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24 25	December 22

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1. List of acronyms and glossary

- 323
 324 AGB above ground biomass: All biomass of living vegetation, both woody and herbaceous,
 325 above the soil including stems, stumps, branches, bark, seeds, and foliage IPCC (2006)
 326
- AD activity data: data on the magnitude of a human activity resulting in emissions or
 removals taking place during a given period of time. Data on land areas, management
 systems, fertilizer use are examples of activity data IPCC (2006)
- BGB below ground biomass: All biomass of live roots. Fine roots of less than (suggested)
 2mm diameter are often excluded because these often cannot be distinguished empirically
 from soil organic matter or litter IPCC (2006)
- **COEAM INPE's Amazon Space Coordination** (Portuguese acronym)
- **CCST INPE's Earth System Science Center** (Portuguese acronym)
- 339 EBA: Portuguese acronym for CCST Project "Improvement of biomass estimation methods340 and models of estimation of emissions by land use change"
- **DIOTG INPE's Division of Earth Observation and Geoinformatics** (Portuguese acronym)
- 344 DW dead wood: Includes all non-living woody biomass not contained in the litter, either
 345 standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface,
 346 dead roots, and stumps, larger than or equal to 10 cm in diameter (or the diameter specified
 347 by the country) IPCC (2006)

- **DETER INPE's Real-Time Deforestation Detection System** (Portuguese acronym)
- **Disordered logging:** for the purposes of this submission, disordered logging refers to logging 352 activities in natural forest land that has a disordered (irregular) pattern, most likely from 353 illegal logging activities
- **EF emission factor**: a coefficient that quantifies the emissions or removals of a gas per unit
 356 activity IPCC (2006)
- Forest Degradation: for the purpose of this submission, forest degradation refers to reduction
 of carbon stocks in forest land remaining forest land in the Amazon biome due to fire on
 managed forest land and disordered logging
- 362 FRA Global Forest Resources Assessments
- 364 GTT MRV REDD+ Working Group of Technical Experts on REDD+ for MRV (Portuguese
 365 acronym)
 366
- 367 INPE National Institute for Space Research (Portuguese acronym)

368	
369	LI – litter: Includes all non-living biomass with a size greater than the limit for soil organic
370	matter (suggested 2 mm) and less than the minimum diameter chosen for dead wood (e.g.
371	10 cm), lying dead, in various states of decomposition above or within the mineral or organic
372	soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the
373	mineral or organic soil (of less than the minimum diameter limit chosen for below-ground
374	biomass) are included in litter where they cannot be distinguished from it empirically - IPCC
375	(2006)
376	
377	MMA - Ministry of Environment (Portuguese acronym)
378	
379	MMU - Minimum mapping unit: the smallest size that determines whether a feature is
380	captured from a remotely sensed image
381	
382	NDVI – Normalized Difference Vegetation Index
383	
384	PAMZ+ – Amazon and Other Biomes Monitoring Program (Portuguese acronym)
385	
386	Phytophysiognomies: refer to the type of vegetation present in a given biome. In each biome
387	or region that are predominant phytophysiognomies or vegetation
388	
389	PRODES – INPE's Monitoring Program of the Brazilian Amazon Forest by Satellite
390	(Portuguese acronym)
391	
392	SINAFLOR – National System of Forest Products Origen Control (Portuguese acronym)
393	
394	SRTM – Shuttle Radar Topography Mission
395	
396	TACC – transparency, accuracy, completeness, and comparability
397	
398	TerraClass – Land Use and Occupation Mapping System Project (Portuguese acronym)
399	
400	

401 2. Introduction

402

Brazil welcomes the opportunity to submit a national forest reference emission level (FREL)
for a technical assessment under the United Nations Framework Convention on Climate
Change (UNFCCC), in the context of results-based payments for reducing emissions from
deforestation and forest degradation and the role of conservation, sustainable management
of forests and enhancement of forest carbon stocks in developing countries (REDD+).

408

Brazil has indicated in previous submission that its national FREL would be the sum of the
 FRELs for each of its six biomes. This submission represents Brazil's national FREL.

411

Brazil underlines that the submission of FRELs and/or Forest Reference Levels (FRLs) and subsequent Technical Annexes to the Biennial Update Report (BUR) and Biennial Transparency Report (BTR) with REDD+ results attained are voluntary and exclusively for the purpose of obtaining and receiving results-based payments for REDD+ activities, pursuant to decisions 13/CP.19, paragraph 2, and 14/CP.19, paragraphs 7 and 8¹ and does not interfere with the Nationally Determined Contribution (NDC) submitted by Brazil to the Paris Agreement.

419

420 3. Information used in the construction of Brazil's national FREL421

- 422 3.1. Brazil's biomes
- 423

425

3.1. Brazil s biomes

424 Brazil's national FREL covers all six biomes in the country:

- Amazon: The Amazon biome is formed mainly by forest formations, with the occurrence of small enclaves of savanna and grassland formations. Considered the largest tropical forest in the world, the phytophysiognomies of the Amazon store a large amount of carbon (ARAGÃO et al., 2014).
- 430 **Cerrado:** The second largest Brazilian biome, the Cerrado is characterized by a marked • 431 seasonal distribution of precipitation (with two well-defined seasons: dry and rainy), 432 which results in vegetation adapted to water stress and fire conditions (RIBEIRO; 433 WALTER, 2008). Cerrado phytophysiognomies present high environmental 434 heterogeneity (natural grasslands, shrubs and forest formations), resulting in a high 435 rate of endemism and species diversity, which, together with the strong conversion 436 pressure on natural habitats, has placed the Cerrado among the hotspots global 437 biodiversity (MMA, 2002)
- Caatinga: The main type of vegetation in the Caatinga is the steppe savanna, represented by different physiognomic formations (forested, arboreal, parks, grassy-woody) and contact formations, forming mosaics that are influenced by the local topography and geomorphology. Other phytophysiognomies occur in reduced areas (less than 15% of the biome), due to altitude and proximity to other biomes, such as

¹ Available at: <u>https://unfccc.int/sites/default/files/resource/docs/2013/cop19/eng/10a01.pdf</u>

443the Atlantic Forest and the Cerrado (MCTI, 2015). The heterogeneity of the vegetation444(LUETZELBURG, 1922-23; DUQUE, 1980; ANDRADE-LIMA, 1981) and the variability of445rainfall and water stress give the biome high levels of diversity and endemism of fauna446and flora (LEAL et al., 2005). In the Caatinga, the irregularity of the rains and the long447periods of drought directly impact the survival of the population and agricultural448production indices, and the accentuation of the desertification process is identified as449one of its main vulnerabilities

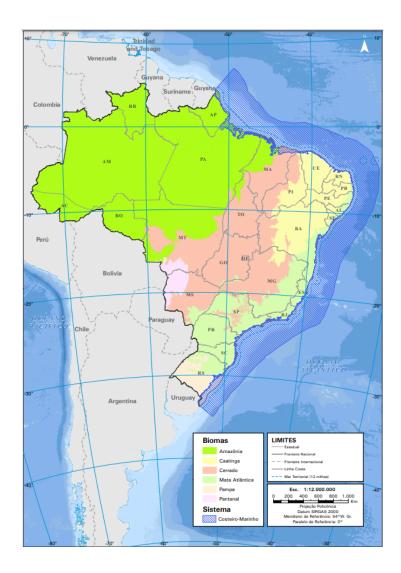
- 450 Atlantic Forest: The Atlantic Forest is mainly characterized by forest formations, • 451 although there are areas of fields, savannas, sandbanks and mangroves (Atlas dos 452 Remanescentes Florestais da Mata Atlântica – technical report, 2019). The Atlantic 453 Forest is also considered a biodiversity hotspot due to habitat loss and fragmentation, 454 high rates of endemism and the large number of endangered species. Due to its 455 history of use and occupation since the colonial period, it is the biome that has the 456 lowest percentages of its original vegetation, despite the increase in regenerating 457 areas (Fundação SOS Mata Atlântica/INPE, 2019). Much of the original area of the 458 biome has given way to agricultural crops, development of industries, oil extraction 459 centers, port areas and it is where most of the country's population live, placing the 460 Atlantic Forest as responsible for 80% of the national GDP (IBGE, 2012).
- 461 **Pampa:** The Pampa is mainly characterized by the presence of grassland formations, • 462 although there are forest phytophysiognomies (gallery forests) and rocky outcrops. 463 Currently, approximately 51% of the original vegetation of the grasslands has been 464 lost due to anthropic activities, occupation and economic use (HASENACK et al., 2007). 465 Another point that highlights the uniqueness of the Pampa is related to the 466 heterogeneity of characteristics due to the peculiarity of the vegetation, soils and geological and geomorphological conditions, hydrological aspects and climatic order 467 468 (BOLDRINI et al., 2010).
- 469 Pantanal: According to POTT & SILVA. (2016) and SILVA et al. (2021), nowadays it is 470 recognized that the Pantanal Biome is composed of the intersection of four large 471 phytoecological regions: Seasonal Deciduous Forest, Seasonal Semideciduous Forest, 472 savanna (Cerrado), and Steppic savanna (Chaco). This Biome also contains elements 473 of Ombrophylous Forest, typical of the Amazon. In addition, there are the floristic 474 contacts and the pioneer (early successional) formations. The dynamics of flooding in 475 the Pantanal is related to the precipitation of a large amount of water (between 476 December and January) in the Central Plateau region of the Cerrado biome and its 477 consequent flow to the floodplains, where it forms lakes, swamps and marshes, 478 resulting in flooding of part of its extension (PADOVANI, 2017).
- 479

The area of each biome was defined according to the "Map of Biomes and Coastal-Marine System of Brazil" (IBGE, 2019),
 that have established new boundaries for the six Brazilian biomes, compatible with the scale of 1:250,000. Figure 1
 presents the

483 map with the geographical distribution of the Brazilian biomes, developed by IBGE, in 2019.

484 **Table 1** shows the geographic area covered by each biome, and the corresponding percentage

485 contribution to the total national area (IBGE, 2019).



487

488 Figure 1 – Biomes and Coastal-Marine System Map of Brazil

489 OBS: Biomas = biomes / Amazônia = Amazon / Mata Atlântica = Atlantic Forest / Sistema Costeiro-Marinho =
 490 Marine-Coast System / Limites = Limits / Estadual = State / Fronteira Nacional = National boundary / Fronteira

491 Internacional = International boundary / Linha Costa = Coastal line / Mar Territorial = Sea territory

- 492 Source: IBGE, 2019
- 493

494 Table 1 - Extent of the six Brazilian biomes and their relative contribution to the total

495 national area

Biome	Area (ha)	Contribution to national area (%)
Amazon	421.274.200	49,5
Cerrado	198.301.700	23,3
Caatinga	86.281.800	10,1
Atlantic forest	110.741.900	13,0
Pampa	19.381.800	2,3
Pantanal	15.098.800	1,8

Biome	Area (ha)	Contribution to national area (%)
Total	851.080.200	100

497 OBS: please note that the area in Table 1 does not include the area of the coastal-marine system.

498 Source: IBGE, 2019 and Brazil, 2020

499

500 3.2. Forest definition

501

502 For the purpose of this submission, the **forest definition** adopted is the same as that used by 503 Brazil in its latest GHG inventory (hereinafter referred to as "4th National GHG Inventory" -504 Brazil, 2020) and in its "Global Forest Resources Assessment - FRA" (FAO, 2020). The definition 505 is reproduced below:

506

507 "Minimum area of 0.5 hectares with trees of minimum height of 5 meters and
508 minimum canopy coverage of 10 percent, or trees capable of reaching these limits in
509 situ. Does not include areas predominantly used for agricultural or urban purpose".

510

511 Forest area, as defined above, comprise those areas with predominance of tree species and 512 a continuous or discontinuous canopy formation. Given this comprehensive definition, forest 513 formations comprise various types of various phytophysiognomies in the different Brazilian 514 biomes (Figures 2 to 7). Brazil's national FREL adopts the official classification system for 515 native vegetation of Brazil (NFMA - IBGE, 2012) and the categorization of these 516 phytophysiognomies, whether forested or not, is consistent with the 4th National GHG 517 Inventory and the FRA (**Table 2**).

518

519 Table 2 – Phytophysiognomies used in Brazil's national FREL

4 th National GHG Inventory	FRA	NFMA land use/cover classification	Vegetation typology	Phytophysiognomies	Initials	
				Alluvial Open Humid Forest	Aa	
		Evergreen	Open Humid	Lowland Open Humid Forest	Ab	
	Forest (F)	Primary Forest	Forest	Ombrophilous Open Forest – Mountain	Am	
				Sub-montane Open Humid Forest	As	
<u> </u>				Alluvial Decidual Seasonal Forest	Са	
Forest (F)		st (F	L) Decidual	Decidual	Lowland Deciduous Seasonal Forest	Cb
ore		Primary P Forest	Forest	Montane Deciduous Seasonal Forest	Cm	
ш.				Sub-montane Deciduous Seasonal Forest	Cs	
			Dense Humid	Alluvial Dense Humid Forest	Da	
		Evergreen Primary		Lowland Dense Humid Forest	Db	
		Forest	Forest	Montane Dense Humid Forest	Dm	
				Sub-montane Dense Humid Forest	Ds	

4 th National GHG Inventory	FRA	NFMA land use/cover classification	Vegetation typology	Phytophysiognomies	Initials			
			_	Steppes				
		Wooded	Steppes	Wooded Steppes	Ea			
			Transition	Contact Steppes / Mixed Ombrophilous Forest	EM			
		Contact	zone	Contact Steppes / Seasonal Forest				
				Contact Steppes / Formations				
		Semi-	Semi-	Alluvial Semi-deciduous Seasonal Forest				
		deciduous	deciduous	Lowland Semi-deciduous Seasonal Forest				
		Primary	Primary	Montane Semi-deciduous Seasonal Forest	Fm			
		Forest	Forest	Submontane Semi Deciduous Seasonal Forest	Fs			
				Campinarana	L			
		Evergreen Primary	Campinarana	Forested <i>Campinarana</i>	La			
		Forest	campinarana	Wooded Campinarana	Ld			
			Transition	wooded campinarana	Lu			
		Contact	zone	Contact Campinarana / Ombrophilous Forest	LO			
		_	Mixed Humid	Alluvial Mixed Ombrophilous Forest	Ma			
		Evergreen Primary Forest		Upper Montana Mixed Ombrophilous Forest				
			Forest	Montane Mixed Humid Forest	Mm			
				Sub-montane Mixed Ombrophilous Forest	Ms			
			Transition zone	Contact Seasonal Forest / Mixed Ombrophilous Forest	NM			
				Contact Seasonal Forest / Pioneer Formations – Specific for Pioneer Formation with Marine Influence (<i>Restinga</i>)		NP		
		Contact		Contact Dense Ombrophilous Forest / Mixed Ombrophilous Forest	OM			
				Contact Ombrophilous Forest / Seasonal Forest	ON			
				Contact Ombrophilous Forest / Pioneer Formations – Specific for Pioneer Formation with Marine Influence (<i>Restinga</i>)	OP			
			Pioneer Formation	Pioneer Formations Areas	Р			
		Evergreen Primary		Pioneer Formation of Fluviomarine Influence (mangroves)	Pf			
		Forest		Pioneering Formation of Marine Influence (sand banks)	Pm			
		Primary Semi- deciduous Forest		Savanna	S			
			Savanna	Wooded Savanna				
		Wooded	Savanna	Forested Savanna	Sd			
				Contact Savanna/ Mixed Ombrophilous Forest	SM			
		Contact	Transition zone	Contact Savanna / Seasonal Forest	SN			
		Contact		Contact Savanna / Ombrophilous Forest	SO			
				Contact Savanna / Savanna Steppes	ST			

4 th National GHG Inventory	FRA	NFMA land use/cover classification	Vegetation typology	Phytophysiognomies	Initials	
				Contact Savanna / Savanna Steppes / Seasonal Forest	STN	
				Contact Savanna/Savanna Steppes	ST	
		Primary	Savanna	Savanna Steppes	Т	
		Deciduous Forest	Steppes	Forested Steppe Savanna	Td	
		Wooded	Savanna Steppes	Wooded Steppe Savanna	Та	
		Contact	Transition zone	Contact Savanna Steppes / Seasonal Forest	TN	
	Other woody areas (OFL)	Contact	Campinarama	<i>Campinarana</i> – shrub	Lb	
Other woody areas (OFL)		Evergreen Primary Forest	Palm Grove	Fluvial and/or lacustrine influenced Vegetation		
y are		Wooded	Pioneer Formations	Upper Montane Refuges	RI	
poo				Montane Refuges	Rm	
er v				Submontane Refuges	Rs	
Othe		Wooded	Savanna	Savanna – parque	Sp	
		Savanna	Savanna Est	Savanna Steppes – parque	Тр	
			Steppes	Steppes – Grassy-Woody	Eg	
	Grassland (G)	Natural Grassland	Steppes	Steppes – Parque	Ep	
			Campinarama	Campinarana – Grassy-Woody	Lg	
Other land			Savanna	Savanna – Grassy-Woody	Sg	
			Savanna Estépica	Savanna Steppes – Grassy-Woody		
			Rocks	Other Rock Outcrops	Ar	
			Dunas	Dunas	Dn	

521 Source: Brazil, 2020



- 525 Figure 2 Pictorial representation of Lowland Open Ombrophilous Forest Amazon
- **biome**
- 527 Source: FUNCATE / INPE



- 531 Figure 3 Pictorial representation of Wooded Savanna Cerrado biome
- 532 Source: FUNCATE / INPE



536 Figure 4 – Pictorial representation of Dense Ombrophilous Forest – Atlantic Forest biome

- 537 Source: FUNCATE WWF



541 Figure 5 – Pictorial representation of Contact Savanna / Seasonal Forest – Caatinga biome

542 Source: FUNCATE / INPE



Figure 6 – Pictorial representation of Lowland Semi-deciduous Seasonal Forest – Pampa
 biome

- 547 Source: FUNCATE / INPE
- 548



549 550

551 Figure 7 – Pictorial representation of Steppe Savanna – Pantanal biome

552 Source: FUNCATE / INPE

554 3.3. Managed forest land

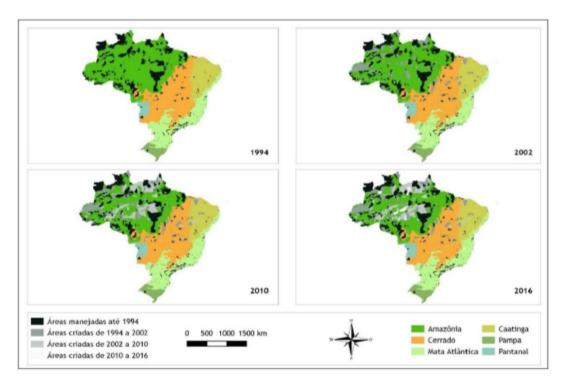
555

553

Brazil have followed the IPCC "managed land proxy" in all its national GHG inventory, as well
in this submission to determine the anthropogenic GHG emissions related to forest land.

According to the 4th National GHG inventory **managed forests** are "natural forests, where 559 560 human action did not cause significant changes in characteristics, classified based on the map 561 of past natural vegetation and on its phytophysiognomies. It is in a protected area 562 (Conservation Unit - UC or Indigenous Lands - TI) and, therefore, its CO₂ removals are accounted for, based on a scientific survey, when they remain with the same coverage 563 between the evaluated periods"; and unmanaged forests are "natural forests, where human 564 action did not cause significant changes in characteristics, classified based on the map of past 565 natural vegetation and on its phytophysiognomies. Emissions and removals are only 566 567 accounted for when converted to anthropogenic use. CO₂ removals are not counted when it 568 remains intact between the periods evaluated since there is no anthropic intervention" 569 (Brazil, 2020).

570



571 572

573 Figure 8 – Managed Forest land

574

575 OBS: In black, managed lands created until 1994; in dark grey, areas created from 1994 to 2002; in light grey,
576 areas created between 2002 and 2010; and in white, areas created from 2010-2016.
577

578 Source: Brazil, 2020

580 3.4. Ancient native vegetation map and EBA

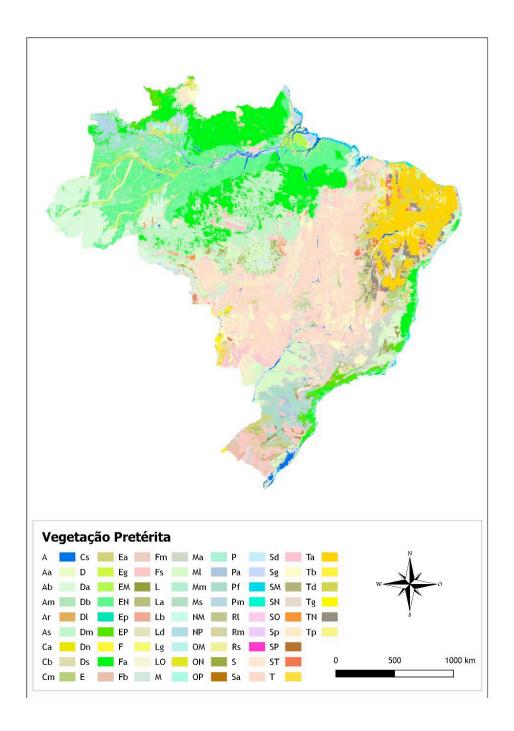
581

582 The ancient native vegetation map used in this submission, for the purpose of 583 phytophysiognomies identification (classification), was the same as that used in the context 584 of the 4th National GHG Inventory (*Figure 9*). The map shows phytophysiognomies according 585 to the IBGE classification system and the categories – forest or not forest – according to the 586 2020 "Global Forest Recourses Assessment - FRA". See

587 Box 1 for a brief description of the methodology applied to develop the "ancient native588 vegetation map".

589

590 In addition to the ancient native vegetation map, more recent estimates of biomass data for 591 the Amazon (EBA, for the acronym in Portuguese), developed by the Earth System Science 592 Center from the National Institute of Space Research (CCST/INPE, for the acronym in 593 Portuguese) were also used. See **Box 2** for a brief description of "EBA".



- 597 Figure 9 Ancient native vegetation map
- 598 Source: Brazil, 2020

Box 1 – Brief description of the methodology applied to develop the "ancient native vegetation map"

"The 4th National GHG Inventory had a more up-to-date and accurate basis for the development of a map of ancient natural vegetation (i.e., distribution and classification of the various phytophysiognomies, disregarding the intervention and human occupation) forall Brazilian biomes. This basis was the result of the vegetation map provided by IBGE (2017), with adjustments made by the Brazilian Forest Service (SFB, for the acronym in Portuguese) for the anthropized areas (Brazil, 2019); comparisons with the map of natural vegetation used in the 3rd National GHG Inventory (MCTI, 2015 and Brazil, 2016); and details of predominant phytophysiognomies using secondary databases, as described below.

To verify the compatibility between the maps produced by IBGE, the SFB and the 3rd National GHG Inventory, analysis of the intersection between these maps was conducted, resulting in a single shapefile consisting only of the common areas among them. Subsequently, the phytophysiognomies classes, described in the Technical Manual of Brazilian Vegetation (IBGE, 2012), were associated.

For some of the areas currently anthropized, the SFB classified the phytophysiognomies only in relation to the dominant class. Therefore, for the 4th National GHG Inventory it was decided to cross-reference this information with other environmental databases to obtain a more detailed classification. For example, to classify the alluvial forests, hydrological data from the National Water Agency² were used, by identifying polygons with fluvial influence and cross-checking them with watercourses and artificial water masses vector files. To classify phytophysiognomies in relation to altitude, the 4th National GHG Inventory used the altitude data of Shuttle Radar Topography Mission - SRTM (NASA, 2019).

Thus, the ancient natural vegetation map of the 4th National GHG Inventory is the result of a combination of sources and processing of geospatial data from different maps from IBGE (2017), SFB and the 3rd National GHG Inventory (MCTI, 2015 and Brazil, 2016)".

Source: Brazil, 2020

² Available at: <u>http://metadados.ana.gov.br/geonetwork/srv/pt/main.home?uuid=2fb4464c-fc83-41d0-b63a-d020395a4a99</u>

Box 2 – Brief description of EBA³

"The Earth System Science Center from the National Institute for Space Research (CCST/INPE) aims at supporting and directing research to improve the accuracy of biomass and carbon estimation in the Amazon biome. Ometto et al. (2014) compared some of the biomass maps available for the region and concluded that there are significant differences between them. Nevertheless, the carbon stock estimated by the different methodologies can be considered similar due to the high uncertainty of the estimated values. Consequently, this uncertainty is propagated to the estimated carbon dioxide emissions of the country.

Given the differences found in the biomass maps available for the Brazilian Amazon and the uncertainties associated with the methods that enabled their estimation, the CCST/INPE sought to invest in technologies that could contribute to the reduction of these uncertainties.

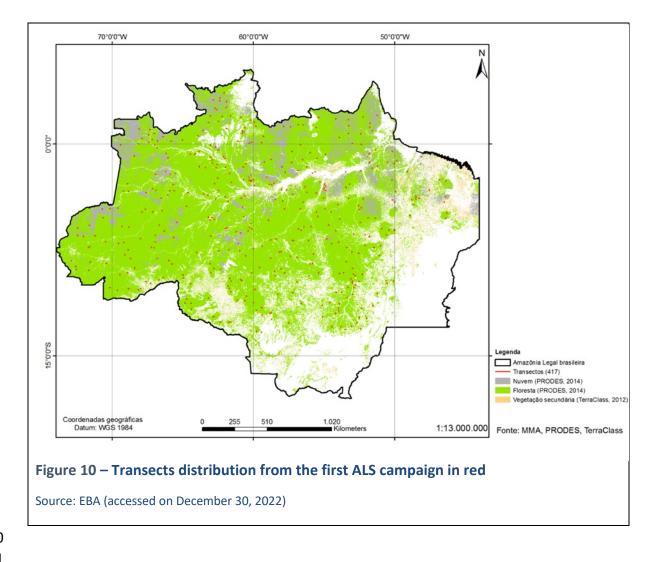
Studies indicate that, in addition to the use of forest inventory data, airborne laser data (ALS, acronym in English) can contribute to the increase of the sampled area and make it possible to extract metrics about the structure and height of the forest canopy (ASNER et al., 2012; ASNER & MASCARO, 2014).

Thus, the CCST/INPE, with the support of the Amazon Fund and resources from the National Development Bank (BNDES for the acronym in Portuguese), implemented a project referred to as "Improvement of biomass estimation methods and models for the estimation of emissions from land use change".

The aero survey covered transects with a width of 300 m and length of 12.5 km (375 ha), with no overlap between the flight ranges. Initially, the transects were randomly selected within forest areas of the Amazon biome, disregarding areas mapped by PRODES (2014), but considering secondary forest areas identified by TerraClass (2012). Some of these transects were directed to cover areas with forest inventory plots.

In the flight campaign, data from 417 transects (*Figure 10*) were collected, covering 156,522 ha".

³ More information is available (in Portuguese) at: <u>http://www.ccst.inpe.br/projetos/eba-estimativa-de-biomassa-na-amazonia/</u>



601

3.5. Pools, gases, and activities included in Brazil's nationalFREL

604

The following table summarizes the carbon pools, greenhouse gases (GHG) and REDD+ activities that have been included in the national FREL. Exclusions and/or omissions and future potential improvements are explained in section 0.

608

609 Table 3 – Pools, gases and activities included in Brazil's national FREL

Biome/information	Amazon	Cerrado	Caatinga	Pantanal	Atlantic forest	Pampa		
	Deforestation							
	(Minimum mapping unit of 1 hectare)							
	Degradation							
	(Minimum mapping	Not included						
REDD+ activities	unit of 3 hectare)							
	Not included in this submission:							
	Conservation of forest carbon stocks							
	Sustainable management of forest							
	Enhancement of carbon stocks							

Biome/information Amazon		Cerrado	Caatinga	Pantanal	Atlantic forest	Pampa			
	Above-ground biomass (AGB)								
Carbon pools	Below-ground biomass (BGB)								
	Litter (LI)								
	Dead wood (DW)								
	CO ₂								
GHG	CH4		Not included						
	N ₂ O	Not included							

611 The **definition of deforestation** adopted by the National Policy on Climate Change refers to the conversion of natural areas to other land-use categories. For the purpose of this 612 613 submission and consistent with previous FRELs submissions, the definition of deforestation is 614 more restrictive. It only includes the conversion of native forest phytophysiognomies into other land use categories (non-forest land). Consequently, different estimates of 615 616 deforestation could be found for each biome if a different definition would be applied (more information can be found in section about "Consistency"). The deforestation activity data 617 618 (deforestation areas) are obtained from the **PRODES Program**⁴. Additional information 619 related to the deforestation activity data used in this submission can be found in section 8.1. 620

For the Amazon and Cerrado biomes, emissions from deforestation are net emissions, i.e., they are the result of the difference between the gross emissions from deforestation and the **removals from the natural regeneration of areas previously deforested (secondary vegetation).** Data to estimate removals were obtained from the **TerraClass Project**⁵ ⁶. Additional information regarding secondary vegetation data can be found in section 8.3 and **Box 4**.

627

628 In Brazil, deforestation in the Amazon and Cerrado is typically followed by biomass burning

629 ("slash and burn" - Figure 11). Therefore, non-CO₂ emissions for Amazon and Cerrado biomes
 630 were considered in the construction of the national FREL.

⁴ More information is available (in Portuguese) at:

http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes (Accessed November 9, 2022)

⁵ More information (in Portuguese) is available at: <u>https://www.terraclass.gov.br/geoportal-aml/</u> (Accessed November 9, 2022)

⁶ More information (in Portuguese) is available at: <u>https://www.terraclass.gov.br/geoportal-aml/</u> (Accessed November 9, 2022)



Figure 11 – "Slash and burn" process typically used in the deforestation of the Amazon and
 Cerrado

- 636 Source: INPE
- 637

638 Presently, there is not a single **definition of forest degradation** applied in the country, nor the identification of all potential drivers of forest degradation (e.g., fire, logging, invasive 639 640 species, etc.). Due to lack of a complete database related to all potential drivers, for the 641 purpose of this submission Brazil assumes forest degradation as the reduction of carbon 642 stocks in forest land remaining forest land in the Amazon biome due to fire on managed 643 forest land and disordered logging⁷. Degradation activity data were available at INPE's **DETER** 644 **Program**⁸. Additional information related to forest degradation data is provided in section 645 8.2.

646

Box 3 – Brazilian main monitoring programs relevant to this submission

The activity data related to deforestation and forest degradation (deforestation and forest degradation areas) used in this submission for all Brazilian biomes derive from the **Amazon and Other Biomes Monitoring Program (PAMZ+**, for the acronym in Portuguese) developed by the Earth Observation and Geoinformatics Division (DIOTG, for the acronym in Portuguese) at the Amazon Space Coordination (COEAM, for the acronym in Portuguese)

⁷ Is worth to recall that in previous submissions Brazil have presented information regarding degradation, including " preliminary thoughts" developed by the GTT-MRV (refer to Annex III of " Brazil's submission of a Forest Reference Emission Level (FREL) for reducing emissions from deforestation in the Amazonia biome for REDD+ results-based payments under the UNFCCC from 2016 to 2020", available at: https://redd.unfccc.int/files/frelc_modifiedversion_correction2019.pdf). The "definition" presented for the purpose of this submissions, have taken into consideration previous information presented, as well as, progress made in INPES' monitoring system (i.e., DETER), in order to implement a pragmatic approach to allow the GHG emissions estimation initially for the Amazon biome. Brazil recognize that further consideration is required, in particular to identify and quantify GHG emissions from other degradation drivers in all Brazilian biomes. ⁸ More information is available (in Portuguese) at:

http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/deter/deter (Accessed November 9, 2022)

at the National Institute for Space Research (INPE). PAMZ+ has three operational systems to monitor land use and land cover and corresponding changes through satellite images with different temporal and spatial resolutions:

- Satellite Monitoring Program of the Brazilian Amazon Forest (PRODES): since 1. 1988, PRODES monitors the advance of deforestation in the Legal Amazon, being considered the most important tropical forest monitoring program in the world. Currently, the program was expanded and systematically monitors the annual loss of primary vegetation in all the Brazilian biomes. PRODES uses Landsat-like images (NASA/USGS), called "Landsat class" images, which ranges in spatial resolution from 20-30 meters and have at least three available spectral bands (green, red, and infrared) within the electromagnetic spectrum. PRODES currently uses images from Landsat-8, SENTINEL-2 (European Union), and CBERS-4/4A (INPE/CRESDA, Brazil/China). In forestlands, PRODES identifies polygons of deforestation caused by clear-cut and due to forest progressive degradation. In other phytophysiognomies, such as grasslands and savanna-like biomes, PRODES identify only polygons of complete removal of natural vegetation. Specialists map these polygons through visual photointerpretation using the TerraAmazon software. PRODES is an incremental system and identifies deforestation polygons which area is greater than 1 ha. To improve PAMZ+ data dissemination, INPE has developed an online portal (TerraBrasilis - http://terrabrasilis.dpi.inpe.br) that aggregates PRODES and DETER data.
- 2. Near Real-Time Deforestation Detection System (DETER): DETER, launched in 2004, is an surveillance support system that quickly maps deforested and degraded areas within forest formations in the Brazilian Legal Amazonia. Since 2015, DETER uses images from the WFI sensor onboarding CBERS-4, CBERS-4A/INPE, and Amazônia-1/INPE satellites (56-64 meters of spatial resolution). Photointerpreters map deforestation and forest degradation using color composites satellite images in addition to soil and shadow fraction images generated through Linear Spectral Mixture Models (LSMM), which highlight, respectively, image features related to selective logging and burning scars. Forest cover patterns identification in images are based on five main elements: tonality, color, form, texture, and context. Alerts from DETER are divided into two groups: the first refers to deforestation classified as either: (a) deforestation with exposed soil; (b) deforestation with vegetation; and (c) mining (Figure 4.2); the second group embraces degradation alerts classified as either: (a) degradation; (b) selective geometric logging; (c) selective logging; and(d) forest fire scar. DETER identifies polygons which area is greater than 3 ha.
- 3.

Land Use and Occupation Mapping System Project (TerraClass): Terraclass project was launched in 2010, firstly in the Legal Brazilian Amazon and since 2020 in the Cerrado biome, with the aim of qualifying deforestation identified by PRODES project. Through visual interpretation of color composites and application of remote sensing techniques (such as Linear Spectral Mixture Models, segmentation, cloud detection and threshold slicing) to Landsat satellite images (30 m of spatial resolution), Terraclass classifies areas identified as deforestation into the following thematic classes: primary forest, secondary forest, silviculture, cultivated pasture on shrubland, cultivated pasture on herbaceous land, perennial agricultural crop, semi-perennial agricultural crop, temporary agricultural crop, mining, urban areas, 'others', not observed area, current year deforestation, non-forest vegetation, and hydrography within the Brazilian Legal Amazon. In the Cerrado, deforestation is qualified as primary forest, secondary forest, silviculture, cultivated pasture, perennial agricultural crop, semi-perennial agricultural crop, one cycle temporary agricultural crop, mining, urban areas, other edified areas, others, not observed, annual deforestation, and hydrography. Terraclass has as minimum mapping area of 4 ha for both Amazon and Cerrado. The project aims to generate land use and land cover data every two years. Currently, TerraClass data are available for 2004, 2008, 2010, 2012, and 2014 for the Brazilian Legal Amazon and 2018 for the Cerrado Biome.

The systems are complementary and are designed to meet different objectives.

648	3.5.1. Descriptions of changes to previously submitted
649	forest reference emission levels and/or forest reference
650	
651	Paragraphs 11 and 10 of decision 12/CP.17, respectively, point out that a subnational FREL
652	may be developed as an interim measure during the transition to a national FREL; and that a
653	stepwise approach to a national FREL may be appropriate, allowing the Parties to improve
654	submissions over time by incorporating more up-to-date data, refining methodologies and,
655	where appropriate, including additional pools and activities.
656	
657	The main changes included in this submission and that are detailed in the sections to follow
658	are:
659	
660	1. Inclusion of all 6 Brazilian biomes;
661	2. Inclusion of forest degradation in the Amazon biome;
662	3. Estimation of net emissions from deforestation in the Amazon and Cerrado biomes;
663	4. Change in the biome's geographical boundaries using the most recent official data
664	(IBGE, 2019);
665	5. Use of a minimum mapping area (MMU) of 1 hectare for the identification of
666	deforestation polygons in all Brazilian biomes;
667	6. Reference period calculated using 5 years; and
668	7. Inclusion of uncertainties analysis.
669	
670	The status of the "areas for future improvements" identified in the reports of the technical
671	assessment carried out in previous Brazilian submissions are explained in section 8.9.
672	
673	

674 3.5.2. Potential future improvements

675

676 In previous FREL submissions Brazil have presented subnational FRELs for the Amazon and 677 Cerrado biomes⁹. In this submission Brazil have incorporated more up-to-date data and 678 refined methodologies to submit a national FREL, that cover 100% of its national territory. 679 The FREL has been developed based on the average net GHG emission estimates for Amazon 680 and Cerrado biomes and the average gross GHG emissions for the remaining four Brazilian 681 biomes considering the five annual periods (from 2016-2017 to 2020-2021).

682

Nevertheless, is important to clarify that due to its large territorial extension and forest
 diversity within the different biomes, it was not possible yet to include in this submission all
 REDD+ activities, and to estimate emissions and removals for all GHGs and all carbon pools
 for all biomes.

687

688 In this submission, Brazil has included uncertainty estimates for all data input and all emissions and removals results. However, it was not possible to use country specific 689 uncertainty values for many of the emission and removal factors and other parameters. For 690 691 these, uncertainty values derived from the 2006 IPCC Guidelines default values have been 692 used. Plans for future submissions include the development of country specific uncertainty 693 estimates for carbon content for all carbon pools in all biomes and phytophysiognomies, as 694 already done for the Amazon biome, and country specific uncertainty estimates for the 695 parameters used in the natural regeneration and degradation calculations (e.g. biomass 696 growth yearly rate, combustion factor).

697

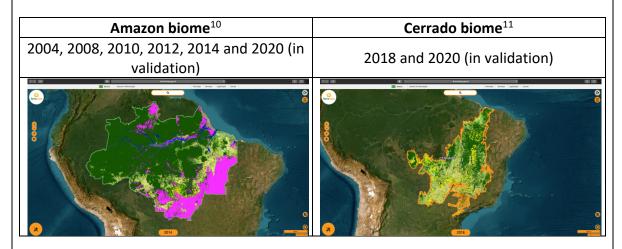
In the following boxes a justification for the non-inclusion of the soil carbon pool in the construction of the national FREL (**Box 8**) is provided, as well as an explanation of the challenges faced to estimate emissions from forest degradation from fire in managed land in the Cerrado biome (**Box 5**); from fire in forest managed land in other biomes (**Box 6**); degradation from regular selective logging (**Box 7**); and removals from natural regeneration (**Box 4**) for all biomes except Amazonia and Cerrado.

⁹ Available at: <u>https://redd.unfccc.int/submissions.html?country=bra</u>

Box 4 – Removals

Carbon removals from the annual increase in biomass from natural regeneration of areas previously deforested (**secondary vegetation growth**), have been estimated for the Amazon and Cerrado biomes, using data from **TerraClass Project**.

TerraClass Project was initiated in 2010 in the Amazon biome with the aim to "qualify" the deforestation in the Amazon region; and to offer subsidies for the development of governmental actions related to the development of sustainable agricultural production, preservation of national biodiversity and maintenance of environmental services quality. In 2015, the Project was expanded to include the Cerrado biome. Nowadays, maps with the identification of secondary vegetation are available in TerraClass only for specific years, as indicated below:



Source: TerraClass

The fact that TerraClass does not provide a complete time-series for both Amazon and Cerrado biomes did not allow the estimation of removals for each single year of the reference level period. Hence, in the construction of the national FREL, a linear annual growth was assumed for all years of the reference period, based on the average carbon removals (tonne of C per hectare per year) in those areas of secondary vegetation identified for each biome, as presented in the 4th National GHG Inventory (additional information in section "Estimation of Brazil's national FREL").

Pending on additional resources for TerraClass Project, Brazil plans to estimate specific annual removals from secondary vegetation for each single year in future submissions.

706 707

¹⁰ More information (in Portuguese) is available at: <u>https://www.terraclass.gov.br/geoportal-aml/</u> (Accessed November 9, 2022)

¹¹ More information (in Portuguese) is available at: <u>https://www.terraclass.gov.br/geoportal-aml/</u> (Accessed November 9, 2022)

Box 5 – Degradation due to fire in managed forest land in the Cerrado

INPE's "Queimadas" Program¹² uses images of low (1km) from MODIS program to monitor "fire spots" in the entire country. For each "fire spot" identified, a 1km² buffer area is created to provide an approximate estimate of the "total burned area". This estimate does not correspond to the "burned area scar" since not necessarily all the vegetation included in the buffer zone might have been affected by the fire.

Presently, on an experimental basis, the "Queimadas Program" is using 30m spatial resolution data to monitor both "fire spots" and "burned area scars" in the Cerrado biome based on data from Thematic Mapper (TM) and Operational Land Imager (OLI) onboard satellites LANDSAT 5 and LANDSAT 8, assuming a maximum of 10% cloud cover. The "burned area scars" have been identified using a semi-automatic algorithm and the multi-temporal change between images (Melchiori, 2014). The results of the local evaluation depend not only on the classifier algorithm, but also on the data used as a reference. Therefore, it is essential that reference data are reliable and cover the same study period. There is no guarantee that this experimental initiative using medium spatial resolution will have continuity. Besides that, only results for years 2018 and 2019 are available.

As an example of the experimental initiative just mentioned, this box provides estimates of GHG emissions using "burned area scars" generated by INPE's Queimada Monitoring Group.

Period	Emissions from forest degradation due to fire in managed forest land in the Cerrado biome (tonnes CO ₂ eq)					
2017-2018	29,718,968					
20182019	60,925,571					

Source: own elaboration

For the Amazon biome, the "burned area scars" derive from visual interpretation of DETER data that allows then to estimate emissions from forest degradation due to fire. Unfortunately, the DETER system has not been developed for the Cerrado biome preventing the same approach used for Amazonia to extend to the Cerrado.

