Consultoria. Disponivel em: https://www.scotconsultoria.com.br/noticias/cartas/39422/carta-insumos---custo-para-formacao--de-um-hectare-de-pasto.htm

SECRETARIA DE ESTADO DO MEIO AMBIENTE E DESENVOLVIMENTO SUSTENTÁVEL DO AMAZONAS – SEMA. 2006. Indicadores de Efetividade da Implementação de Unidades de Conservação Estaduais do Amazonas – Série Técnica. Governo do Estado do Amazonas. Manaus, Amazonas, Brasil. 63 p.

SECRETARIA DE MEIO AMBIENTE E DESENVOLVIMENTO SUSTENTÁVEL – SEMA. 2007. Unidade de Conservação de Uso Sustentável do Juma – Baixo rio Aripuanã/Amazonas. Governo do Estado do Amazonas. 66 p.

SIPAM - Sistema de Proteção da Amazônia. 2001. Base vetorial digital na escala 1:250.000 do Sistema de Proteção da Amazônia.

SOARES-FILHO, B. S., NEPSTAD, D, CURRAN, L., VOLL, E., CERQUEIRA, G., GARCIA, R. A., RAMOS, C. A., MCDONALD, A., LEFEBVRE, P., SCHLESINGER, P. 2006. Modeling conservation in the Amazon basin. Nature, V. 440, P. 520-523.

SOARES-FILHO, B. S.; BARBOSA F. A. et, al. 2015- Cenários para a pecuária de corte amazônica. Belo Horizonte: Ed. IGC/UFMG. 29p.

WWF – Brasil, 2018. Maior aumento de desmatamento da Amazônia em dez anos. Accessed in 17th September. Available in: https://www.wwf.org.br/?68662/maior-aumento-desmatamento-amazonia-dez-anos

APPENDIX

APPENDIX I: <REFERENCES SUPPORTING THE ASSUMPTION OF: I) PREDOMINANCE OF ILLEGAL DEFORESTATION, II) DEFORESTATION RISE IN 2019 AND III) THE LACK OF COMMITMENT OF BRAZILIAN GOVERNMENT WITH THE AMAZON DEFORESTATION>

References supporting the predominance of illegal deforestation compared to legal deforestation in the Brazilian Amazon:

1. *http://climainfo.org.br/2019/09/17/quase-toda-a-madeira-que-sai-da-amazonia-e-ilegal/?fbclid=IwAR0NO3tLddiap99NL4IKeaZFz9WoIObucX9ye5N7MMDQxUK_rShWCeUT7oM*

2. *https://sustentabilidade.estadao.com.br/blogs/ambiente-se/gastos-com-acoes-de-gestao-ambiental-do-pais-despencam/*

3. *https://oglobo.globo.com/sociedade/ibama-corta-22-das-acoes-de-fiscalizacao-previstas-23937584*

4. *https://noticias.uol.com.br/ultimas-noticias/agencia-estado/2019/08/31/investigacoes-revelam-quadrilhas-e-ganho-milionario-por-tras-do-desmate.htm?fbclid=IwAR0WGByjcshyf7HS-vnmVGYtRCT8Ng-a7iQFXgittMxDRfq1cY9BbSX5Tp8*

References supporting the lack of commitment of Brazilian government with deforestation in the Amazon biome:

1. *http://climainfo.org.br/2019/09/12/coronel-e-exonerado-do-ibama-por-ter-dito-em-publico-que-protegeria-garimpo-ilegal/?fbclid=IwAR0-NO7XnziH6PqvLGRKYxBCwMVq-RRk0v4kd83HaWkrySZ8jNZVDiih9YE*

2. *https://www.theguardian.com/environment/2019/sep/09/amazon-fires-brazil-rainforest?fbclid=IwAR1IQ0OPRIYyI1LBnz7MJTh2qX_SrQVOLnKbbMUL8vJqRcUmyQq5HOMVAsI*

3. *https://brasil.elpais.com/brasil/2019/09/09/politica/1568057092_806142.html?ssm=FB_CC&fbclid=IwAR0sCOiLNoWL4pfMIVUgTfyvIwMS7cPf0dUisr03n8Ahy8orCt7UO9fXXho*

4. *https://ultimosegundo.ig.com.br/ciencia/meioambiente/2019-08-28/bolsonaro-sera-denunciado-por-crime-contra-a-humanidade-e-ecocidio.html.amp?fbclid=IwAR24hxEymnfnC0oYnmDDu1mLcyf6LcVaqpduSuAJmvHqVnLeQmqsYm4S1wY*