The situation regarding the identification of forest degradation by fires is then the following: (1) "burned area scars", instrumental to estimate GHG emissions from fire, is not available through the national coverage 1km x 1km spatial resolution data provided by MODIS; and (2) "burned area scars" available through the ongoing experimental initiative

¹² More information (in Portuguese) is available at: <u>https://queimadas.dgi.inpe.br/queimadas/aq1km/</u> (Accessed November 9, 2022)

at INPE might not have continuity in the short/medium term. Considering these and the possibility that "burned area scars" data might not be available for future results, impacting the consistency between the national FREL and the results in the BUR Technical Annex, it was decided not to include GHG emissions from forest degradation due to fire in managed forest land occurring in the Cerrado biome.

Pending on additional resources for INPE's "Queimadas" Program, Brazil plans to include these emissions in future submissions.

Box 6 – Degradation due to fire in managed forest land in other biomes (and non-CO₂ emissions)

According the INPE's "Queimadas" Program data the burned areas in each biome and each year of the reference period are provided in the table below. The table also includes the relative contribution (%) of each biome to the total annual area burned.

Year / Biome burned area (km²)	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal	Total (annual)
2016	65,139 (23%)	33,309 (12%)	151,142 (54%)	18,608 (7%)	1,527 (1%)	11,245 (4%)	280,970
2017	91,240 (30%)	29,704 (10%)	158,352 (52%)	16,260 (5%)	1,608 (1%)	9,829 (3%)	306,993
2018	43,171 (25%)	25,432 (15%)	85,374 (50%)	13,295 (8%)	615 (0%)	3,094 (3%)	170,981
2019	72,450 (23%)	55,184 (17%)	148,211 (47%)	19,405 (6%)	1,396 (0%)	20,833 (7%)	317,479
2020	77,396 (25%)	30,453 (10%)	139,644 (45%)	17,928 (6%)	6,113 (2%)	40,606 (13%)	312,140
2021	45,585 (17%)	49,869 (18%)	137,631 (50%)	20,876 (8%)	1,228 (0%)	19,219 (7%)	274,408

Source: https://queimadas.dgi.inpe.br/queimadas/aq1km/

The absolute values of the burned areas were obtained using 1km x 1km spatial resolution data but, as mentioned before, they do not necessarily represent the "burned area scars". From the table it is clear that the biome most affected by fires in the Cerrado biome (annual average of 49.5%), followed by the Amazonia biome (annual average of 24%); for the Caatinga biome, the annual average is 13.6%, whereas for Atlantic Forest, Pampa and Pantanal biomes, the annual averages are 6.7%, 0.5% and 6%, respectively. Amazonia and the Cerrado biomes comprise, on average, almost 75% of the area burned in the reference period.

Besides the areas burned in Atlantic Forest, Pampa and Pantanal being much smaller than those in Amazonia and Cerrado, for these biomes and for the Caatinga, the total carbon stock is also comparatively smaller and the potential impact on the GHG emissions is not expected to be large. This is one of the justifications of why forest degradation due to fire is not included in the estimates of the average annual emissions in these biomes.

A graphical representation of the data in the table is presented in the figure below.

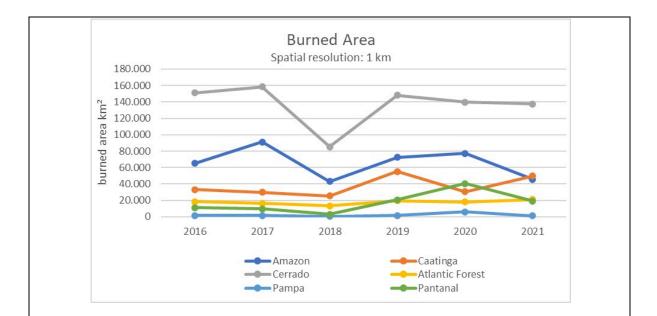


Figure 12 – Burned area per biome

Source: "Queimadas" Program

In addition, is worth to mentioning that not all fires occur in forest managed land and not all fires generate "burned area scars", as already indicated. The following figures provide examples of forest fires in dense forest areas.



Figure 13 – Examples of forest fires in dense forest areas

Source: INPE

From the above figures, it can be seen that fires affect mainly the lower portions of the canopy but depending on its intensity, it may also propagate to higher levels. When the

higher levels of the canopy are not reached, the area affected by the fire will hardly leave a scar that can be identifiable in orbital images.

Therefore, this submission does not include GHG emissions from degradation due to fire in managed forest land expect for the Amazon biome.

Pending on additional resources for the INPE's "Queimadas" Program, Brazil plans to include these emissions in future submissions (if demonstrated to be significant).

Box 7 – Decrease in carbon stocks due to orderly logging

DETER System maps changes in forest cover due to timber extraction considering "disordered selective cutting" (Type 1) and "orderly selective cutting" (Type 2).

In the estimates of emissions from forest degradation, the changes in carbon stocks decrease from "orderly selective cutting" (regular logging) were not included in the construction of this FREL, since the orderly pattern it is associated with activities under sustainable management plans.

The **National System of Forest Products Origin Control (SINAFLOR**, for the acronym in Portuguese)¹³ is in the process of including in its database all approved sustainable management plans (including their geographic coordinates). In the absence of this information, it was not possible to identify among which of the "orderly selective cutting" areas were associated with approved sustainable management activities or not. In this submission it was assumed that all "orderly selective cutting" were associated with approved sustainable management plans, and hence not considered as forest degradation. Brazil plans to revise such classification, in future submissions, once the SINAFLOR database is updated.

Nevertheless, decreases in carbon stocks in areas associated with "orderly selective cutting" (regular logging) were considered in cases where these areas were subject subsequently to other activities (forest fires or deforestation).

It is worth noting that the shapefiles, used in this submission (see "Activity data vectorial files (shapefiles") contain data on changes in forest cover due to "orderly selective cutting" (regular logging); but only the data related to "disordered selective cutting" (irregular logging) have been used to estimate forest degradation emissions, due to the rationale explained above.

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¹³ More information is available (in Portuguese) at: <u>http://www.ibama.gov.br/sinaflor</u> (Accessed on November 9, 2022)

Box 8 – Soil carbon

Soil Organic Carbon (SOC) was not included in the construction of the national FREL based on the following rationale:

- (1) Normally, the largest changes in SOC result from the conversion of forest land to other land-use categories (e.g., Cropland, Grassland). In this submission, the identification of the land-use category post deforestation was not made, and hence there would be high uncertainties associated with the SOC changes estimates.
- (2) The 4th National Inventory indicates that SOC contributed only with 2.5% to the total net emissions in the LULUCF sector during the period 2010-2016 (Brazil, 2020). The reference report of the 4th Inventory provides details about the methodology used to estimate SOC emissions, following the IPCC 2006 Guidelines and presents for each type of land use/land cover conversion the change factors used.

Considering the low contribution of SOC to the total LULUCF emissions and considering that this submission is national, it was decided that SOC would not have a significant contribution to the national FREL and hence was not considered.

719 3.6. Amazon biome

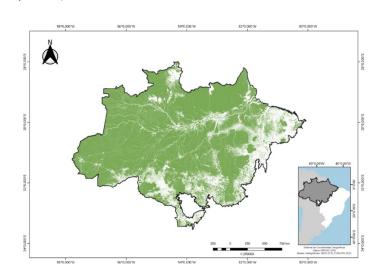
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721 3.6.1. Activity data

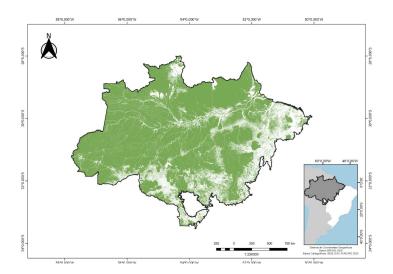
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As explained in section "Pools, gases, and activities included in Brazil's national FREL", the activity data used for the Amazon biome (deforestation areas, degradation areas – fire and selective logging and natural regeneration areas) were obtained from PRODES, DETER and TerraClass, respectively. The following figures present the distribution of the native forest in the Amazon biome in 2016 (first year of the reference level period) and 2021 (final year of the reference level period).

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- 730 731
- 732 Figure 14 Native forest (in green) distribution in the Amazon biome in 2016
- 733 Source: PRODES
- 734



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737 Figure 15 – Native forest (in green) distribution in the Amazon biome in 2021

738 Source: PRODES

Emission factors 3.6.2. 740

741

Thirty-six (36) forest phytophysiognomies are present in the vegetation map of the Amazon 742 743 biome, the most abundant ones being Submontane Dense Ombrophilous Forest (Ds) and 744 Lowland Dense Ombrophilous Forest (Db). Table 4 presents the average, minimum and 745 maximum values of carbon stocks for each carbon pool considered per forest phytophysiognomies. For each type of forest phytophysiognomies, the total stock 746 747 corresponds to the sum of the individual carbon stocks for the four carbon pools included: above ground biomass (AGB), below ground biomass (BGB), dead wood (DW) and litter (LI). 748

743		
750	Table	4

750	Table 4 – Forest phytophysiognomies considered in the Amazon biome and respective
751	carbon stocks per carbon pool (average and ranges - in tC/ha)

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
• -	Alluvial Open	90.45	9.93	7.37	5.16	112.91
Aa	Ombrophilous Forest	(0 - 142.65)	(0 - 113.98)	(0 - 13.34)	(0 - 16.31)	(0 - 205.91)
	Alluvial Lowland	97.61	10.05	7.92	5.62	121.20
Ab	Ombrophilous Forest	(0 - 143.82)	(0 - 194.66)	(0 - 13.52)	(0 - 19.85)	(0 - 286.24)
	Montane Open	99.51	30.85	9.35	3.99	143.70
Am	Ombrophilous Forest	(63.34 - 139.27)	(19.64 - 43.17)	(5.95 - 13.09)	(2.54 - 5.59)	(118.55 - 201.12)
As	Sub-montane Open	74.78	8.97	6.12	4.26	94.13
AS	Ombrophilous Forest	(0 - 161.38)	(0 - 434.74)	(0 - 14.17)	(0 - 19.89)	(0- 594.72)
	Lowland Decidual	37.28	77.24	2.11	2.44	119.07
Cb	Seasonal Forest	(4.8 - 75.2)	(4.77 - 251.17)	(0.19 - 4.1)	(0.34 - 5.25)	(23.87 - 290.83)
	Sub-montane Decidual	67.15	7.94	5.44	3.94	84.47
Cs	Seasonal Forest	(1.84 - 139.27)	(0.18 - 164.75)	(0.08 - 13.09)	(0.11 - 16.31)	(2.85 - 261.23)
Da	Alluvial Dense Ombrophilous Forest	75.64	22.40	7.01	3.20	108.25
Da		(0 - 150.03)	(0 - 257.45)	(0 - 14.1)	(0 - 48.23)	(0 - 372.97)
Db	Lowland Dense	92.41	28.69	8.67	3.74	133.51
DD	Ombrophilous Forest	(0 - 190.35)	(0 - 251.55)	(0 - 17.89)	(0 - 56.9)	(0 - 422.15)
Dm	Montane Dense	80.60	25.34	7.56	3.28	116.78
DIII	Ombrophilous Forest	(0 - 125.02)	(0 - 156.81)	(0 - 11.75)	(0 - 10.17)	(0 - 271.85)
Ds	Sub-montane Dense	86.24	26.20	8.07	3.52	124.03
DS	Ombrophilous Forest	(0 - 199.12)	(0 - 461.28)	(0 - 18.72)	(0 - 29.25)	(0 - 604.11)
Fa	Alluvial Semi-deciduous	44.77	7.41	3.68	2.49	58.35
га	Seasonal Forest	(0 - 121.91)	(0 - 242.02)	(0 - 13.41)	(0 - 10.5)	(0 - 324.98)
	Lowland Semi-deciduous	53.33	7.20	4.29	3.08	67.90
Fb	Seasonal Forest	(1.88 - 104.82)	(0.19 - 247.71)	(0.1 - 8.54)	(0.11 - 9.21)	(2.33 - 330.23)
	Montane Semi-deciduous	101.21	10.12	8.20	5.84	125.37
Fm	Seasonal Forest	(92.83 - 106.69)	(9.28 - 10.67)	(7.52 - 8.64)	(5.36 - 6.16)	(114.99 - 132.16)
Fs		55.96	6.56	4.48	3.24	70.24

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
	Sub-montane Semi- deciduous Seasonal Forest	(0 - 139.27)	(0 - 245.67)	(0 - 13.09)	(0 - 16.31)	(0 - 324.98)
		28.08	23.76	1.59	6.74	60.17
L	Campinarana	(4.7 0 103.02)	(1.46 - 171.02)	(0 - 4.68)	(0.19 - 55.93)	96.79 - 328.91)
	Wooded Campinarana	74.37	96.50	7.70	5.75	184.32
La	wooded Campinarana	(0 - 162.15)	(0 - 204.73)	(0 - 15.24)	(0 - 41.72)	(0 - 337.23)
	Forested Compinence	74.69	10.07	6.09	4.48	95.33
Ld	Forested Campinarana	(0 - 139.27)	(0 - 118.17)	(0 - 13.09)	(0 - 39-89)	(0 - 266.28)
LO	Contact Campinarana /	95.66	17.31	8.11	5.19	126.27
LO	Ombrophilous Forest	(0 - 139.27)	(0 - 169.11)	(0 - 13.09)	(0 - 8.65)	(0 - 270.91)
	Contact Ombrophilous	47.9	5.47	3.93	2.89	60.19
ON	Forest / Seasonal Forest	(1.18 - 139.27)	(0.12 - 113.98)	(0.1 - 13.09)	(0.07 - 16.31)	(1.16 - 201.12)
	Contact Ombrophilous	68.71	15.41	5.73	7.68	97.53
ONs	Forest / Seasonal Forest	(13 - 73.3)	(1.3 - 17.45)	(1.05 - 6.13)	(0.75 - 8.63)	(13.2 - 105.51)
ONts	Contact Ombrophilous Forest / Seasonal Forest	27.02	2.7	2.19	1.56	33.47
		118.82	36.94	11.2	4.76	171.72
Р	Pioneer Formation	(62.08 - 128.28)	19.94 - 39.77)	(6.02 - 12.06)	(2.45 - 5.15)	(19.24 - 185.26)
D(Pioneer Formation with	30.74	9.91	3.14	0.59	44.38
Pf	fluvial and/or lacustrine influence	(0 - 133.92)	(0 - 39.77)	(0 - 12.06)	(0 - 7.73)	(0 - 185.26)
		42.6	49.64	1.83	2.38	96.45
S	Savanna	(8.17 - 90.87)	(0.82 - 115.06)	(0.08 - 8.54)	(0.47 - 4.35)	(7.79 - 174.68)
Sa	Wooded Savanna	49.44	74.31	1.43	3.06	128.24
34		(0 - 139.27)	(0 -273.26)	(0 - 14.01)	(0 - 20.69)	(0 - 416.33)
Sd	Forested Savanna	64.55	15.6	6.85	9.67	96.67
Su	Forested Savarina	(0 - 158.6)	(0 - 270.38)	(0 - 17.45)	(0 - 25.77)	(0 - 446.46)
SN	Contact Savanna /	45.55	8.7	3.61	2.81	60.67
311	Seasonal Forest	(0 - 106.55)	(0 - 162.65)	(0 - 11.05)	(0 - 16.31)	(0 - 238.09)
SNm	Contact Savanna / Seasonal Forest	40.54	19.74	4.64	7.1	72.02
	Contact Savanna /	63.61	17.3	5.62	7.89	94.42
SNs	Seasonal Forest	(8.32 - 73.3)	(0.83 - 21.55)	(0.67 - 6.13)	(0.48 - 8.63)	(14.25 - 105.51)
	Contact Savanna /	50.95	12.79	4.53	5.78	74.05
SNts	Seasonal Forest	(2.95 - 71.97)	(0.3 - 2011)	(0.24 - 6.07)	(0.17 - 8.57)	(0.01 - 104.15)
	Contact Savanna /	60.25	16.55	5.62	3.32	85.74
SO	Ombrophilous Forest	(0.94 - 139.27)	(0.21 - 130.29)	(0.09 - 13.09)	(0.06 - 16.31)	(1.36 - 201.12)
	Contact Savanna /	55.52	22.11	6.15	8.63	92.41
SOs	Ombrophilous Forest	(41.49 - 97.59)	(21.52 - 23.89)	(4.76 - 10.31)	(732 - 12.57)	(75.09 - 142.78)
	Contact Savanna /	13.71	45.79	0.54	0.96	61
SP	Pioneer Formation – Specific for Pioneer	(10.81 - 16.01)	(36.11 - 53.48)	(0.42 - 0.63)	(0.76 - 1.12)	(48.1 - 71.24)

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
	Formation com Marine Influence (<i>Restinga</i>)					
ST	Contact Savanna /	39.38	67.64	2.39	2.52	111.93
	Savanna Steppes	(2.82 - 75.2)	(4.16 - 251.17)	(0.11 - 5.82)	(0.2 - 5.25)	(14.64 - 290.83)
	Forested Savanna Steppes	31.62	50.88	3.45	3.35	89.3
Td		(8.74 - 94.26)	(1.06 - 156.48)	(0.86 - 10.37)	(0.61 - 10.15)	(13.78 - A74.56)
	Contact Savanna Steppes / Seasonal Forest	39.88	14.82	3.15	2.4	60.25
TN		(27.4 - 65.98)	(4.77 - 25.36)	(2.02 - 5.34)	(1.75 - 3.81)	(59.07 - 78.32)

753 OBS: AGB – above ground biomass / BGB – below ground biomass / DW – dead wood / LI – litter

754

755 Source: EBA raster

OBS: Is worth to note that the values presented in table 23 of the 4th National GHG Inventory
 (Brazil, 2020) differ from the values presented in this table, even if both the inventory and the
 FREL use EBA values. The values in this table were extracted directly from the EBA raster file
 considering each deforestation polygons and hence, they are values that represent "activity
 data level". In the 4th National GHG Inventory, table 23 values represent the "biome level".
 Other emission factors and parameter used to estimate GHG emissions and removals in the

762 Other emission factors and parameter used to estimate GHG emissions and removals763 Amazon biome are presented in the following table.

764

765 Table 5 – Other emission factors and parameters used in the Amazon biome

Emission factor	Value	Unit	Source
Combustion factor (C _f)	0.368	Dimensionless	Table 49 (Brazil, 2020) – value for the Amazon biome
Emission factor (G _{ef}) CH ₄	6.8	g/kg dry matter (d.m.)	Table 2.5 (IPCC, 2006) – values for
Emission factor (G _{ef}) N ₂ O	0.2	g/kg dry matter (d.m.)	Tropical Forest
Carbon content	0.47	tonne C/tonne d.m.	IPCC, 2006
AGB "loss factor" CS1	- 29	%	
AGB "loss factor" CS2	- 27	%	
AGB "loss factor" CS3	- 26	%	Table 30 (Brazil, 2020)
AGB "loss factor" CS4	- 22	%	
Removal factor	3.03	tonne C/ha year	Table 29 (Brazil, 2020) – annual removal factor per unit area for secondary forest in pasture land

766 767

767 OBS: CS – disordered logging 768

770 3.7. Cerrado biome

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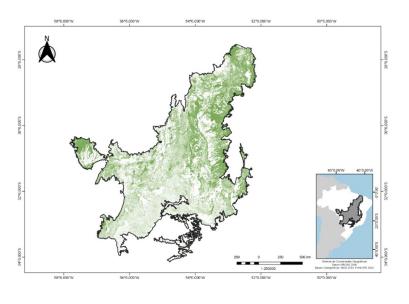
772 3.7.1. Activity data

773

As explained in section "Pools, gases, and activities included in Brazil's national FREL", activity
data (deforestation areas) for the Cerrado biome were obtained from PRODES. The following
figures present the native forest distribution in the Cerrado biome in 2016 (first year of the

reference level period) and 2021 (final year of the reference level period).

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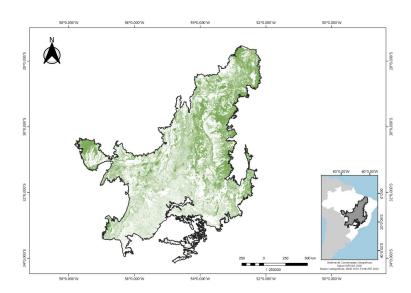


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781 Figure 16 – Native forest (in green) distribution in the Cerrado biome in 2016

782 Source: PRODES



784 785

786 Figure 17 – Native forest (in green) distribution in the Cerrado biome in 2021

787 Source: PRODES

789 3.7.2. Emission factors

790

Thirty-three (33) forest phytophysiognomies are present in the vegetation map of the Cerrado biome, the most abundant one being the Wooded Savanna (Sa). **Table 6** presents the forest phytophysiognomies considered in the Cerrado biome, for the construction of the FREL, and the respective carbon stocks for each carbon pool. For each type of forest phytophysiognomies, the total stock corresponds to the sum of the individual stocks of the four carbon pools included: above ground biomass (AGB), below ground biomass (BGB), dead wood (DW) and litter (LI).

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Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL (
Aa	Alluvial Open Ombrophilous Forest	117.29	11.73	9.5	6.77	145.3
Ab	Alluvial Lowland Ombrophilous Forest	133.9	13.39	10.85	7.73	165.89
As	Sub-montane Open Ombrophilous Forest	71.1	7.11	5.76	4.11	88.08
Ca	Lowland Decidual Seasonal Forest	88.36	21.27	9.75	2.08	121.46
Cb	Lowland Decidual Seasonal Forest	69.38	16.65	7.63	11.21	104.87
Cm	Montana Dacidual Cascanal Farast	31.1	11.5	4.67	4.67	51.94
Cm	Montane Decidual Seasonal Forest	84.38	20.25	9.28	13.63	127.54
6	Sub montone Desidual Second Forest	41.4	15.3	6.21	6.1	69.01
Cs	Sub-montane Decidual Seasonal Forest	84.38	20.25	9.28	13.63	127.54
Da	Alluvial Dense Ombrophilous Forest	90.51	28.06	8.51	3.63	130.71
Db	Lowland Dense Ombrophilous Forest	85.73	45.38	2.98	4.11	138.2
Ds	Sub-montane Dense Ombrophilous Forest	81.99	25.42	7.71	3.29	118.41
	Alluvial Semi-deciduous Seasonal Forest	52.99	5.3	4.29	3.06	65.64
_		56.89	11.38	6.26	1.34	75.86
Fa		58.05	13.66	2.98	5.24	79.93
		121.92	29.26	13.41	2.87	167.46
	Lowland Semi-deciduous Seasonal Forest	65.98	6.6	5.34	3.81	81.73
Fb		63.07	14.84	2.98	3.03	83.92
		63.07	33.4	2.98	3.03	102.48
F	Mantana Carri da iduara Casa a l Farrat	50.48	26.73	2.98	2.42	82.61
Fm	Montane Semi-deciduous Seasonal Forest	50.48	11.88	2.98	2.42	67.76
_		39.96	7.99	4.4	2.58	54.93
Fs	Sub-montane Semi-deciduous Seasonal Forest	62.23	14.64	2.98	3.63	83.48
Ma	Mixed Alluvial Ombrophilous Forest	64.25	15.12	2.98	3.08	85.43
MI	High-montane Mixed Ombrophilous Forest	78.82	18.54	2.98	3.78	104.12
Mm	Montane Mixed Ombrophilous Forest	60.11	14.15	2.98	2.88	80.12
ON	Contact Ombrophilous Forest / Seasonal Forest	72.88	15.48	6.06	7.77	102.18

799 Table 6 – Forest phytophysiognomies considered in the Cerrado biome and respective 800 carbon stocks (tC/ha)

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
Р	Pioneer Formation	24.64	9.12	2.71	4	36.51
Pf	Pioneer Formation with fluvial and/or lacustrine influence	25.82	9.55	2.84	0.04	38.26
Pm	Pioneer Formation with Marine Influence (restinga)	23.46	8.68	2.58	0.04	34.76
S	Savanna	26.69	16.94	3.12	4.88	51.63
Sa	Wooded Savanna	12.03	24.54	1.68	3.06	41.31
		46.14	10.15	5.08	7.45	68.82
6.1	Forested Savanna	35.06	7.71	3.86	5.66	52.29
Sd		69.2	15.22	7.61	11.17	103.21
		33.29	7.32	3.66	5.38	49.64
SM	Contact Savanna / Ombrophilous Mixed Forest	44.16	16.07	3.21	4.15	67.57
SN	Contact Savanna / Seasonal Forest	43.49	15.42	4.26	5.33	68.5
SO	Contact Savanna / Ombrophilous Forest	39.01	17.61	4.12	5.59	66.33
ST	Contact Savanna / Savanna Steppes	18.64	13.26	3.21	4.34	36.11
STN	Contact Savanna / Savanna Steppes/ Seasonal Forest	25.27	15.5	3.2	4.44	47.57
Т	Savanna Steppes	17.8	7.7	2.97	2.33	30.8
Та	Wooded Savanna Steppes	9.6	5.8	1.25	1.25	17.9
Td	Forested Savanna Steppes	26	9.6	4.68	3.05	43.33
TN	Contact Savanna Steppes / Seasonal Forest	30.03	10.28	4.46	4.15	45.83

OBS: AGB – above ground biomass / BGB – below ground biomass / DW – dead wood / LI – litter

804 Source: Table 24 (Brazil, 2020)

806 Other emission factors and parameter used to estimate GHG emissions and removals in the807 Cerrado biome are presented in the following table.

809 Table 7 – Other emission factors and parameters used in the Cerrado biome

Emission factor	Value	Unit	Source
Combustion factor (C _f)	0.379	dimensionless	Table 49 (Brazil, 2020) – value for the Amazon biome
Emission factor (G _{ef}) CH ₄	6.8	g/kg dry matter (d.m.)	Table 2.5 (IPCC, 2006) – values for
Emission factor (G _{ef}) N ₂ O	0.2	g/kg dry matter (d.m.)	Tropical Forest
Carbon content	0.47	Tone C/tone d.m.	IPCC, 2006
Removal factor	2.85	tonne C/ha year	Table 29 (Brazil, 2020) – annual removal factor per unit area for secondary forest in pasture land

812 3.8. Caatinga biome

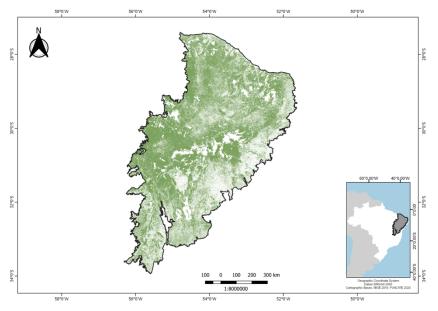
813

814 3.8.1. Activity data

815

As explained in section "Pools, gases, and activities included in Brazil's national FREL", activity
data for the Caatinga biome were obtained from PRODES. The following figures present the
native forest distribution in the Caatinga biome in 2016 (first year of the reference level

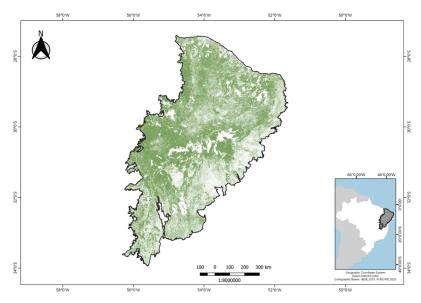
- 819 period) and 2021 (final year of the reference level period).
- 820



822 Figure 18 – Native forest (in green) distribution in the Caatinga biome in 2016

- 823 Source: PRODES
- 824

821



825

826 Figure 19 – Native forest (in green) distribution in the Caatinga biome in 2021

827 Source: PRODES

828 3.8.2. Emission factors

829

Twenty-four (24) forest phytophysiognomies are present in the vegetation map of the Caatinga biome, the most abundant one being Wooded Savanna Steppes (Sa). **Table 8** present the forest phytophysiognomies considered in the Caatinga biome, for the construction of the FREL, and the respective carbon stocks for each carbon pool. For each type of forest phytophysiognomies, the total stock corresponds to the sum of the individual stocks of the four carbon pools included: above ground biomass (AGB), below ground biomass (BGB), dead wood (DW) and litter (LI).

837

838	Table 8 – Forest phytophysiognomies considered in the Caatinga biome and respective
839	carbon stocks

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
Aa	Alluvial Open Ombrophilous Forest	44.7	8.08	3.78	0.77	57.33
Ab	Lowland Open Ombrophilous Forest	44.7	8.08	3.78	0.77	57.33
Am	Montane Open Ombrophilous Forest	44.7	8.08	3.78	0.77	57.33
As	Sub-montane Open Ombrophilous Forest	76.4	28.3	11.46	11.21	127.3
Ca	Seasonal Forest Decidual Alluvial	88.6	21.3	9.75	2.08	121.72
Cb	Lowland Decidual Seasonal Forest	55.3	8.5	4.68	6.86	75.30
Cm	Montane Decidual Seasonal Forest	31.1	11.5	4.66	4.57	51.84
Cs	Sub-montane Decidual Seasonal Forest	41.4	15.3	6.21	6.08	69.05
Da	Alluvial Dense Ombrophilous Forest	149	22.5	10.90	3.43	185.70
Dm	Montane Dense Ombrophilous Forest	149	22.5	10.90	3.43	185.70
Ds	Sub-montane Dense Ombrophilous Forest	149	22.5	10.90	3.43	185.70
Fa	Alluvial Semi-deciduous Seasonal Forest	74	11.4	6.26	1.34	92.94
Fb	Lowland Semi-deciduous Seasonal Forest	80.4	14.8	6.80	3.99	106.01
Fm	Montane Semi-deciduous Seasonal Forest	59.3	22	8.90	8.71	98.89
Fs	Sub-montane Semi-deciduous Seasonal Forest	82.7	30.6	12.41	12.15	137.89
Pf	Pioneer Formation of Fluviomarine Influence (Mangroves)	123	37.8	9.53	0.18	170.54
Pm	Pioneer Formation with Marine Influence (Restinga)	102	21.9	22.18	1.41	147.09
Sa	Wooded Savanna	12	24.5	1.68	3.06	41.31
Sd	Forested Savanna	39.5	14.6	5.92	5.79	65.79
SN	Contact Savanna / Forest	44.7	14.7	5.32	4.89	69.66
ST	Contact Savanna / Pioneer Formation - Specific for Pioneer Formation com Marine Influence (<i>Restinga</i>)	13.5	9.24	1.82	1.88	26.47
Та	Wooded Savanna Steppes (Open caatinga)	9.59	5.85	1.25	1.6	18.28
Td	Forested Savanna Steppes (Dense caatinga)	26	9.62	4.68	3.05	43.34
TN	Contact Savanna / Seasonal Forest	42.1	13.1	5.05	3.9	64.16

840

841 OBS: AGB – above ground biomass / BGB – below ground biomass / DW – dead wood / LI – litter

845 3.9. Atlantic Forest biome

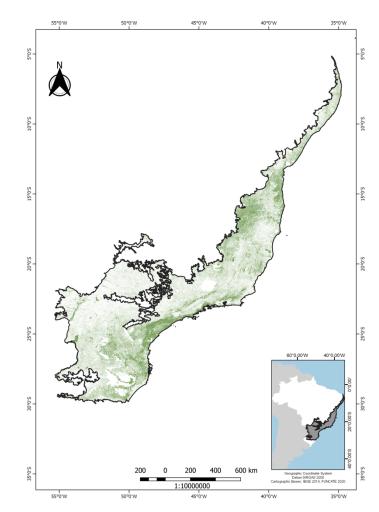
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847 3.9.1. Activity data

848

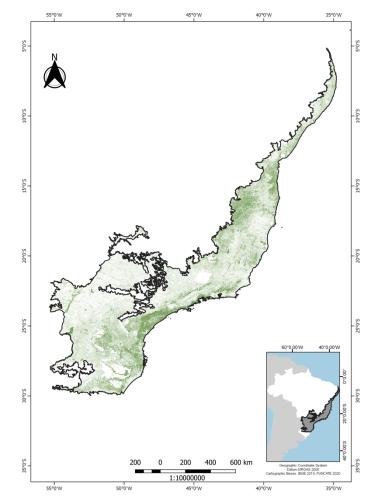
853

As explained in section "Pools, gases, and activities included in Brazil's national FREL", activity data for the Atlantic Forest biome were obtained from PRODES. The following figures presents the native forest distribution in the Atlantic Forest biome in 2016 (first year of the reference level period) and 2021 (end year of the reference level period).



854

- 855 Figure 20 Native forest (in green) distribution in the Atlantic Forest biome in 2016
- 856 Source: PRODES



859 Figure 21 – Native forest (in green) distribution in the Atlantic Forest biome in 2021

- 860 Source: PRODES
- 861

862 3.9.2. Emission factors

863

864 Forty-eight (48) forest phytophysiognomies are present in the vegetation map of the Atlantic 865 Forest biome, the most abundant ones being Submontane Semi-deciduous Seasonal Forest (FS), Montane Semi-deciduous Seasonal Forest (FM) and Montane Mixed Ombrophilous 866 867 Forest (Mm). Table 9 present the forest phytophysiognomies considered in the Atlantic Forest 868 biome, for the construction of the FREL, and the respective carbon stocks for each carbon 869 pool. For each type of forest phytophysiognomies, the total stock corresponds to the sum of 870 the individual stocks of the four carbon pools included: above ground biomass (AGB), below 871 ground biomass (BGB), dead wood (DW) and litter (LI).

873	Table 9 – Forest phytophysiognomies	considered i	in the	Atlantic	Forest	biome	and
874	respective carbon stocks						

Initial	nitial Phytophysiognomies		BGB	DW	LI	TOTAL C
Aa	Alluvial Open Ombrophilous Forest	35.06	7.19	2.98	1.86	47.09
Ab	Lowland Open Ombrophilous Forest	35.06	7.19	2.98	1.86	47.09

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
Am	Montane Open Ombrophilous Forest	35.06	7.19	2.98	1.68	46.91
Am	Sub-montane Open Ombrophilous Forest	35.00	7.19	2.98	4.19	49.42
Ca	Alluvial Decidual Seasonal Forest	88.6	21.3	9.8	2.1	121.8
Cb	Lowland Decidual Seasonal Forest	52.08	10.68	2.98	2.1	68.24
Cm	Montane Decidual Seasonal Forest	52.00	11.92	2.98	2.79	75.83
Cs	Sub-montane Decidual Seasonal Forest	74.1	19.6	8.2	4.6	106.5
D	Dense Ombrophilous Forest (Pluvial Tropical Forest)	63.17	14.84	2.98	3.03	84.02
		127.1				
Da	Alluvial Dense Ombrophilous Forest		29.9	14	2.9	173.9
Db	Lowland Dense Ombrophilous Forest	85.73 64.63	20.15	2.98	4.11	112.97
DI	High-montane Dense Ombrophilous Forest		15.19	2.98	3.1	85.9
Dm	Montane Dense Ombrophilous Forest		32.9	2.98	7	182.88
Ds	Sub-montane Dense Ombrophilous Forest	141.1	33.16	2.98	3.41	180.65
E	Steppes	0.8	0.16	0.04	0.04	1.04
EM	Contact Steppes / Mixed Ombrophilous Forest	49.26	10.1	2.98	2.36	64.70
EN	Contact Steppes / Seasonal Forest	52.17	10.69	2.98	2.5	68.34
F	Seasonal Forest Semi decidual	57.86	11.86	2.98	2.78	75.48
Fa	Alluvial Semi-deciduous Seasonal Forest	58.05	11.9	2.98	5.24	78.17
Fb	Lowland Semi decidual Seasonal Forest	63.07 75.1	14.82	2.98	3.03	83.90
Fm			17.65	2.98	3.76	99.49
Fs	Sub-montane Semi-deciduous Seasonal Forest		22.68	2.98	3.63	125.79
La	Wooded Campinarana	8.88	4.7	0.44	0.43	14.45
M	Mixed Ombrophilous Forest	62.51	12.81	2.98	3	81.3
Ma	Mixed Alluvial Ombrophilous Forest	64.25	15.1	2.98	3.08	85.41
MI	High-montane Mixed Ombrophilous Forest	78.82	18.52	2.98	3.78	104.10
Mm	Montane Mixed Ombrophilous Forest	108.3	25.45	2.98	5.42	142.15
Ms	Sub-montane Mixed Ombrophilous Forest	108	19	11.9	3.8	142.7
NM	Contact Seasonal Forest / Mixed Ombrophilous Forest	58.28	11.95	2.98	2.8	76.01
NP	Contact Seasonal Forest / Pioneer Formation - Specific for Pioneer Formation com Marine Influence (<i>Restinga</i>)	57.95	11.88	2.98	2.78	75.59
ОМ	Contact Dense Ombrophilous Forest/ Mixed Ombrophilous Forest	62.89	14.78	2.98	3.02	83.67
ON	Contact Ombrophilous Forest / Seasonal Forest	59.13	13.89	2.98	2.84	78.84
OP	Contact Ombrophilous Forest/ Pioneer Formation - Specific for Pioneer Formation com Marine Influence (<i>Restinga</i>)	63.26	14.87	2.98	3.04	84.15
Р	Pioneer Formation Areas	79.15	18.6	2.98	3.8	104.53
Pf	Vegetation with Fluviomarine Influence	62.42	14.67	2.98	2.99	83.06
Pm	Vegetation with Marine Influence (Restinga)	79.71	18.73	2.98	3.28	104.70
S	Savanna	26.69	16.94	3.12	4.88	51.63
Sa	Wooded Savanna	12.03	24.54	1.68	3.06	41.31
Sd	Forested Savanna	69.2	15.22	7.61	11.17	103.2
SM	Contact Savanna / Mixed Ombrophilous Forest	44.16	16.07	3.21	4.15	67.59
SN	Contact Savanna / Seasonal Forest	43.49	15.42	4.26	5.33	68.50
SO	Contact Savanna / Ombrophilous Forest	39.01	17.61	4.12	5.59	66.33
SP	Contact Savanna / Pioneer Formation	36.94	7.57	2.98	1.78	49.27

Initial	Phytophysiognomies		BGB	DW	LI	TOTAL C
ST	T Contact Savanna / Pioneer Formation - Specific for Pioneer Formation com Marine Influence (<i>Restinga</i>)		13.26	3.21	4.34	36.11
Т	Contact Savanna / Savanna Steppes		4.31	0.4	0.39	13.23
Та	Wooded Savanna Steppes		4.3	0.4	0.4	13.23
Td	Forested Savanna Steppes	18.94	10.03	0.93	0.91	30.81
TN	Contact Savanna Steppes/Seasonal Forest	55.88	11.7	2.98	2.68	73.24

876 OBS: AGB – above ground biomass / BGB – below ground biomass / DW – dead wood / LI – litter

877

878 Source: Table 25 (Brazil, 2020)

879

880 3.10. Pampa biome

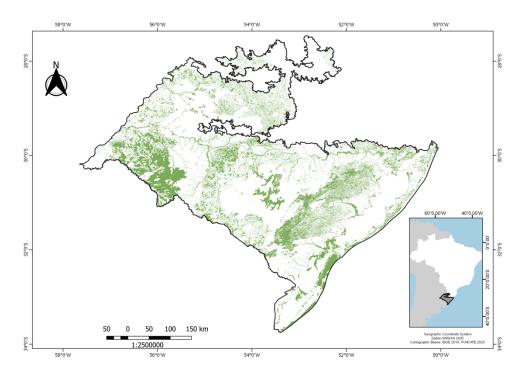
881

882 3.10.1. Activity data

883

As explained in section "Pools, gases, and activities included in Brazil's national FREL", activity data for the Pampa biome were obtained from PRODES. The following figures present the native forest distribution in the Pampa biome in 2016 (first year of the reference level period) and 2021 (final year of the reference level period).

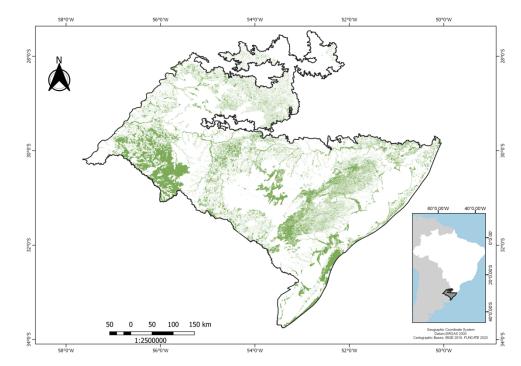
888





891 Source: PRODES

892





894 Figure 23 – Native forest (in green) distribution in the Pampa biome in 2021

895 Source: PRODES

896

897 3.10.2. Emission factors

898

Twenty-eight (28) forest phytophysiognomies are present in the vegetation map of the Pampa biome, the most abundant one being Steppes (E). **Table 10** present the forest phytophysiognomies considered in the Pampa biome, for the construction of the FREL, and the respective carbon stocks for each carbon pool considered. For each type of forest phytophysiognomies, the total stock corresponds to the sum of the individual stocks of the four carbon pools included: above ground biomass (AGB), below ground biomass (BGB), dead wood (DW) and litter (LI).

906

Table 10 – Forest phytophysiognomies considered in the Pampa biome and respective
 carbon stocks

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
Са	a Alluvial Decidual Seasonal Forest		23.69	10.86	2.93	136.17
Cb	b Lowland Decidual Seasonal Forest		12.25	2.98	2.5	69.80
Cm	Cm Montane Decidual Seasonal Forest		28.94	13.26	4.51	167.29
Cs	Cs Sub-montane Decidual Seasonal Forest		28.94	13.26	4.38	167.16
Da	a Alluvial Dense Ombrophilous Forest		15.21	2.98	3.1	85.91
Db	Db Lowland Dense Ombrophilous Forest		20.17	2.98	4.11	112.98
Dm	m Montane Dense Ombrophilous Forest		28.97	12.53	3.53	159.41
Ds	s Sub-montane Dense Ombrophilous Forest		30.31	13.89	3.87	174.38
E	Steppes	1.03	4.74	0	3.63	9.40

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
Ea	Wooded Steppes	37.74	10.58	5.12	2.07	55.51
EM	Contact Steppes / Mixed Ombrophilous Forest	1.03	4.74	0	3.63	9.40
EN	Contact Steppes / Seasonal Forest	0.73	0.77	0	3.63	5.13
EP	Contact Steppes / Formations		10.58	5.12	2.07	55.51
Fa	Alluvial Semi-deciduous Seasonal Forest	58.04	13.66	2.98	5.24	79.92
Fb	Lowland Semi-deciduous Seasonal Forest	62.65	15.04	6.89	1.47	86.05
Fm	Montane Semi-deciduous Seasonal Forest	82.24	16.12	3.06	5.35	106.76
Fs	Sub-montane Semi-deciduous Seasonal Forest	78.82	18.92	8.48	3.07	109.29
Ma	Mixed Alluvial Ombrophilous Forest	64.249	15.12	2.98	3.08	85.42
Ms	Sub-montane Mixed Ombrophilous Forest	92.77	23.49	10.77	3.68	130.71
Mm*	Montane Mixed Ombrophilous Forest					142.15
NM	Contact Seasonal Forest / Mixed Ombrophilous Forest	120.58	28.94	13.26	4.38	167.16
NP	Contact Seasonal Forest / Pioneer Formation com Marine Influence (<i>Restinga</i>)	1.04	10.15	0	1.59	12.77
ом	Contact Dense Ombrophilous Forest/ Mixed Ombrophilous Forest	120.58	28.94	13.26	4.38	167.16
ОР	Contact Ombrophilous Forest/ Pioneer Formation com Marine Influence (<i>Restinga</i>)	1.04	10.15	0	1.59	12.77
Р	Pioneer Formation Areas	1.03	4.74	0	3.63	9.40
Pf	Vegetation with Fluviomarine Influence	1.04	10.15	0	1.59	12.77
Pm	Vegetation with Marine Influence (Restinga)	1.04	10.15	0	1.59	12.77
Т	Savanna Steppes	120.58	28.94	13.26	4.38	167.16

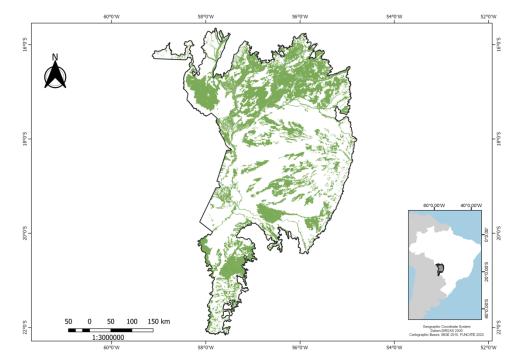
910 OBS: AGB – above ground biomass / BGB – below ground biomass / DW – dead wood / LI – litter

- 912 Source: Table 27 (Brazil, 2020)

biome
k

3.11.1. Activity data

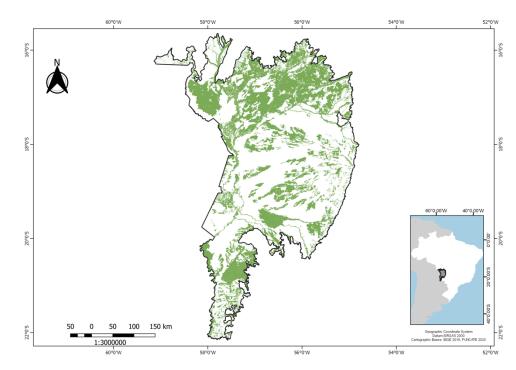
As explained in section "Pools, gases, and activities included in Brazil's national FREL", activity
data (deforestation areas) for the Pantanal biome were obtained from PRODES. The following
figures show the distribution of the native forest distribution in the Pantanal biome in 2016
(first year of the reference level period) and 2021 (final year of the reference level period).





925 Figure 24 – Native forest (in green) distribution in the Pantanal biome in 2016

- 926 Source: PRODES
- 927





929 Figure 25 – Native forest (in green) distribution in the Pantanal biome in 2021

- 930 Source: PRODES
- 931
- 932

933 3.11.2. Emission factors

934

Fifteen (15) forest phytophysiognomies are present in the vegetation map of the Pantanal biome, the most abundant ones being Wooded Savanna (Sa) and Forested Savanna (Sd). **Table 11** present the forest phytophysiognomies considered in the Pantanal biome, for the construction of the FREL, and the respective carbon stocks for each carbon pool. For each type of forest phytophysiognomies, the total stock corresponds to the sum of the individual stocks of the four carbon pools included: above ground biomass (AGB), below ground biomass (BGB), dead wood (DW) and litter (LI).

942

943	Table 11 – Forest phytophysiognomies considered in the Pantanal biome and respective
944	carbon stocks

Initial	Phytophysiognomies	AGB	BGB	DW	LI	TOTAL C
Ca	Alluvial Decidual Seasonal Forest	88.62	21.27	9.75	2.08	121.72
Cb	Lowland Decidual Seasonal Forest	69.38	16.65	7.63	11.21	104.87
Cs	Sub-montane Decidual Seasonal Forest	84.38	20.25	9.28	13.63	127.54
Fa	Alluvial Semi-deciduous Seasonal Forest	121.92	29.26	13.41	2.87	167.46
Fb	Lowland Semi-deciduous Seasonal Forest		6.6	5.34	3.81	81.73
Fs	Sub-montane Semi-deciduous Seasonal Forest		14.64	2.98	3.63	83.48
SN	Contact Savanna / Seasonal Forest		24.53	1.68	3.06	41.31
TN	Contact Savanna Steppes / Seasonal Forest		29.26	13.41	2.87	167.46
S	Savanna	69.2	15.22	7.61	11.17	103.21
Sa	Wooded Savanna	12.03	24.53	1.68	3.06	41.31
Sd	Forested Savanna	69.2	15.22	7.61	11.17	103.21
ST	Contact Savanna / Savanna Steppes		13.76	6.58	1.4	81.56
Т	Savanna Steppes	120.58	28.94	13.26	4.38	167.16
Та	Wooded Savanna Steppes	4.31	7.15	0.22	0.28	11.96
Td	Forested Savanna Steppes	66.43	14.62	7.31	10.73	99.09

945 946

OBS: AGB – above ground biomass / BGB – below ground biomass / DW – dead wood / LI – litter

947

948 Source: Table 28 (Brazil, 2020)

949

951 4. Methodological information used in the construction of Brazil's952 national FREL

953

954 4.1. The role of the Working Group of Technical Experts on955 REDD+ for MRV

956

957 On April 4th, 2022, the Brazilian Ministry of the Environment (MMA, for the acronym in 958 Portuguese) created the **Working Group of Technical Experts on REDD+ for MRV** (GTT MRV 959 REDD+, for the acronym in Portuguese) through Ordinance No. 7/2022. This group is 960 composed of experts in the areas of climate change and forestry from renowned Brazilian 961 institutions.

963 The GTT MRV REDD+ has provided important inputs for the development of this FREL, 964 including advise on the definition of deforestation and degradation, the forest physiognomies 965 to be considered, the carbon pools and GHG to be included¹⁴.

966 967

962

968 4.2. Estimation of Brazil's national FREL

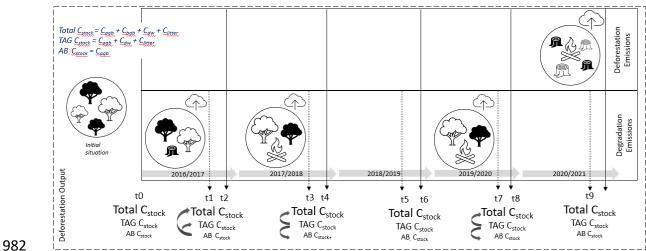
969

970 The methodologies used to estimate greenhouse gas (GHG) emissions resulting from 971 deforestation and forest degradation, and carbon removals are based on the 2006 IPCC 972 Guidelines (IPCC, 2006).

973

974 Overall, estimates of GHG emissions (measured in tonnes of carbon dioxide equivalent (tCO_2 975 equivalent) result from the multiplication of activity data and emission factors. Emissions 976 were calculated chronologically to allow the gradual reduction of carbon stocks in the 977 appropriate pools over time, when appropriate. This approach ensures that emissions are not 978 overestimated, since the carbon stock available at time *t* is the remaining stock at the time *t*-979 1 (Figure 26).

¹⁴ The GTT MRV REDD+ proceedings are registered in Portuguese and made publicly available on the website of the MMA through the following link: <u>http://redd.mma.gov.br/pt/reunioes</u>



981

984 Figure 26 – Methodological approach to estimate GHG emissions from deforestation and
 985 forest degradation

986 Source: own elaboration

987

988 Considering that different REDD+ activities impact different carbon pools, the following terms 989 were used in the calculation spreadsheets:

Total carbon stock (Total C_{stock}): sum of the four carbon pools considered – above
 ground biomass, below ground biomass, dead wood, and litter, relevant to the
 estimation of emissions associated with deforestation:

993
$$Total C_{stock} = C_{ABG} + C_{BGB} + C_{DW} + C_{LI}$$

Aerial carbon stock (T_{AG} C_{stock}): sum of the aerial carbon pools – above ground
 biomass, dead wood and litter, relevant to the estimation of emissions related to fire
 in managed forest land:

 $997 \qquad TAG C_{stock} = C_{AGB} + C_{DW} + C_{LI}$

998 3. Carbon stock in above ground biomass (AGB C_{stock}): it concerns only above ground
999 biomass, relevant to the estimation of emissions associated with disordered logging:

 $1000 \qquad \qquad AGB. C_{stock} = C_{AGB}$

1001

1003

1002 The calculations can be divided into three phases:

1004**PHASE 1** - Spatial data layers (maps) were assessed through GIS tools to check gaps,1005and topology, among others. Problems encountered at this stage and how they were1006corrected are described in "Quality control and quality assurance procedures". Since

1007	the data volume is very large, the results of this phase were exported as three different
1008	outputs (i.e., three worksheets for subsequent calculations), as detailed below:
1009	
1010	DEFORESTATION OUTPUT: Contains all deforested areas from 2016-2017 to
1011	2020-2021 and corresponding trajectories, i.e. forest areas that were
1012	first subject to degradation and were subsequently deforested are
1013	included in these files and tables. In the case of the Amazon biome,
1014	these results were subdivided into two parts: i) deforested areas with
1015	minimum mapping unit (MMU) between 1 ha and 6.25 ha; and ii)
1016	deforested areas of 6.25 ha and above. This subdivision was necessary
1017	since the deforestation data produced annually by INPE for the Legal
1018	Amazon region (PRODES) uses MMU of 6.25 ha or above, to ensure
1019	consistency along the timeseries since 1988
1020	DEGRADATION OUTPUT: Contains all forest areas in managed land subject
1021	to degradation in the Amazon biome and that are not converted to
1022	deforestation until the last annual period of the reference period (2020-
1023	2021)
1024	SECONDARY VEGETATION OUTPUT: Contains all areas under natural forest
1025	regeneration in previously deforested areas for years 2014 and 2020
1026	(for the Amazon biome) and 2018 and 2020 (for the Cerrado biome)
1027	
1028	PHASE 2 – in this phase, GHG emissions calculations were performed
1029	chronologically for forest degradation and deforestation. This implies that the carbon
1030	losses from the initial carbon stock in 2016 were accounted for as each REDD+ activity
1031	occurred and the carbon stocks were progressively updated so as to avoid double
1032	counting between deforestation and degradation in the case of the Amazon biome. In
1033	other words, the process and sequence of degradation was considered for the
1034	purposes of calculating emissions in subsequent deforestation (for more details refer
1035	to section 8.4). This approach was not applied for removals by secondary vegetation,
1036	as detailed below. The calculations and results of this phase were also subdivided
1037	according to three output components:
1038	
1039	DEFORESTATION OUTPUT: Contains GHG emissions from deforestation.
1040	The estimates of emissions from deforestation considered total carbon
1041	stock (sum of above ground in the above ground biomass
1042	DEGRADATION OUTPUT: Contains GHG emissions from forest degradation
1043	for the Amazon biome. Emissions from degradation by fire considered
1044	only the aerial carbon stock (sum of carbon stock in above ground
1045	biomass, dead wood and litter). The estimates of emissions from
1046	degradation due to disordered logging considered only the carbon
1047	stock in the above ground biomass
1048	SECONDARY VEGETATION OUTPUT: Contains removal estimates due to
1049	biomass growth in secondary vegetation areas. Due to the lack of
1050	annual data, the annual average of carbon removals were applied to
1051	the entire period from 2016-2017 to 2020-2021
1052	

PHASE 3 – During this phase the results and final balance of emissions and removals
 were estimated and the net GHG emissions for the Amazon and Cerrado biomes
 produced. For the Caatinga, Atlantic Forest, Pampa and Pantanal biomes, only gross
 GHG emissions were estimated.

- 1058 Detailed descriptions of the application of the above approaches are available in:
 - "Detail description for estimating GHG emissions/removals in the Amazon biome";
 - "Detailed description for estimating GHG emissions/removals in the Cerrado biome"; and
 - "Detail description for estimating GHG emissions/removals in the Atlantic Forest, Caatinga, Pampa and Pantanal biomes".
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1067 4.3. Equations used in the construction of Brazil's national FREL

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Emission and removal estimate for the national FREL are based on the 2006 IPCC gain-loss method (IPCC, 2006). The following equations are used, taking into account the REDD+ activities and the non-CO₂ gases considered for each biome, as indicated in **Table 3**. Detailed information related to the estimation in each biome are described in the section "Estimation of Brazil's national FREL". Equation 1 is an adaptation of equation 2.3 in the 2006 IPCC Guidelines:

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- 1076 1077

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 $\Delta C_B = \Delta C_{AGB} + \Delta C_{BGB} + \Delta C_{DW} + \Delta C_{LI}$ Equation 1

1078 Where:

• ΔC_B = carbon stock change

- ΔC_{AGB} = above-ground biomass stock change
- ΔC_{BGB} = below-ground stock change
- ΔC_{DW} = dead-wood stock change
- ΔC_{LI} = litter stock change
- 1083 1084 1085

4.3.1. Gross deforestation emissions

1086 1087

For each deforestation polygon *i*, identified at each annual period of the reference level period, the associated CO₂ emission is estimated as the product of its area (hectares) and the total carbon stocks (sum of the carbon stocks in the carbon pools considered), multiplied by 44/12 to convert tonnes of carbon in tonnes of carbon dioxide.Erro! Fonte de referência não e ncontrada.

1094
$$GE_{b,t,f,p} = A_{b,t,f,p} * (Ca_{b,t,f,p} + Cb_{b,t,f,p} + Cd_{b,t,f,p} + Cl_{b,t,f,p}) * 44/12$$
 Equation 2

1095	Where:					
1096	• $GE_{b,t,f,p}$ = CO ₂ emissions associated with deforestation in the polygon p, under					
1097	phytophysiognomies f of the biome b, at the annual period t; (tonnes)					
1098	• $A_{b,t,f,p}$ = area of deforestation polygon p, under phytophysiognomies f of the biome					
1099	b, at the annual period t; (ha)					
1100	• $Ca_{b,t,f,p}$ = carbon stock in above ground biomass in polygon p under					
1101	phytophysiognomies f of biome b at the annual period t (tC)					
1102	 Cb_{b,t,f,p} = carbon stock in below ground biomass in polygon p under 					
1103	phytophysiognomies f of biome b at the annual period t (tC)					
1104	 Cd_{b,t,f,p} = carbon stock in deadwood in polygon p under phytophysiognomies f of 					
1105	biome b at the annual period t (tC)					
1106	 Cl_{b,t,f,p} = carbon stock in litter in polygon p under phytophysiognomies f of biome b 					
1107	at the annual period t (tC)					
1108	• $44/12 = \text{conversion factor from C to CO}_2$; (dimensionless)					
1109						
1110	For each biome b and annual period t , the total gross CO_2 emissions from deforestation is					
1111	estimated as the sum of the CO ₂ emissions from all deforested polygons identified in that					
1112	period, as expressed in Equation 3:					
1113						
	$\nabla^{P_{ht}}$ on $\nabla^{P_{ht}}$ on $\nabla^{P_{ht}}$					
1114	$GE_{1} \equiv \sum_{n} GE_{1}$ Equation 3					
1114	$GE_{bt} = \sum_{p=1}^{P_{b,t}} GE_{b,t,p}$ Equation 3					
1115	Where:					
1115 1116	 Where: <i>GE_t</i> = total CO₂ emissions for period <i>t</i> in biome <i>b</i>; tonnes of CO₂ 					
1115 1116 1117	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ 					
1115 1116 1117 1118	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; 					
1115 1116 1117 1118 1119	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ 					
1115 1116 1117 1118 1119 1120	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; 					
1115 1116 1117 1118 1119	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; 					
1115 1116 1117 1118 1119 1120 1121	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; dimensionless 					
1115 1116 1117 1118 1119 1120 1121	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; 					
1115 1116 1117 1118 1119 1120 1121 1122 1123	 Where: <i>GE</i>_t = total CO₂ emissions for period <i>t</i> in biome <i>b</i>; tonnes of CO₂ <i>GE</i>_i = CO₂ emissions associated with deforested polygon <i>p</i>; tonnes of CO₂ <i>P</i>_{b,t} = number of deforested polygons identified in the period <i>t</i> and biome <i>b</i>; dimensionless 4.3.2. Gross emissions due degradation from fire 					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; dimensionless 4.3.2. Gross emissions due degradation from fire To estimate emissions from forest degradation due to fire, the generic equation 2.14 in the 					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125	 Where: <i>GE</i>_t = total CO₂ emissions for period <i>t</i> in biome <i>b</i>; tonnes of CO₂ <i>GE</i>_i = CO₂ emissions associated with deforested polygon <i>p</i>; tonnes of CO₂ <i>P</i>_{b,t} = number of deforested polygons identified in the period <i>t</i> and biome <i>b</i>; dimensionless 4.3.2. Gross emissions due degradation from fire 					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; dimensionless 4.3.2. Gross emissions due degradation from fire To estimate emissions from forest degradation due to fire, the generic equation 2.14 in the 2006 IPCC GLs, was used¹⁵, as reproduced below in equation 4: 					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; dimensionless 4.3.2. Gross emissions due degradation from fire To estimate emissions from forest degradation due to fire, the generic equation 2.14 in the 2006 IPCC GLs, was used¹⁵, as reproduced below in equation 4: 					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126 1127	 Where: GE_t = total CO₂ emissions for period t in biome b; tonnes of CO₂ GE_i = CO₂ emissions associated with deforested polygon p; tonnes of CO₂ P_{b,t} = number of deforested polygons identified in the period t and biome b; dimensionless 4.3.2. Gross emissions due degradation from fire To estimate emissions from forest degradation due to fire, the generic equation 2.14 in the 2006 IPCC GLs, was used¹⁵, as reproduced below in equation 4: 					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126 1127 1128	Where:• GE_t = total CO2 emissions for period t in biome b ; tonnes of CO2• GE_i = CO2 emissions associated with deforested polygon p ; tonnes of CO2• $P_{b,t}$ = number of deforested polygons identified in the period t and biome b ; dimensionless4.3.2.Gross emissions due degradation from fireTo estimate emissions from forest degradation due to fire, the generic equation 2.14 in the 2006 IPCC GLs, was used ¹⁵ , as reproduced below in equation 4: $L_{disturbance} = \{A_{disturbance} \times B_w \times (1 + R) \times CF \times fd\}$ Equation 4					
1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125 1126 1127 1128 1129	Where:• GE_t = total CO2 emissions for period t in biome b ; tonnes of CO2• GE_i = CO2 emissions associated with deforested polygon p ; tonnes of CO2• $P_{b,t}$ = number of deforested polygons identified in the period t and biome b ; dimensionless4.3.2.Gross emissions due degradation from fireTo estimate emissions from forest degradation due to fire, the generic equation 2.14 in the 2006 IPCC GLs, was used ¹⁵ , as reproduced below in equation 4: $L_{disturbance} = \{A_{disturbance} \times B_w \times (1 + R) \times CF \times fd\}$ Equation 4Where:					

d.m. ha⁻¹

¹⁵ Equation 2.14 of Chapter 2 (Generic Methodologies Applicable to Multiple Land-Use Categories) of Volume 4 (Agriculture, Forestry and Other Land Use) of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Available at: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4 Volume4/V4 02 Ch2 Generic.pdf

1133 1134 1135 1136 1137 1138 1139 1140 1141	 R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)⁻¹. R has been set to zero, assuming no changes of below-ground biomass CF = carbon fraction of dry matter, tonne C (tonnes d.m.)⁻¹ fd = fraction of biomass lost in disturbance Non-CO ₂ emissions are estimated following equation 2.27 in the 2006 IPCC GLs ¹⁶ , reproduced in equation 5:
1142	$L_{fire} = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$ Equation 5
1143	
1144	Where:
1145	 <i>L_{fire}</i> = amount of GHG emissions from fire of each GHG (CH₄ and N₂O)
1146	 A = area burned; hectares
1147	 M_B = biomass available; tonnes per hectare
1148	• C _f = combustion factor; dimensionless
1149	 G_{ef} = emission factor; g/kg of dry matter burned
1150	
1151	Each tonne of GHG was converted to tonne of CO ₂ equivalent, using the 100-year GWP values
1152	from the IPCC 5 th Assessment Report ¹⁷ :
1153	
1154	• CH ₄ to CO ₂ = 28
1155	 N₂O to CO₂ = 265
1156	
1157	
1158	4.3.3. Gross emissions due to disordered logging
1159	degradation

For each identified disordered logging polygon (CS), a trajectory was assessed (i.e.,
recurrences during the reference period, if any) and a singlular above-ground "biomass loss
factor" used accordingly - *Table 12*. The percent losses of above ground biomass (ΔCL CS AGB)
in table 12 are the same as those in table 30 of Brazil (2020).

1165

1160

1166Table 12 – Representation of possible disordered logging trajectories (recurrences) and1167respective above-ground "biomass loss factor"

Potential trajectory from F-CS							
Initial area	Disordered l	Disordered logging within the reference level period					
F	CS1				-29%		
F	CS1	CS2			-27%		
F	CS1	CS2	CS3		-26%		
F	CS1	CS2	CS3	CS4	-22%		

¹⁶ Equation 2.27 of IPCC 2006 Chapter 2

¹⁷ Table 8.A.1 available at: <u>https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf</u>

1169 Source: Table 30 (Brazil, 2020)

1170

11714.3.4.Removals due to natural forest regeneration in areas1172previously deforested

1173

For each polygon *j* identified at year *t* of the reference period as undergoing natural regeneration, the CO₂ removal was estimated as the product of its area and the mean annual biomass growth, following equation 2.9 of the 2006 IPCC GLs and reproduced in equation 6:

Equation 6

1178

1179

1180 Where:

1181	٠	$GE_{j,t}$ = annual increase in biomass carbon stocks in natural regeneration polygon j at
1182		time t due to biomass growth in areas of natural regeneration; tonnes of CO ₂ per
1183		year per hectare
1184	•	A _{i,j} = area of polygon j under natural forest regeneration (secondary vegetation) at

• EF = mean annual biomass growth; tonnes of C per hectare

 $GE_{i,i} = \sum_{1}^{NR} A_{i,t} \times EF \times \frac{44}{12}$

- **NR** = number of natural regeneration polygons identified at time *t*
- 44/12 = conversation factor from C to CO₂
- 1188 1189

1185 1186

1187

1190

1191 4.3.5. Uncertainties equations

1192
1193 Uncertainties associated with GHG emissions were estimated using equations described in
1194 volume 1, chapter 3, page 3.28 of 2006 IPCC Guidelines:

1195

1196 COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

1197
$$U_{total} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2}$$
 Equation 7

- 1199 Where:
- 1200 **U**_{total} = the percent uncertainty of the product of the quantities
- 1201 U_i = the percent uncertainty associated with each of the quantities 1202
- 1203 COMBINING UNCERTAINTIES APPROACH 1 ADDITION AND SUBTRACTION

1204
$$U_{total} = \frac{\sqrt{(U_{1} \times 1)^{2} + (U_{2} \times 2)^{2} + \dots + (U_{n} \times n)^{2}}}{|x_{1} + x_{2} + \dots + x_{n}|}$$
Equation 8
1205
1206 Where:
1207 • U_{total} = the percent uncertainty of the product of the quantities
1208 • X_i and U_i = the added quantities and the percentage uncertainties associated with
1209 them, respectively
1210
1211 Applying equations 7 for equation 2, will result in:
1212 $U_{GE_{ij}} = \sqrt{U_{Aij}^{2} + U_{EF_{j}}^{2}}$ Equation 9
1213
1214 Where:
1215 • $GE_{i} = CO_{2}$ emissions due to deforestation of areas under phytophysiognomies I (t)
1216 • $A_{i} = \text{Total}$ area deforested under phytophysiognomies I (tc/ha)
1217 • $C_{i} = \text{Total}$ carbon content of areas under phytophysiognomies I (tC/ha)
1218 • $C_{i} = Cab_{i} + Cbb_{i} + Cdw_{i} + Cli_{i}$ as defined in Equation 2
1219
1220 Applying equation 8:
1221 $U_{C_{i}} = \frac{\sqrt{(U_{cab_{i}} * Cab_{i})^{2} + (U_{cab_{i}} * Cab_{i})^{2} + (U_{cab_{i}} * Cab_{i})^{2}}{C_{i}}}{C_{i}}$ Equation 10
1222 The above equations assume that each component is not correlated. This is reasonable in
1223 relation to activity data (i.e., deforested area) and the total carbon content, but it does not
1224 always apply in relation to the carbon content for each carbon pool. In the case where the
1225 carbon content for below-ground biomass, litter and dead wood are estimated based on the

estimate of the carbon stock in above-ground biomass, the equations should be revised. For
example, in the case in which all other carbon pools were obtained from aerial biomass,
equation 11 applies:

1230

1231
$$C_i = Cab_i + Rbb_i * Cab_i + Rdw_i * Cab_i + Rli_i * Cab_i$$
 Equation 11

- 1232
- 1233 Where:

1234	٠	Rbb_i = Ratio below ground biomass / aboveground biomass for phytophysiognomies I
1235	٠	Rdw_i =Ratio dead wood biomass / above ground biomass for phytophysiognomies I

1236 • *Rli*_i = Ratio litter / above ground biomass for phytophysiognomies i

1238 Applying equations 7 and 8:

1240

1241 Specific information on how activity data uncertainty (U_{Aij}) and EF uncertainties (U_{EFj}) were 1242 estimated can be found in section "Accuracy".

 $U_{C_{i}} = \sqrt{U_{Cab_{i}}^{2} + \frac{\left(\left(Rbb_{i}*U_{Rbb_{i}}\right)^{2} + \left(Rdw_{i}*U_{Rdw_{i}}\right)^{2} + \left(Rli_{i}*U_{Rli_{i}}\right)^{2}\right)}{(1+Rbb_{i}+Rdw_{i}+Rli_{i})^{2}}} \quad \text{Equation 12}$

1244	4.3.6. FREL
1245	
1246	The annual emissions were obtained using the following equation, taking into account the
1247	REDD+ activities and removals considered in each biome, as indicated in Table 3:
1248	
1249	Gross/Net emissions = Gross emissions from deforestation + Gross emissions from forest
1250	degradation due to fire + Gross emissions from degradation due to disordered logging –
1251	Removals from natural forest regeneration (only for Amazon and Cerrado biomes)
1252	Equation 13
1253	
1254	Finally, the national FREL was obtained from the sum of the average of gross/net annual
1255	emissions in the reference level period:
1256	
1257	$MGE_p = \sum_{1}^{b} GE_t$ Equation 14
1257 1258	$MGE_p = \sum_{1}^{b} GE_t$ Equation 14
-	$MGE_p = \sum_{1}^{b} GE_t$ Equation 14 Where:
1258	
1258 1259	 Where: MGE_p = average gross/net GHG emissions for biome b; tonnes of CO₂ eq per year
1258 1259 1260 1261	 Where: MGE_p = average gross/net GHG emissions for biome b; tonnes of CO₂ eq per year GE_t = gross/net emission in year t; tonnes of CO₂ eq
1258 1259 1260	 Where: MGE_p = average gross/net GHG emissions for biome b; tonnes of CO₂ eq per year

 1264 5. Transparent, complete, consistent, and accurate information 1265 1266 In addition to information presented in previous sections, this section follows the 1267 contained in the Annex to decision 12/CP.17¹⁸ on submitting reference levels 1268 principles of: Transparency, Accuracy, Completeness and Consistency (TACC prin 1269 						
1270 1271	5.1. Transparency					
1272						
1273	For additional information aiming to enhance the transparency of the submission, refer to					
1274	annexes:					
1275						
1276	 Additional information related to deforestation activity data; 					
1277	 Additional information related to forest degradation activity data; 					
1278	• Additional information related to the areas of natural forest regeneration (secondary					
1279	vegetation);					
1280	• Detail description for estimating GHG emissions/removals in the Amazon biome;					
1281	• Detailed description for estimating GHG emissions/removals in the Cerrado biome;					
1282	• Detail description for estimating GHG emissions/removals in the Atlantic Forest,					
1283	Caatinga, Pampa and Pantanal biomes; and					
1284	 Detail description for estimating the national FREL. 					
1285						
1286						
1287	5.2. Accuracy					
4200						

1289 The uncertainty associated with CO₂ emissions was estimated based on the uncertainty 1290 associated with activity data (e.g., deforested area) and the uncertainty associated with EF 1291 (e.g., carbon content in each carbon pool) – for the general equations applied, refer to section 1292 "Uncertainties equations".

1293

1294 5.2.1. Activity data uncertainty

1295

The accuracy of the deforested areas in each biome was estimated using the methodology proposed in (Olofsson, et al., 2014). To determine the accuracy of the interpreter and estimate an uncertainty to be associated with the deforested areas in each annual period from 2016/2017 to 2020/2021, a stratified random sampling was applied according to the two categories adopted (natural forest and deforestation). Reference maps were used for each year from 2016 to 2021.

1302

Sample size, that is, the number of points sampled per stratum, was defined by applying theso-called "Neyman optimal allocation", described by (Cochran, 1977) (Congalton & Green,

¹⁸ Available at: <u>https://unfccc.int/sites/default/files/resource/docs/2011/cop17/eng/09a02.pdf</u>

1305 1306 1307	2009) and (Stehman, 2012). First, the total sample size was defined, considering all biomes as a single territory to be sampled:			
1308	$n = \left[\frac{\sum_{i=1}^{H} W_i * S_i}{s(\hat{O})}\right]^2 \qquad \text{Equation 15}$			
1309				
1310	Where:			
1311				
1312	 n = total number of samples 			
1313	 W_i = proportion of category i 			
1314	• $S_i = \sqrt{U_i * (1 - U_i)}$ = standard deviation of category <i>i</i>			
1315	• $s(\widehat{o})$ = standard error expected from sampling			
1316	• U _i = estimated map accuracy (given by the interpreter)			
1317				
1318	Sample distribution per category (n _i) was estimated using:			
1319				
1320	$n_i = n * rac{(t_{xi})^a * N_i * \sqrt{U_i * (1 - U_i)}}{\sum_{i=1}^H (t_{xi})^a * \sqrt{U_i} * (1 - U_i)}$ Equation 16			
1321				
1322	Where:			
1323				
1324	• $\mathbf{t}_{xi} = P_i * N_i$; where:			
1325	• \mathbf{P}_i = proportion of category <i>i</i> in relation to total population			
1326	 N_i = category <i>i</i> population (i.e., total number of pixels occupied by category <i>i</i>) 			
1327	 a=1/2 or 1/3 according to (Särndal, Swensson, & Wretman, 1992) 			
1328				
1329	The following table presents the sample plots numbers per biome and category that were			
1330	considered for estimating activity data accuracy.			
4004				

1332 Table 13 – Sample distribution per biome and category

Biome	Natural vegetation	Deforestation	Total
Amazon	386	208	594
Cerrado	367	202	569
Caatinga	449	116	565
Atlantic forest	368	166	534
Pampa	325	417	742
Pantanal	525	491	1016

1333

1336 Once the sample size was defined for each biome and category (i.e., natural vegetation and

deforestation), the sampled plots were assessed using higher spatial resolution images,allowing for the confirmation or not of the classification.

¹³³⁴Source: own calcultations1335

1340 This step was carried out using a computational system developed by INPE, that allowed the 1341 interpreter to simultaneously observe the sampled plot and the high spatial resolution 1342 images, complemented by graphical data describing NDVI (Normalized Difference Vegetation 1343 Index) dynamics that allowed to identify variations associated with removal, growth or 1344 vegetation cover stability at the sample plot over time. The following figure gives an example for each biome of a sample randomly selected, with the supplementary information used to 1345 1346 estimate the mapping accuracy: for each sampled point (image at the center) the interpreter 1347 had (on the right upside corner) additional high spatial resolution images and the NDVI graph 1348 (at the bottom).

1349



1350

1351 Figure 27 – Sample example in each biome for estimating mapping accuracy

1352 Source: INPE

- 1354 Based on the results of the sample plots process, an error matrix was elaborated for each
- 1355 biome and category Table 14.
- 1356

1357 Table 14 – Error matrix for each biome and category

D'	Category Error			
Biome		Deforestation	Natural vegetation	Total
	Deforestation	201	8	209
Amazon	Natural vegetation	7	378	385
	Total	208	386	594
	Deforestation	174	20	194
Cerrado	Natural vegetation	28	347	375
	Total	202	367	569
	Deforestation	108	13	121
Caatinga	Natural vegetation	8	436	444
	Total	116	449	565
Atlantic	Deforestation	159	50	209
forest	Natural vegetation	7	318	325
iorest	Total	166	368	534
	Deforestation	408	36	444
Pampa	Natural vegetation	9	289	298
	Total	417	325	742
	Deforestation	487	20	507
Pantanal	Natural vegetation	4	505	509
	Total	491	525	1016

1358

1359 Source: own calcultations

1360

From the above matrices it is possible to calculate producer's accuracy (omission) and user's
accuracy (inclusion) and the 95% confidence intervals of the classification of the deforested
area. The results are presented in following table.

1364

1365 Table 15 – Accuracy matrix for each biome and category

Biome	Category	User's accuracy %	Deforestation area uncertainty %
Amazon	Deforestation	96.2	10.5
Amazon	Natural vegetation	98.2	10.5
Cerrado	Deforestation	89.7	15.8
Cerrado	Natural vegetation	92.5	15.8
Contingo	Deforestation	89.3	26.8
Caatinga	Natural vegetation	98.2	20.0
Atlantic forest	Deforestation	76.1	30.6
Atlantic Torest	Natural vegetation	97.8	30.6
Domno	Deforestation	91.9	6.2
Pampa	Natural vegetation	97.0	0.2
Pantanal	Deforestation	96.1	6.9
Pantanai	Natural vegetation	99.2	0.9

5.2.2. Emission factors uncertainty

1368 1369

1370 Above ground biomass uncertainty

1371

For the Amazon biome, uncertainty values for above ground biomass were directly obtained
 from the EBA project¹⁹, with uncertainty values associated with each pixel in the EBA raster
 file.

1375

For the other biomes, uncertainty values associated with each phytophysiognomies vegetation in the biome were used, collected from either bibliographic reference or estimated based on IPCC default values (Table 4.7 in page 4.53 of chapter 4, volume 4 of the 2006 IPCC Guidelines)²⁰. Uncertainty default values were estimated using the predominant, minimum, and maximum limits, assuming a triangular distribution (as suggested by the 2006 IPCC Guidelines). Table 12 shows the values used in table 4.7 and the associated 95% confidence interval.**Erro! Fonte de referência não encontrada.**

1383

1384Table 16 – Confidence interval and estimated uncertainty for above ground biomass for1385Cerrado, Atlantic Forest, Caatinga, Pampa and Pantanal biomes

Domain	Ecological zone	Continent	Above-ground biomass (t d.m. ha ⁻¹)	Uncertainty (%)
Tropical	Tropical rain forest (TRF)	North and South America	300 (120-400)	-43/+37
	Tropical moist deciduous forest (TMDF)	North and South America	220 (210-280)	-10/+14
	Tropical dry forest (TDF)	North and South America	210 (200-410)	-24/+38
	Tropical shrubland (TS)	North and South America	80 (40-90)	-33/+24
	Tropical mountain systems	North and South America	60-230	-46/+46

1386

1387 Source: own calcultations based on Table 4.7 of 2006 IPCC Guidleines1388

1389 To estimate phytophysiognomies uncertainties, each phytophysiognomies was associated 1390 with an ecological zone of **Table 16**.

1391

¹⁹ <u>http://www.ccst.inpe.br/projetos/eba-estimativa-de-biomassa-na-amazonia/</u> (in Portuguese)

²⁰ Available at: <u>https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf</u>

1393Table 17 – Association of each phytophysiognomies with the ecological zone of Table 4.7 of13942006 IPCC Guidelines

Phytophysiognomies	Sigla	Ecological zone
Alluvial Open Humid Forest	Aa	TRF
Lowland Open Humid Forest	Ab	TRF
Ombrophilous Open Forest – Mountain	Am	TRF
Sub-montane Open Humid Forest	As	TRF
Alluvial Decidual Seasonal Forest	Са	TDF
Lowland Deciduous Seasonal Forest	Cb	TDF
Montane Deciduous Seasonal Forest	Cm	TDF
Sub-montane Deciduous Seasonal Forest	Cs	TDF
Alluvial Dense Humid Forest	Da	TRF
Lowland Dense Humid Forest	Db	TRF
Montane Dense Humid Forest	Dm	TRF
Sub-montane Dense Humid Forest	Ds	TRF
Steppes	E	TS
Wooded Steppes	Ea	TDF
Contact Steppes / Formations	EP	TS
Alluvial Semi-deciduous Seasonal Forest	Fa	TMDF
Lowland Semi-deciduous Seasonal Forest	Fb	TMDF
Montane Semi-deciduous Seasonal Forest	Fm	TMDF
Submontane Semi Deciduous Seasonal Forest	Fs	TMDF
Campinarana	L	TS
Forested Campinarana	La	TS
Wooded Campinarana	Ld	TMDF
Contact Campinarana / Ombrophilous Forest	LO	TMDF
Alluvial Mixed Ombrophilous Forest	Ma	TRF
Upper Montana Mixed Ombrophilous Forest	MI	TRF
Montane Mixed Humid Forest	Mm	TRF
Sub-montane Mixed Ombrophilous Forest	Ms	TRF
Contact Seasonal Forest / Mixed Ombrophilous Forest	NM	TRF
Contact Seasonal Forest / Pioneer Formations – Specific for Pioneer Formation with Marine Influence (<i>Restinga</i>)	NP	TMDF*
Contact Dense Ombrophilous Forest / Mixed Ombrophilous Forest	OM	TRF
Contact Ombrophilous Forest / Seasonal Forest	ON	TRF
Contact Ombrophilous Forest / Pioneer Formations – Specific for Pioneer Formation with Marine Influence (<i>Restinga</i>)	OP	TRF*
Pioneer Formations Areas	Р	TMDF
Pioneer Formation of Fluviomarine Influence (mangroves)	Pf	TMDF
Pioneering Formation of Marine Influence (sand banks)	Pm	TS
Savanna	S	TS
Wooded Savanna	Sa	TS
Forested Savanna	Sd	TDF

Phytophysiognomies	Sigla	Ecological zone
Contact Savanna/ Mixed Ombrophilous Forest	SM	TS
Contact Savanna / Seasonal Forest	SN	TS
Contact Savanna / Ombrophilous Forest	SO	TS
Contact Savanna / Savanna Steppes	ST	TS
Contact Savanna / Savanna Steppes / Seasonal Forest	STN	TS
Contact Savanna/Savanna Steppes	ST	TS
Savanna Steppes	Т	TS
Wooded Steppe Savanna	Та	TS
Forested Steppe Savanna	Td	TS
Contact Savanna Steppes / Seasonal Forest	TN	TS

- 1395 OBS: TS for the Pampa biome
- 1396 Source: own calcultations

1397 Other carbon pools uncertainty (below ground biomass, litter, and dead wood)

1398

1399 Currently, Brazil doesn't have country specific uncertainties values for other carbon pools:
1400 below-ground biomass, litter, and dead wood. Therefore, IPCC default values were used, as
1401 described below.

- 1402
- 1403 Below ground biomass

Table 4.4 of the 2006 IPCC Guidelines provides default values for the ratio below ground biomass/above ground biomass (root-to shoot ratio - R). However, the table does not provide ranges for all ecological zones. As the ratio "0,20" is used for many phytophysiognomies, and also in order to be conservative, the value 38% was assumed as the uncertainty value for R in this submission.

1409 Table 18 – Below ground uncertainty values

Ecological zone	Above-ground biomass	R [tonne root d.m. (tonne shoot d.m.) ⁻¹]	Uncertainty (%)
Tropical rainforest		0.37	
Tropical moist deciduous	above-ground biomass <125 tonnes ha-1	0.20 (0.09 - 0.25)	38
forest	above-ground biomass >125 tonnes ha-1	0.24 (0.22 - 0.33)	19
Tropical dry forest	above-ground biomass <20 tonnes ha-1	0.56 (0.28 - 0.68)	34
Topical dry forest	above-ground biomass>20 tonnes ha-1	0.28 (0.27 - 0.28)	2
Tropical shrubland		0.40	
Tropical mountain systems		0.27 (0.27 - 0.28)	2

1410

1411 Source: own calcultations based on Table 4.4 of 2006 IPCC Guidleines

1412 <u>Dead wood</u>

Table 3.2.2 of the 2003 IPCC GPG LULUCF²¹ has the value 0.11 as the ratio for dead wood and
above ground biomass for "Tropical forest", associating a value of 150% for the uncertainty.
This uncertainty estimate was considered for all cases in which dead wood was estimated
from above ground biomass using an expansion factor.

- 1417
- 1418 <u>Litter</u>

Table 3.2.1 of the 2003 IPCC GPG LULUCF²² indicate the value of 2.1 tC/ha (1-3) for litter in "tropical broadleaf deciduous forests". Based on a triangular distribution, an uncertainty value of 39% was estimated to be used in all phytophysiognomies. However, in most cases the carbon content in litter is estimated from above ground biomass carbon content using an expansion factor. Hence, a value of 22% of uncertainty was associated with the expansion factor in order to be consistent, on average, with the default value provided in the 2003 IPCC GPG LULUCF.

1426

1427 Uncertainty of carbon removals due to natural forest regeneration in areas previously1428 deforested

1429

The annual removal value is calculated multiplying the area identified as undergoing natural
regeneration by the mean annual biomass growth for secondary forest with past pasture
history (tC/ha year).

1433

The accuracy of the identification of secondary vegetation areas was carried out using the same methodology described for deforestation. The uncertainties estimated for the secondary vegetation area in the Amazon and Cerrado biomes were 9.7% and 5.3%, respectively.