5. *https://www.cartacapital.com.br/sociedade/queimadas-sao-apenas-a-ponta-do-iceberg-na-devastacao-da-amazonia/?fbclid=IwAR0INQ---hrqGlz2wgL-GVlknpNyKYKy3A-ez7NnrL7zzSoWDL6siET4Aiw#.XWWZC0JcTSU.facebook*

6. http://climainfo.org.br/2019/09/05/enquanto-a-amazonia-queima-ruralistas-e-governo-desmontam-o-codigo-florestal/?fbclid=IwAR1xEMAjujr_l-XwfYp7BjOnA8H7VskYz5ii1Ym0y1rfFTVN5Cd8pw5kYP4

7. https://ambiencia.blogfolha.uol.com.br/2019/09/04/camara-aprova-pagamento-de-servicos-ambientais-mas-pode-fragilizar-lei-florestal/

8. https://oglobo.globo.com/sociedade/ministerio-do-meio-ambiente-reduz-em-34-verba-para-combater-incendios-em-2020-23925224?fbclid=IwAR1qQ2isL884WeDcWpKgwPnssdg-xXBrw0AgWAQrOG6clzCrAOH8McImM9w

9. https://www.washingtonpost.com/world/the_americas/now-begins-the-biggest-challenge-of-the-amazon-fires-putting-them-out/2019/08/26/43c526d0-c80b-11e9-9615-8f1a32962e04_story.html?fbclid=IwAR03L1iTQG1Gn9IDu7MAdsRVGrLaiqDl_zCl89FhZ3o65oRuViG4AUUo9To

10. https://www.bbc.com/portuguese/brasil-49256294?fbclid=IwAR1sD2gJRyJcWDBSsBMtoBpzJtfB7oO4koa50u0yDMKnOKIgqJKOIdwXJbE

11. https://edition.cnn.com/2019/07/02/americas/amazon-brazil-bolsonaro-deforestation-scli-intl/index.html?fbclid=IwAR0syniF1mznzue7u9xT2y7NTe2WnPV8gF6BKNmEgU3T8YMM7GfPm7tTy1A

12. http://www.inpe.br/noticias/noticia.php?Cod_Noticia=5178&utm_source=dlvr.it&utm_medium=facebook&fbclid=IwAR2mqL_mXOX2O8nC4NnJjfwJzb7EOtIHoRybVoaXK7MT1zGkoADba48uY60

13. https://www.bbc.com/portuguese/brasil-49402290

References supporting the assumption of rising in Amazon deforestation and fire outbreaks in the year 2019:

1. https://g1.globo.com/natureza/noticia/2019/09/01/agosto-tem-o-maior-numero-de-focos-de-queimadas-na-amazonia-dos-ultimos-9-anos-segundo-o-inpe.ghtml?fbclid=IwAR35wTI97obpaOwlhSQpZZV8vEkzJEnw0WE2QH4WhV096kn-mIF8wrCKWWo

2. https://noticias.uol.com.br/ultimas-noticias/agencia-estado/2019/08/31/investigacoes-revelam-quadrilhas-e-ganho-milionario-por-tras-do-desmate.htm?fbclid=IwAR0WGByjcshyf7HS-vnmVGYtRCT8Ng-a7iQFXgittMxDRfq1cY9BbSX5Tp8

3. https://revistagloborural.globo.com/Noticias/Sustentabilidade/noticia/2019/08/grupo-no-whatsapp-contratou-motoqueiros-e-motosserras-para-desmatar-e-incendiar-floresta.html?fbclid=IwAR3g3K1W4KmcoYKyzNbeTEIGec3h5pjcZoA2vVShJX5S8gkOY22EaVHbw_8

4. https://www.sciencemag.org/news/2019/08/theres-no-doubt-brazils-fires-are-caused-deforestation-scientists-say?fbclid=IwAR1FzUo4kFdmMegJpRgic7FgoyP5QtkTvH1-aIMoL1_YvsRuUnTXmSeulyE

5. https://g1.globo.com/natureza/noticia/2019/08/23/nasa-diz-que-2019-e-o-pior-ano-de-queimadas-na-amazonia-brasileira-desde-2010.ghtml?fbclid=IwAR0KGd-ESHqNpOgqTvMXythqfJzHGv0_guMa_joK3rpLVb-0Cz4yM1RUp5I

6. https://www1.folha.uol.com.br/ambiente/2019/08/em-dia-do-fogo-sul-do-pa-registra-disparo-no-numero-de-queimadas.shtml?fbclid=IwAR2fk2ebJTWHEBX6gDXn9Su5TF1bvdk4iK2DsZHXtYTc4kIumRMaMoXMmJQ

7. https://oglobo.globo.com/sociedade/noruega-paralisa-repasses-para-fundo-amazonia-23879397?fbclid=IwAR2x-TSfq45Tf0Qb-WYeP4QYlWc8Vq01eRHC3w4imlTr_FHSiAIhxyjL39o