1438

1439 For the mean annual biomass growth, the values used in the 4th National GHG Inventory were 1440 adopted (3.03 tC/ha/year for the Amazon biome and 2.85 tC/ha/year for the Cerrado biome). 1441 It was not possible to obtain uncertainty estimates for these values from the mentioned 1442 references. Typical uncertainty values are described in table 4.9 of the "2006 IPCC Guidelines. 1443 However, this table does not show ranges for all ecological zones. Based on the values in the 1444 table, an uncertainty of 50% (with one significant digit) was adopted for both the Amazon and 1445 the Cerrado biomes. Using the uncertainty propagation equation for the multiplication 1446 presented above, the uncertainty for CO₂ removal was estimated for both Amazon and 1447 Cerrado biomes, equal to 50% (with one significant digit).

²¹ Available at: <u>https://www.ipcc-</u>

nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_2_Forest_Land.pdf ²² Available at: https://www.ipcc-

nggip.iges.or.jp/public/gpglulucf/gpglulucf files/Chp3/Chp3 2 Forest Land.pdf

1449 1450	Uncertainty of gross emissions due to degradation from fire
1451 1452 1453	The annual gross emissions due to degradation from fire are estimated applying equations 4 and 5 described above.
1454 1455 1456 1457	The accuracy of the forest areas subject to degradation from fire was carried out using the same methodology described for deforestation, providing an estimated uncertainty of 19% for the Amazon biome.
1458 1459 1460 1461	The combustion factor uncertainty was obtained from table 2.6 of the 2006 IPCC Guidelines for "all primary forests" (0,36 with a 71% uncertainty) consistent with the value used in this submission (0.368).
1462 1463 1464	The uncertainty of the emission factors for non-CO ₂ gases were obtained from table 2.5 of the 2006 IPCC guidelines (58% for CH_4 and 53% for N_2O).
1465 1466	Uncertainty of gross emissions due to irregular logging degradation
1467 1468 1469 1470	For each polygon where irregular logging has been identified, emissions have been estimated multiplying its area by a biomass loss factor. Logging recurrences are possible for the same polygon. As shown before, biomass loss factors decrease for recurrent loggings.
1471 1472 1473	The accuracy of the areas subject to irregular logging has been estimated as 20% based on expert evaluation.
1474 1475 1476	The uncertainty of the biomass loss factors (0.29, 0.27, 0.26 and 0.22 for first, second, third and fourth recurrences) were considered to be 8% based on expert evaluation.

1477 5.3. Completeness

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1481

1479 Complete information, for REDD+ purposes, means the provision of data and information that1480 allows for the reconstruction of the FREL.

Additional information is meant only to enhance clarity and transparency of Brazil's National FREL. Brazil recalls paragraph 2 of Decision 13/CP.19 on guidelines and procedures for the technical assessment of FREL submissions and paragraph 4 of the Annex of the same decision.

1486 In general, all information related to land use environmental monitoring is publicly available 1487 at **TerraBrasilis²³**, a geographic data platform developed by INPE and EMBRAPA for the 1488 organization, access and use through a web portal of all information produced by its 1489 environmental monitoring programs.

1491Thedataandinformation,usedinthissubmission,areavailableat:1492http://redd.mma.gov.br/en/submissions

1493

1495

1490

1494 5.3.1. Activity data vectorial files (shapefiles)

1496 The following vectorial files containing activity data (i.e., deforestation, degradation and 1497 revegetation polygons) and supporting material (i.e., biomes limits, forest physiognomies and 1498 managed land areas) are available:

	File name	Content	Source
1.	Biomes_map	Revised biomes limits	(IBGE, 2019)
2.	Ancient_vegetation_ map	Ancient vegetation map with forest	4 th National
		phytophysiognomies	GHG Inventory
3.	Amazon_Deforestation_1to6ha	Deforestation polygons for Amazon	
		biome for the period 2016/2017- 2020/2021	PRODES ²⁴
4.	Amazon_Deforestation_greater_6ha	Deforestation polygons for Amazon biome for the period 2016/2017- 2020/2021	PRODES ³
5.	Amazon_Degradation	Degradation polygons for Amazon for the period 2016/2017-2020/2021	DETER ²⁵
6.	2014_Amazon_secondary_vegetation	Secondary vegetation map for 2014 in the Amazon biome	
7.	2020_Amazon_secondary_vegetation	Secondary vegetation map for 2020 in the Amazon biome	TerraClass ²⁶
8.	2018_Cerrado secondary_vegetation	Secondary vegetation map for 2018 in the Cerrado biome	-

²³ More information is available (in Portuguese) at: <u>http://terrabrasilis.dpi.inpe.br/en/home-page/</u> (accessed on November 9, 2022)

²⁴ <u>http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes</u> (in Portuguese)

²⁵ <u>http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/deter/deter</u> (in Portuguese)

²⁶ <u>https://www.terraclass.gov.br</u> (in Portuguese)

File name	Content	Source
9. 2020_Cerrado_secondary_vegetation	Secondary vegetation map for 2020 in	
	the Cerrado biome	
10. Cerrado_Deforestation	Deforestation polygons for Cerrado	
	biome for the period 2016/2017-	
	2020/2021	
11. Atlantic_Forest_Deforestation	Deforestation polygons for	
	Atlantic_Forest biome for the period	
	2016/2017-2020/2021	
12. Caatinga_Deforestation	Deforestation polygons for Caatinga	
	biome for the period 2016/2017-	
	2020/2021	
13. Pampa_Deforestation	Deforestation polygons for Pampa	
	biome for the period 2016/2017-	
	2020/2021	
14. Pantanal_Deforestation	Deforestation polygons for Pantanal	
	biome for the period 2016/2017-	
	2020/2021	
15. Managed_land_Amazon	Map of all "managed land" for Amazon	4 th National
		GHG Inventory
16. Managed_land_Cerrado	Map of all "managed land" for Cerrado	4 th National
		GHG Inventory
17. Scenes_in_Biome	Map based on landsat satellite grid	FUNCATE
	scenes crossed with biomes	FUNCATE

1501

5.3.2. Activity data Geotiff (raster)

1502

1503 The following raster files containing supporting material (i.e., carbon stocks per pool for the 1504 Amazon biome) are available:

1505

	File name	Content	Source			
1.	EBA_AB	Above-ground carbon stocks for the Amazon biome				
2.	2. EBA_BB Below-ground carbon stocks for the Amazon biome					
3.	3. EBA_DW Dead wood carbon stocks for the Amazon biome					
4.	EBA_LI	Litter carbon stocks for the Amazon biome				
5.	EBA_uncertainty	Uncertainty values of the carbon stocks for the Amazon biome				

1506

5.3.3. Calculation shapefiles

1507 1508

1509 The following vectorial files containing data used in the calculation's spreadsheet are 1510 available:

Deforestation areas estimated in 1 hectare and for 6.25 hectares in the Amazon biome, for the period 2016/2017- 2020/2021, and related forest phytophysiognomies and carbon stocks

²⁷ <u>http://www.ccst.inpe.br/projetos/eba-estimativa-de-biomassa-na-amazonia/</u> (in Portuguese)

	File name	Content
2.	Data4Emissions_Amazon_deforestation_greater6ha	Deforestation areas estimated in more than 6.25 hectares in the Amazon biome, for the period 2016/2017-2020/2021, and
		related forest phytophysiognomies and carbon stocks
3.	Data4Emissions_Amazon_VS	Secondary vegetation areas for the Amazon biome for 2014 and 2020
4.	Data4Emissions_Amazon_degradation	Degradation areas related to fire and disordered logging in the Amazon biome, for the period 2016/2017-2020/2021, and related forest phytophysiognomies and carbon stocks
5.	Data4Emissions_Cerrado_deforestation	Deforestation areas in the Cerrado biome for the period 2016/2017-2020/2021, and related forest phytophysiognomies and carbon stocks
6.	Data4Emissions_Cerrado_VS	Secondary vegetation areas for the Cerrado biome for 2018 and 2020
7.	Data4Emissions_Atlantic_forest_deforestation	Deforestation areas in the Atlantic Forest biome, for the period 2016/2017- 2020/2021, and related forest phytophysiognomies and carbon stocks
8.	Data4Emissions_Caatinga_deforestation	Deforestation areas in the Caatinga biom for the period 2016/2017-2020/2021, an related forest phytophysiognomies and carbon stocks
9.	Data4Emissions_Pampa_deforestation	Deforestation areas in the Pampa biome, for the period 2016/2017-2020/2021, and related forest phytophysiognomies and carbon stocks
10.	Data4Emissions_Pantanal_deforestation	Deforestation areas in the Pantanal biom for the period 2016/2017-2020/2021, and related forest phytophysiognomies and carbon stocks

1513 5.3.4. Calculation spreadsheet

The following calculations spreadsheets are available:

	File name	Content
1.	Amazon_Emissions_Output_Deforestation_1to6	Emissions from deforestation in the Amazon biome from polygons of 1 hectare and 6.25 hectare for the period 2016/2017-2020/2021
2.	Amazon_Emissions_Output_Deforestation_greater6ha	Emissions from deforestation in the Amazon biome from polygons greater than 6.25 hectare for the period 2016/2017-2020/2021
3.	Amazon_Emissions_Output_Degradation	Emissions from forest degradation due to fire and disordered logging in the Amazon biome for the period 2016/2017-2020/2021

File name	Content		
4. Amazon_Removals	Removals from Secondary vegetation areas for the Amazon biome for 2014 and 2020		
5. Amazon_Net_Emissions	Net Emissions from deforestation in the Amazon biome for the period 2016/2017-2020/2021		
6. Cerrado_Net_Emissions	Net emissions from deforestation in the Cerrado biome for the period 2016/2017-2020/2021		
7. Atlantic_forest_Net_Emissions_Deforestation	Net emissions from deforestation in the Atlantic Forest biome for the period 2016/2017-2020/2021		
8. Caatinga_Net_Emissions_Deforestation	Net emissions from deforestation in the Caatinga biome for the period 2016/2017-2020/2021		
9. Pampa_Net_Emissions_Deforestation	Net emissions from deforestation in the Pampa biome for the period 2016/2017- 2020/2021		
10. Pantanal_Net_Emissions_Deforestation	Net emissions from deforestation in the Pantanal biome for the period 2016/2017-2020/2021		
11. National_FREL	Brazil's national FREL for the period 2016/2017-2020/2021		

1518	5.4.	Consistency
1010	5.4.	CONSISTENCY

1519

1520 5.4.1. Consistency with the latest National Greenhouse Gas 1521 Inventory 1522

Paragraph 8 of Decision 12/CP.17 indicates that the reference levels should keep consistency with the country's latest National GHG Inventory. The 4th National GHG Inventory was submitted by Brazil to the UNFCCC in December 2020 and reports net GHG emissions for the LULUCF sector for the period 1990-2016 (Brazil, 2020). Estimates of CO₂ emissions and removals due to land use and land-cover change and Harvested Wood Products, as well as non-CO₂ gases emissions used the 2006 IPCC GLs as a basis for the approaches and methodologies used.

1530

Brazil applied IPCC's definition of consistency (IPCC, 2006) and in the construction of this national FREL used the same methodologies and datasets as those applied to estimates CO_2 and non- CO_2 emissions from the conversion of forest areas (managed and unmanaged) to other land-use categories in the 4th National GHG Inventory.

1535

1536 It should be pointed out, however, that there are differences between the estimates provided 1537 in the 4th National GHG Inventory and this FREL submission, due to more updated and 1538 accurate data and information that were available at the time of construction of the FREL, in 1539 particular:

- 1541 1. Change in the biome's geographical boundaries; and
- 1542 2. Use of minimum mapping area (MMU) of 1 hectare for the identification of deforestation polygons in the Amazon biome.

1544 5.4.1.1. Change in biomes' geographical boundaries 1545 1546 IBGE (2019) updated the geographical boundaries of the national biomes which were not available by the time of the development of the 4th National GHG Inventory. The Inventory 1548 thus used the boundaries defined in the 2004 IBGE map and that present some differences

1549 when compared to the new limits established in 2019 IBGE map, as indicated in **Table 19**.

1550

1551Table 19 – Comparison between the geographical areas defined in IBGE (2019) and IBGE1552(2004) and the corresponding biome percent cover in the Brazilian territory

Biome	Area IBGE (2019) (ha)	Contribution to national area (%)	Area IBGE (2004) / 4 th National GHG Inventory (ha)	Contribution to national area (%)
Amazon	421.274.200	49,5	420.877.900	49,4
Cerrado	198.301.700	23,3	203.582.600	23,9
Caatinga	86.281.800	10,1	82.784.500	9,7
Atlantic forest	110.741.900	13,0	111.557.200	13,1
Pampa	19.381.800	2,3	17.882.600	2,1
Pantanal	15.098.800	1,8	15.130.300	1,8
Total	851.080.200	100	851.815.000	100

1553

1554 OBS: please note that the difference in the geographical area of Brazil from IBGE (2004) 1555 (851,815,000 ha) and IBGE (2019) (851,080,200 ha) results from the elimination of areas that 1556 are now considered under the so called Coastal Marine System.

1557

1558 Source: IBGE, 2019 and Brazil, 2020

1559

Tables 20 to 25 provide the implication of the of the change in each biome limit on the estimates of the gross GHG emissions from deforestation for Caatinga, Atlantic Forest, Pampa and Pantanal, respectively. For the Amazon, the changes in deforested area and consequent emissions are not significant.

- 1564
- 1565

1566 Table 20 – CO₂ emissions from gross deforestation, MMU 6,25ha, based in the former (IBGE,

1567 2004) and in the current (IBGE, 2019) biome limit for Amazon

Period	200	4 limit	201	9 limit	Change in	Change in
	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	area 2019/2004	emissions 2019/2004
2016-2017	665,821.49	295,787,546.69	672,853.72	297,211,456.19	1.06%	0.48%
2017-2018	696,589.84	317,127,695.68	692,431.08	301,865,997.55	-0.60%	-4.81%
2018-2019	1,064,179.34	476,284,434.39	1,067,613.09	474,543,048.25	0.32%	-0.37%
2019-2020	1,038,806.82	461,063,907.52	1,031,985.74	443,258,448.53	-0.66%	-3.86%
2020-2021	1,212,868.69	556,489,285.94	1,215,904.49	546,613,958.95	0.25%	-1.77%

1568

- 1569 Source: own estimates
- 1570

Table 21 – CO₂ emissions from gross deforestation based in the former (IBGE, 2004) and in the current (IBGE, 2019) biome limit for Cerrado

Period	200	4 limit	2019 limit		Change in	Change in
	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	area 2019/2004	emissions 2019/2004
2016-2017	600,141.45	108,508,958.58	569,967.98	103,183,642.91	-5.03%	-4.91%
2017-2018	536,438.13	97,433,138.48	550,809.22	101,775,493.28	2.68%	4.46%
2018-2019	531,278.93	95,623,692.67	494,315.49	88,886,236.32	-6.96%	-7.05%
2019-2020	602,798.37	106,842,798.79	603,072.06	108,662,302.47	0.05%	1.70%
2020-2021	648,277.57	115,451,945.66	632,946.89	114,670,094.80	-2.36%	-0.68%

1573

1574 Source: own estimates

1575

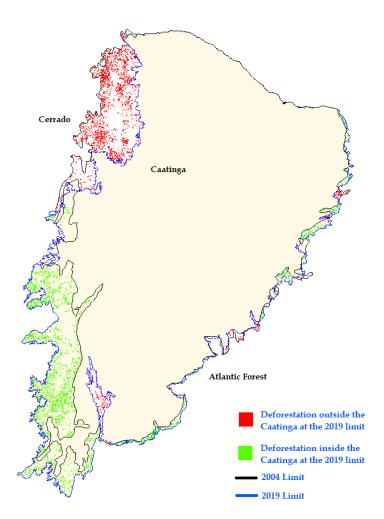
1576 Table 22 – CO₂ emissions from gross deforestation based in the former (IBGE, 2004) and in 1577 the current (IBGE, 2019) biome limit for Caatinga

Period	2004	4 limit	2019	9 limit	Change in	Change in
	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	area 2019/2004	emissions 2019/2004
2016-2017	188,728.60	22,910,435.87	213,662.91	28,318,171.77	13.21%	23.60%
2017-2018	214,048.22	28,240,728.05	206,501.48	25,191,250.31	-3.53%	-10.80%
2018-2019	147,212.90	17,152,017.82	176,297.51	23,870,541.00	19.76%	39.17%
2019-2020	201,102.29	27,639,350.08	209,054.43	28,416,932.63	3.95%	2.81%
2020-2021	183,418.70	22,497,567.21	198,817.41	25,414,848.62	8.40%	12.97%

¹⁵⁷⁸

1579 Source: own estimates

Note that the area of the Caatinga biome increased from IBGE (2004) to IBGE (2019) - from
82,784,500 ha to 86,281,800 ha. The deforestation areas in the Caatinga are shown in Figure
28 – in red, the deforestation areas "lost" to the Cerrado biome due to the new boundaries
and in green, the deforestation areas inherited from the Cerrado biome. Quantitatively, the
area lost is equal to 77,978.21 ha and the area "gained" is 136,942.27 ha, a difference of
58,964.06 ha.



1591 Figure 28 – Deforestation areas in the Caatinga "lost" to the Cerrado biome (in red) and the 1592 deforestation areas inherited from the Cerrado biome (in green) due to the new boundaries

- 1593 Source: own calcultations

1596 Table 23 – CO₂ emissions from gross deforestation based in the former (IBGE, 2004) and in 1597 the current (IBGE, 2019) biome limit for Atlantic Forest

Period	2004	limit	2019	limit	Change in	Change in
	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Change in area 2019/2004	Change in emissions 2019/2004
2016-2017	90,314.95	36,776,886.09	85,870.10	36,434,019.13	-4.92%	-0.93%
2017-2018	118,244.12	44,592,425.10	117,209.42	45,100,212.60	-0.88%	1.14%
2018-2019	90,449.21	39,189,284.79	89,850.38	39,463,223.90	-0.66%	0.70%
2019-2020	63,404.89	23,410,615.21	62,142.54	23,544,177.11	-1.99%	0.57%
2020-2021	73,255.71	29,285,094.32	68,964.58	28,761,217.90	-5.86%	-1.79%

1598

1600

1601 The Atlantic Forest boundaries were reduced from IBGE (2004) (122,557,200 ha) to IBGE 1602 (2019) (110,741,900 ha) but this change had a very small impact in the average annual 1603 emissions, which ranged from -1,79% to 1,14% during the reference period.

1604

Table 24 – CO₂ emissions from gross deforestation based in the former (IBGE, 2004) and in
 the current (IBGE, 2019) biome limit for Pampa

Period	200	94 limit	2019	9 limit	Change in	Change in
	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	area 2019/2004	emissions 2019/2004
2016-2017	35,425.69	3,709,137.07	35,948.28	3,629,784.82	1.48%	-2.14%
2017-2018	34,691.03	3,999,802.73	34,986.84	3,798,003.85	0.85%	-5.05%
2018-2019	38,132.31	3,583,817.00	39,058.02	3,574,669.24	2.43%	-0.26%
2019-2020	32,598.77	3,521,888.02	33,197.97	3,460,472.47	1.84%	-1,74%
2020-2021	55,738.82	5,892,710.46	56,665.90	5,850,601.61	1.66%	-0.71%

1607

1609

1610 The Pampa boundaries were reduced from IBGE (2004) (17,882,600 ha) to IBGE (2019) 1611 (19,381,800 ha) but this change had a very small but consistent decrease in emissions, which 1612 ranged from – 5.05% to –0.26% during the reference period.

1613

¹⁵⁹⁹ Source: own estimates

¹⁶⁰⁸ Source: own estimates

1615 Table 25 – CO₂ emissions from gross deforestation based in the former (IBGE, 2004) and in 1616 the current (IBGE, 2019) biome limit for Pantanal

Period	2004	4 limit	2019) limit	Change in	Change in
	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	Deforestation area (ha)	Gross emission (tCO ₂ /ha)	area 2019/2004	emissions 2019/2004
2016-2017	32,036.69	6,979,761.01	34,286.50	7,296,713.06	7.02%	4.54%
2017-2018	25,882.18	5,608,315.32	23,976.11	5,101,430.68	-7.36%	-9.04%
2018-2019	17,489.73	3,906,089.98	21,684.31	4,684,070.20	23.98%	19.92%
2019-2020	25,173.13	5,937,112.64	24,558.11	5,655,515.57	-2.44%	-4.74%
2020-2021	27,462.26	7,600,592.87	27,760,72	7,446,456.25	1.09%	-2.03%

1617

1618 Source: own estimates

1619

1620 The Pantanal boundaries were slightly reduced from IBGE (2004) (15,130,300 ha) to IBGE 1621 (2019) (15,098,800 ha) but the changes in emissions was second to the Caatinga biome. The 1622 change in emissions ranged from –9.04% to 19.92% during the reference period.

1623

1624 Is important to note that none of the observed changes imply under or over estimations of 1625 the FREL, since there is no overlap between the geographical areas of the biomes or gaps in 1626 Brazil's geographical coverage, and all emissions are estimated. It just a matter of allocation 1627 within the biomes. Nevertheless, the change in the boundaries of the biomes resulted in the 1628 selection of different EF per phytophysiognomies and consequently in different impacts on 1629 the emissions. For example, in the Pantanal biome in 2020-2021 area deforested have 1630 increased by 1%; but emissions have decreased by 2%.

- 1631
- 1632

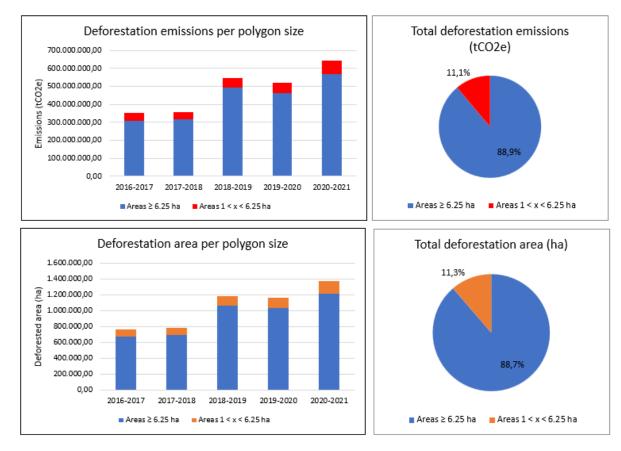
5.4.1.2. Implications of the use of the MMU of 1 ha in the estimation of the area deforested in the Amazon biome

1633 1634

The most significant difference between the estimates of gross deforestation in this national 1635 FREL submission and those in the 4th National GHG Inventory refers to the use of a MMU of 1 1636 ha for the Amazon biome, instead of the MMU of 6.25 ha used in the 4th National GHG 1637 Inventory. The PRODES program conducted by INPE and that provides the official annual 1638 1639 estimates of gross deforestation for the Legal Amazonia area uses MMU of 6.25 ha to ensure 1640 consistency in the timeseries since 1988. At that time, the estimates were obtained from the 1641 analysis of the deforestation polygons copied from the satellite image to transparent overlays, and 6.25 ha MMU corresponded to 1 mm² in paper. To ensure consistency 1642 1643 throughout the entire annual time series since 1988, INPE continues to use the MMU of 6.25 1644 ha.

1646 The use of a MMU of 1 hectare responds to the one of the areas for future improvements 1647 identified during previous technical analysis²⁸. The impact of including deforested areas 1648 between 1 ha and 6.25 ha is an average increase of 11.3 % in total deforested area and an 1649 average increase in CO₂e emissions of 11.2 % in the period from 2016/2017 to 2020/2021 1650 (Figures below).

1651



1652 1653

Figure 29 – Impact of including deforested areas between 1 ha and 6.25 ha in deforested
 areas and GHG emission estimates

- 1656 Source: own calcultations
- 1657

16585.4.2.Consistency with other forest information reported1659internationally by Brazil

1660

Although there is no requirement under the UNFCCC REDD+ that Brazil ensures consistency with forest information reported to other international bodies, Brazil plans to ensure this consistency in future submissions, in particular, between the he national inventory report of anthropogenic emissions by sources and removals by sinks of GHG to the Paris Agreement, future REDD+ submissions, and information reported to the Global Forest Resources Assessments (FRA - refer to **Box 9**).

²⁸ Paragraph 20 of Report of the technical assessment of the proposed forest reference emission level of Brazil submitted in 2018 (FCCC/TAR/2018/BRA). Available at: https://unfccc.int/sites/default/files/resource/tar2018 BRA.pdf

1667 1668 1669 1670	Brazil plans to evaluate the use, across all submissions, of biomass and carbon stocks derived from the National Forest Inventory (NFI) ²⁹ . Nowadays, the NFI has been developed at the sub-national level. The following States have completed and validated the results:
1671	
1672	• Ceará
1673	Federal District
1674	Espírito Santo
1675	Paraíba
1676	• Paraná
1677	Rio de Janeiro
1678	Rio Grande do Norte
1679	Rondônia
1680	Rio Grande do Sul
1681	Santa Catarina
1682	Sergipe
1683	
1684	Results are updated regularly at NFI website ³⁰ and the Global Forest Resources Assessments
1685	(FRA) platform ³¹ .

Box 9 – Brazil's participation in the Global Forest Resources Assessments (FRA)

Forest Resources Assessments (FRA) are produced by countries reports based on data analysis done approximately every two years in advance of a reference year. Countries must carry out projections for the reference year based on the data available up to the date of preparation of the report.

In 2018, the Brazilian National Forest Inventory (NFI) had collected data approximately in 53% of the national territory. Data were collected in all biomes with the exception of the Pantanal biome.

Although the first NFI collection cycle was not completed, Brazil opted to use the NFI data for the FRA 2020 communication. The data used for biomass and carbon stocks estimation were obtained from Brazil NFI, collected until and available by December 2018. This was the first time that the FRA carbon stocks were calculated with data from the NFI.

In the NFI, information on carbon stocks is presented by forest typology according to IBGE Brazilian vegetation map and considering the boundaries of the 6 Brazilian biomes (Amazonia, Cerrado, Atlantic Forest, Caatinga, Pampa and Pantanal). For forest extension, data from IBGE Brazilian vegetation map was also used, which gives the information about

²⁹ More information about the NFI (in Portuguese) is available at: <u>https://www.gov.br/agricultura/pt-br/assuntos/servico-florestal-brasileiro/ifn-inventario-florestal-nacional</u>

³⁰ Latest NFI information is available at: <u>https://snif.florestal.gov.br/pt-br/inventario-florestal-nacional-ifn/ifn-dados-abertos</u>

³¹ Information presented by Brazil to the FRA is available at: <u>https://fra-data.fao.org/BRA/fra2020/home/</u>

the original vegetation cover all over the country according to the national vegetation classification categories.

The NFI is based on a systematic sampling design, with clusters of four sub unities of 20m x 50m each, distributed in a national grid of 20 km x 20 km. Data of living trees over 10 cm DBH were processed for calculating average carbon stocks (ton/ha) for each biome and for each forest type within each biome, using available and published allometric equation fitted for forest types. For the vegetation types with low number of clusters in the biome, total samples for all biomes of that specific forest type were used. Carbon stock was estimated using the default IPCC factor of 0.49 applied to the biomass values. To retrieve field data for forest type, NFI used the same vegetation map used to estimate forest extension; and for estimating the total biomass carbon stock each forest type, values were multiplied by its correspondent area given by the map. Although the NFI has information collected on soil and litter pools, such data were not used because it was not proper analyzed up to December 2018.

Only for the Pantanal biome, where there was no NFI data collected, the data used was the same used for the 2015 FRA submission (i.e., data based on bibliography references).

There is methodological consistency between the national GHG inventory and the Brazil's FRA. The vegetation map used is the same, as well as the definition of forest; both coincide with those used by the Brazilian Forestry Service. Nevertheless, There is a time difference in the preparation and reference dates of these reports, which causes some delay in the alignment of these activities. Usually, the FRA are made on advance and the national GHG inventory are made after the reference year.

It should be noted that the NFI is still under development; and its preliminary results for carbon stocks need to be further assessed, in under to better understand the differences with the current values used in the national GHG inventory.

1687

The use of data (biomass and carbon stocks) derived from the National Forest Inventory could potentially result in more accurate GHG emissions estimates, but it is expected to result in differences compared to the current estimates. To illustrate the impact of using biomass and carbon stocks values derived from the NFI, a preliminary analysis was made using current available NFI values for selected phytophysiognomies in Pampa and Atlantic Forest biomes. The results are presented in the following tables.

1696Table 26 – Gross emissions from deforestation estimated in this national FREL and using1697data from the NFI to estimate total carbon stocks and related CO2 emissions in Decidual16991699

1698 Seasonal Forest in the Pampa biome, and the percent differences

Period	Gross emissions due to e	Gross emissions due to deforestation (t CO ₂)	
	FREL	NFI/FRA	
2016-2017	577,399	397,224	-31.20%
2017-2018	490,971	346,827	-29.36%
2018-2019	618,398	413,814	-33.08%
2019-2020	1,025,863	665,818	-35.10%
2020-2021	1,220,998	841,923	-31.05%

1699

1700 Source: own estimates

1701

1702Table 27 – Gross emissions from deforestation estimated in this national FREL and using1703data from the NFI to estimate total carbon stocks and related CO2 emissions in Semi

1704 Decidual Seasonal Forest in the Pampa biome, and the percent differences

Period	Gross emissions due to o	Gross emissions due to deforestation (t CO ₂)	
	FREL	NFI/FRA	
2016-2017	861,105	508,955	-40.90%
2017-2018	1,076,098	640,186	-40.51%
2018-2019	833,665	493,778	-40.77%
2019-2020	546,397	322,216	-41.03%
2020-2021	1,834,345	1,092,614	-40.44%

1705

1706 Source: own estimates

1707

1708 Table 28 – Gross emissions from deforestation estimated in this national FREL and using

1709 data from the NFI to estimate total carbon stocks and related CO₂ emissions in Decidual

1710 Seasonal Forest in the Atlantic Forest biome, and the percent differences

Period	Gross emissions due to	deforestation (t CO ₂)	Difference
	FREL	NFI/FRA	
2016-2017	2,920,464	1,956,509	-33.01%
2017-2018	6,648,687	4,802,191	-27.77%
2018-2019	3,002,620	1,990,977	-33.69%
2019-2020	2,869,147	2,055,625	-28.35%
2020-2021	2,815,634	1,872,648	-33.49%

1711

1712 Source: own estimates

1713Table 29 – Gross emissions from deforestation estimated in this national FREL and using1714data from the NFI to estimate total carbon stocks and related CO2 emissions in Semi

1715 Decidual Seasonal Forest in the Atlantic Forest biome, and the percent differences

Period	Gross emissions due to e	Gross emissions due to deforestation (t CO ₂)	
	FREL	NFI/FRA	
2016-2017	7,418,204	5,195,614	-29.96%
2017-2018	13,450,046	9,783,804	-27.26%
2018-2019	11,958,518	8,392,139	-29.82%
2019-2020	6,664,709	4,878,819	-26.80%
2020-2021	9,138,749	6,440,005	-29.53%

1716

1717 Source: own estimates

1718 6. Results

1719

Brazil's national FREL is the sum of the estimated GHG emissions for each of the six Brazilian
biomes. The following sections presents the results of GHG emissions for each of the Brazilian
biomes, estimated according to the methodology and information previously described.

1724 6.1. Amazon biome

1725

1726 The following tables and figure present the area deforested in each annual period of the 1727 reference period and corresponding net GHG emissions associated with deforestation and 1728 forest degradation in the Amazon biome.

1729

Table 30 - CO₂ removals and GHG emissions associated with gross deforestation and
 degradation in the Amazon Biome

Period	Removals by secondary vegetation (tonnes CO ₂ yr ⁻¹)	Deforestation emissions (tonnes CO2 eq yr ⁻¹)	Degradation emissions due to fire in managed land (tonnes CO ₂ eq yr ⁻¹)	Degradation emissions due to disordered logging (tonnes CO ₂ yr ⁻¹)
2016-2017	-167,812,819	351,860,631	42,107,135	7,160,053
2017-2018	-167,812,819	358,656,510	12,392,623	4,991,741
2018-2019	-167,812,819	546,672,701	16,644,544	17,376,069
2019-2020	-167,812,819	521,509,008	45,788,437	20,682,306
2020-2021	-167,812,819	645,550,074	9,144,334	29,253,071

1732

OBS: the differences with results presented in previous REDD+ technical annex is due to changes made in this submission (listed in section 3.5.1), including response to recommendations from past technical analysis (presented and explained in section 8.9). In particular, due to the use of updated values of emission factors from EBA, changes in the biome boundaries and the inclusion of deforestation areas smaller than 6.25 ha.

1738

1739 Source: own calcultations

1740

1742 Table 31 – Net GHG emissions associated with deforestation and degradation in the Amazon

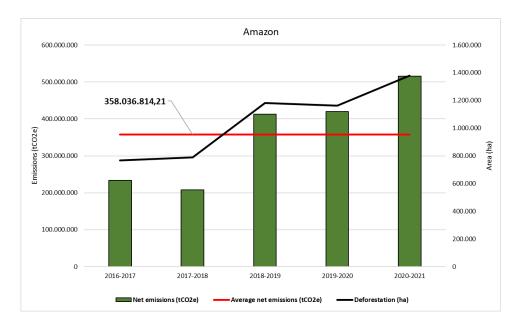
1743 Biome

Period	Annual area deforested (ha yr ⁻¹)	Gross GHG emissions (tonnes CO2 eq yr ⁻¹)	Net GHG emissions (tonnes CO2 eq yr ⁻¹)
2016-2017	767,091	401,028,346	233,215,527
2017-2018	789,489	375,955,047	208,142,228
2018-2019	1,180,965	580,576,676	412,763,857
2019-2020	1,161,545	587,865,207	420,052,388
2020-2021	1,378,554	683,822,891	516,010,072
	Average		358,036,814

1744

1745 Source: own calcultations

1746



1747

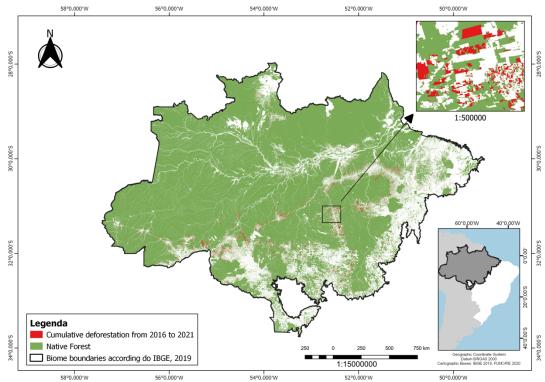
1748 Figure 30 – Net GHG emissions and deforestation in the Amazon biome (2016/2017 – 1749 2020/2021)

1750 Source: own calcultations

1751

1752 The following figure shows the forest cover distribution at year 2021 and the polygons 1753 deforested between 2016 and 2021 in the Amazon biome.

1754 defores



1755section: section: sectio: section: section:

1760 6.2. Cerrado biome

1761

1762 The following table and figure present the area deforested in each annual period of the 1763 reference period and corresponding net GHG emissions associated with deforestation and 1764 forest degradation in the Cerrado biome.

1765

1766	Table 32 – Annual area deforested and corresponding net GHG emissions associated with
1767	deforestation in the Cerrado Biome

Period	Annual area deforested (ha yr ⁻¹)	Removals by secondary vegetation (tonnes CO ₂ yr ⁻¹)	Deforestation emissions (tonnes CO ₂ eq yr ⁻¹)	Net emissions (tonnes CO2 eq yr ⁻¹)
2016-2017	569,968	-74,427,056	106,175,202	31,748,146
2017-2018	550,809	-74,427,056	104,768,029	30,340,973
2018-2019	494,315	-74,427,056	91,442,096	17,015,040
2019-2020	603,072	-74,427,056	111,753,842	37,326,786
2020-2021	632,947	-74,427,056	118,004,276	43,577,220
	32,001,633			

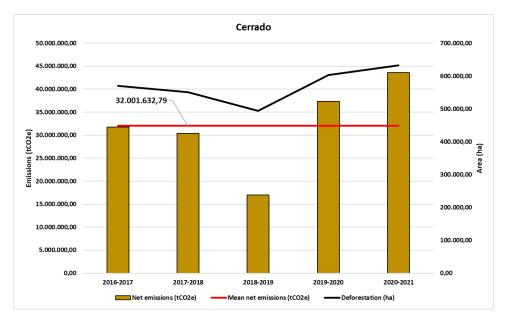
1768

1769 OBS: the differences with results presented in previous REDD+ technical annex is due to 1770 changes made in this submission (listed in section 3.5.1), including response to 1771 recommendations from past technical analysis (presented and explained in section 8.9). In

¹⁷⁵⁸ Source: own calcultations based on PRODES data

- 1772 particular, due to the use of updated values of emission factor from EBA and changes in the
- biome boundaries.
- 1774

1775 Source: own calcultations



1776

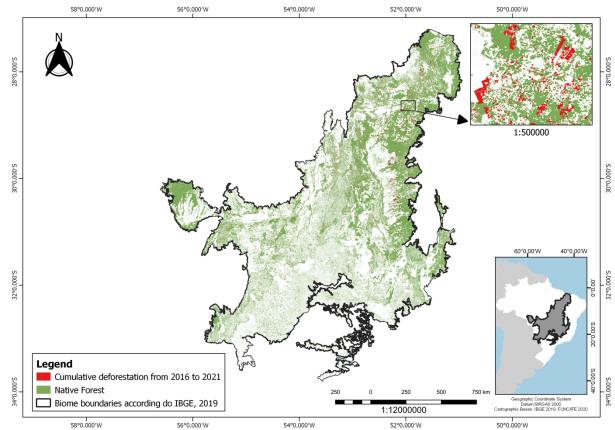
1777Figure 32 – Net GHG emissions and deforestation in the Cerrado biome (2016/2017 –17782020/2021)

1779 Source: own calcultations

1780

1781 The following figure shows the forest cover at year 2021 and the polygons deforested

1782 between 2016 and 2021 in the Cerrado biome.



1784
 1785
 Figure 33 – Forest cover (in green) and deforested polygons (in red) in the Cerrado biome
 1786 (2016/2017 – 2020/2021)

1787 Source: own calcultations based on PRODES data

1788

1789 6.3. Caatinga biome

1790

1791 The following table and figure present the area deforested in each annual period of the 1792 reference period and corresponding CO₂ emissions associated with gross deforestation in the 1793 Caatinga biome.

1794

1795 Table 33 – Gross GHG emissions associated with deforestation in the Caatinga Biome

Period	Annual area deforested (ha yr ⁻¹)	Gross CO ₂ emissions (tonnes CO ₂ yr ⁻¹)	
2016-2017	213,663	28,318,172	
2017-2018	206,501	25,191,250	
2018-2019	176,298	23,870,541	
2019-2020	209,054	28,416,933	
2020-2021	198,817	25,414,849	
Ανε	Average		

1796

1797 Source: own calcultations

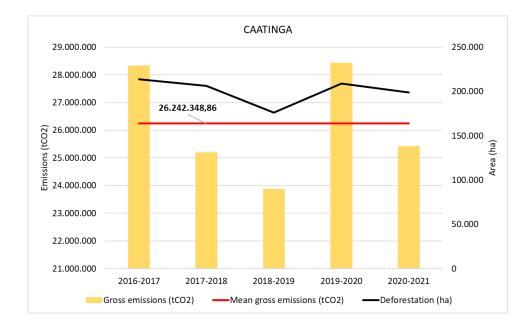


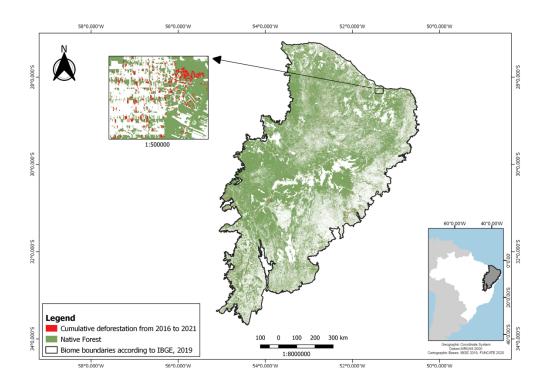
Figure 34 – Gross CO₂ emissions and annual deforestation in the Caatinga biome (2016/2017 2020/2021)

1803 Source: own calcultations

1804

1807

1805 The following figure shows the forest cover at year 2021 and the polygons deforested 1806 between 2016 and 2021 in the Caatinga biome.



1808 1809

1810 Figure 35 – Forest cover (in green) and deforested polygon (in red) in the Caatinga biome
1811 (2016/2017 – 2020/2021)

1812 Source: own calcultations based on PRODES data

1815

1814 6.4. Atlantic Forest biome

1816 The following table and figure present the area deforested in each annual period of the 1817 reference period and corresponding CO₂ emissions associated with gross deforestation in the 1818 Atlantic Forest biome.

1819

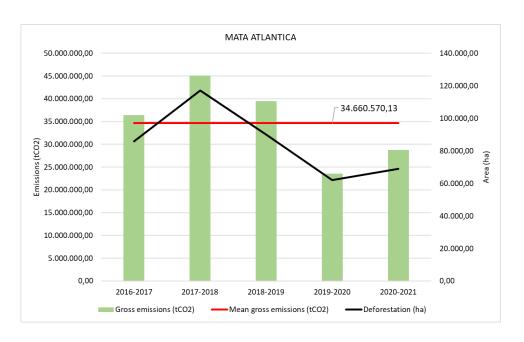
Table 34 – Annual area deforested and corresponding gross GHG emissions associated with deforestation in the Atlantic Forest Biome

Period	Annual area deforested (ha yr ⁻¹)	Gross CO ₂ emissions (tonnes CO ₂ yr ⁻¹)
2016-2017	85,870	36,434,019
2017-2018	117,209	45,100,213
2018-2019	89,850	39,463,224
2019-2020	62,143	23,544,177
2020-2021	68,965	28,761,218
Ave	34,660,570	

1822

1823 Source: own calcultations

1824



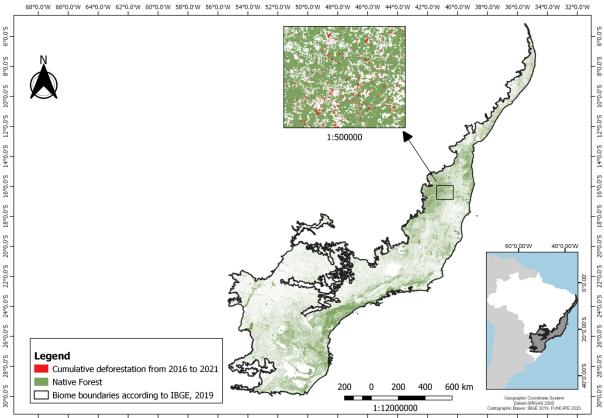
1825 1826

1827Figure 36 – Gross CO2 emissions and annual deforestation in the Atlantic Forest biome1828(2016/2017 – 2020/2021)

1829 Source: own calcultations

1830

1831 The following figure shows the forest cover distribution at year 2021 and the polygons 1832 deforested between 2016 and 2021 in the Atlantic Forest biome.



1833 1834

68°0.0°W 66°0.0°W 64°0.0°W 62°0.0°W 60°0.0°W 58°0.0°W 56°0.0°W 54°0.0°W 52°0.0°W 50°0.0°W 48°0.0°W 46°0.0°W 44°0.0°W 42°0.0°W 40°0.0°W 38°0.0°W 36°0.0°W 34°0.0°W 32°0.0°W

Figure 37 – Forest cover (in green) and deforested polygon (in red) in the Atlantic Forest biome (2016/2017 – 2020/2021)

- 1837 Source: own calcultations based on PRODES data
- 1838

1839 6.5. Pampa biome

1840

1841 The following table and figure the area deforested in each annual period of the reference 1842 period and corresponding CO₂ emissions associated with gross deforestation in the Pampa 1843 biome.

1844

1845 Table 35 – Annual area deforested and corresponding gross GHG emissions associated with

1846 deforestation in the Pampa Biome

Period	Annual area deforested (ha yr ⁻¹)	Gross CO ₂ emissions (tonnes CO ₂ yr ⁻¹)
2016-2017	35,948	3,629,785
2017-2018	34,987	3,798,004
2018-2019	39,058	3,574,669
2019-2020	33,198	3,460,472
2020-2021	56,666	5,850,602
Av	4,062,706	

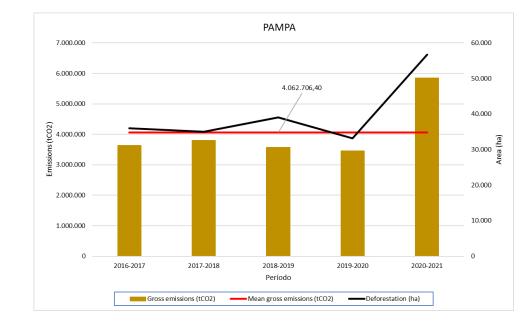
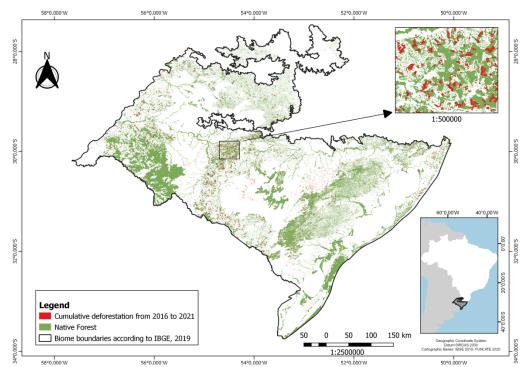


Figure 38 – Gross CO₂ emissions and annual deforestation in the Pampa biome (2016/2017 2020/2021)

1853 Source: own calcultations

The following figure shows the forest cover distribution at year 2021 and the polygonsdeforested between 2016 and 2021 in the Pampa biome.





(2016/2017 – 2020/2021)

¹⁸⁶¹ Source: own calcultations based on PRODES data

1864

1863 6.6. Pantanal biome

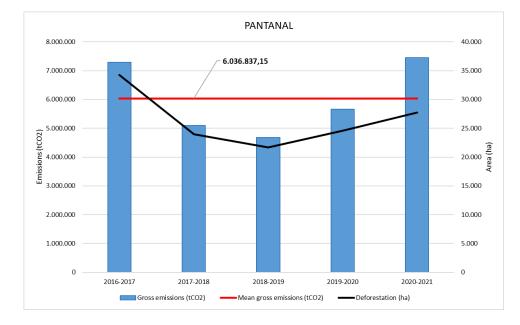
1865 The following table and figure the area deforested in each annual period of the reference 1866 period and corresponding CO₂ emissions associated with gross deforestation in the Pantanal 1867 biome.

1868

Table 36 – Annual area deforested and corresponding gross GHG emissions associated with deforestation in the Pantanal Biome

Period	Annual area deforested (ha yr⁻¹)	Gross CO ₂ emissions (tonnes CO ₂ yr ⁻¹)
2016-2017	34,287	7,296,713
2017-2018	23,976	5,101,431
2018-2019	21,684	4,684,070
2019-2020	24,558	5,655,516
2020-2021	27,761	7,446,456
Ave	6,036,837	

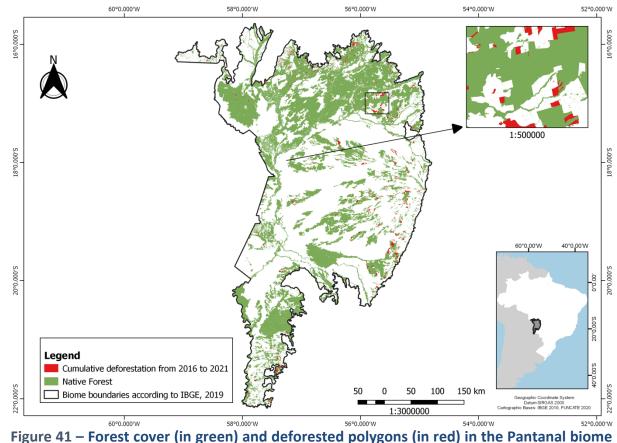
1871 1872



1873 1874

1875 Figure 40 – Gross CO₂ emissions and annual deforestation in the Pantanal biome 1876 (2016/2017 – 2020/2021)

- 1877 Source: own calcultations
- 1878
- 1879 The following figure shows the forest cover distribution at year 2021 and the polygons1880 deforested between 2016 and 2021 in the Pantanal biome.
- 1881
- 1882



1884 Figure 41 – Forest cover (in green) and deforested polygo
 1885 (2016/2017 – 2020/2021)

1886 Source: own calcultations based on PRODES data1887

1888 6.7. Brazil's National FREL

1889

1883

Brazil's national FREL is estimated as the sum of the gross average GHG emissions from
Atlantic Forest, Caatinga and Pantanal biomes and the net GHG emissions (in tonnes CO₂eeq) from Amazon and Cerrado biomes - Table 37 and Figure 42.

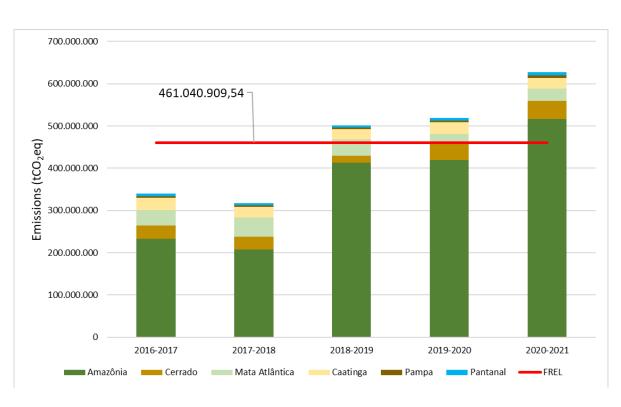
1893

1894 Table 37 – Brazil's national FREL for 2016-2017 / 2020-2021 period

Biome	Average emissions (tCO₂eq)	Туре
Amazônia	358,036,814	Net emissions
Cerrado	32,001,633	Net emissions
Atlantic forest	34,660,570	
Caatinga	26,242,349	
Pampa	4,062,706	Gross emissions
Pantanal	6,036,837	
FREL (sum)	461,040,910	

1896 Source: own calcultations





1900 Figure 42 – Brazil's national FREL for 2016-2017 / 2020-2021 period

1901 Source: own calculations

1902

1898 1899

Based on this FREL, Brazil intends to seek for results-based payments resulting from theimplementation of its policies and plans for REDD+.

1905

Box 10- Relevant policies and plans for REDD+

Brazil's sovereign commitment to the protection of native vegetation and the integrity of the climate system for the well-being of present and future generations was reiterated by <u>Law No. 12.651/2012</u> (Forest Code). Also, a series of policies, laws, regulations, actions and initiatives from various stakeholders contribute to REDD+ implementation, both at the national and biome/regional level. The National Strategy for REDD+ (ENREDD+) was set out in 2015 with the objective to contribute to scale up the implementation of policies to reduce deforestation and forest degradation from the Amazon and Cerrado biomes to the national level.

The action plans to prevent and control deforestation in the Amazon and in the Cerrado were the main mediators instruments of public policies in the territory. Since 2004 (in the case of the Amazon) and since 2010 (in the case of the Cerrado), the efforts made have shown meaningful results in terms of reducing deforestation rates. Nevertheless, there has been an upward trend in deforestation in the Amazon, which reflects a certain exhaustion of previous plans, with the need to develop more effective solutions to prevent and counter illegal deforestation. In this context, considering the search for new solutions in addition to those that had been performing well, in 2019 there was a transition to the new Plan for the

Control of Illegal Deforestation and Recovery of Native Vegetation, which encompasses the entire territory, approved by the Commission for the Control of Illegal Deforestation and Recovery of Native Vegetation – CONAVEG (Decree No. 10.142/2019). The purpose of the new plan is to reduce illegal deforestation and degradation of native vegetation through positive measures that impact on new dynamics and encourage sustainable production models as an alternative to the suppression of native vegetation.

The National Plan for the Control of Illegal Deforestation and Recovery of Native Vegetation provides guidelines for combating deforestation based on three cross-cutting themes: business environment, innovation and technological solutions, and financing for sustainable practices. In order to support coordination and integration of these themes, the Plan was structured in 05 major axes: (i) zero tolerance to deforestation and firefighting, (ii) land tenure regularization, (iii) territorial management, (iv) bio-economy, (v) payment for environmental services.

It is also worth to mention the approval of the National Policy for Payments for Environmental Services (Law 14.119/2021) witch has been under discussion within the Technical Committee for its regulatory procedures.

Specifically about results-based payments, the National REDD+ Committee (Decree No. 10.144/2019) took important steps in the implementation of REDD+ beyond the Amazon, with the approval, in 2022, of the fundraising limits and eligibility criteria for the entities of the Cerrado biome, based on the results for reducing deforestation in this biome verified by the UNFCCC.

1906

6.8. **Uncertainties** 1907

1908

1909 The following tables presents the uncertainty estimates for gross GHG emissions associated 1910 with deforestation, degradation, and removals from secondary vegetation. Values presented 1911 in percent uncertainties around the estimated value, representing a 95% confidence interval.

1912

1913 Table 38 – Uncertainty of gross CO₂ emissions from deforestation

Year	Amazon	Cerrado	Caatinga	Atlantic Forest	Pampa	Pantanal
2017	8.3	13	18	18	18	24
2018	8.0	12	19	15	18	25
2019	8.3	13	17	17	17	23
2020	8.1	13	17	15	18	24
2021	8.0	12	18	16	15	26
Average	8.1	13	18	16	17	24

1915 Source: own calculations

1917 Table 39 – Uncertainty of CO₂ removals from secondary vegetation and CO₂ emissions from 1918 degradation

	Removals from se	condary vegetation	Degradation due to fire	Degradation due to logging
Year	Amazon	Cerrado	Am	nazon
	%	%	%	%
2017	50	50	38	15
2018	50	50	58	12
2019	50	50	36	11
2020	50	50	35	10
2021	50	50	33	10
Average	50	50	35	10

1919

1920 Source: own calculations

1921

1922 Table 40 – Uncertainty of CH₄ emissions

	Defore	Degradation due to fire	
Year	Amazon	Cerrado	Amazon
	%	%	%
2017	92	93	99
2018	92	93	110
2019	92	93	98
2020	92	93	98
2021	92	92	97
Average	92	93	98

1923

1924 Source: own calculations

1925

1926 Table 41 – Uncertainty of N₂O emissions

	Defore	Degradation due to fire	
Year	Amazon	Cerrado	Amazon
	%	%	%
2017	89	90	96
2018	89	89	110
2019	89	90	96
2020	89	89	95
2021	89	89	95
Average	89	89	95

19271928 Source: own calculations1929

1930 Table 42 – Uncertainty of net emissions

Year	Amazon	Cerrado	
	%	%	
2016-2017	44	130	
2017-2018	46	130	
2018-2019	27	230	
2019-2020	27	130	
2020-2021	23	92	
Average	30	120	

1931

1932 Source: own calculations

1933

As mentioned in the 2019 Refinement to the 2006 IPCC Guidelines (footnote in 3.20 of Vol. 1) the option for expressing uncertainties in percent terms allows the results to be presented in a user-friendly way. However, caution should be exercised in the interpretation of the results in cases where the point estimate is very small when compared with the size of the confidence interval (e.g., a sector or inventory where removals and emissions are of similar sizes).

1939

1940 That is exactly the case for the net emissions in the Cerrado biome where gross emissions and 1941 removals from regeneration have the same order of magnitude. For more clear 1942 understanding we also include the uncertainty of the net emissions expressed as the 95% 1943 confidence interval.

1944

1945 Table 43 – Uncertainty of net emissions expressed as 95% interval around the mean

	Confidence Interval		Confidence Interval	
Year			Cerrado	
		(tonne	es CO ₂ eq)	
2016-2017	128.841.401	333.042.673	-8.160.194	71.656.486
2017-2018	111.260.659	303.444.501	-9.386.771	70.068.717
2018-2019	301.626.426	521.235.832	-22.214.306	56.244.385
2019-2020	304.268.561	532.312.691	-2.817.145	77.470.717
2020-2021	398.690.026	632.779.443	3.299.709	83.854.731
Average	250.580.365	462.920.077	-7.806.659	71.809.924

1946

1947 Source: own calculations

1949 7. References

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2100	

8. Annex: Additional Information 2101

2102

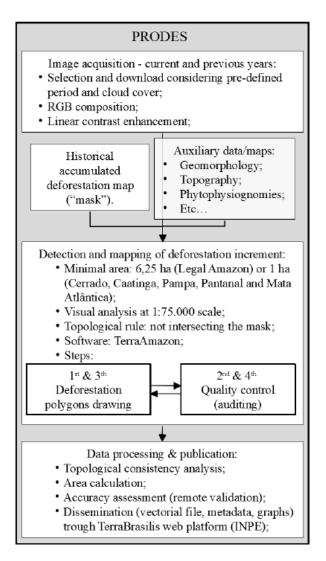
8.1. Additional information related to defore station activity 2103 data

2104

2105

2106 The mapping of the areas deforested in each biome followed the methodology developed and used in PRODES-Amazônia (Almeida, et al., 2020) and PRODES-Cerrado (INPE, 2018), in 2107 2108 order to ensure that the identification of deforestation polygons is consistent throughout all 2109 Brazilian territory. In general, the methodology involves visual analysis followed by manual 2110 vectorization of deforestation using medium-resolution satellite images (Landsat type) -2111 Figure 43.

2112





- 2115 Figure 43 – General description of PRODES methodology
- 2116 Source: Adapted from Almeida, et al., 2020
- 2117

- 2118The images used to identify the deforested polygons were selected following a priority period2119in order to have regular annual intervals. The defined periods include a priority quarter
- associated with an extended period which adds one or two months beyond the priority
- 2121 quarter.

Biome	Priority period	Extended period		
Amazon July-August-September		July-August-September-October- November		
Cerrado	July-August-September	June-July-August-September		
Caatinga	August-September-October (ASO)	July-August-September-October- November-December		
Pampa	September-October-November (SON)	August-September-October- November-December		
Pantanal	July- August-September (JAS)	July-August-September-October		
Atlantic Forest - north	October-November -December (OND)	September-October-November- December		
Atlantic Forest south-center	June-July-August (JJA)	June-July-August-September		

2122 Table 44 – Satellite images selection period

2123

2124 Source: INPE/FUNCATE

2125

- 2126 Table 45 Average interval of days considered in the selection of images, for each biome,
- 2127 and period of analysis period

Period	Average interval of days					
Periou	Amazon	Cerrado	Atlantic Forest	Caatinga	Pampa	Pantanal
2016-2017	361	370	377	408	360	364
2017-2018	364	352	374	358	369	368
2018-2019	389	378	356	388	381	363
2019-2020	362	369	343	356	323	367
2020-2021	367	365	360	330	392	369

2128

2129 Source: FUNCATE

2130

For each of the biomes, there was a team of qualified interpreters that generated deforestation data for each of the periods, thus reducing potential inconsistencies in the identification of deforestation patterns in each of the maps produced.

2134

A reference map was generated from satellite imagery for the reference period and each biome, indicating the accumulated areas of deforestation and non-deforestation (considered natural areas). From this reference map, according to the methodology presented in **Figure 43**, areas were identified and mapped at the scale of 1:100,000. **Table 46** shows the number of scenes for each biome for each year analyzed. The sum of the areas of the deforestation polygons identified within a given geographical extent (e.g., biome) is referred to as increment of deforestation.

2143 Deforestation increments in forest areas in the period 2016 to 2021 constitute the activity 2144 data to estimate CO₂ emissions from deforestation. Brazil's National FREL considers the 2145 increments of deforestation (ha/yr) for each of the following periods: 2016-2017, 2017-2018, 2018-2019, 2019-2020, 2020-2021.

2147

Table 46 – Number of scenes analyzed in each annual period of the historical series, for each
 biome

Biome	Number of Landsat scenes used to cover the biome
Amazon	203
Cerrado	126
Atlantic Forest	89
Caatinga	52
Pampa	17
Pantanal	16

2150

2151

2152 8.2. Additional information related to forest degradation2153 activity data

2154

Spatial data on forest degradation are available through INPE's DETER System, whose methodology is described in Almeida et al. (2022). In summary, DETER's methodology is based on the visual analysis of CBERS WFI satellite images in color composites of bands 5 (R), 4 (G) and 3 (B) and shadow fraction and vegetation images acquired through linear model analysis of spectral mixture, in addition to multi-time series of Landsat and CBERS images (Almeida, et al., 2022).

2161

Degradation polygons in the DETER system are associated with logging (orderly/geometric and irregular/disordered) and "fire scars". The area of the polygons identified as degradation in each annual period may continue to be exploited or burned in subsequent years and may eventually be deforested, either partially or totally. Therefore, a given polygon classified as degraded may be reclassified as deforested in subsequent years.

2167

Areas of selective logging and "fire scars" in Amazon biome are available for all years of the reference period.

- 2170
- 2171

2172 8.2.1. Orderly and disordered logging

2173

2174 Mapping classes for logging follow distinct patterns that result from the very the way the 2175 wood exploration is carried out. DETER classified the logging activities into two categories: 2176 irregular/disordered logging and regular/orderly (Almeida, et al., 2022).

- 2177
- Irregular/disordered logging: it is considered a common type of wood extraction, where trees of commercial interest are removed without prior planning, identified unorderly shape of roads and extensions inside the forest and with the presence of storage patios with disordered dimensions and arranged randomly arranged.
- 2182 2. <u>Regular/orderly logging:</u> it is considered to be related to an exploration based on some type of management plan (legal or not), in which one perceives the spatial organization of elements such as roads and storage patios inside the forest.
- Only logging with disordered geometric patterns available in the DETER System was considered in this FREL submission as part of forest degradation. Once the SINAFLOR data are available (see **Box 7**), it will be possible to verify if the non-regular logging is indeed associated with forest degradation and not to management plans. The data will be instrumental to further discriminate forest degradation activities from those associated with approved management plans.

2192

2185

2193 It is noteworthy that the definition of the logging classes is based only on the interpretation 2194 of the image based on the observed patterns of logging, and there is a limited capacity to 2195 identify the number of trees felled per hectare, volume extracted and secondary impact 2196 inside the forest or the legality of the intervention. *Figure 44* presents examples of alerts 2197 related to logging activities following DETER methodology (Almeida et al., 2022).

	Corte seletivo geométrico CBERS-4 169/105 05/09/2020
	Corte seletivo desordenado CBERS-4 179/111 23/10/2020

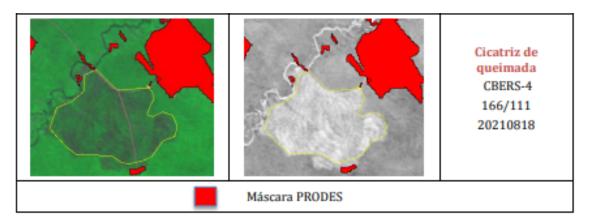
- 2201 Figure 44 Example of orderly (up) and disordered (bottom) logging from DETER system
- 2202 Source: DETER
- 2203

2205

2204 8.2.2. Fire scar

According to Valeriano et al. (2016) a **"fire scar"** an area that presents spectral characteristics associated with a fire occurrence. **Figure 45** presents an example of an area affected by fire that was mapped under as a DETER "fire scar".

2209



- 2211 Figure 45 Example of a "fire scar" in the DETER system
- 2212 Source: DETER

2213	
2214 2215 2216	8.3. Additional information related to the areas of natural forest regeneration (secondary vegetation)
2217 2218 2219 2220 2221 2222	8.3.1. Secondary vegetation – Amazon To estimate net emissions in the Amazon biome, the areas of natural forest regeneration in areas previously deforested in the Amazon biome were first obtained from the TerraClass Project , were assessed. Unlike PRODES and DETER, such mapping is not produced with the same frequency as PRODES and DETER data, and information is only available for years 2014
2223 2224 2225 2226 2227 2228 2229	According to Almeida, et al. (2016), areas of secondary vegetation consist of those forest areas that have been deforested and later abandoned for natural regeneration. Areas mapped as secondary vegetation may be in different stages of regeneration: initial, when the canopy is homogeneous and few species are found; or advanced, when the heterogeneity of the canopy and the diversity of species is similar to the original forest (Vieira, et al., 2003).
2230 2231 2232 2233 2234 2235 2236 2237	For 2014, the methodology used to map areas of secondary vegetation was based on the use of fraction images and color composites of Landsat-5/TM 3, 4 and 5 bands. Using the images and a linear mixing model, it was possible to identify a threshold above which the soil cover is dominated by secondary vegetation. These values varied for each image and once the spectral pattern was identified, image slicing technique was applied to create a thematic image (Almeida C. A., Valeriano, Escada, & Rennó, 2010).
2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250	For 2020 the methodology was based on a random stratified sampling in two stages. Initially, the Amazon biome was stratified by state and, later, by percentage of deforested area. To obtain the strata, the percent data of secondary vegetation mapped by TerraClass in the years 2014, 2012 and 2010 were used. After the stratification, parcels with 20 km by 20 km were randomly selected and training samples collected and subject to automatic classification, performed by a machine learning algorithm on cloud-based geospatial analysis platform Google Earth Engine (GEE). The classification used all available images for the period between June 2020 and October 2020, obtained by Sentinel-2/MSI satellite. Based on the area mapped in each of the parcels, the areas of secondary vegetation for the nine Amazon States and, later, for the Legal Amazon were estimated by direct expansion. Next, a subset of parcel training samples was used to map the secondary vegetation area to the State, providing spatially explicit areas.
2251 2252 2253	8.3.2. Secondary vegetation – Cerrado Secondary vegetation defined by TerraClass Cerrado is related to a natural vegetation
1115	- DECUDUALY VERELATION DELIDED BY TELEVILLANS CELLADO IS LEIATED TO A DATILIAL VERELATION

Secondary vegetation defined by TerraClass Cerrado is related to a natural vegetation
formation, with predominance of savanna forest (*"cerradão"*) with trees with height between
15 and 18 meters and characterized by trees and shrubs with tortuous trunks that had been

previously deforested. In the Cerrado biome, secondary vegetation data are available only forthe years 2018 and 2020.

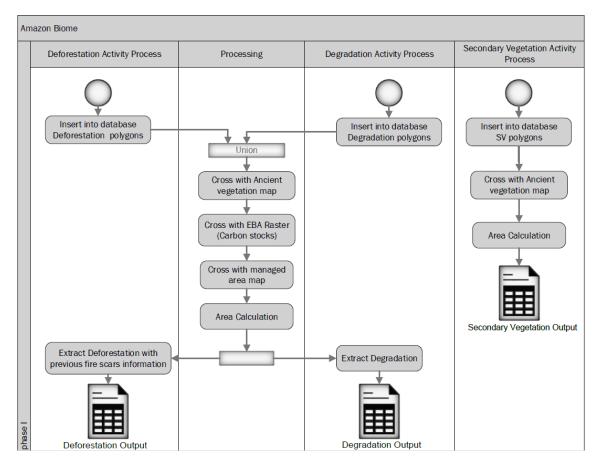
2258

2259 8.4. Detail description for estimating GHG emissions/removals2260 in the Amazon biome

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The operational procedures, based on the methodological approach described in page 56, used to estimate GHG emissions due to deforestation, forest degradation and removals from secondary vegetation growth in the Amazon biome are detailed below. Overview of phase 1 is presented in **Figure 46**, where spatial data is assembled and spreadsheets are acquired to next calculation steps.

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2268 2269

Figure 46 – Phase 1 workflow in GIS to deliver deforestation, degradation and secondary
 vegetation outputs to further phases

- 2272 Source: own elaboration
- 2273
- 2274

2275 8.4.1. Deforestation output – Amazon biome

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PHASE 1 – GIS operations

The 1st phase involves several spatial operations in a GIS environment (especially TerraAmazon software), with the aim to consolidate and merge maps presenting deforestation areas and other important information. The following steps (**Erro! Fonte de r eferência não encontrada.**) summarize these operations:

- Step 1: Vectorial data gathering and verification (database creation), considering:
 a. PRODES maps presenting polygons of native vegetation conversion increments
- 2285
- a. PRODES maps presenting polygons of native vegetation conversion increments for the periods 2016-2017, 2017-2018, 2018-2019, 2019-2020 and 2020-2021
 - b. DETER degradation maps presenting fire scars and selective logging areas
- 2286 c. Biomes boundaries (*Figure 1*)
 - d. Ancient native vegetation map (*Figure 9*)
- e. Managed areas map
 - Verifications consists in a routine of procedures to identify topology errors (such as overlaps and gaps) and lack of information.
- Step 2: Spatial operations execution to join step 1 data and then to filter only
 deforestation polygons (i.e., native vegetation clearing occurring in forest
 phytophysiognomies according to the ancient native vegetation map).
- Step 3: Association of the emission factors (i.e., carbon stocks per unit area) to each deforestation polygon through the extraction of the spatial average value from the EBA raster map (4th National GHG Inventory maps presenting each carbon pool).
- Step 4: Exportation of an electronic spreadsheet containing, for each annual period of
 the reference period, the deforestation polygons and their corresponding
 phytophysiognomies and associated carbon stocks for above-ground biomass, below ground biomass, dead wood and litter Table 47.
- Table 47 Outcome of phase 1 "GIS operations" for the Amazon deforestation component,
 which is the input for next phases.

Variable name	Description	Unit	Spreadsheet column	Source
Biome	Biome classification: Amazon	n/a	A	IBGE, 2019
main_class	REDD+ activity classification: Deforestation	n/a	В	PRODES
class_name	REDD+ activity/year classification	n/a	С	
year	Year where the REDD+ activity have occurred	n/a	D	
deter2017		n/a	E	DETER

Variable name	Description	Unit	Spreadsheet column	Source
deter2018	Degradation classification in corresponding	n/a	F	
deter2019	year:	n/a	G	
deter2020	 Fire ("burn scar") Disordered logging ("CS") 	n/a	Н	
deter2021	- orderly logging ("CSR")	n/a	I	
status			J	
source_inv	Corresponding biome classification in the 4 th GHG National Inventory	n/a	К	4 th GHG National
phytophysiognomy	Ancient vegetation phytophysiognomies	n/a	L	Inventory
category	Vegetation category: Forest (F)	n/a	М	
managed_land	indicates whether the polygon is situated in a managed area ("t" = true) or not ("f" = falsa)	n/a	N	-
EBA_cagb	Carbon content – above ground biomass carbon pool	tC/ha	0	EBA (4 th GHG
EBA_cbgb	Carbon content – below ground biomass carbon pool	tC/ha	Р	National Inventor)
EBA_cdw	Carbon content – dead wood carbon pool	tC/ha	Q	
EBA_clitter	Carbon content – litter carbon pool	tC/ha	R	
EBA_c4	Total carbon	tC/ha	S	
area_ha	Polygon area	ha	Т	Own estimates

2309 Source: Electronic spreadsheet "P3h_FREL_AMAZONIA_EMISSOES_DESMATAMENTO_1ha-

2310 6ha_Cenario3_v20201030.xlxs"

2311

		A	В	С	D	E	F	G	н	1	J	K	L	M	Ν	0	Р	Q	R	S	Т
	1.1	biome	main_class	class_name	year	deter2017	deter2018	deter2019	deter2020	deter2021	status	source_inv	phytophysiognomy	category	managed_land	eba_cagb	eba_cbgb	eba_cdw	eba_clitter	eba_ctotal	area_ha
2242	2 4	Amazonia	DESMATAMENTO	d2017	201	7 CQ1					DETER	Amazonia	Aa	F	f	17,09	1,71	1,38	0,99	21,17	0,834
2312	3 4	Amazonia	DESMATAMENTO	d2017	201	7		CQ1			DETER	Amazonia	Aa	F	f	40,19	4,02	3,26	2,32	49,79	0,0032

2314 Figure 47 – Illustrative representation of the electronic spreadsheet output from Phase 1

2315 Source: own elaboration

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Each line of the spreadsheet represents a group of polygons with the same characteristics, except for their individual area. The "area_ha" attribute represents the sum of the individual deforested polygons areas. Such aggregation was necessary due to the large amount of data generated for the Amazon biome, which are not supported by Excel.

2321

PHASE 2 – Emissions calculations

2323	Emissi	ons calculations were performed in chronological order, according to the occurrence of
2324	degrad	lation and/or deforestation activities, always applying the degradation losses before
2325	losses	due to deforestation within the same year. The following steps were followed ³² :
2326		
2327	0	Step 1 : Calculation of carbon stocks available in <i>t0</i> (in tonnes of C, i.e., tC/ha stock
2328		values already multiplied by areas in ha) by total and carbon pools:
2329		Column U: total C stock <i>t0 [=S3*T3]</i>
2330		Column V: aerial C stock <i>t0 [=(O3+Q3+R3)*T3]</i>
2331		Column W: above ground C stock <i>t0 [=O3*T3]</i>
2332		
2333	0	Step 2: Calculation of C, CH ₄ and N ₂ O emissions and other losses due to degradation
2334		in 2017:
2335		Column X: C emissions due to fire in managed lands
2336		Column Y: CH ₄ emissions due to fire in managed lands
2337		Column Z: N ₂ O emissions due to fire in managed lands
2338		Column AA: C emissions due to disordered logging (CS)
2339		Column AB: Closs due to fire in unmanaged lands
2340		Column AC: Closs due to orderly logging (CSR)
2341		
2342	0	Step 3 : Calculation of remaining carbon stocks after degradation in 2017, representing
2343		carbon stocks available for deforestation in 2017:
2344		Column AD: total C stock <i>t1</i>
2345		Column AE: aerial C stock t1
2346		Column AF: above ground C stock t1
2347		
2348	0	Step 4 : Calculation of C, CH_4 and N_2O emissions due to deforestation in 2017:
2349		Column AG: C emissions due to deforestation
2350		Column AH: CH ₄ emissions due to deforestation (resulting from slash and burn)
2351		Column AI: N ₂ O emissions due to deforestation (resulting from slash and burn)
2352		Charles F. Cala Jatian of an data strategies with the effect 2017 and a strategies at the strategies
2353	0	Step 5 : Calculation of carbon stocks available after 2017, representing carbon stocks
2354		available for degradation in 2018:
2355		Column AJ: aerial C stock <i>t2</i>
2356		Column AK: above ground C stock <i>t2</i>
2357	0	Stop 6: Colculation of C. CH, and N.O. omissions and other lasses due to degradation
2358 2359	0	Step 6 : Calculation of C, CH ₄ and N ₂ O emissions and other losses due to degradation in 2018:
2559		111 2018.
2360		Column AL: C emissions due to fire in managed lands
2361		Column AM: CH ₄ emissions due to fire in managed lands
2362		Column AN: N ₂ O emissions due to fire in managed lands
2363		Column AO: C emissions due to disordered logging (CS)
2364		Column AP: C carbon loss due to fire in unmanaged lands
2365		Column AQ: C carbon loss due to orderly logging (CSR)
2366		

³² Refer to file: "P3h_FREL_AMAZONIA_EMISSOES_DESMATAMENTO_1ha-6ha_Cenario3_v20201030.xlxs"

2367	0	Step 7 : Calculation of carbon stocks available after 2018 degradation, representing
2368		carbon stocks available for deforestation in 2018:
2369		Column AR: total C stock t3
2370		Column AS: aerial C stock t3
2371		Column AT: above ground C stock t3
2372		
2373	0	Step 8 : Calculation of C, CH ₄ and N ₂ O emissions due to deforestation in 2018:
2374	-	Column AU: C emissions due to deforestation
2375		Column AV: CH ₄ emissions due to deforestation (resulting from slash and burn)
2376		Column AW: N ₂ O emissions due to deforestation (resulting from slash and burn)
2377		
2378	0	Step 9: Calculation of carbon stocks available after 2018, representing carbon stocks
2379	Ŭ	available for degradation in 2019:
2380		Column AX: aerial C stock <i>t4</i>
2381		Column AY: above ground C stock <i>t4</i>
2382		
2383	0	Step 10 : Calculation of C, CH_4 and N_2O emissions due to degradation in 2019:
2385	0	Column AZ: C emissions due to fire
2385		Column BA: CH ₄ emissions due to fire
2385		Column BB: N_2O emissions due to fire
2380		Column BC: Cemissions due to disordered logging (CS)
2388		Column BD: C carbon loss due to fire in unmanaged lands
2389		-
		Column BE: C carbon loss due to orderly logging (CSR)
2390		Step 11 . Colculation of carbon stacks available ofter 2010 degradation representing
2391	0	Step 11 : Calculation of carbon stocks available after 2019 degradation, representing the earbon stocks available for deforestation in 2010.
2392		the carbon stocks available for deforestation in 2019:
2393		Column BF: total C stock t5
2394		Column BG: aerial C stock t5
2395		Column BH: above ground C stock t5
2396	_	Stan 12 : Calculation of C. Cl. and N. O amissions due to defense tation in 2010.
2397	0	Step 12 : Calculation of C, CH_4 and N_2O emissions due to deforestation in 2019:
2398		Column BI: Cemissions due to deforestation
2399		Column BJ: CH ₄ emissions due to deforestation (resulting from slash and burn)
2400		Column BK: N ₂ O emissions due to deforestation (resulting from slash and burn)
2401		Charles 12 Calls Julian of an dealer standard with the Charles 2010 and an attraction and the standard
2402	0	Step 13 : Calculation of carbon stocks available after 2019, representing carbon stocks
2403		
		available for degradation in 2020:
2404		Column BL: aerial C stock t6
2405		0
2405 2406		Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i>
2405 2406 2407	0	Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i> Step 14: Calculation of C, CH ₄ and N ₂ O emissions due to degradation in 2020:
2405 2406 2407 2408	0	Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i> Step 14 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation in 2020: Column BN: C emissions due to fire
2405 2406 2407 2408 2409	0	Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i> Step 14 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH ₄ emissions due to fire
2405 2406 2407 2408 2409 2410	0	Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i> Step 14 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH ₄ emissions due to fire Column BP: N ₂ O emissions due to fire
2405 2406 2407 2408 2409 2410 2411	0	Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i> Step 14 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH ₄ emissions due to fire Column BP: N ₂ O emissions due to fire Column BQ: C emissions due to disordered logging (CS)
2405 2406 2407 2408 2409 2410	0	Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i> Step 14 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH ₄ emissions due to fire Column BP: N ₂ O emissions due to fire

2414 2415 2416	0	Step 15 : Calculation of carbon stocks available after 2020 degradation, representing the carbon stocks available for deforestation in 2020:
2410		Column BT: aerial C stock t7
2418		Column BU: above ground C stock t7
2419		Column BV: above ground C stock t7
2420		
2421	0	Step 16: Calculation of C, CH ₄ and N ₂ O emissions due to deforestation in 2020:
2422		Column BW: Cemissions due to deforestation
2423		Column BX: CH ₄ emissions due to deforestation (resulting from slash and burn)
2424		Column BY: N ₂ O emissions due to deforestation (resulting from slash and burn)
2425		
2426	0	Step 17: Calculation of carbon stocks available after 2020, representing carbon stocks
2427		available for degradation in 2021:
2428		Column BZ: aerial C stock t8
2429		Column CA: above ground C stock <i>t8</i>
2430		
2431	0	Step 18 : Calculation of C, CH_4 and N_2O emissions due to fire degradation in 2021:
2432		Column CB: C emissions due to fire
2433		Column CC: CH ₄ emissions due to fire
2434 2435		Column CD: N ₂ O emissions due to fire
2435 2436		Column CE: C emissions due to disordered logging (CS) Column CF: C loss due to fire in unmanaged lands
2430 2437		Column CG: C loss due to orderly logging (CSR)
2437		Column CC. Closs due to orderly logging (CSK)
2439	0	Step 19: Calculation of carbon stocks available after 2021 degradation, representing
2440	0	the stocks available for deforestation in 2021:
2441		Column CH: Total C stock <i>t9</i>
2442		Column CI: above ground C stock t9
2443		Column CJ: above ground C stock t9
2444		
2445	0	Step 20: Calculation of C, CH ₄ and N ₂ O emissions due to deforestation in 2021:
2446		Column CK: Cemissions due to deforestation
2447		Column CL: CH4 emissions due to deforestation (resulting from slash and burn)
2448		Column CM: N ₂ O emissions due to deforestation (resulting from slash and burn)
2449		
2450	The fo	blowing table presents a numerical example of the calculations that have been carried
2451		s important to note the evolution of total carbon stocks. In green: initial total carbon
2452		; in blue: total carbon stocks after degradation events or not; in yellow: emissions due
2453		orestation whose values are associated with the reduced carbon stocks after previous
2454	degra	dation.
2455		
2456		

Table 48 – Example of GHG emissions for an area presenting a trajectory that passes through degradation by fire to deforestation³³

Column	Phase, Step	Attribute	Value
А	Phase 1	biome	Amazon
В	Phase 1	main_class	DESMATAMENTO
С	Phase 1	class_name	d2021
D	Phase 1	year	2021
E	Phase 1	deter2017	CQ1
F	Phase 1	deter2018	CQ2
G	Phase 1	deter2019	CQ3
Н	Phase 1	deter2020	CQ4
I	Phase 1	deter2021	CQ5
J	Phase 1	status	DETER
К	Phase 1	source_inv	Amazonia
L	Phase 1	phytophysiognomy	Fs
М	Phase 1	category	F
N	Phase 1	managed_land	t
0	Phase 1	eba_cagb	71.74
Р	Phase 1	eba_cbgb	7.17
Q	Phase 1	eba_cdw	5.81
R	Phase 1	eba_clitter	4.14
S	Phase 1	eba_ctotal	88.86
Т	Phase 1	area_ha	3.83
U	Phase 2,	Total carbon stock (t C) - t0	240.19
0	Step 1		340.18
V	Phase 2,	Total aerial carbon stock (t C) - t0	312.73
	Step 1 Phase 2,		
W	Step 1	Above ground living carbon stock (t C) - t0	274.64
х	Phase 2,	Emissions due to fire in 2017 in managed lands (tC)	115.09
	Step 2		113.05
Y	Phase 2, Step 2	Emissions due to fire in 2017 in managed lands (tCH ₄)	1.67
	Phase 2,		0.05
Z	Step 2	Emissions due to fire in 2017 in managed lands (tN ₂ O)	0.05
AA	Phase 2,	Emissions due to selective logging in 2017 (tC)	0.00
	Step 2 Phase 2,	Carbon stock decrease due to fire in unmanaged lands	
AB	Step 2	in 2017 (tC)	0.00
AC	Phase 2,	Carbon stock decrease due to selective regular logging	0.00
AL	Step 2	in 2017 (tC)	0.00
AD	Phase 2,	Total carbon stock (t C) - t1	225.10
	Step 3 Phase 2,		
AE	Step 3	Total aerial carbon stock (t C) - t1	197.65

³³ Extracted from: "P3h_FREL_AMAZONIA_EMISSOES_DESMATAMENTO_1ha-6ha_Cenario3_v20201030.xlxs"

Column	Phase, Step	Attribute	Value
AF	Phase 2, Step 3	Above ground living carbon stock (t C) - t1	101.07
AG	Phase 2, Step 4	Emissions due to deforestation in 2017 (tC)	0.00
АН	Phase 2, Step 4	Emissions due to post-fire deforestation in 2017 (tCH ₄)	0.00
AI	Phase 2, Step 4	Emissions due to post-fire deforestation in 2017 (tN_2O)	0.00
AJ	Phase 2, Step 5	Total aerial carbon stock (t C) - t2	197.65
AK	Phase 2, Step 5	Above ground living carbon stock (t C) - t2	101.07
AL	Phase 2, Step 6	Emissions due to fire in 2018 in managed lands (tC)	72.73
AM	Phase 2, Step 6	Emissions due to fire in 2018 in managed lands (tCH ₄)	1.05
AN	Phase 2, Step 6	Emissions due to fire in 2018 in managed lands (tN ₂ O)	0.03
AO	Phase 2, Step 6	Emissions due to selective logging in 2018 (tC)	0.00
AP	Phase 2, Step 6	Carbon stock decrease due to fire in unmanaged lands in 2018 (tC)	0.00
AQ	Phase 2, Step 6	Carbon stock decrease due to selective regular logging in 2018 (tC)	0.00
AR	Phase 2, Step 7	Total carbon stock (t C) - t3	152.36
AS	Phase 2, Step 7	Total aerial carbon stock (t C) - t3	124.91
AT	Phase 2, Step 7	Above ground living carbon stock (t C) - t3	37.19
AU	Phase 2, Step 8	Emissions due to deforestation in 2018 (tC)	0.00
AV	Phase 2, Step 8	Emissions due to post-fire deforestation in 2018 (tCH ₄)	0.00
AW	Phase 2, Step 8	Emissions due to post-fire deforestation in 2018 (tN_2O)	0.00
AX	Phase 2, Step 9	Total aerial carbon stock (t C) - t4	124.91
AY	Phase 2, Step 9	Above ground living carbon stock (t C) - t4	37.19
AZ	Phase 2, Step 10	Emissions due to fire in 2019 in managed lands (tC)	45.97
ВА	Phase 2, Step 10	Emissions due to fire in 2019 in managed lands (tCH ₄)	0.67
ВВ	Phase 2, Step 10	Emissions due to fire in 2019 in managed lands (tN ₂ O)	0.02
BC	Phase 2, Step 10	Emissions due to selective logging in 2019 (tC)	0.00
BD	Phase 2, Step 10	Carbon stock decrease due to fire in unmanaged lands in 2019 (tC)	0.00
BE	Phase 2, Step 10	Carbon stock decrease due to selective regular logging in 2019 (tC)	0,00

Column	Phase, Step	Attribute	Value
BF	Phase 2, Step 11	Total carbon stock (t C) - t5	106.39
BG	Phase 2, Step 11	Total aerial carbon stock (t C) - t5	78.95
ВН	Phase 2, Step 11	Above ground living carbon stock (t C) - t5	13.69
BI	Phase 2, Step 12	Emissions due to deforestation in 2019 (tC)	0.00
BJ	Phase 2, Step 12	Emissions due to post-fire deforestation in 2019 (tCH ₄)	0.00
ВК	Phase 2, Step 12	Emissions due to post-fire deforestation in 2019 (tN_2O)	0.00
BL	Phase 2, Step 13	Total aerial carbon stock (t C) - t6	78.95
BM	Phase 2, Step 13	Above ground living carbon stock (t C) - t6	13.69
BN	Phase 2, Step 14	Emissions due to fire in 2020 in managed lands (tC)	29.05
BO	Phase 2, Step 14	Emissions due to fire in 2020 in managed lands (tCH ₄)	0.42
BP	Phase 2, Step 14	Emissions due to fire in 2020 in managed lands (tN_2O)	0.01
BQ	Phase 2, Step 14	Emissions due to selective logging in 2020 (tC)	0.00
BR	Phase 2, Step 14	Carbon stock decrease due to fire in unmanaged lands in 2020 (tC)	0.00
BS	Phase 2, Step 14	Carbon stock decrease due to selective regular logging in 2020 (tC)	0.00
ВТ	Phase 2, Step 15	Total carbon stock (t C) - t7	77.34
BU	Phase 2, Step 15	Total aerial carbon stock (t C) - t7	49.89
BV	Phase 2, Step 15	Above ground living carbon stock (t C) - t7	5.04
BW	Phase 2, Step 16	Emissions due to deforestation in 2020 (tC)	0.00
BX	Phase 2, Step 16	Emissions due to post-fire deforestation in 2020 (tCH ₄)	0.00
BY	Phase 2, Step 16	Emissions due to post-fire deforestation in 2020 (tN_2O)	0.00
BZ	Phase 2, Step 17	Total aerial carbon stock (t C) - t8	49.89
СА	Phase 2, Step 17	Above ground living carbon stock (t C) - t8	5.04
СВ	Phase 2, Step 18	Emissions due to fire in 2021 in managed lands (tC)	18.36
СС	Phase 2, Step 18	Emissions due to fire in 2021 in managed lands (tCH ₄)	0.27
CD	Phase 2, Step 18	Emissions due to fire in 2021 in managed lands (tN_2O)	0.01
CE	Phase 2, Step 18	Emissions due to selective logging in 2021 (tC)	0.00

Column	Phase, Step	Attribute	Value
CF	Phase 2, Step 18	Carbon stock decrease due to fire in unmanaged lands in 2021 (tC)	0.00
CG	Phase 2, Step 18	Carbon stock decrease due to selective regular logging in 2021 (tC)	0.00
СН	Phase 2, Step 19	Total carbon stock (t C) - t9	58.98
CI	Phase 2, Step 19	Total aerial carbon stock (t C) - t9	31.53
CJ	Phase 2, Step 19	Above ground living carbon stock (t C) - t9	1.85
СК	Phase 2, Step 20	Emissions due to deforestation in 2021 (tC)	58.98
CL	Phase 2, Step 20	Emissions due to post-deforestation fire in 2021 (tCH ₄)	0.17
СМ	Phase 2, Step 20	Emissions due to post-deforestation fire in 2021 (tN_2O)	0.00

Step 21: Through dynamic tables, the sum of GHG emissions per REDD+ activity
 considered and annual period was calculated. The values obtained in this phase are in
 tonnes of C, CH₄ and N₂O.