8. https://www.economist.com/leaders/2019/08/01/deathwatch-for-the-amazon

9. https://oglobo.globo.com/sociedade/alertas-do-inpe-sobre-desmatamento-na-amazonia-crescem-278-em-julho-23857095

10. https://edition.cnn.com/2019/07/02/americas/amazon-brazil-bolsonaro-deforestation-scli-intl/index.html?fbclid=IwAR0syniF1mznzue7u9xT2y7NTe2WnPV8gF6BKNmEgU3T8YMM7GfPm7tTy1A

11. https://blogdopedlowski.com/2019/07/18/dados-do-inpe-mostram-desmatamento-em-ritmo-explosivo-na-amazonia/?fbclid=IwAR2mbQPxTqVf5SgU_KeWyrQiMtOfvHEKNSXJyYXdR8OeQdzdmES4CzDpfH8

12. http://climainfo.org.br/2019/09/08/desmatamento-cresce-222-na-amazonia-em-agosto/?fbclid=IwAR2rzXD08Rj4kX8D0GhPoHmMrITqVqCB03PzX5gbMMRAJuIYad8SGCxc8_U

13. https://www.wwf.org.br/?68662/maior-aumento-desmatamento-amazonia-dez-anos

APPENDIX II: < *INVESTMENT ANALYSIS TO DETERMINE THAT THE PROPOSED PROJECT ACTIVITY IS NOT THE MOST ECONOMICALLY OR FINANCIALLY ATTRACTIVE OF THE IDENTIFIED LAND USE SCENARIOS*>

Please refer to the excel spreadsheet: “Appendix 2_ADDITIONALITY INVESTMENT ANALYSIS.xls”

APPENDIX III: < GEOGRAPHIC COORDINATES OF THE RED PROJECT FOR THE JUMA RESERVE BOUNDARIES >

Geographic coordinates of the RED Project for the Juma Reserve boundaries, according to the Law decree n°26.010 of 3th july 2006, that refers to its creation

PONTO	S	W	PONTO	S	W
01	5,181944	60,43889	30	5,523889	60,43778
02	5,257778	60,54528	31	5,583611	60,43444
03	5,342778	60,49278	32	5,615556	60,42333
04	5,375278	60,50083	33	5,594167	60,3525
05	5,406667	60,51694	34	5,6325	60,32139
06	5,423611	60,50694	35	5,663889	60,38889
07	5,471389	60,51222	36	5,656111	60,39806
08	5,519722	60,55333	37	5,658611	60,46389
09	5,563056	60,56222	38	5,612778	60,44889
10	5,572778	60,58528	39	5,619722	60,50333
11	5,574444	60,63806	40	5,575833	60,50556
12	6,501944	60,54583	41	5,573333	60,48889
13	6,2675	60,06611	42	5,543611	60,49639
14	6,170278	60,10083	43	5,542778	60,46889
15	6,151389	60,08028	44	5,439167	60,45333
16	6,151111	60,03222	45	5,440556	60,47472
17	6,233889	60,00389	46	5,434167	60,47528
18	6,211111	59,94361	47	5,431667	60,45694
19	5,653611	59,92111	48	5,396944	60,45361
20	5,624444	59,99889	49	5,396111	60,47194
21	5,586389	60,06361	50	5,3875	60,47167

22	5,566667	60,14806	51	5,387222	60,46583
23	5,626389	60,22611	52	5,373611	60,46778
24	5,560278	60,23333	53	5,356944	60,46083
25	5,550278	60,23806	54	5,286667	60,46972
26	5,554444	60,30361	55	5,279444	60,4475
27	5,542778	60,32778	56	5,2475	60,43333
28	5,536111	60,39111	57	5,1975	60,42167
29	5,518056	60,39278	58	5,193056	60,43278

APPENDIX IV: *JUMA VCS NON-PERMANENCE RISK REPORT*

Please refer to the excel spreadsheet: "Appendix IV_ *Juma_VCS-Non-Permanence-Risk-Report-Template-Short-Form-v4.0*

APPENDIX V: *JUMA VCS RISK REPORT CALCULATION TOOL V4.0*

Please refer to the excel spreadsheet: "Appendix V_Juma_VCS-Risk-Report-Calculation-Tool-v4.0"

Appendix VI:_*JUMA EX-ANTE CALCULATION*

Please refer to the excel spreadsheet: "Appendix VI_Ex-ante calculation"

Appendix VII_ cartographic database used for the baseline model

https://drive.google.com/file/d/133oVgRdERPcLjwPo_EpkvtFCfo4iWqKs/view