2463

	А	В	С	D	E	F	G
	Soma de EM por	Soma de EM por	Soma de EM por				
	queimada em 2017	queimada em 2017	queimada em		Soma de EM por	Soma de EM por	Soma de EM por
	(tC) AREAS	(tCH4) AREAS	2017(tN2O) AREAS	Soma de EM por	desmatamento	desmatamento	desmatamento
1	MANEJADAS	MANEJADAS	MANEJADAS	CS em 2017 (tC)	2017 (tC)	em 2017 (tCH4)	em 2017 (tN2O)
2	32.376,37	468,42	13,78	1.523,80	10.871.135,25	47.440,38	1.395,31

2464 2465

Figure 48 – Emission results by the year 2017 according to the sources/activities in the Deforestation Outputs

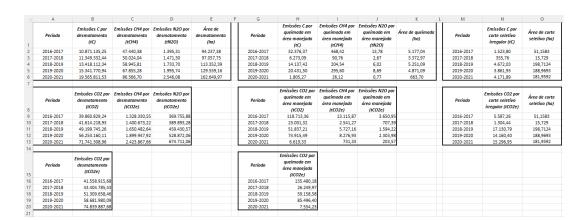
- 2468 Source: own elaboration
- 2469

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 Step 22: Emissions are converted into tones of CO2 equivalent. These values are used in the final calculation, added to the other outputs, to obtain the average net emission for the relevant biome. Figure 49 presents an example of CO2 eq emissions by REDD+ activity for the biome.



2475 2476 Figure 49 – Emission results for gross deforestation

2477 Source: own elaboration 2478

2479

Degradation output – Amazon biome 8.4.2. 2480

- PHASE 1 GIS operations 2481
- 2482

The 1st phase involves several "georeferenced operations" using SIG tools, with the aim to 2483 consolidate all different degradation activity data. As result, a spreadsheet was obtained, 2484 2485 containing the information presented in Table 49. Each line of the spreadsheet represents a 2486 group of polygons with the same characteristics, with the exception of the area (hectares). 2487 The area represents the sum of the individual polygons. Such aggregation was necessary due 2488 to the large amount of data.

2489

2490 Table 49 – Amazon degradation output main parameters

Variable name	Description	Unit	Spreadsheet column	Source
Biome	Biome classification: Amazon	n/a	А	IBGE, 2019
Main_class	REDD+ activity classification: "DEGRAD" meaning "degradation"	n/a	В	DETER
deter2017	Degradation classification in	n/a	С	
deter2018	corresponding year: - Fire ("burn scar")	n/a	D	
deter2019	- Disordered logging ("CS")	n/a	E	
deter2020	- orderly logging ("CSR")	n/a	F	
deter2021		n/a	G	
status			Н	
source_inv	Corresponding biome classification in the 4 th GHG National Inventory	n/a	I	4 th GHG National
Phytophysiognomy	Ancient vegetation phytophysiognomies	n/a	J	Inventory
category	Vegetation category: Forest (F)	n/a	К	
Managed_land	indicates whether the polygon is situated in a managed area ("t" = true) or not ("f" = falsa)		L	
EBA_cagb	Carbon content – above ground biomass carbon pool	tC/ha	Μ	EBA
EBA_cbgb	Carbon content – below ground biomass carbon pool	tC/ha	N	
EBA_cdw	Carbon content – dead wood carbon pool	tC/ha	0	
EBA_clitter	Carbon content – litter carbon pool	tC/ha	Р	

				column	
EBA_c	total	Total carbon	tC/ha	Q	
area_l	าล	Polygon area	ha	R	Own estimates
Source:	Electronic sprea	dsheet "1c_Amazon_Emissions_C	utput_Degradati	on.xls″	
• PH	ASE 2 – Emiss	ions calculations			
Emissi	ons calculatio	ns were performed in chrono	ological order,	according to the	e occurrence of
degrad	dation proces	ses (fire and/or disordered	l logging). Th	e following ste	eps have been
follow	ed ³⁴ :				
0	-	llation of carbon stocks avai	•		na stock values
		iplied by areas (in ha)) by tot	tal and carbon	pools:	
		5: total C stock <i>t0</i> T: aerial C stock <i>t0</i>			
		J: above ground C stock <i>tO</i>			
0	Step 2: Calc	ulation of C, CH_4 and N_2O	emissions fro	m degradation	due to fire in
	managed for	est areas or disordered logg	ing (CS) in 201	7:	
		/: C emissions due to fire in r	-		
		N: CH4 emissions due to fire	-		
		(: N2O emissions due to fire	-		
		Y: C emissions due to disorde Y: C loss due to fire in unman		5)	
		A: C loss due to orderly logg	0		
			5		
0	Step 3: Calcu	ulation of remaining carbon	stocks after d	egradation prod	cesses in 2017,
	-	e carbon stocks available for	⁻ potential deg	radation in 201	8:
		AB: aerial C stock t1			
	Column A	AC: above ground C stock <i>t1</i>			
~	Stop A: Calc	ulation of C, CH_4 and N_2O	omissions fro	m dogradation	dua ta fira in
0	-	est areas or disordered logg		-	due to me m
	-	AD: C emissions due to fire		0.	
		AE: CH ₄ emissions due to fire			
	Column A	AF: N ₂ O emissions due to fire	2		
	Column A	AG: C emissions due to disor	dered logging	(CS)	
		AH: C loss due to fire in unma	-		
	Column A	AI: C loss due to orderly logg	ing (CSR)		

Unit

Spreadsheet

Source

Variable name

Description

³⁴ Refer to file: "1c_Amazon_Emissions_Output_Degradation.xls "

2528	0	Step 5: Calculation of carbon stocks available after degradation processes in 2018,
2529		definining the carbon stocks available for potential degradation in 2019:
2530		Column AJ: aerial C stock t2
2531		Column AK: above ground C stock <i>t2</i>
2532		
2533	0	Step 6 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation by fire in managed
2534		forest areas or disordered logging (CS) in 2019:
2535		Column AL: C emissions due to fire
2536		Column AM: CH ₄ emissions due to fire
2537		Column AN: N ₂ O emissions due to fire
2538		Column AO: C emissions due to disordered logging (CS)
2539		Column AP: C loss due to fire in unmanaged lands
2540		Column AQ: C loss due to orderly logging (CSR)
2541		
2542	0	Step 7 : Calculation of the remaining carbon stocks available after degradation in 2019,
2543		defining the carbon stocks available for potential degradation in 2020:
2544		Column AR: aerial C stock <i>t3</i>
2545		Column AS: above ground C stock <i>t3</i>
2546		
2547	0	Step 8 : Calculation of C, CH ₄ and N ₂ O emissions due to degradation by fire in managed
2548	-	forest areas or disordered logging (CS) in 2020:
2549		Column AT: CO_2 emissions due to fire
2550		Column AU: CH ₄ emissions due to fire
2551		Column AV: N_2O emissions due to fire
2552		Column AW: C emissions due to disordered logging (CS)
2553		Column AX: C loss due to fire in unmanaged lands
2554		Column AY: C loss due to orderly logging (CSR)
2555		
2556	0	Step 9: Calculation of carbon stocks available after degradation processes in 2020,
2557	•	defining the carbon stocks available for potential degradation in 2021:
2558		Column AZ: aerial C stock <i>t4</i>
2559		Column BA: above ground C stock t4
2560		
2561	0	Step 10: Calculation of CO ₂ , CH ₄ and N ₂ O emissions from degradation due to fire in
2562	-	managed forest areas or disordered logging (CS) in 2021:
2563		Column BB: CO_2 emissions due to fire
2564		Column BC: CH ₄ emissions due to fire
2565		Column BD: N_2O emissions due to fire
2566		Column BE: C emissions due to disordered logging (CS)
2567		
2568	0	Step 11: Through dynamic tables, the sums of GHG emissions were calculated. The
2569	Ŭ	values obtained in this phase are in tons of C, CH_4 and N_2O .
2570		
2571	0	Step 12: Emissions are converted into tones of CO2 equivalent. These values will be
2572	2	used in the final calculation and added to the other outputs, to obtain average net
2573		emission from the biome.

2575 8.4.3. Secondary vegetation output – Amazon biome

PHASE 1 – GIS operations

2577

The 1st phase involves several spatial operations using SIG tools, with the aim to consolidate all different secondary vegetation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 50**. Each line of the spreadsheet represents a group of polygons with the same characteristics, with the exception of the area (hectares). The area represents the sum of the individual polygons. Such aggregation was necessary due to the large amount of data.

2584

2585 Table 50 – Amazon secondary vegetation output main parameters

Variable name	Description	Source
Biome	Biome classification: Amazon	
class_2014	Secondary vegetation class for year 2014	TerraClass
class_2020	Secondary vegetation class for year 2020	
phytophysiognomy	Ancient vegetation phytophysiognomies	4 th GHG National
category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)	Inventory
area_ha	Polygon area	Own estimates

2587 2588	• P	HASE 2 – Removals calculations
2589	C	
2590 2591		2020)
2592	C	
2593 2594		2020) considering factor of 3,03 tC/ha.yr
2595	C	Step 3 : Conversion of tonnes of C tonnes to CO ₂ equivalent
2596		
2597	C	Step 4 : Calculation of the average annual removal average rate (tC/yr)
2598 2599	C	Step 5: Application of the value obtained for each year of the reference period
2600		
2601		
2602		

2603	8.4.4.	Net GHG emission – Amazon	biome ³⁵

2604 2605 2606 2607 2608 2609	 PHASE 3 – Consolidation of results Step 1: Calculation of the annual net GHG emission: sum of gross GHG emissions by deforestation and degradation minus removals by natural forest regeneration in each annual period
2610	
2611 2612 2613 2614 2615 2616 2617	 8.5. Detailed description for estimating GHG emissions/removals in the Cerrado biome The operational procedures, based on the methodological approach described in page 56, used to estimate GHG emission due to deforestation and removals from growth of natural forest regeneration in the Cerrado biome are presented in sequence.
2618 2619	8.5.1. Deforestation output – Cerrado biome
2620 2621 2622	• PHASE 1 – GIS operations The 1 st phase involves several spatial operations using GIS tools, with the aim to consolidate

all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 51**. Each line of the spreadsheet represents a single deforestation polygon.

2626

2627 Table 51 – Cerrado deforestation output main parameters

Variable name	Description	Unit	Spreadsheet column	Source
fid		n/a	Α	
Biome	Biome classification: Cerrado	n/a	В	IBGE, 2019
State	Brazilian political-administrative state	n/a	С	
Main_class	REDD+ activity	n/a	D	
Class_name	REDD+ activity/year classification		E	DDODEC
Year	Mapping year	n/a	F	PRODES
Image_date	Image date of each polygon	n/a	G	
source_inv	Corresponding biome classification in the 4 th GHG National Inventory	n/a	Н	4 th GHG National
phytophysiognomies	Ancient vegetation phytophysiognomies	n/a	I	Inventory

³⁵ Refer to file "3_Amazon_net_emissions.xlxs"

Varia	ble name	Description	Unit	Spreadsheet column	Source
Categ	ory	Land use category: Forest (F)	n/a	J	
rr_cagb		Above ground carbon stock	tC/ha	К	
rr_cb	gb	Below ground carbon stock	tC/ha	L	
rr_cdw Dead wood carbon stock tC/ha M					
rr_clitterLitter carbon stocktC/haN					
rr_cto	otal	Total carbon stock	tC/ha	0	
Area_	ha	Polygon area	ha	Р	Own calculations
0	Column Q: Column Q: Column R: Column R: Column R: Column R: Column R: Column Column S: a C	ion of C and CO ₂ due to defores C emissions due to deforestatio CO ₂ emissions due to deforestat ion of the mass of fuel available	n tion e for fire ue to "sl		
0	Step 4 : Through The values obta N₂O.	I ₂ O emissions due to deforestat pivot tables, the sum of emissi ined at this stage are in tonnes	ons per of CO ₂ , 1	tonnes of CH₄ a	nd tonnes of
 Step 5: Emissions are converted into tones of CO₂ equivalent. These values will be used in the final calculation and added to the other outputs, to obtain the average net emission for the biome. 					
	8.5.2.	Secondary vegetation ou	utput –	- Cerrado bi	ome
• P	HASE 1 – Georefe	renced operations			
conso conta group The a	blidate all differen hining the informator of polygons with	everal "georeferenced operation t deforestation activity data. As tion presented in Table 52 . Each the same characteristics, with e sum of the individual polygon at of data.	result, a line of t the exce	a spreadsheet w the spreadshee ption of the are	vas obtained, t represents a ea (hectares).

2661 Table 52 – Cerrado secondary vegetation output main parameters

Variable name	Description	Source
Biome	Biome classification: Cerrado	
class_2018	Secondary vegetation class for year 2018	TerraClass
class_2020	Secondary vegetation class for year 2020	
phytophysiognomy	Ancient vegetation phytophysiognomies	4 th GHG National
category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)	Inventory
Area_ha	Polygon area	Own calculations

2662

2663	•	PHASE 2 – Emissions calculations
2664		
2665		• Step 1 : Calculation of total area of secondary vegetation per year (2014 and 2020)
2666		
2667		• Step 2 : Calculation of C removals by secondary vegetation per year (2014 and 2020)
2668		considering factor of 3,03 tC/ha.yr
2669		
2670		 Step 3: Conversion of C tones to CO₂ equivalent
2671		
2672		 Step 4: Calculation of the annual removal average rate (tC/yr)
2673		
2674		• Step 5: Application of the value obtained for each year of the series
2675		
2676		8.5.3. Net GHG emission – Cerrado biome
2677	•	PHASE 3 – Consolidation of results
2678		
2679		• Step 1 : Calculation of the annual net GHG emission: sum of gross GHG emissions by
2680		deforestation minus removals by secondary vegetation in each period
2681		
2682		• Step 2: Calculation of average net emissions in the period
2683		
2684		8.6. Detail description for estimating GHG emissions/removals
2685		in the Atlantic Forest, Caatinga, Pampa and Pantanal biomes
2686	•	PHASE 1 – GIS operations
2687		·
2688	The	e 1 st phase involves several spatial operations using GIS tools, with the aim to consolidate

all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 53**. Each line of the spreadsheet represents a single deforestation polygon.

Table 53 – Atlantic Forest, Caatinga, Pampa and Pantanal biomes deforestation output main parameters

Variable name	Description	Unit	Spreadsheet column	Source	
fid		n/a	А		
Biome	Biome classification	n/a	В	IBGE, 2019	
Main_class	REDD+ activity	n/a	С		
Year	Mapping year	n/a	D	PRODES	
Image_date	Image date of each polygon	n/a	E		
source_inv	Corresponding biome classification in the 4 th GHG National Inventory	n/a	F		
phytophysiognomies	Ancient vegetation phytophysiognomies	n/a	G		
Category	Land use category: Forest (F)	n/a	Н	4 th GHG	
rr_cagb	Above ground carbon stock	tC/ha	I	National Inventory	
rr_cbgb	Below ground carbon stock	tC/ha	J		
rr_cdw	Dead wood carbon stock	tC/ha	К		
rr_clitter	Litter carbon stock	tC/ha	L		
rr_ctotal	I Total carbon stock		М		
Area_ha	Polygon area	ha	Ν	Own calculations	

2696	•	PH	IASE 2 – Emissions calculations
2697			
2698		0	Step 1: Calculation of C and CO2 due to deforestation:
2699			Column Q: C emissions due to deforestation
2700			Column R: CO ₂ emissions due to deforestation
2701			
2702		0	Step 2 : Through pivot tables, the sums of emissions per year and GHG are calculated.
2703			The values obtained at this stage are in tons of CO ₂ , tons of CH ₄ and tons of N ₂ O.
2704			
2705		0	Step 3: Emissions are converted into tones of CO ₂ . These values will be used in the
2706			final calculation, added to the other outputs, to obtain average net emission from the
2707			biome.
2708			
2709	٠	PH	IASE 3 – Consolidation of results
2710			
2711		0	Step 1 : Calculation of the gross CO ₂ emissions per period as the sum of individual
2712			emissions per polygon
2713			
2714		0	Step 2: Calculation of average gross emissions in the period and biome
2715			

 2717 2718 o Step 1: regrouping the emissions for each biome and year 2719 2720 o Step 2: calculation of the net emissions balance per year 2721 o Step 3: calculation of the average net emission in the period 2016/2017-2019-/2 2723 considered as the National FREL 2724 	2716 8	. Detail description for estimating the national FREL
 2719 2720 • Step 2: calculation of the net emissions balance per year 2721 2722 • Step 3: calculation of the average net emission in the period 2016/2017-2019-/2 2723 considered as the National FREL 	2717	
 Step 2: calculation of the net emissions balance per year Step 3: calculation of the average net emission in the period 2016/2017-2019-/2 o Step 3: calculation of the average net emission in the period 2016/2017-2019-/2 	2718 o	Step 1: regrouping the emissions for each biome and year
 2721 2722 o Step 3: calculation of the average net emission in the period 2016/2017-2019-/2 2723 considered as the National FREL 	2719	
 Step 3: calculation of the average net emission in the period 2016/2017-2019-/2 considered as the National FREL 	2720 o	Step 2: calculation of the net emissions balance per year
2723 considered as the National FREL	2721	
	2722 o	Step 3: calculation of the average net emission in the period 2016/2017-2019-/2021,
2724	2723	considered as the National FREL
	2724	
2725	2725	

2726 8.8. Quality control and quality assurance procedures

2727

The following figure, summarize the quality control (QC) and quality assurance (QA) procedures that were adopted and implemented, by different actors, during the elaboration of Brazil's national FREL proposal. Is worth to recall that INPE's monitoring programs, also have they own QA/QC procedures, ensuring that activity data used in this submission is highly accurate.

2732 2733

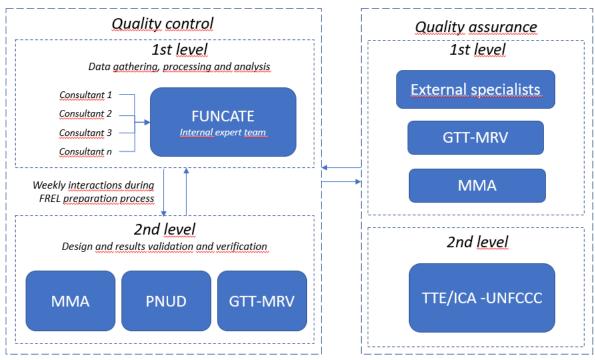


Figure 50 –QA and QC procedures adopted/implemented during the elaboration of Brazil's
 National FREL

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2734

2738 8.8.1. Quality control

2739

Throughout the preparation of Brazil's National FREL, technical QC procedures were implemented to evaluate and correct (when necessary) the quality of the results, as recommended by the 2006 IPCC Guidelines.

2743

These procedures were implemented at two different levels (**Figure 50**): at a first level within FUNCATE expert team directly involved in the preparation of the GHG estimates; and at a second level within MMA expert team, technical coordinator and selected GTT-MRV members directly involved in the elaboration of the FREL submission document, but not directly involved in the calculation of the estimates.

2749

2750 From this perspective, the quality control system has been delineated for (non-exhaustive list2751 to date):

2752	
2753	(i) Routine checks to ensure the integrity, correctness and completeness of all data used in
2754	the FREL elaboration:
2755	
2756	- Level 1: All data necessary for estimating emissions/removals (i.e., activity data and
2757	EF) were subject to completeness checks, to ensure that all necessary data have been
2758	gathered. Maps used have undergone integrity assessments (i.e., topological analyses
2759	relevant to this type of data), and corrections have been applied when necessary.
2760	
2761	- Level 2: All data were examined by the MMA, technical coordinator, and UNDP team.
2762	
2763	(ii) Calculation checks:
2764	
2765	- Level 1: Calculations were carried out, in parallel, by two different experts to ensure
2766	the consistency and accuracy of the results.
2767	
2768	- Level 2: All results were examined by the MMA, technical coordinator, and UNDP
2769	team.
2770	
2771	(iii) Documentation and archiving:
2772	
2773	- Level 1: Several reports were produced throughout the project detailing the input
2774	data and procedures adopted.
2775	
2776	 Level 2: Weekly meetings were held between FUNCATE, MMA and UNDP to discuss
2777	and decide on the process, gaps, assumptions, preliminary results, etc. Meetings were
2778	recorded.
2779	
2780 2781	The main errors and/or gaps identified during the QC procedures, and corrections applied are presented in the following tables.

2782 Table 54 – Errors and/or gaps identified during the quality control check – Amazon biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
Overlap of polygons	Same polygons have different classification in terms of phytophysiognomies	Error due to the large amount of information to be assessed	Overlaps can be generated emissions overload	0,24% of the total area deforested on Forest category	A TerraAmazon tool was used to eliminate polygon overlap in the ancient vegetation map
Gaps in the ancient vegetation map	Polygons without information of the forest phytophysiognomies and/or category	Gasps may have been created due to differences in the biome's limits	Without the forest phytophysiognomies emissions can't be estimated	1% of the total area deforested	Due to its insignificance, missing area was not considered in the final estimates

2783

2784 Table 55 – Errors and/or gaps identified during the quality control check – Cerrado biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
Gaps in the ancient vegetation map	Polygons without information of the forest phytophysiognomies and/or category	Gasps may have been created due to differences in the biome's limits	Without the forest phytophysiognomies emissions can't be estimated	0.0033% of the total area deforested	Due to its insignificance, missing area was not considered in the final estimates
Inconsistencies between carbon stocks included in the shapefile and the ones reported in the 4 th National GHG Inventory	Sum of carbon stocks pools in the shapefile differs from values reported in the 4 th National GHG Inventory	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	3.2% of the total area deforested	Values from the 4 th National GHG Inventory were used, adjusted per biome

2785

2786 Table 56 – Errors and/or gaps identified during the quality control check – Atlantic Forest biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
Gaps in the ancient vegetation map	Polygons without information of the forest phytophysiognomies and/or category	Gasps may have been created due to differences in the biome's limits	Without the forest phytophysiognomies emissions can't be estimated	1.6% of the total area deforested	Due to its insignificance, missing area was not considered in the final estimates
Inconsistencies between carbon stocks included in the shapefile and the	Sum of carbon stocks pools in the shapefile differs from values	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	3.2% of the total area deforested	Values from the 4 th National GHG Inventory

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
ones reported in the 4 th National GHG Inventory	reported in the 4 th National GHG Inventory				were used, adjusted per biome
PRODES residue class	PRODES residue class refers to deforestation areas identified after the occurrence. For example, a 2018 residue class, implies that the deforestation has been reported in 2018, but have occurred before 2018	This class is part of the PRODES Cerrado data transferred to Atlantic Biome. This means this is not an error, is part of the methodology	Deforestation and corresponding emission may have occurred "outside" the reference level period	0.5% of the emissions	Residue class was not included in the final estimates
Unknown forest phytophysiognomies	Ancient vegetation map present's unknown forest phytophysiognomies: SNm, SMm, SNs, SNtm and TNm	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	0.5% of the emissions	Carbon stocks values from the "higher" forest phytophysiognomies have been used

Table 57 – Errors and/or gaps identified during the quality control check – Caatinga biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
Gaps in the ancient vegetation map	Polygons without information of the forest phytophysiognomies and/or category	Gasps may have been created due to differences in the biome's limits	Without the forest phytophysiognomies emissions can't be estimated	85% of the total area deforested	Forest phytophysiognomies were identified (based on information reported in the 4 th National GHG Inventory) and included in the ancient vegetation map
Inconsistencies between carbon stocks included in the shapefile and the ones reported in the 4 th National GHG Inventory	Sum of carbon stocks pools in the shapefile differs from values reported in the 4 th National GHG Inventory	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	0,93% of the total area deforested	Values from the 4 th National GHG Inventory were used, adjusted per biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
PRODES residue class	PRODES residue class refers to deforestation areas identified after the occurrence. For example, a 2018 residue class, implies that the deforestation has been reported in 2018, but have occurred before 2018	This class is part of the PRODES Cerrado data transferred to Atlantic Biome. This means this is not an error, is part of the methodology	Deforestation and corresponding emission may have occurred "outside" the reference level period	3% of the emissions	Residue class was not included in the final estimates
Unknown forest phytophysiognomies	Ancient vegetation map present's unknown forest phytophysiognomies: SNm, SNs, SNtm, SNts, STNtm, STNts, STs, STts, STtm, TNm, TNs, TNtm, TNts	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	3.3% of the emissions	Carbon stocks values from the "higher" forest phytophysiognomies have been used

0 Table 58 – Errors and/or gaps identified during the quality control check – Pampa biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
Gaps in the ancient vegetation map	Polygons without information of the forest phytophysiognomies and/or category	Gasps may have been created due to differences in the biome's limits	Without the forest phytophysiognomies emissions can't be estimated	0.03% of the total area deforested	Forest phytophysiognomies from the neighbor polygon were used
Inconsistencies between carbon stocks included in the shapefile and the ones reported in the 4 th National GHG Inventory	Sum of carbon stocks pools in the shapefile differs from values reported in the 4 th National GHG Inventory	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	10,3% of the total area deforested	Values from the 4 th National GHG Inventory were used, adjusted per biome
New forest phytophysiognomies	A new forest phytophysiognomies (Mm) were identified	New forest phytophysiognomies due to new biome's limits	Reduction of the estimate accuracy	0.003% of the emissions	Carbon stocks values from other biome (Atlantic forest) have been used

2792 2793 Table 59 – Errors and/or gaps identified during the quality control check – Pantanal biome

Error/gap	Description	Possible cause	Impact	Significance	Correction applied
Gaps in the ancient vegetation map	Polygons without information of the forest phytophysiognomies and/or category	Gasps may have been created due to differences in the biome's limits	Without the forest phytophysiognomies emissions can't be estimated	0.04% of the total area deforested	Forest phytophysiognomies were identified (based on information reported in the 4 th National GHG Inventory) and included in the ancient vegetation map
Inconsistencies between carbon stocks included in the shapefile and the ones reported in the 4 th National GHG Inventory	Sum of carbon stocks pools in the shapefile differs from values reported in the 4 th National GHG Inventory	Most likely due to human errors when inserting data	Reduction of the estimate accuracy	24,86% of the total area deforested	Values from the 4 th National GHG Inventory were used, adjusted per biome
PRODES residue class	PRODES residue class refers to deforestation areas identified after the occurrence. For example, a 2018 residue class, implies that the deforestation has been reported in 2018, but have occurred before 2018	This class is part of the PRODES Cerrado data transferred to Atlantic Biome. This means this is not an error, is part of the methodology	Deforestation and corresponding emission may have occurred "outside" the reference level period	0.06% of the emissions	Residue class was not included in the final estimates

2795 8.8.2. Quality assurance

As described in section "The role of the Working Group of Technical Experts on REDD+ for MRV", all key inputs for the development of this submission have been presented and discussed by the GTT MRV REDD+.

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2796

The GTT MRV REDD+ also was instrumental in the process of quality assurance of the results,
by performing expert judgment assessment in order to identify potential outliers that could
result in under or over estimation.

2804

A draft proposal of the submission (including preliminary results) was presented to the GTT
 MRV REDD+ and "technical validation processes" happened on October 30, November 1st,
 and December 12 2022.

2808

As result of the "technical validation process", is worth to mention that the GTT-MRV considered the data, information and results presented in this FREL submission complete, methodological robust, and representing the most up to set of information available in the country.

2813

Finally, since REDD+ submissions are subject to technical analysis by LULUCF experts from the UNFCCC roster of experts, it can be expected that additional QA procedures will be carried out during the technical analysis.

- 2817
- 2818
- 2819

2820 8.9. Status of recommendations/encouragements from2821 previous technical analysis

2822

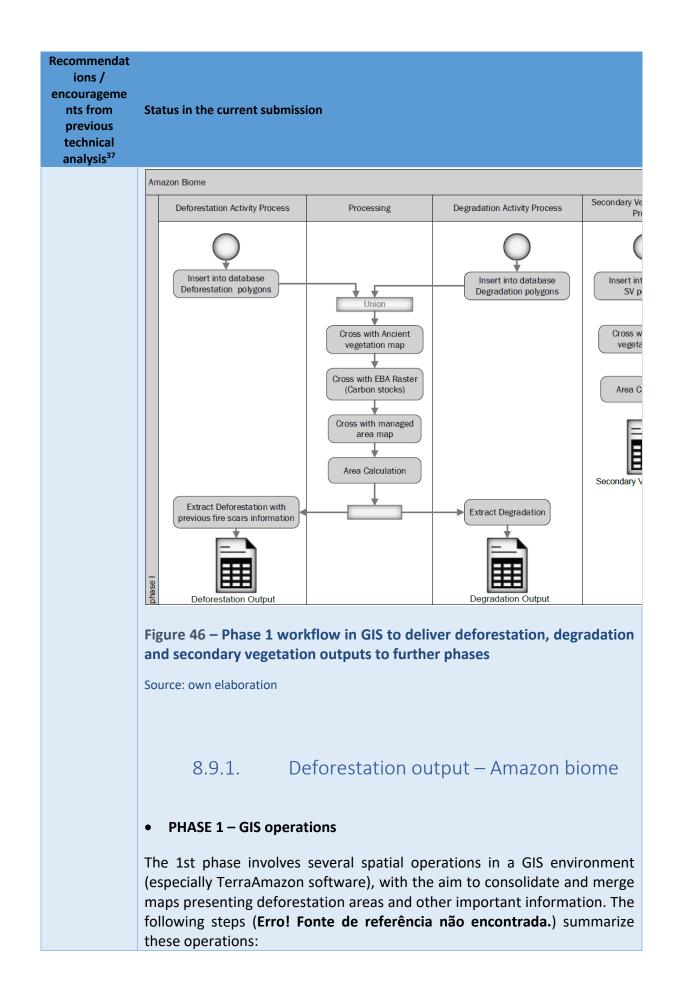
2823 Table 60 – Status of recommendations/encouragements from previous technical analysis -

2824 FREL Amazônia A, B³⁶

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
Digitalization of deforestation maps: it was noted that estimates of deforestation for the years 1996–1997 are less accurate than the rest of the time series. The AT considers that a better estimation of estimates for the years 1996–1997 may be achieved through digitalization of the deforestation maps	All thematic maps used in this FREL submission were designed in digital format according to the same criteria of extracting information from orbital images, thus avoiding possible inconsistencies and inaccuracies between maps elaborated by different methodologies. It is understood that the 1996 and 1997 maps have no impact on the accuracy of the FREL proposed here, since Brazil have decided for a shorten reference level period (i.e., 5 years), aligned with other international guidance's. In addition, quality control procedures have been implemented to exclude "less accurate AD" – refer to section "The operational procedures, based on the methodological approach described in page 56, used to estimate GHG emissions due to deforestation, forest degradation and removals from secondary vegetation growth in the Amazon biome are detailed below. Overview of phase 1 is presented in Figure 46 , where spatial data is assembled and spreadsheets are acquired to next calculation steps.

³⁶ Available at: <u>https://redd.unfccc.int/files/redd_brazil_frel_final_19nov.pdf</u>

³⁷ Paragraphs 37, 38 and 39 of the "Report of the technical assessment of the proposed forest reference emission level of Brazil submitted in 2014" (FCCC/TAR/2014/BRA) Available at: <u>https://unfccc.int/resource/docs/2014/tar/bra01.pdf</u>



Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission				
	 creation), a. PRG cor 201 b. DET log c. Bio d. And e. Ma Ver top info Step 2: Spa filter only occurring native vega Step 3: As unit area) the spatial Inventory of the spatial Inventory of Step 4: Exp annual per and their c stocks for wood and 	Vectorial data gathering considering: DDES maps presenting po- oversion increments for th 18, 2018-2019, 2019-2020 a TER degradation maps pres- ging areas mes boundaries (<i>Figure 1</i>) cient native vegetation map naged areas map "ifications consists in a rou- ology errors (such as over ormation. atial operations execution to deforestation polygons (i. in forest phytophysiognome etation map). sociation of the emission for to each deforestation poly- average value from the EBA maps presenting each carboo portation of an electronic spe- riod of the reference perio orresponding phytophysiog above-ground biomass, I litter - Table 47.	olygons ne peri nd 202 enting (<i>Figur</i> tine of erlaps o join s e., nat nies ac actors gon the readsh d, the nomies	i of native iods 2016-20 0-2021 fire scars an <i>e 9</i>) procedures and gaps) an step 1 data a ive vegetatic cording to th (i.e., carbon rough the ex map (4th Na ⁻). eet containin deforestations and associa- ground biom	vegetation 017, 2017- d selective to identify nd lack of nd then to on clearing ne ancient stocks per traction of tional GHG g, for each n polygons ted carbon nass, dead
	deforestation con Variable name	nponent, which is the input Description	t for ne Unit	Spreadsheet	Source
	Biome	Biome classification: Amazon	n/a	column A	IBGE, 2019
	main_class	REDD+ activity classification: Deforestation	n/a	В	PRODES

ions / ncourageme nts from previous technical analysis ³⁷	Status in the current	submission			
allalysis	class_name	REDD+ activity/year classification	n/a	С	
	year	Year where the REDD+ activity have occurred	n/a	D	_
	deter2017	Degradation classification in	n/a	E	DETER
	deter2018	corresponding year:	n/a	F	
	deter2019	- Fire ("burn scar")	n/a	G	_
	deter2020	 Disordered logging ("CS") orderly logging ("CSR") 	n/a	Н	
	deter2021		n/a		_
	status			J	
	source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	K	4th GHG National Inventory
	phytophysiognomy	Ancient vegetation phytophysiognomies	n/a	L	
	category	Vegetation category: Forest (F)	n/a	М	
	managed_land	indicates whether the polygon is situated in a managed area ("t" = true) or not ("f" = falsa)	n/a	Ν	
	EBA_cagb	Carbon content – above ground biomass carbon pool	tC/ha	0	EBA (4th GHG
	EBA_cbgb	Carbon content – below ground biomass carbon pool	tC/ha	Р	National Inventor
	EBA_cdw	Carbon content – dead wood carbon pool	tC/ha	Q	
	EBA_clitter	Carbon content – litter carbon pool	tC/ha	R	
	EBA_c4	Total carbon	tC/ha	S	
	area_ha	Polygon area	ha	Т	Own estimate

ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission			
	Figure 47 – Illustrative representation of the electronic spreadsheet output from Phase 1 Source: own elaboration			
	Each line of the spreadsheet represents a group of polygons with the sacharacteristics, except for their individual area. The "area_ha" attributer represents the sum of the individual deforested polygons areas. Su aggregation was necessary due to the large amount of data generated the Amazon biome, which are not supported by Excel.			
	PHASE 2 – Emissions calculations			
	Emissions calculations were performed in chronological order, according the occurrence of degradation and/or deforestation activities, alwa applying the degradation losses before losses due to deforestation with the same year. The following steps were followed:			
	 Step 1: Calculation of carbon stocks available in <i>t0</i> (in tonnes of 0 i.e., tC/ha stock values already multiplied by areas in ha) by total an carbon pools: Column U: total C stock <i>t0</i> [=S3*T3] Column V: aerial C stock <i>t0</i> [=(O3+Q3+R3)*T3] Column W: above ground C stock <i>t0</i> [=O3*T3] 			
	 Step 2: Calculation of C, CH4 and N2O emissions and other losses du to degradation in 2017: Column X: C emissions due to fire in managed lands Column Y: CH4 emissions due to fire in managed lands Column Z: N2O emissions due to fire in managed lands Column AA: C emissions due to disordered logging (CS) Column AB: C loss due to fire in unmanaged lands Column AC: C loss due to orderly logging (CSR) 			
	 Step 3: Calculation of remaining carbon stocks after degradation i 2017, representing carbon stocks available for deforestation in 2017 Column AD: total C stock <i>t1</i> Column AE: aerial C stock <i>t1</i> Column AF: above ground C stock t1 			

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
	 Step 4: Calculation of C, CH4 and N2O emissions due to deforestation in 2017: Column AG: C emissions due to deforestation Column AH: CH4 emissions due to deforestation (resulting from slash and burn) Column AI: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 5: Calculation of carbon stocks available after 2017, representing carbon stocks available for degradation in 2018: Column AJ: aerial C stock <i>t2</i> Column AK: above ground C stock <i>t2</i>
	• Step 6 : Calculation of C, CH4 and N2O emissions and other losses due to degradation in 2018:
	Column AL: C emissions due to fire in managed lands Column AM: CH4 emissions due to fire in managed lands Column AN: N2O emissions due to fire in managed lands Column AO: C emissions due to disordered logging (CS) Column AP: C carbon loss due to fire in unmanaged lands Column AQ: C carbon loss due to orderly logging (CSR)
	 Step 7: Calculation of carbon stocks available after 2018 degradation, representing carbon stocks available for deforestation in 2018: Column AR: total C stock t3 Column AS: aerial C stock t3 Column AT: above ground C stock t3
	 Step 8: Calculation of C, CH4 and N2O emissions due to deforestation in 2018: Column AU: C emissions due to deforestation Column AV: CH4 emissions due to deforestation (resulting from slash and burn) Column AW: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 9: Calculation of carbon stocks available after 2018, representing carbon stocks available for degradation in 2019: Column AX: aerial C stock t4

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
	Column AY: above ground C stock <i>t4</i>
	 Step 10: Calculation of C, CH4 and N2O emissions due to degradation in 2019: Column AZ: C emissions due to fire Column BA: CH4 emissions due to fire Column BB: N2O emissions due to fire Column BC: C emissions due to fire Column BD: C carbon loss due to disordered logging (CS) Column BD: C carbon loss due to fire in unmanaged lands Column BE: C carbon loss due to orderly logging (CSR)
	 Step 11: Calculation of carbon stocks available after 2019 degradation, representing the carbon stocks available for deforestation in 2019: Column BF: total C stock t5 Column BG: aerial C stock t5 Column BH: above ground C stock t5
	 Step 12: Calculation of C, CH4 and N2O emissions due to deforestation in 2019: Column BI: C emissions due to deforestation Column BJ: CH4 emissions due to deforestation (resulting from slash and burn) Column BK: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 13: Calculation of carbon stocks available after 2019, representing carbon stocks available for degradation in 2020: Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i>
	 Step 14: Calculation of C, CH4 and N2O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH4 emissions due to fire Column BP: N2O emissions due to fire Column BQ: C emissions due to disordered logging (CS) Column BR: C loss due to fire in unmanaged lands Column BS: C loss due to orderly logging (CSR)

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
	 Step 15: Calculation of carbon stocks available after 2020 degradation, representing the carbon stocks available for deforestation in 2020: Column BT: aerial C stock t7 Column BU: above ground C stock t7 Column BV: above ground C stock t7
	 Step 16: Calculation of C, CH4 and N2O emissions due to deforestation in 2020: Column BW: C emissions due to deforestation Column BX: CH4 emissions due to deforestation (resulting from slash and burn) Column BY: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 17: Calculation of carbon stocks available after 2020, representing carbon stocks available for degradation in 2021: Column BZ: aerial C stock <i>t8</i> Column CA: above ground C stock <i>t8</i>
	 Step 18: Calculation of C, CH4 and N2O emissions due to fire degradation in 2021: Column CB: C emissions due to fire Column CC: CH4 emissions due to fire Column CD: N2O emissions due to fire Column CE: C emissions due to disordered logging (CS) Column CF: C loss due to fire in unmanaged lands Column CG: C loss due to orderly logging (CSR)
	 Step 19: Calculation of carbon stocks available after 2021 degradation, representing the stocks available for deforestation in 2021: Column CH: Total C stock <i>t9</i> Column CI: above ground C stock t9 Column CJ: above ground C stock t9
	 Step 20: Calculation of C, CH4 and N2O emissions due to deforestation in 2021: Column CK: C emissions due to deforestation Column CL: CH4 emissions due to deforestation (resulting from slash and burn)

ions / encourageme nts from previous technical analysis ³⁷	Status ir	the curren	t submission	
			nn CM: N2O emissions due to deforestation (and burn)	resulting from
	have b stocks. degrad values degrad	een carrie In green: ation ever are asso ation. 18 – Exam	ble presents a numerical example of the cal ed out. Is important to note the evolution o initial total carbon stocks; in blue: total carbon nts or not; in yellow: emissions due to defore ociated with the reduced carbon stocks a uple of GHG emissions for an area presentin ugh degradation by fire to deforestation	f total carbor on stocks afte station whose after previous
	Colum	Phas e,	Attribute	Value
	A	Step Phas e 1	biome	Amazon
	В	Phas e 1	main_class	DESMATAMEN TO
	С	Phas e 1	class_name	d2021
	D	Phas e 1	year	2021
	E	Phas e 1	deter2017	CQ1
	F	Phas e 1	deter2018	CQ2
	G	Phas e 1	deter2019	CQ3
	Н	Phas e 1	deter2020	CQ4
	I	Phas e 1 Phas	deter2021	CQ5
	J	e 1 Phas	status	DETER
	К	e 1 Phas	source_inv	Amazonia
	L	e 1 Phas	phytophysiognomy	Fs
	M	e 1 Phas	category	F
	N	Phas e 1	managed_land	t

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status i		rrent submission	
	0	Phas e 1	eba_cagb	71.74
	Р	Phas e 1	eba_cbgb	7.17
	Q	Phas e 1	eba_cdw	5.81
	R	Phas e 1	eba_clitter	4.14
	S	Phas e 1	eba_ctotal	88.86
	т	Phas e 1	area_ha	3.83
	U	Phas e 2, Step 1	Total carbon stock (t C) - t0	340.18
	v	Phas e 2, Step 1	Total aerial carbon stock (t C) - t0	312.73
	w	Phas e 2, Step 1	Above ground living carbon stock (t C) - t0	274.64
	x	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tC)	115.09
	Y	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tCH4)	1.67
	z	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tN2O)	0.05
	AA	Phas e 2, Step 2	Emissions due to selective logging in 2017 (tC)	0.00
	АВ	Phas e 2, Step 2	Carbon stock decrease due to fire in unmanaged lands in 2017 (tC)	0.00
	AC	Phas e 2, Step 2	Carbon stock decrease due to selective regular logging in 2017 (tC)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status ir	1 the cu	rrent submission	
	AD	Phas e 2, Step 3	Total carbon stock (t C) - t1	225.10
	AE	Phas e 2, Step 3	Total aerial carbon stock (t C) - t1	197.65
	AF	Phas e 2, Step 3	Above ground living carbon stock (t C) - t1	101.07
	AG	Phas e 2, Step 4	Emissions due to deforestation in 2017 (tC)	0.00
	АН	Phas e 2, Step 4	Emissions due to post-fire deforestation in 2017 (tCH4)	0.00
	AI Phas e 2, Step 4 Emissions due to post-fire deforestation in 2017 (tN2 4 AJ Phas e 2, Step 5		Emissions due to post-fire deforestation in 2017 (tN2O)	0.00
			Total aerial carbon stock (t C) - t2	197.65
	АК	Phas e 2, Step 5	Above ground living carbon stock (t C) - t2	101.07
	AL	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tC)	72.73
	AM	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tCH4)	1.05
	AN	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tN2O)	0.03
	AO	Phas e 2, Step 6	Emissions due to selective logging in 2018 (tC)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status ir	n the cu	rrent submission	
	АР	Phas e 2, Step 6	Carbon stock decrease due to fire in unmanaged lands in 2018 (tC)	0.00
	AQ	Phas e 2, Step 6	Carbon stock decrease due to selective regular logging in 2018 (tC)	0.00
	AR	Phas e 2, Step 7	Total carbon stock (t C) - t3	152.36
	AS	Phas e 2, Step 7	Total aerial carbon stock (t C) - t3	124.91
	AT	Phas e 2, Step 7	Above ground living carbon stock (t C) - t3	37.19
	AU	Phas e 2, Step 8	Emissions due to deforestation in 2018 (tC)	0.00
	AV	Phas e 2, Step 8	Emissions due to post-fire deforestation in 2018 (tCH4)	0.00
	AW	Phas e 2, Step 8	Emissions due to post-fire deforestation in 2018 (tN2O)	0.00
	AX	Phas e 2, Step 9	Total aerial carbon stock (t C) - t4	124.91
	AY	Phas e 2, Step 9	Above ground living carbon stock (t C) - t4	37.19
	AZ	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tC)	45.97
	ВА	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tCH4)	0.67

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status ir	n the cu	rrent submission	
	BB	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tN2O)	0.02
	BC	Phas e 2, Step 10	Emissions due to selective logging in 2019 (tC)	0.00
	BD	Phas e 2, Step 10	Carbon stock decrease due to fire in unmanaged lands in 2019 (tC)	0.00
	BE	Phas e 2, Step 10	Carbon stock decrease due to selective regular logging in 2019 (tC)	0,00
	BF S BF S BG S BH S		Total carbon stock (t C) - t5	106.39
			Total aerial carbon stock (t C) - t5	78.95
			Above ground living carbon stock (t C) - t5	13.69
	BI	Phas e 2, Step 12	Emissions due to deforestation in 2019 (tC)	0.00
	BJ	Phas e 2, Step 12	Emissions due to post-fire deforestation in 2019 (tCH4)	0.00
	ВК	Phas e 2, Step 12	Emissions due to post-fire deforestation in 2019 (tN2O)	0.00
	BL	Phas e 2, Step 13	Total aerial carbon stock (t C) - t6	78.95
	BM	Phas e 2, Step 13	Above ground living carbon stock (t C) - t6	13.69

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in	ו the cu	rrent submission	
	BN	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tC)	29.05
	во	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tCH4)	0.42
	BP	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tN2O)	0.01
	BQ	Phas e 2, Step 14	Emissions due to selective logging in 2020 (tC)	0.00
	BR	Phas e 2, Step 14	Carbon stock decrease due to fire in unmanaged lands in 2020 (tC)	0.00
	BS		Carbon stock decrease due to selective regular logging in 2020 (tC)	0.00
	BT	Phas e 2, Step 15	Total carbon stock (t C) - t7	77.34
	BU	Phas e 2, Step 15	Total aerial carbon stock (t C) - t7	49.89
	BV	Phas e 2, Step 15	Above ground living carbon stock (t C) - t7	5.04
	BW	Phas e 2, Step 16	Emissions due to deforestation in 2020 (tC)	0.00
	вх	Phas e 2, Step 16	Emissions due to post-fire deforestation in 2020 (tCH4)	0.00
	BY	Phas e 2, Step 16	Emissions due to post-fire deforestation in 2020 (tN2O)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status ir		rrent submission	
	BZ	Phas e 2, Step 17	Total aerial carbon stock (t C) - t8	49.89
	СА	Phas e 2, Step 17	Above ground living carbon stock (t C) - t8	5.04
	СВ	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tC)	18.36
	CC Phas e 2, Step 18 Emissions due to fire in 2021 in managed lands (tCH4) 18			
	CD	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tN2O)	0.01
	CE	Phas e 2, Step 18	Emissions due to selective logging in 2021 (tC)	0.00
	CF	Phas e 2, Step 18	Carbon stock decrease due to fire in unmanaged lands in 2021 (tC)	0.00
	CG	Phas e 2, Step 18	Carbon stock decrease due to selective regular logging in 2021 (tC)	0.00
	СН	Phas e 2, Step 19	Total carbon stock (t C) - t9	58.98
	CI S		Total aerial carbon stock (t C) - t9	31.53
	СЈ	Phas e 2, Step 19	Above ground living carbon stock (t C) - t9	1.85
	СК	Phas e 2, Step 20	Emissions due to deforestation in 2021 (tC)	58.98

ions / encourageme nts from previous technical analysis ³⁷	Status i	n the cu	rrent sul	bmissio	n								
	CL	Phas e 2, Step 20	Emissio	ons due	to post-	-defore:	station f	fire in 2	021 (tC	H4)	0.17		
	СМ	Phas e 2, Step 20	Emissic	ons due	to post-	defores	station f	ire in 2	021 (tN	20)	0.00		
	Soma	REDD values	+ activi s obtair	ity cor ned in t	this ph	d and ase ar	annua e in to	al peri nnes c	od wa	as calo 14 ano	nission: culated d N2O.	•	
	Soma de EM por queimada em 2017 (tC) AREASSoma de EM por queimada em 2017 (tCH4) AREASSoma de EM por queimada emSoma de EM por queimada em1MANEJADASMANEJADAS2017(tN2O) AREAS DANEJADASSoma de EM por desmatamentodesmatamento desmatamentodesmatamento desmatamento232.376,37468,4213,781.523,8010.871.135,25							nento de en					
	Figure source Source:	s/activ	ities in	the D			-		017 a	ccord	ing to	the	
		on, addeo	d to the o	ther outp	outs, to o	btain th	e averag	e net en	nission fo	or the re	used in the final ne relevant biome. biome.		
	A Periodo 1 2 2016-2017 3 2017-2018 4 2018-2019 5 2019-2020 6 2020-2021 7	B Emissões C por desmatamento (tC) 10.871.135,25 11.349.332,44 13.418.112,34 15.341.770,94 19.565.811,53	C Emissões CH4 por desmatamento (rCH4) 47.440,38 50.024,04 58.945,81 67.855,28 86.566,70		E F Área de desmatamento (ha) 94.237,38 97.057,75 113.352,39 129.559,16 162.649,97	G Periodo 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021	H Emissões C por queimada em área manejada (tC) 32.376,37 6.273,09 14.137,42 20.431,50 1.805,27	1 Emissões CH4 por queimada em área manejada (tCH4) 468,42 90,76 204,54 205,60 26,12		K Área de queimada (ha) 5.177,04 3.372,97 5.251,09 4.871,09 663,70	L M Periodo 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021	N Emissões C corte seleti irregular (1 1.523,80 355,76 4.672,03 3.861,93 4.171,89	
	Periodo 9 2016-2017 10 2017-2018 11 2018-2019 12 2019-2020 13 2020-2021 14	Emissões CO2 po desmatamento (tCO2) 39.860.829,24 41.614.218,93 49.199.745,26 56.253.160,11 71.741.308,96	r Emissões CH4 por desmatamento (tCO2e) 1.328.330,55 1.400.673,22 1.650.482,64 1.899.947,92 2.423.867,66	Emissões N2O por desmatamento (tCO2e) 369.755,88 389.893,28 459.430,57 528.872,06 674.711,06		Periodo 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021	queimada em área manejada (tCO2) 118.713,36 23.001,32 51.837,21 74.915,49 6.619,33	Emissões CH4 por queimada em área manejada (tCO2e) 13.115,87 2.541,27 5.727,16 8.276,93 731,33	Emissões N2O por queimada em área manejada (tCO2e) 3.650,95 707,39 1.594,22 2.303,98 203,57		Periodo 2016-2017 2017-2018 2019-2019 2019-2020 2020-2021	Emissões CO. corte seleti irregular (ICI 5.587,26 1.304,44 17.130,7 14.160,4 15.296,9	
	Período 15 16 2016-2017 17 2017-2018 18 2018-2019 19 2019-2020 20 2020-2021 21	Emissões CO2 po desmatamento (LCO2e) 41.558.915,6 51.309.658,4 58.681.980,0 74.839.887,6	13 16 19			Período 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021	Emissões CO2 por queimada em área manejada (tCO2e) 135,480,18 26,249,97 59,158,58 85,496,40 7,554,23						

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current	t submission			
	PHASE 1 – GIS open The 1st phase involve consolidate all differen the information presen polygons with the same	put – Amazon biome	erations" using Si As result, a sprea of the spreadshe ception of the are	dsheet was obtair et represents a gr ea (hectares). The	ned, containing roup of area
	Table 49 – Amaz Variable name	on degradation outpo	ut main para Unit	meters Spreadsheet column	Source
	Biome	Biome classification: Amazon	n/a	A	IBGE, 2019
	Main_class	REDD+ activity classification: "DEGRAD" meaning "degradation"	n/a	В	DETER
	deter2017	Degradation	n/a	С	
	deter2018	classification in	n/a	D	
	deter2019	corresponding year:	n/a	E	
	deter2020	- Fire ("burn	n/a	F	
	deter2021	scar") - Disordered logging ("CS") - orderly logging ("CSR")	n/a	G	
	status			Н	
	source_inv	Corresponding biome classification in the 4th GHG	n/a	I	

Recommendat ions / encourageme nts from previous technical analysis³⁷

Status in the current submission

	National			4th GHG
	Inventory			National
Phytophysiognomy	Ancient vegetation	n/a	J	Inventory
	phytophysiognomies			
category	Vegetation	n/a	К	
	category: Forest (F)			-
Managed_land	indicates whether		L	
	the polygon iS			
	situated in a			
	managed area			
	("t" = true) or			
	not ("f" = falsa)			
EBA_cagb	Carbon content –	tC/ha	М	EBA
	above ground			
	biomass carbon			
	pool			
EBA_cbgb	Carbon content –	tC/ha	Ν	
	below ground			
	biomass carbon			
	pool			
EBA_cdw	Carbon content –	tC/ha	0	
	dead wood			
	carbon pool			
EBA_clitter	Carbon content –	tC/ha	Р	
	litter carbon pool			
EBA_ctotal	Total carbon	tC/ha	Q	
area_ha	Polygon area	ha	R	Own
				estimates

- Source: Electronic spreadsheet "1c_Amazon_Emissions_Output_Degradation.xls"
- 0
- PHASE 2 Emissions calculations
- Emissions calculations were performed in chronological order, according to the occurrence of degradation processes (fire and/or disordered logging). The following steps have been followed:

Step 1: Calculation of carbon stocks available in *t0* (tons of C, i.e., tC/ha stock values already multiplied by areas (in ha)) by total and carbon pools: Column S: total C stock *t0*

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
	Column T: aerial C stock t0
	Column U: above ground C stock t0
	Step 2: Calculation of C, CH_4 and N_2O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2017:
	Column V: C emissions due to fire in managed lands Column W: CH4 emissions due to fire in managed lands Column X: N2O emissions due to fire in managed lands
	Column Y: C emissions due to disordered logging (CS)
	Column Z: C loss due to fire in unmanaged lands
	Column AA: C loss due to orderly logging (CSR)
	Step 3: Calculation of remaining carbon stocks after degradation processes in 2017, definining the carbon stocks available for potential degradation in 2018:
	Column AB: aerial C stock t1
	Column AC: above ground C stock t1
	Step 4: Calculation of C, CH_4 and N_2O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2018:
	Column AD: C emissions due to fire
	Column AE: CH ₄ emissions due to fire
	Column AF: N2O emissions due to fire
	Column AG: C emissions due to disordered logging (CS)
	• Column AH: C loss due to fire in unmanaged lands
	Column AI: C loss due to orderly logging (CSR)
	Step 5: Calculation of carbon stocks available after <i>degradation processes in 2018, definining the carbon stocks available for potential degradation in 2019:</i>
	Column AJ: aerial C stock t2

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
	Column AK: above ground C stock t2
	 8.9.2. Step 6: Calculation of C, CH₄ and N₂O emissions due to degradation by fire in managed forest areas or disordered logging (CS) in 2019: Column AL: C emissions due to fire
	Column AM: CH₄ emissions due to fire Column AN: N2O emissions due to fire Column AO: C emissions due to disordered logging (CS) Column AP: C loss due to fire in unmanaged lands Column AQ: C loss due to orderly logging (CSR)
	Step 7: Calculation of the remaining carbon stocks available after degradation in 2019, defining the carbon stocks available for potential degradation in 2020: Column AR: aerial C stock t3 Column AS: above ground C stock t3
	Step 8: Calculation of C, CH ₄ and N ₂ O emissions due to degradation by fire in managed forest areas or disordered logging (CS) in 2020: Column AT: CO ₂ emissions due to fire Column AU: CH4 emissions due to fire
	Column AV: N ₂ O emissions due to fire
	Column AW: C emissions due to disordered logging (CS)
	Column AX: C loss due to fire in unmanaged lands Column AY: C loss due to orderly logging (CSR)
	 Step 9: Calculation of carbon stocks available after degradation processes in 2020, defining the carbon stocks available for potential degradation in 2021: Column AZ: aerial C stock <i>t4</i> Column BA: above ground C stock <i>t4</i>

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current sul	bmission	
	due to fire i 2021: Column E Column E C		d logging (CS) in ing (CS) 5 emissions were cons of C, CH₄ and CO2 equivalent. and added to the the biome. CO2 equivalent. and added to the the biome. CO2 equivalent. and added to the the biome.
		secondary vegetation output main pa	
	Variable name	Description	Source
	Biome	Biome classification: Amazon	TorraClass
	class_2014 class_2020	Secondary vegetation class for year 2014 Secondary vegetation class for year 2020	TerraClass
	phytophysiognomy	Ancient vegetation phytophysiognomies	
	category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)	4th GHG National Inventory

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current s	ubmission	
	area_ha	Polygon area	Own estimates
	• PHASE 2 – Ren	novals calculations	
	-	culation of the total area of natural fo 014 and 2020)	rest regeneration
	-	culation of C removals by natural forest and 2020) considering factor of 3,03 tC	. .
	o Step 3: Cor	oversion of tonnes of C tonnes to CO_2 eq	quivalent
	 Step 4: Ca (tC/yr) 	lculation of the average annual remo	oval average rate
	 Step 5: Appresent of the state of the state	oplication of the value obtained for operiod	each year of the
	8.9.4.	Net GHG emission – Amazo	on biome
	• PHASE 3 – Con	solidation of results	
	GHG emissi	culation of the annual net GHG emiss ions by deforestation and degradation r est regeneration in each annual period	-
		tailed description for estimati ns/removals in the Cerrado bio	-
	described in page	procedures, based on the methodo 56, used to estimate GHG emission due n growth of natural forest regenerationed in sequence.	e to deforestation

Recommendat ions / encourageme nts from previous technical analysis³⁷

Status in the current submission

8.10.1. Deforestation output – Cerrado biome

• PHASE 1 – GIS operations

The 1st phase involves several spatial operations using GIS tools, with the aim to consolidate all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 51**. Each line of the spreadsheet represents a single deforestation polygon.

Variable name	Description	Unit	Spreadsheet column	Source
fid		n/a	А	
Biome	Biome classification: Cerrado	n/a	В	IBGE, 2019
State	Brazilian political- administrative state	n/a	С	
Main_class	REDD+ activity	n/a	D	
Class_name	REDD+ activity/year classification		E	
Year	Mapping year	n/a	F	PRODES
Image_date	Image date of each polygon	n/a	G	
source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	н	
phytophysiognomies	Ancient vegetation phytophysiognomies	n/a	I	
Category	Land use category: Forest (F)	n/a	J	4th GHG National
rr_cagb	Above ground carbon stock	tC/ha	К	Inventory
rr_cbgb	Below ground carbon stock	tC/ha	L	
rr_cdw	Dead wood carbon stock	tC/ha	Μ	

Table 51 – Cerrado deforestation output main parameters

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current sul	omission			
	rr_clitter	Litter carbon stock	tC/ha	Ν	
	rr_ctotal	Total carbon stock	tC/ha	0	
	Area_ha	Polygon area	ha	Ρ	Own calculations
		and CO_2 due to defore			
		ns due to deforestati e missions due to defo			
	Step 2: Calculation o "slash and burn" typ Column S: above gro		ilable for	fire combu	stion in the
	 burn" defore Column T: CH Column U: N 	ulation of CH4 and N station: 14 emissions due to d 20 emissions due to d	eforestati	on	to "slash and
	are calculate	igh pivot tables, the si d. The values obtained 4 and tonnes of N2O.			
	Step 5: Emissions are converted into tones of CO ₂ equivalent. These values will be used in the final calculation and added to the other outputs, to obtain the average net emission for the biome.				
		y vegetation output – – Georeferenced oper		biome	
	SIG tools, activity d the info spreadsh	hase involves several , with the aim to cons ata. As result, a sprea rmation presented eet represents a gro	solidate al adsheet w in Table oup of po	l different vas obtaine 52 . Each olygons wi	deforestation ed, containing line of the ith the same

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission		
	-	resents the sum of the individuation was necessary due to the large ar	
	 ○ Table 52 – Ce 	errado secondary vegetation output	main parameters
	Variable name	Description	Source
	Biome	Biome classification: Cerrado	
	class_2018	Secondary vegetation class for year 2018	TerraClass
	class_2020	Secondary vegetation class for year 2020	
	phytophysiognomy	Ancient vegetation phytophysiognomies	4th GHG National
	category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)	Inventory
	Area_ha	Polygon area	Own calculations
	2020) • Step 2: Calculat	culations tal area of secondary vegetation per y tion of C removals by secondary ve considering factor of 3,03 tC/ha.yr	
	Step 3: Conversion c	of C tones to CO2 equivalent	
	Step 4: Calculation o	f the annual removal average rate (t	C/yr)
	Step 5: Application c	of the value obtained for each year of	f the series
		ission – Cerrado biome onsolidation of results	

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current su	bmission			
	 Step 1: Calculation of the annual net GHG emission: sum of gross GHG emissions by deforestation minus removals by secondary vegetation in each period 				
	Step 2: C	alculation of average r	net emis	ssions in the J	period
	Atlantic I	escription for estimatir Forest, Caatinga, Pamp – GIS operations	-		
	with the data. As informat	hase involves several aim to consolidate a result, a spreadshee ion presented in Table its a single deforestation	ll differ et was e 53 . Ea	ent deforest obtained, cc ch line of the	ation activity ontaining the
	 represents a single deforestation polygon. Table 53 – Atlantic Forest, Caatinga, Pampa and Pantanal biomes deforestation output main parameters 				
	 ○ Table 53 – A 	tlantic Forest, Caating	a, Pamp	a and Pantar	nal biomes
	 ○ Table 53 – A 	tlantic Forest, Caating	a, Pamp		nal biomes Source
	 Table 53 – A deforestatio 	tlantic Forest, Caating n output main parame	a, Pamp eters	a and Pantar Spreadsheet	
	 Table 53 – A deforestatio Variable name 	tlantic Forest, Caating n output main parame	a, Pamp eters Unit	a and Pantar Spreadsheet column	
	 Table 53 – A deforestatio Variable name fid 	tlantic Forest, Caating n output main parame Description	a, Pamp eters Unit n/a	a and Pantar Spreadsheet column A	Source
	 Table 53 – A deforestatio Variable name fid Biome 	tlantic Forest, Caatings n output main parame Description Biome classification	a, Pamp eters Unit n/a n/a	a and Pantar Spreadsheet column A B	Source
	 Table 53 – A deforestatio Variable name fid Biome Main_class 	tlantic Forest, Caatings n output main parame Description Biome classification REDD+ activity	a, Pamp eters Unit n/a n/a n/a	a and Pantar Spreadsheet Column A B C	Source IBGE, 2019
	 Table 53 – A deforestatio Variable name fid Biome Main_class Year 	tlantic Forest, Caatings n output main parame Description Biome classification REDD+ activity Mapping year Image date of each	a, Pamp eters Unit n/a n/a n/a n/a	a and Pantar Spreadsheet Column A B C D	Source IBGE, 2019
	 Table 53 – A deforestatio Variable name fid Biome Main_class Year Image_date 	tlantic Forest, Caatings n output main parame Description Biome classification REDD+ activity Mapping year Image date of each polygon Corresponding biome classification in the 4 th GHG National	a, Pamp eters Unit n/a n/a n/a n/a n/a	a and Pantar Spreadsheet C C D E	Source IBGE, 2019 PRODES
	 Table 53 – A deforestatio Variable name fid Biome Main_class Year Image_date source_inv 	tlantic Forest, Caating n output main parame Description Biome classification REDD+ activity Mapping year Image date of each polygon Corresponding biome classification in the 4 th GHG National Inventory Ancient vegetation	a, Pamp eters Unit n/a n/a n/a n/a n/a n/a	a and Pantar Spreadsheet Column A B C D E F	Source IBGE, 2019 PRODES

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current su	bmission			
	rr_cbgb	Below ground carbon stock	tC/ha	J	
	rr_cdw	Dead wood carbon stock	tC/ha	К	
	rr_clitter	Litter carbon stock	tC/ha	L	
	rr_ctotal	Total carbon stock	tC/ha	Μ	
	Area_ha	Polygon area	ha	Ν	Own calculations

PHASE 2 – Emissions calculations

Step 1: Calculation of C and CO2 due to deforestation: Column Q: C emissions due to deforestation

• Column R: CO2 emissions due to deforestation

Step 2: Through pivot tables, the sums of emissions per year and GHG are calculated. The values obtained at this stage are in tons of CO2, tons of CH_4 and tons of N_2O .

- **Step 3**: Emissions are converted into tones of *CO2*. These values will be used in the final calculation, added to the other outputs, to obtain average net emission from the biome.
- 0

PHASE 3 – Consolidation of results

Step 1: Calculation of the *gross* CO₂ emissions per period as the sum of individual emissions per polygon

Step 2: Calculation of average gross emissions in the period and biome

- o Detail description for estimating the national FREL
- Step 1: regrouping the emissions for each biome and year
- 0

0

o Step 2: calculation of the net emissions balance per year

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
	Step 3: calculation of the average net emission in the period 2016/2017-2019-/2021, considered as the National FREL
	Quality control and quality assurance procedures"
Continuation of improvement of the carbon map: the AT acknowledges the significant efforts made thus far by Brazil to assess the spatial distribution in carbon densities in the Amazonia biome and commends Brazil for continuing to work on updating and improving the carbon map based on new and improved ground data from its first national forest inventory	Brazil continues to improve the estimates and spatial distribution of carbon stocks in all biomes. These efforts have been mainly conducted within the scope of the LULUCF sector of the National GHG Inventory In addition, updated data/information from the EBA project have been used to estimate the "carbon map", particularly for the Amazon biome – refer to Box 2 . Future additional improvements are expected once the NFI is fully completed and validated.
Treatment of emissions from dead wood (i.e. the inclusion of this pool or the provision of more information on the justification of its omission);	Dead wood poll has been included – refer to section "Pools, gases, and activities included in Brazil's national FREL"

Recommendat ions / encourageme nts from previous technical analysis ³⁷ Treatment of non-CO ₂ gases, to maintain consistency with the GHG inventory included in the national	Status in the current submission Non-CO2 gases have been included in the estimates for: 1) Deforestation in the Amazon and Cerrado biomes 2) Degradation by forest fires in the Amazon biome Nevertheless, due to current limitations non-CO2 gases that may occur in other biomes have not yet been included – refer to Box 6
communicatio n In assessing the activities included in the FREL, the AT considers that degradation is a significant activity based on the estimates provided by Brazil. The justification provided by Brazil to omit this activity is that the time series available is too short to allow an adequate understanding of the degradation process. Based on the available information, the AT notes that, so far, there is no evidence of displacement of emissions (i.e., decreased deforestation in the Amazonia	National discussions about "forest degradation" and "deforestation" have been quite exhaustive over the last few years in the context of the GTT-MRV. In this new submission, due to available data, forest degradation was included in the Amazon biome only. The selected drivers of degradation were fires in managed forest land and disordered logging. For the Cerrado biome, it was not possible to take into account degradation due to fire because of lack of activity data and high uncertainties. For other Biomes it was recognized that fires do not play a significant role in forest degradation (see Box 5 and Box 6) and disordered logging, when it occurs, presents low intensity, and its identification in orbital images is not feasible with spatial resolutions currently used by INPE. Regarding the relationship between degradation and deforestation, it should be noted that the process and sequence of degradation was considered for the purposes of calculating emissions in subsequent deforestation. That is, although the relationship has not been thoroughly analyzed, its consequences in terms of reducing carbon stocks for the purposes of calculating emissions associated with deforestation have been taken into account

Recommendat ions / encourageme nts from previous technical analysis ³⁷	Status in the current submission
biome	
resulting in increasing	
degradation).	
In addition,	
the AT notes	
that the	
current	
exclusion of	
degradation	
appears to be	
conservative in	
the context of	
constructing	
the FREL.	
Overall, the AT	
considers better	
understanding	
of the	
relationship	
between	
degradation	
and	
deforestation	
as an area for	
future	
technical	
improvement of the FREL.	
The AT notes	
that, when	
emissions	
from	
degradation	
are included in	
the FREL,	
Brazil will need to	
demonstrate	
how double	
counting of	
emissions	
included under	
degradation	
and	
deforestation	
is avoided (e.g.	
for forests that	

ions / encourageme nts from previous technical	Status in the current submission	
analysis ³⁷		
were subject		
to selective		
ogging and		
subsequently		
clear cut)		

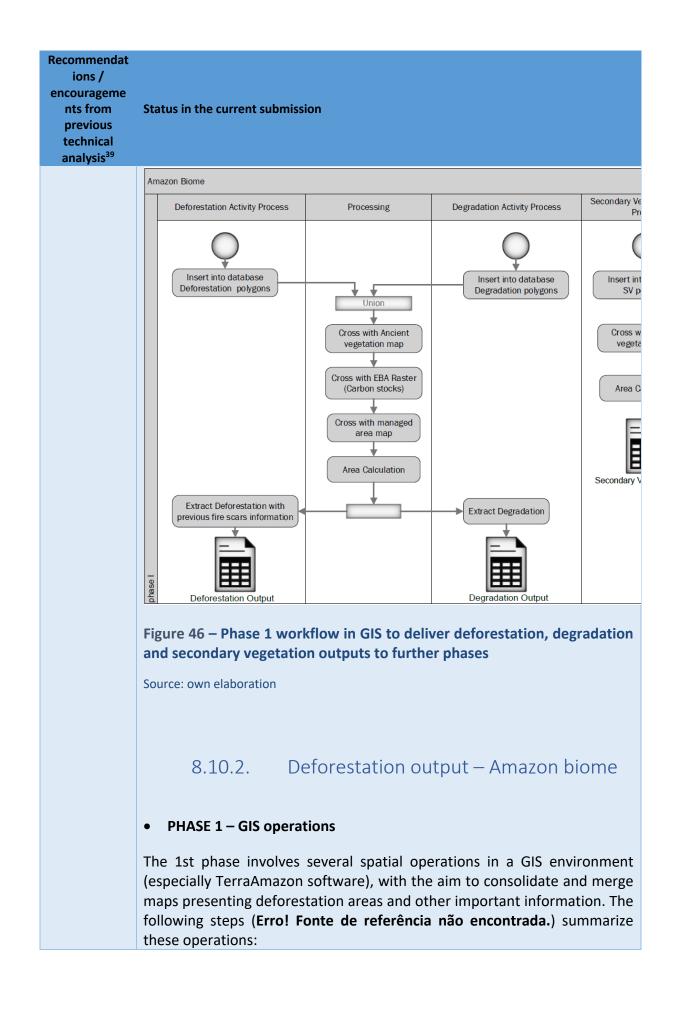
2825

Table 61 – Status of recommendations/encouragements from previous technical analysis FREL Amazônia C³⁸

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
Exclude the less accurate AD	Unlike other submissions, no analog data was used for estimating Brazil's National FREL In addition, quality control procedures have been implemented to exclude "less accurate AD" – refer to section "The operational procedures, based on the methodological approach described in page 56, used to estimate GHG emissions due to deforestation, forest degradation and removals from secondary vegetation growth in the Amazon biome are detailed below. Overview of phase 1 is presented in Figure 46 , where spatial data is assembled and spreadsheets are acquired to next calculation steps.

³⁸ Available at: <u>https://redd.unfccc.int/files/frelc_modifiedversion_correction2019.pdf</u>

³⁹ Paragraphs 41 and 42 of the "Report of the technical assessment of the proposed forest reference emission level of Brazil submitted in 2018" (FCCC/TAR/2018/BRA). Available at: <u>https://unfccc.int/sites/default/files/resource/tar2018_BRA.pdf</u>



Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission							
	 creation), a. PRG cor 202 b. DE log c. Bio d. And e. Ma Ventop offilter only occurring native veg Step 3: As unit area) the spatial Inventory Step 4: Expannual per and their costocks for wood and Table 47 – Outomodeling 	Vectorial data gathering considering: DDES maps presenting por oversion increments for the 18, 2018-2019, 2019-2020 a TER degradation maps press ging areas mes boundaries (<i>Figure 1</i>) cient native vegetation maps inaged areas map rifications consists in a rou- bology errors (such as over cormation. atial operations execution to deforestation polygons (i. in forest phytophysiognometation map). sociation of the emission ff to each deforestation poly average value from the EBA maps presenting each carboo portation of an electronic sp riod of the reference perio- corresponding phytophysiog above-ground biomass, for litter - Table 47.	olygons ne peri nd 202 enting o (<i>Figur</i> tine of erlaps a e., nat nies ac actors gon the readsh d, the peration	s of native iods 2016-20 0-2021 fire scars an e 9) procedures and gaps) an step 1 data a ive vegetatic cording to th (i.e., carbon rough the ex map (4th Na). eet containin deforestation s and associa ground biom	vegetation 017, 2017- d selective to identify nd lack of nd then to on clearing ne ancient stocks per traction of tional GHG g, for each n polygons ted carbon nass, dead			
	deforestation con	nponent, which is the input Description	t for ne Unit	Spreadsheet	Source			
	Biome	Biome classification: Amazon	n/a	column A	IBGE, 2019			
	main_class	REDD+ activity classification: Deforestation	n/a	В	PRODES			

ncourageme nts from previous technical analysis ³⁹	Status in the current	submission			
anarysis	class_name	REDD+ activity/year classification	n/a	С	
	year	Year where the REDD+ activity have occurred	n/a	D	_
	deter2017	Degradation classification in	n/a	E	DETER
	deter2018	corresponding year:	n/a	F	-
	deter2019	- Fire ("burn scar")	n/a	G	-
	deter2020	 Disordered logging ("CS") orderly logging ("CSR") 	n/a	Н	-
	deter2021	- orderry logging (CSK)	n/a	 	_
	status		in a	J	
	source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	K	4th GHG National Inventory
	phytophysiognomy	Ancient vegetation phytophysiognomies	n/a	L	
	category	Vegetation category: Forest (F)	n/a	М	_
	managed_land	indicates whether the polygon is situated in a managed area ("t" = true) or not ("f" = falsa)	n/a	Ν	_
	EBA_cagb	Carbon content – above ground biomass carbon pool	tC/ha	0	EBA (4th GHG
	EBA_cbgb	Carbon content – below ground biomass carbon pool	tC/ha	Р	National Inventor
	EBA_cdw	Carbon content – dead wood carbon pool	tC/ha	Q	_
	EBA_clitter	Carbon content – litter carbon pool	tC/ha	R	_
	EBA_c4	Total carbon	tC/ha	S	_
	area_ha	Polygon area	ha	Т	Own estimates

ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
technical	 Figure 47 – Illustrative representation of the electronic spreadsheet output from Phase 1 Source: own elaboration Each line of the spreadsheet represents a group of polygons with the same characteristics, except for their individual area. The "area_ha" attribute represents the sum of the individual deforested polygons areas. Such aggregation was necessary due to the large amount of data generated for the Amazon biome, which are not supported by Excel. PHASE 2 – Emissions calculations Emissions calculations were performed in chronological order, according to the occurrence of degradation and/or deforestation activities, always applying the degradation losses before losses due to deforestation within the same year. The following steps were followed: Step 1: Calculation of carbon stocks available in <i>t0</i> (in tonnes of C i.e., tC/ha stock values already multiplied by areas in ha) by total and carbon pools: Column U: total C stock <i>t0 [=S3*T3]</i> Column V: aerial C stock <i>t0 [=O3+T3]</i> Step 2: Calculation of C, CH4 and N2O emissions and other losses due
	 to degradation in 2017: Column X: C emissions due to fire in managed lands Column Y: CH4 emissions due to fire in managed lands Column Z: N2O emissions due to fire in managed lands Column AA: C emissions due to disordered logging (CS) Column AB: C loss due to fire in unmanaged lands Column AC: C loss due to orderly logging (CSR) Step 3: Calculation of remaining carbon stocks after degradation in
	2017, representing carbon stocks available for deforestation in 2017 Column AD: total C stock <i>t1</i> Column AE: aerial C stock <i>t1</i> Column AF: above ground C stock t1

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	 Step 4: Calculation of C, CH4 and N2O emissions due to deforestation in 2017: Column AG: C emissions due to deforestation Column AH: CH4 emissions due to deforestation (resulting from slash and burn) Column AI: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 5: Calculation of carbon stocks available after 2017, representing carbon stocks available for degradation in 2018: Column AJ: aerial C stock <i>t2</i> Column AK: above ground C stock <i>t2</i>
	• Step 6 : Calculation of C, CH4 and N2O emissions and other losses due to degradation in 2018:
	Column AL: C emissions due to fire in managed lands Column AM: CH4 emissions due to fire in managed lands Column AN: N2O emissions due to fire in managed lands Column AO: C emissions due to disordered logging (CS) Column AP: C carbon loss due to fire in unmanaged lands Column AQ: C carbon loss due to orderly logging (CSR)
	 Step 7: Calculation of carbon stocks available after 2018 degradation, representing carbon stocks available for deforestation in 2018: Column AR: total C stock t3 Column AS: aerial C stock t3 Column AT: above ground C stock t3
	 Step 8: Calculation of C, CH4 and N2O emissions due to deforestation in 2018: Column AU: C emissions due to deforestation Column AV: CH4 emissions due to deforestation (resulting from slash and burn) Column AW: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 9: Calculation of carbon stocks available after 2018, representing carbon stocks available for degradation in 2019: Column AX: aerial C stock t4

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Column AY: above ground C stock <i>t4</i>
	 Step 10: Calculation of C, CH4 and N2O emissions due to degradation in 2019: Column AZ: C emissions due to fire Column BA: CH4 emissions due to fire Column BB: N2O emissions due to fire Column BC: C emissions due to disordered logging (CS) Column BD: C carbon loss due to fire in unmanaged lands Column BE: C carbon loss due to orderly logging (CSR)
	 Step 11: Calculation of carbon stocks available after 2019 degradation, representing the carbon stocks available for deforestation in 2019: Column BF: total C stock t5 Column BG: aerial C stock t5 Column BH: above ground C stock t5
	 Step 12: Calculation of C, CH4 and N2O emissions due to deforestation in 2019: Column BI: C emissions due to deforestation Column BJ: CH4 emissions due to deforestation (resulting from slash and burn) Column BK: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 13: Calculation of carbon stocks available after 2019, representing carbon stocks available for degradation in 2020: Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i>
	 Step 14: Calculation of C, CH4 and N2O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH4 emissions due to fire Column BP: N2O emissions due to fire Column BQ: C emissions due to disordered logging (CS) Column BR: Closs due to fire in unmanaged lands Column BS: Closs due to orderly logging (CSR)

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	 Step 15: Calculation of carbon stocks available after 2020 degradation, representing the carbon stocks available for deforestation in 2020: Column BT: aerial C stock t7 Column BU: above ground C stock t7 Column BV: above ground C stock t7
	 Step 16: Calculation of C, CH4 and N2O emissions due to deforestation in 2020: Column BW: C emissions due to deforestation Column BX: CH4 emissions due to deforestation (resulting from slash and burn) Column BY: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 17: Calculation of carbon stocks available after 2020, representing carbon stocks available for degradation in 2021: Column BZ: aerial C stock <i>t8</i> Column CA: above ground C stock <i>t8</i>
	 Step 18: Calculation of C, CH4 and N2O emissions due to fire degradation in 2021: Column CB: C emissions due to fire Column CC: CH4 emissions due to fire Column CD: N2O emissions due to fire Column CE: C emissions due to disordered logging (CS) Column CF: C loss due to fire in unmanaged lands Column CG: C loss due to orderly logging (CSR)
	 Step 19: Calculation of carbon stocks available after 2021 degradation, representing the stocks available for deforestation in 2021: Column CH: Total C stock <i>t9</i> Column CI: above ground C stock t9 Column CJ: above ground C stock t9
	 Step 20: Calculation of C, CH4 and N2O emissions due to deforestation in 2021: Column CK: C emissions due to deforestation Column CL: CH4 emissions due to deforestation (resulting from slash and burn)

ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the currei	nt submission				
			nn CM: N2O emissions due to deforestation (and burn)	resulting from			
	have b stocks. degrad values degrad	The following table presents a numerical example of the calculations that have been carried out. Is important to note the evolution of total carbon stocks. In green: initial total carbon stocks; in blue: total carbon stocks afte degradation events or not; in yellow: emissions due to deforestation whose values are associated with the reduced carbon stocks after previous degradation. Table 48 – Example of GHG emissions for an area presenting a trajectory					
	that pa		ough degradation by fire to deforestation				
	Colum n	Phas e, Step	Attribute	Value			
	А	Phas e 1	biome	Amazon			
	В	Phas e 1	main_class	DESMATAMEN TO			
	С	Phas e 1	class_name	d2021			
	D	Phas e 1	year	2021			
	E	Phas e 1	deter2017	CQ1			
	F	Phas e 1	deter2018	CQ2			
	G	Phas e 1	deter2019	CQ3			
	н	Phas e 1	deter2020	CQ4			
	1	Phas e 1	deter2021	CQ5			
	J	Phas e 1	status	DETER			
	К	Phas e 1	source_inv	Amazonia			
	L Phas phytophysiognomy Fs						
		Phas		-			
	м	e 1	category	F			

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir		rrent submission	
	0	Phas e 1	eba_cagb	71.74
	Р	Phas e 1	eba_cbgb	7.17
	Q	Phas e 1	eba_cdw	5.81
	R	Phas e 1	eba_clitter	4.14
	S	Phas e 1	eba_ctotal	88.86
	т	Phas e 1	area_ha	3.83
	U	Phas e 2, Step 1	Total carbon stock (t C) - t0	340.18
	v	Phas e 2, Step 1	Total aerial carbon stock (t C) - t0	312.73
	w	Phas e 2, Step 1	Above ground living carbon stock (t C) - t0	274.64
	x	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tC)	115.09
	Y	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tCH4)	1.67
	z	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tN2O)	0.05
	AA	Phas e 2, Step 2	Emissions due to selective logging in 2017 (tC)	0.00
	АВ	Phas e 2, Step 2	Carbon stock decrease due to fire in unmanaged lands in 2017 (tC)	0.00
	AC	Phas e 2, Step 2	Carbon stock decrease due to selective regular logging in 2017 (tC)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	AD	Phas e 2, Step 3	Total carbon stock (t C) - t1	225.10
	AE	Phas e 2, Step 3	Total aerial carbon stock (t C) - t1	197.65
	AF	Phas e 2, Step 3	Above ground living carbon stock (t C) - t1	101.07
	AG	Phas e 2, Step 4	Emissions due to deforestation in 2017 (tC)	0.00
	АН	Phas e 2, Step 4	Emissions due to post-fire deforestation in 2017 (tCH4)	0.00
	AI	Phas e 2, Step 4	Emissions due to post-fire deforestation in 2017 (tN2O)	0.00
	AJ	Phas e 2, Step 5	Total aerial carbon stock (t C) - t2	197.65
	АК	Phas e 2, Step 5	Above ground living carbon stock (t C) - t2	101.07
	AL	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tC)	72.73
	AM	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tCH4)	1.05
	AN	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tN2O)	0.03
	AO	Phas e 2, Step 6	Emissions due to selective logging in 2018 (tC)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in	ו the cu	rrent submission	
	АР	Phas e 2, Step 6	Carbon stock decrease due to fire in unmanaged lands in 2018 (tC)	0.00
	AQ	Phas e 2, Step 6	Carbon stock decrease due to selective regular logging in 2018 (tC)	0.00
	AR	Phas e 2, Step 7	Total carbon stock (t C) - t3	152.36
	AS	Phas e 2, Step 7	Total aerial carbon stock (t C) - t3	124.91
	AT	Phas e 2, Step 7	Above ground living carbon stock (t C) - t3	37.19
	AU	Phas e 2, Step 8	Emissions due to deforestation in 2018 (tC)	0.00
	AV	Phas e 2, Step 8	Emissions due to post-fire deforestation in 2018 (tCH4)	0.00
	AW	Phas e 2, Step 8	Emissions due to post-fire deforestation in 2018 (tN2O)	0.00
	AX	Phas e 2, Step 9	Total aerial carbon stock (t C) - t4	124.91
	AY	Phas e 2, Step 9	Above ground living carbon stock (t C) - t4	37.19
	AZ	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tC)	45.97
	ВА	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tCH4)	0.67

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	BB	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tN2O)	0.02
	BC	Phas e 2, Step 10	Emissions due to selective logging in 2019 (tC)	0.00
	BD	Phas e 2, Step 10	Carbon stock decrease due to fire in unmanaged lands in 2019 (tC)	0.00
	BE	Phas e 2, Step 10	Carbon stock decrease due to selective regular logging in 2019 (tC)	0,00
	BF	Phas e 2, Step 11	Total carbon stock (t C) - t5	106.39
	BG	Phas e 2, Step 11	Total aerial carbon stock (t C) - t5	78.95
	BH BH Pha e 2, Step 11		Above ground living carbon stock (t C) - t5	13.69
	ВІ	Phas e 2, Step 12	Emissions due to deforestation in 2019 (tC)	0.00
	BJ Phas e 2, Step 12 Phas e 2, Step 12 Phas e 2, Step 12 Phas e 2, 12 Phas e 2, 12 Phas		Emissions due to post-fire deforestation in 2019 (tCH4)	0.00
			Emissions due to post-fire deforestation in 2019 (tN2O)	0.00
	BL	Phas e 2, Step 13	Total aerial carbon stock (t C) - t6	78.95
	BM	Phas e 2, Step 13	Above ground living carbon stock (t C) - t6	13.69

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	BN	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tC)	29.05
	во	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tCH4)	0.42
	ВР	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tN2O)	0.01
	BQ	Phas e 2, Step 14	Emissions due to selective logging in 2020 (tC)	0.00
	BR Phas e 2, Step 14		Carbon stock decrease due to fire in unmanaged lands in 2020 (tC)	0.00
	BS	Phas e 2, Step 14	Carbon stock decrease due to selective regular logging in 2020 (tC)	0.00
	BT BT 15		Total carbon stock (t C) - t7	77.34
	BU	Phas e 2, Step 15	Total aerial carbon stock (t C) - t7	49.89
	BV	Phas e 2, Step 15	Above ground living carbon stock (t C) - t7	5.04
	BW BW BW 13 Phas e 2, Step 16		Emissions due to deforestation in 2020 (tC)	0.00
	вх	Phas e 2, Step 16	Emissions due to post-fire deforestation in 2020 (tCH4)	0.00
	BY	Phas e 2, Step 16	Emissions due to post-fire deforestation in 2020 (tN2O)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	BZ	Phas e 2, Step 17	Total aerial carbon stock (t C) - t8	49.89
	СА	Phas e 2, Step 17	Above ground living carbon stock (t C) - t8	5.04
	СВ	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tC)	18.36
	CC C	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tCH4)	0.27
	CD P CD F CE S		Emissions due to fire in 2021 in managed lands (tN2O)	0.01
			Emissions due to selective logging in 2021 (tC)	0.00
	CF	Phas e 2, Step 18	Carbon stock decrease due to fire in unmanaged lands in 2021 (tC)	0.00
	CG	Phas e 2, Step 18	Carbon stock decrease due to selective regular logging in 2021 (tC)	0.00
	СН	Phas e 2, Step 19	Total carbon stock (t C) - t9	58.98
	CI	Phas e 2, Step 19	Total aerial carbon stock (t C) - t9	31.53
	CJ	Phas e 2, Step 19	Above ground living carbon stock (t C) - t9	1.85
	СК	Phas e 2, Step 20	Emissions due to deforestation in 2021 (tC)	58.98

Status ii		rrent su	bmissio	on							
CL	Phas e 2, Step 20	Emissi	ons due	to post	t-defore	station 1	fire in 2	021 (tCł	-14)	0.17	
СМ	Phas e 2, Step 20	Emissio	ons due	to post	-defore	station f	ire in 20	021 (tN2	20)	0.00	
queim	ada em 20)17 quei	mada em	2017 qu	ueimada e	l por m		S	oma de	EM por So	
1 MANE	JADAS	MAN	IEJADAS	М		s (CS em 201	.7 (tC) 2	017 (tC)	en	n 2017 (47
-				results	S DY 1	ine ye	ear 20	лт/ Э	ccorc	ang to	τηε
Source: Step 22:	own ela Emission on, addec	boratior s are con l to the o	ו verted in ther out	nto tones puts, to	s of CO2 e obtain th	Outpu equivalen e averag	uts nt. These e net em	values a nission fo	ire used	d in the fin elevant bio	al
Source: Step 22: calculatio	own ela Emission. Dn, addec 49 preso Emissões Cor desmatemento (t ⁰) 10871135,25	boration s are con I to the o ents an e	ו verted in ther out xample o	nto tones puts, to	s of CO2 e obtain th	equivalen e averag ons by RE	uts nt. These e net em	values a nission fo vity for t	ire used	d in the fin elevant bio me.	al
Source: Step 22: calculation Figure	own ela Emission. on, addec 49 preso Emissões cor desmissões cor desmissões cor desmissões cor	boration s are con t to the o ents an e c Emissies CH4 per desmeionento (CCH4)	verted in ther out xample o Emissies N20 por desmotemento (N20)	nto tones puts, to of CO2 e ^E <u>Área de</u> desimitamento (ba)	s of CO2 e obtain th q emissio F G Periodo	Output equivalence e averag ms by RE. M Emissies Cor operimed 5273/9 1413/42 2043/3 1485,27	Jts t. These e net en DD+ acti tritter tritter tritter d542 20154	values a nission fc ivity for t emission 20 per gerimada en (WOO) 1378 1378 1378 1378 1378 1378 1378 1378	rre used or the ro the bior (he bior Area de queimace (ho)	d in the fin elevant bio me.	N Emissões (corte sele irregulor, 1.528,8 355,7 4.672,0 3.86(1)
Source: Step 22: calculatio Figure Periodo 1 2 2017-2018 4 2018-2019 5 2019-2020	own ela Emission. con, addec 49 prese Enisös cor desmanmento (K) 10871135,25 1134932,44 13418112,94 135417,94 135417,94 135417,94	boration s are con d to the o ents an e c Emissões CH4 por desmatamento (CCH4 47.440,38 59.45,81 67.855,28	verted in ther out xample o envide ND pr desindmento (NDO) 1395,31 1471,80 1383,51 1471,80 1383,51 1471,80 1383,51 1471,90 1383,51 1471,90 1383,51 1471,90 1483,51 1471,51 147	to tones puts, to of CO2 e kreade (ba) 94237,38 97057,75 113352,39 12359,16	s of CO2 e obtain th q emissio F G Periodo 2015-2018 2018-2029 2019-2020	Output equivalence e averag ms by RE. M Emissies Cor operimed 5273/9 1413/42 2043/3 1485,27	uts t. These e net en DD+ acti enemote rerement (CT44) 465,42 905,54	values a nission fc ivity for t emission 20 per gerimada en (WOO) 1378 1378 1378 1378 1378 1378 1378 1378	ите used or the ro the bioi к Агеа de queimac (на) 5.177,04 3.372,97 5.251,09 4.871,09 4.871,09	d in the fin elevant bio me. * Periodo 2016-2017 2017-2018 2018-2019 2018-2029 2018-2029	N Emissões (corte sele irregular
	CM CM Soma quein (tC) Al 1 MANE 2 Figure	CL Step 20 Phas e 2, Step 20 • Step 2 20 • Step 2 20 • Step 2 values	CL e 2, Step 20 Phas e 2, Step 20 CM Step 21: The REDD+ active values obtain Soma de EM por Soma queimada em 2017 quei (tc) AREAS (tcH4 MANEJADAS MAN 2 32.376,37 Figure 48 – Emis	CL e 2, Step Emissions due 20 Phas e 20 Phas Emissions due CM e 2, Step Emissions due 20 Step Emissions due 0 Step 21: Through REDD+ activity convalues obtained in Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por (tC) AREAS 1 MANEJADAS 2 32.376,37	CL e 2, Step 20 Emissions due to post 20 Phas e 2, Step 20 Emissions due to post 20 • Step 21: Through dynam REDD+ activity considered values obtained in this plant values obtained in this plant (tC) AREAS • A B • Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por (tCH4) AREAS • MANEJADAS MANEJADAS	CL e 2, Step Emissions due to post-defore 20 Phas e 2, Step Emissions due to post-defore CM e 2, Step Emissions due to post-defore 20 Step 21: Through dynamic tab REDD+ activity considered and values obtained in this phase ar A B C Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por (tC) AREAS Soma de EM por (tC) AREAS Soma de EM por (tC) AREAS 1 MANEJADAS MANEJADAS MANEJADAS	CL e 2, Step Emissions due to post-deforestation for 20 Phas e 2, Step Emissions due to post-deforestation for 20 O Step 21: Through dynamic tables, the REDD+ activity considered and annual values obtained in this phase are in to A B C Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por queimada em 2017 (tC) AREAS MANEJADAS MANEJADAS MANEJADAS MANEJADAS	CL e 2, Step 20 Emissions due to post-deforestation fire in 24 20 Phas e 2, Step 20 Emissions due to post-deforestation fire in 24 20 • Step 21: Through dynamic tables, the sum REDD+ activity considered and annual peri values obtained in this phase are in tonnes of soma de EM por queimada em 2017 queimada em 2017 (tC) AREAS • A B C D • Soma de EM por queimada em 2017 queimada em 2017 (tC) AREAS Soma de EM por 2017(tN20) AREAS Soma de EM por 2017(tN20) AREAS • MANEJADAS MANEJADAS MANEJADAS CS em 201 2	CL e 2, Step Emissions due to post-deforestation fire in 2021 (tCl 20 Phas e 2, Step Emissions due to post-deforestation fire in 2021 (tN) 20 • Step 21: Through dynamic tables, the sum of GI REDD+ activity considered and annual period wa values obtained in this phase are in tonnes of C, CH • A B C D • Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por MANEJADAS Soma de EM por MANEJADAS Soma de EM por MANEJADAS Soma de EM por MANEJADAS	CL e 2, Step 20 Emissions due to post-deforestation fire in 2021 (tCH4) Phas e 2, Step 20 e 2, Step 20 Emissions due to post-deforestation fire in 2021 (tN2O) • Step 21: Through dynamic tables, the sum of GHG en REDD+ activity considered and annual period was cal values obtained in this phase are in tonnes of C, CH4 an • A B C D E • Soma de EM por queimada em 2017 (tC) AREAS Soma de EM por (tCH4) AREAS Soma de EM por Queimada em 2017 (tCH4) AREAS Soma de EM por Queimada em 2017 (tC) 2017 (tC)	CL e 2, Step 20 Emissions due to post-deforestation fire in 2021 (tCH4) 0.17 Phas e 2, Step 20 e 2, Emissions due to post-deforestation fire in 2021 (tN2O) 0.00 • Step 21: Through dynamic tables, the sum of GHG emission REDD+ activity considered and annual period was calculated values obtained in this phase are in tonnes of C, CH4 and N2O. • A B C D E Soma de EM por queimada em 2017 (tC) AREAs Soma de EM por (tC) AREAS

Status in the current submission

8.10.3. Degradation output – Amazon biome

• PHASE 1 – GIS operations

The 1st phase involves several "georeferenced operations" using SIG tools, with the aim to consolidate all different degradation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 49.** Each line of the spreadsheet represents a group of polygons with the same characteristics, with the exception of the area (hectares). The area represents the sum of the individual polygons. Such aggregation was necessary due to the large amount of data.

Variable name	Description	Unit	Spreadsheet column	Source
Biome	Biome classification: Amazon	n/a	A	IBGE, 2019
Main_class	REDD+ activity classification: "DEGRAD" meaning "degradation"	n/a	В	DETER
deter2017	Degradation	n/a	С	
deter2018	classification in corresponding year:	n/a	D	
deter2019	- Fire ("burn scar")	n/a	E	
deter2020	- Disordered logging	n/a	F	
deter2021	("CS") - orderly logging ("CSR")	n/a	G	
status			Н	
source_inv	Corresponding biome classification in the 4th GHG National Inventory		I	4th GHG National Inventory
Phytophysiognomy	Ancient vegetation phytophysiognomies	n/a	J	
category	Vegetation category: Forest (F)	n/a	К	
Managed_land	indicates whether the polygon is situated in a managed area ("t" = true) or not ("f" = falsa)		L	

Table 49 – Amazon degradation output main parameters

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current s	ubmission			
	EBA_cagb	Carbon content – above ground biomass carbon pool	tC/ha	Μ	EBA
	EBA_cbgb	Carbon content – below ground biomass carbon pool	tC/ha	Ν	
	EBA_cdw	Carbon content – dead wood carbon pool	tC/ha	0	
	EBA_clitter	Carbon content – litter carbon pool	tC/ha	Р	
	EBA_ctotal	Total carbon	tC/ha	Q	
	area_ha	Polygon area	ha	R	Own estimates

Source: Electronic spreadsheet "1c_Amazon_Emissions_Output_Degradation.xls"

• PHASE 2 – Emissions calculations

Emissions calculations were performed in chronological order, according to the occurrence of degradation processes (fire and/or disordered logging). The following steps have been followed:

• **Step 1**: Calculation of carbon stocks available in *tO* (tons of C, i.e., tC/ha stock values already multiplied by areas (in ha)) by total and carbon pools:

Column S: total C stock *t0* Column T: aerial C stock *t0* Column U: above ground C stock *t0*

 Step 2: Calculation of C, CH4 and N2O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2017:

> Column V: C emissions due to fire in managed lands Column W: CH4 emissions due to fire in managed lands Column X: N2O emissions due to fire in managed lands Column Y: C emissions due to disordered logging (CS) Column Z: C loss due to fire in unmanaged lands Column AA: C loss due to orderly logging (CSR)

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	 Step 3: Calculation of remaining carbon stocks after degradation processes in 2017, definining the carbon stocks available for potential degradation in 2018: Column AB: aerial C stock <i>t1</i> Column AC: above ground C stock <i>t1</i>
	 Step 4: Calculation of C, CH4 and N2O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2018: Column AD: C emissions due to fire Column AE: CH4 emissions due to fire Column AF: N2O emissions due to fire Column AG: C emissions due to fire Column AG: C emissions due to disordered logging (CS) Column AH: C loss due to fire in unmanaged lands Column AI: C loss due to orderly logging (CSR)
	 Step 5: Calculation of carbon stocks available after degradation processes in 2018, definining the carbon stocks available for potential degradation in 2019: Column AJ: aerial C stock <i>t2</i> Column AK: above ground C stock <i>t2</i>
	 Step 6: Calculation of C, CH4 and N2O emissions due to degradation by fire in managed forest areas or disordered logging (CS) in 2019: Column AL: C emissions due to fire Column AM: CH4 emissions due to fire Column AN: N2O emissions due to fire Column AO: C emissions due to disordered logging (CS) Column AP: C loss due to fire in unmanaged lands Column AQ: C loss due to orderly logging (CSR)
	 Step 7: Calculation of the remaining carbon stocks available after degradation in 2019, defining the carbon stocks available for potential degradation in 2020: Column AR: aerial C stock t3 Column AS: above ground C stock t3
	 Step 8: Calculation of C, CH4 and N2O emissions due to degradation by fire in managed forest areas or disordered logging (CS) in 2020: Column AT: CO2 emissions due to fire Column AU: CH4 emissions due to fire

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Column AV: N2O emissions due to fire Column AW: C emissions due to disordered logging (CS) Column AX: C loss due to fire in unmanaged lands Column AY: C loss due to orderly logging (CSR)
	 Step 9: Calculation of carbon stocks available after degradation processes in 2020, defining the carbon stocks available for potential degradation in 2021: Column AZ: aerial C stock <i>t4</i> Column BA: above ground C stock <i>t4</i>
	 Step 10: Calculation of CO2, CH4 and N2O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2021: Column BB: CO2 emissions due to fire Column BC: CH4 emissions due to fire Column BD: N2O emissions due to fire Column BE: C emissions due to fire Column BE: C emissions due to disordered logging (CS)
	• Step 11 : Through dynamic tables, the sums of GHG emissions were calculated. The values obtained in this phase are in tons of C, CH4 and N2O.
	• Step 12: Emissions are converted into tones of CO2 equivalent. These values will be used in the final calculation and added to the other outputs, to obtain average net emission from the biome.
	8.10.4. Secondary vegetation output – Amazon biome
	• PHASE 1 – GIS operations
	The 1st phase involves several spatial operations using SIG tools, with the aim to consolidate all different secondary vegetation activity data. As result, a spreadsheet was obtained, containing the information presented in Table 50. Each line of the spreadsheet represents a group of polygons with the same characteristics, with the exception of the area (hectares). The area represents the sum of the individual polygons. Such aggregation was necessary due to the large amount of data.

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current sub	
	Table 50 – Amazon so	econdary vegetation output main parameters
	Variable name	Description
	Biome	Biome classification: Amazon
	class_2014	Secondary vegetation class for year 2014
	class_2020	Secondary vegetation class for year 2020
	phytophysiognomy category	Ancient vegetation phytophysiognomies Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)
	area_ha	Polygon area
	 per year (2014) Step 2: Calculyear (2014) and Step 3: Convelotion Step 4: Calcul (tC/yr) 	ation of C removals by natural forest regeneration per d 2020) considering factor of 3,03 tC/ha.yr rsion of tonnes of C tonnes to CO2 equivalent lation of the average annual removal average rate
	GHG emission	Net GHG emission – Amazon biome lidation of results lation of the annual net GHG emission: sum of gross is by deforestation and degradation minus removals by regeneration in each annual period

Status in the current submission

8.11. Detailed description for estimating GHG emissions/removals in the Cerrado biome

The operational procedures, based on the methodological approach described in page 56, used to estimate GHG emission due to deforestation and removals from growth of natural forest regeneration in the Cerrado biome are presented in sequence.

8.11.1. Deforestation output – Cerrado biome

• PHASE 1 – GIS operations

The 1st phase involves several spatial operations using GIS tools, with the aim to consolidate all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 51.** Each line of the spreadsheet represents a single deforestation polygon.

Variable name	e Description		Spreadsheet column	Source
fid		n/a	А	
Biome	Biome classification: Cerrado	n/a	В	IBGE, 2019
State	Brazilian political- administrative state	n/a	С	
Main_class	REDD+ activity	n/a	D	
Class_name	REDD+ activity/year classification		E	PRODES
Year	Mapping year	n/a	F	PRODES
Image_date	Image date of each polygon	n/a	G	
source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	н	4th GHG
phytophysiognomies	Ancient vegetation phytophysiognomies	n/a	I	National Inventory
Category	Land use category: Forest (F)	n/a	J	

Table 51 – Cerrado deforestation output main parameters

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission				
	rr_cagb	Above ground carbon stock	tC/ha	К	
	rr_cbgb	Below ground carbon stock	tC/ha	L	
	rr_cdw	Dead wood carbon stock	tC/ha	Μ	
	rr_clitter	Litter carbon stock	tC/ha	Ν	
	rr_ctotal	Total carbon stock	tC/ha	0	
	Area_ha	Polygon area	ha	Р	Own calculations
	 Step 2: Ca in the "sla Colum Step 3: Ca burn" defo Colum Colum Step 4: Th GHG are c of CO2, to Step 5: Em values wil outputs, to 8.11.2. bior 	In R: CO2 emissions due Iculation of the mass of sh and burn" type defore n S: above ground C stoc alculation of CH4 and N prestation: n T: CH4 emissions due t n U: N2O emissions due rough pivot tables, the s alculated. The values obt nnes of CH4 and tonnes hissions are converted in I be used in the final ca o obtain the average net Secondary vege me oreferenced operations	fuel availa estation k I2O emissi o deforest to deforest to defores um of emi tained at t of N2O. to tones o lculation a emission	ible for fir ions due ation station ssions per his stage a f CO2 equ and added for the bic	to "slash and year and are in tonnes ivalent. These I to the other ome.

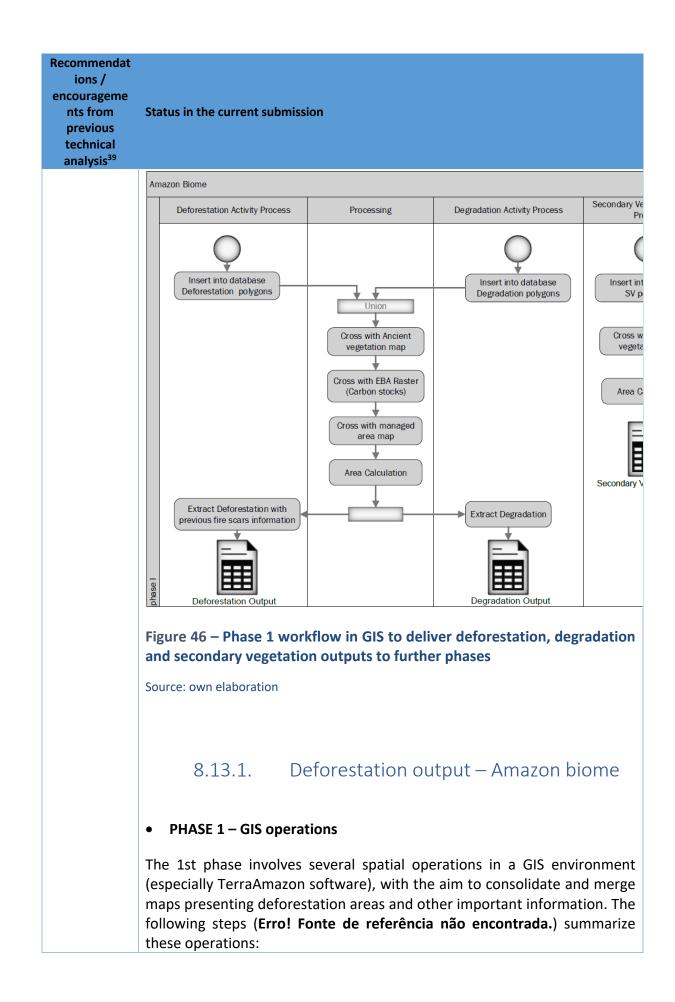
Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission				
	The 1st phase involves several "georeferenced operations" using SIG tools, with the aim to consolidate all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented inTable 52 . Each line of the spreadsheet represents a group of polygons with the same characteristics, with the exception of the area (hectares). The area represents the sum of the individual polygons. Such aggregation was necessary due to the large amount of data. Table 52 – Cerrado secondary vegetation output main parameters				
	Variable name	Description			
	Biome	Biome classification: Cerrado			
	class_2018	Secondary vegetation class for year 2018			
	class_2020	Secondary vegetation class for year 2020			
	phytophysiognomy	Ancient vegetation phytophysiognomies			
	category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)			
	Area_ha	Polygon area (
	 PHASE 2 – Emissions calculations Step 1: Calculation of total area of secondary vegetation per year (2014 and 2020) Step 2: Calculation of C removals by secondary vegetation per year (2014 and 2020) considering factor of 3,03 tC/ha.yr Step 3: Conversion of C tones to CO2 equivalent Step 4: Calculation of the annual removal average rate (tC/yr) Step 5: Application of the value obtained for each year of the series 				
	8.11.3. • PHASE 3 – Conso	Net GHG emission – Cerrado biome			

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current su	bmission					
	GHG emissio	ulation of the annu ons by deforestati n each period			-		
	 Step 2: Calcu 	ulation of average no	et emis:	sions in the perio	od		
	emission Caatinga, • PHASE 1 – GIS o The 1st phase invol- aim to consolidate spreadsheet was ob 53. Each line of the s	 8.12. Detail description for estimating GHG emissions/removals in the Atlantic Forest, Caatinga, Pampa and Pantanal biomes PHASE 1 – GIS operations The 1st phase involves several spatial operations using GIS tools, with the aim to consolidate all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in Table 53. Each line of the spreadsheet represents a single deforestation polygon. Table 53 – Atlantic Forest, Caatinga, Pampa and Pantanal biomes 					
	Variable name	Description	Unit	Spreadsheet column	Source		
	fid		n/a	A			
	Biome	Biome classification	n/a	B	IBGE, 2019		
	Main_class	REDD+ activity	n/a	C	,		
	Year	, Mapping year	, n/a	D	PRODES		
	Image_date	Image date of each polygon	n/a	E	FRODES		
	source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	F			
	phytophysiognomies	Ancient vegetation phytophysiognomies	n/a	G	4th GHG National		
	Category	Land use category: Forest (F)	n/a	Н	Inventory		
	rr_cagb	Above ground carbon stock	tC/ha	I			
	rr_cbgb	Below ground	tC/ha	J			

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current su	Ibmission			
	rr_cdw	Dead wood carbon stock	tC/ha	К	
	rr_clitter	Litter carbon stock	tC/ha	L	_
	rr_ctotal	Total carbon stock	tC/ha	М	
	Area_ha	Polygon area	ha	Ν	Own calculations
	 PHASE 2 – Emissions calculations Step 1: Calculation of C and CO2 due to deforestation: Column Q: C emissions due to deforestation Column R: CO2 emissions due to deforestation Step 2: Through pivot tables, the sums of emissions per year a GHG are calculated. The values obtained at this stage are in to CO2, tons of CH4 and tons of N2O. Step 3: Emissions are converted into tones of CO2. These valu be used in the final calculation, added to the other outputs, to average net emission from the biome. PHASE 3 – Consolidation of results Step 1: Calculation of the gross CO2 emissions per period as th of individual emissions per polygon Step 2: Calculation of average gross emissions in the period biome 				
	FRELStep 1: regro	ail description - ouping the emission lation of the net en	s for each	biome and y	ear
	-	llation of the averag 2019-/2021, conside	•	-	

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Quality control and quality assurance procedures"
Provide information on the extent of deforested areas that are detected at the 1 ha threshold but not retrieved later by the PRODES project using a 6.25 ha threshold, with the aim of showing that no significant deforestation is excluded from the FREL	Deforestation have been estimated used a minimum map unit of 1 hectare – refer to section "Estimation of Brazil's national FREL"
Provide information on how the EFs were derived for the five vegetation types that were not included in the 22 forest types of the FREL	Information on how EFs were derived for each biome have been included – refer to section "Estimation of Brazil's national FREL"
Provide a territorial matrix of the Amazonia biome in the FREL with the distribution considered by the national communicatio n and by the FREL, along with a clear description of	Currently, it is not possible to present a "territorial matrix" since INPE methodology for monitoring deforestation does not include procedures for the identification of land use after deforestation. In other words, it can only be said that the deforestation areas presented here relate to forest conversions (F) to another non-forest land category, as defined as "deforestation", but without a clear definition if the land is Cropland, Grassland, etc.

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
any methodologica l differences	
Better explain the difference of 5,573,793.6 ha between the PRODES deforestation increments in the third national communicatio n and in the FREL	The difference is potentially explained by the fact that in PRODES deforestation estimated are included Other Woody Formations (OFL) which are not considered forest phytophysiognomies in the 4th National Inventory. There is also the fact that PRODES considers the territory of the Legal Amazon, while the National Inventory considered the Amazon biome, whose limits are different
Strengthen the quality control of the submission to eliminate inconsistencie s	In this submission all steps taken were supervised both by internal FUNCATE experts, as well as by other external experts with relevant expertise During activity data collection using orbital images, external consultants with specific expertise in each one of the biomes were hired, to guide the team of interpreters, drawing attention to relevant aspects to be considered in the spatial distribution of phytophysiognomies and in their phenological dynamics, seeking to minimize possible misunderstandings of interpretation During data processing, considering the large volume and control needs for the elaboration of spreadsheets for future calculations, all work was concentrated in a single expert who interacted with those responsible for the calculations. The occurrence of inconsistencies was promptly reported, and further processing followed After the completion of the calculations, even of those intermediaries, the results were discussed in meetings, with the participation of FUNCATE experts, MMA team, technical coordinator and UNDP team For more information, refer to section "The operational procedures, based on the methodological approach described in page 56, used to estimate GHG emissions due to deforestation, forest degradation and removals from secondary vegetation growth in the Amazon biome are detailed below. Overview of phase 1 is presented in Figure 46 , where spatial data is assembled and spreadsheets are acquired to next calculation steps.



Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current	submission			
	 creation), a. PR(cor 201 b. DE log c. Bio d. And e. Ma Ver top filter only occurring native veg Step 2: Spa filter only occurring native veg Step 3: As unit area) the spatial Inventory for annual per and their c stocks for wood and Table 47 – Outo 	Vectorial data gathering considering: DDES maps presenting po- nversion increments for th 18, 2018-2019, 2019-2020 a TER degradation maps pres- ging areas mes boundaries (<i>Figure 1</i>) cient native vegetation map naged areas map rifications consists in a rou- bology errors (such as over ormation. atial operations execution to deforestation polygons (i. in forest phytophysiognome etation map). sociation of the emission f to each deforestation poly average value from the EBA maps presenting each carboo portation of an electronic sp riod of the reference perio orresponding phytophysiog above-ground biomass, I litter - Table 47.	olygons ne peri nd 202 enting (<i>Figur</i> tine of erlaps e., nat nies ac actors gon the readsh d, the pelow-p	iof native v iods 2016-20 0-2021 fire scars and e 9) procedures f and gaps) an step 1 data an ive vegetatio cording to th (i.e., carbon rough the exit map (4th Nat). eet containin deforestation s and associat ground biom	vegetation p17, 2017- d selective to identify nd lack of nd then to on clearing ne ancient stocks per traction of tional GHG g, for each n polygons ted carbon hass, dead
	Variable name	nponent, which is the input Description	Unit	Spreadsheet	Source
	Biome	Biome classification: Amazon	n/a	column A	IBGE, 2019
	main_class	REDD+ activity classification: Deforestation	n/a	В	PRODES

ions / encourageme nts from previous technical analysis ³⁹	Status in the current	submission			
	class_name	REDD+ activity/year	n/a	С	
	year	classification Year where the REDD+ activity have occurred	n/a	D	
	deter2017	Degradation classification in	n/a	E	DETER
	deter2018	corresponding year:	n/a	F	
	deter2019	 Fire ("burn scar") Disordered logging ("CS") 	n/a	G	
	deter2020	- orderly logging ("CSR")	n/a	Н	
	deter2021		n/a	I	
	status			J	
	source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	К	4th GHG National Inventory
	phytophysiognomy	Ancient vegetation phytophysiognomies	n/a	L	
	category	Vegetation category: Forest (F)	n/a	Μ	
	managed _land	indicates whether the polygon is situated in a managed area ("t" = true) or not ("f" = falsa)	n/a	Ν	
	EBA_cagb	Carbon content – above ground biomass carbon pool	tC/ha	0	EBA (4th GHG
	EBA_cbgb	Carbon content – below ground biomass carbon pool	tC/ha	Р	National Inventor
	EBA_cdw	Carbon content – dead wood carbon pool	tC/ha	Q	
	EBA_clitter	Carbon content – litter carbon pool	tC/ha	R	
	EBA_c4	Total carbon	tC/ha	S	
	area_ha	Polygon area	ha	Т	Own estimates
	Source: Electronic spr "P3h_FREL_AMAZON 6ha_Cenario3_v20202 biome main_dass dass_name ye biome main_dass dass_name ye	IA_EMISSOES_DESMATAMENTO	J K s source_inv phyto	L M ophysiognomy category F	N O managed_land eba_cagb_ebb f 17,09

encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Figure 47 – Illustrative representation of the electronic spreadsheet outper from Phase 1
	Source: own elaboration
	Each line of the spreadsheet represents a group of polygons with the sam characteristics, except for their individual area. The "area_ha" attribut represents the sum of the individual deforested polygons areas. Suc aggregation was necessary due to the large amount of data generated for the Amazon biome, which are not supported by Excel.
	PHASE 2 – Emissions calculations
	Emissions calculations were performed in chronological order, according the occurrence of degradation and/or deforestation activities, alwar applying the degradation losses before losses due to deforestation with the same year. The following steps were followed:
	 Step 1: Calculation of carbon stocks available in t0 (in tonnes of i.e., tC/ha stock values already multiplied by areas in ha) by total ar carbon pools: Column U: total C stock t0 [=S3*T3] Column V: aerial C stock t0 [=(O3+Q3+R3)*T3] Column W: above ground C stock t0 [=O3*T3]
	 Step 2: Calculation of C, CH4 and N2O emissions and other losses du to degradation in 2017: Column X: C emissions due to fire in managed lands Column Y: CH4 emissions due to fire in managed lands Column Z: N2O emissions due to fire in managed lands Column AA: C emissions due to disordered logging (CS) Column AB: C loss due to fire in unmanaged lands Column AC: C loss due to orderly logging (CSR)
	 Step 3: Calculation of remaining carbon stocks after degradation 2017, representing carbon stocks available for deforestation in 201 Column AD: total C stock <i>t1</i> Column AE: aerial C stock <i>t1</i> Column AF: above ground C stock t1

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	 Step 4: Calculation of C, CH4 and N2O emissions due to deforestation in 2017: Column AG: C emissions due to deforestation Column AH: CH4 emissions due to deforestation (resulting from slash and burn) Column AI: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 5: Calculation of carbon stocks available after 2017, representing carbon stocks available for degradation in 2018: Column AJ: aerial C stock <i>t2</i> Column AK: above ground C stock <i>t2</i>
	• Step 6 : Calculation of C, CH4 and N2O emissions and other losses due to degradation in 2018:
	Column AL: C emissions due to fire in managed lands Column AM: CH4 emissions due to fire in managed lands Column AN: N2O emissions due to fire in managed lands Column AO: C emissions due to disordered logging (CS) Column AP: C carbon loss due to fire in unmanaged lands Column AQ: C carbon loss due to orderly logging (CSR)
	 Step 7: Calculation of carbon stocks available after 2018 degradation, representing carbon stocks available for deforestation in 2018: Column AR: total C stock t3 Column AS: aerial C stock t3 Column AT: above ground C stock t3
	 Step 8: Calculation of C, CH4 and N2O emissions due to deforestation in 2018: Column AU: C emissions due to deforestation Column AV: CH4 emissions due to deforestation (resulting from slash and burn) Column AW: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 9: Calculation of carbon stocks available after 2018, representing carbon stocks available for degradation in 2019: Column AX: aerial C stock t4

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Column AY: above ground C stock <i>t4</i>
	 Step 10: Calculation of C, CH4 and N2O emissions due to degradation in 2019: Column AZ: C emissions due to fire Column BA: CH4 emissions due to fire Column BB: N2O emissions due to fire Column BC: C emissions due to disordered logging (CS) Column BD: C carbon loss due to fire in unmanaged lands Column BE: C carbon loss due to orderly logging (CSR)
	 Step 11: Calculation of carbon stocks available after 2019 degradation, representing the carbon stocks available for deforestation in 2019: Column BF: total C stock t5 Column BG: aerial C stock t5 Column BH: above ground C stock t5
	 Step 12: Calculation of C, CH4 and N2O emissions due to deforestation in 2019: Column BI: C emissions due to deforestation Column BJ: CH4 emissions due to deforestation (resulting from slash and burn) Column BK: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 13: Calculation of carbon stocks available after 2019, representing carbon stocks available for degradation in 2020: Column BL: aerial C stock <i>t6</i> Column BM: above ground C stock <i>t6</i>
	 Step 14: Calculation of C, CH4 and N2O emissions due to degradation in 2020: Column BN: C emissions due to fire Column BO: CH4 emissions due to fire Column BP: N2O emissions due to fire Column BQ: C emissions due to disordered logging (CS) Column BR: Closs due to fire in unmanaged lands Column BS: Closs due to orderly logging (CSR)

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	 Step 15: Calculation of carbon stocks available after 2020 degradation, representing the carbon stocks available for deforestation in 2020: Column BT: aerial C stock t7 Column BU: above ground C stock t7 Column BV: above ground C stock t7
	 Step 16: Calculation of C, CH4 and N2O emissions due to deforestation in 2020: Column BW: C emissions due to deforestation Column BX: CH4 emissions due to deforestation (resulting from slash and burn) Column BY: N2O emissions due to deforestation (resulting from slash and burn)
	 Step 17: Calculation of carbon stocks available after 2020, representing carbon stocks available for degradation in 2021: Column BZ: aerial C stock <i>t8</i> Column CA: above ground C stock <i>t8</i>
	 Step 18: Calculation of C, CH4 and N2O emissions due to fire degradation in 2021: Column CB: C emissions due to fire Column CC: CH4 emissions due to fire Column CD: N2O emissions due to fire Column CE: C emissions due to disordered logging (CS) Column CF: C loss due to fire in unmanaged lands Column CG: C loss due to orderly logging (CSR)
	 Step 19: Calculation of carbon stocks available after 2021 degradation, representing the stocks available for deforestation in 2021: Column CH: Total C stock <i>t9</i> Column CI: above ground C stock t9 Column CJ: above ground C stock t9
	 Step 20: Calculation of C, CH4 and N2O emissions due to deforestation in 2021: Column CK: C emissions due to deforestation Column CL: CH4 emissions due to deforestation (resulting from slash and burn)

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in	I the curre	nt submission			
		Column CM: N2O emissions due to deforestation (resulting from slash and burn) The following table presents a numerical example of the calculations that have been carried out. Is important to note the evolution of total carbon stocks. In green: initial total carbon stocks; in blue: total carbon stocks after degradation events or not; in yellow: emissions due to deforestation whose values are associated with the reduced carbon stocks after previous degradation. Table 48 – Example of GHG emissions for an area presenting a trajectory				
	have be stocks. degrad values degrad					
		Phas	ough degradation by fire to deforestation			
	Colum n	e, Step	Attribute	Value		
	А	Phas e 1	biome	Amazon		
	В	Phas e 1	main_class	DESMATAMEN TO		
	С	Phas e 1	class_name	d2021		
	D	Phas e 1	year	2021		
	E	Phas e 1	deter2017	CQ1		
	F	Phas e 1	deter2018	CQ2		
		e 1 Phas deter2019				
	G	Phas e 1	deter2019	CQ3		
	G H		deter2019 deter2020	CQ3 CQ4		
		e 1 Phas				
	Н	e 1 Phas e 1 Phas	deter2020	CQ4		
	H	e 1 Phas e 1 Phas e 1 Phas	deter2020 deter2021	CQ4 CQ5		
	H J	e 1 Phas e 1 Phas e 1 Phas e 1 Phas	deter2020 deter2021 status	CQ4 CQ5 DETER		
	H I J K	e 1 Phas e 1 Phas e 1 Phas e 1 Phas e 1 Phas	deter2020 deter2021 status source_inv	CQ4 CQ5 DETER Amazonia		

ions / encourageme nts from previous technical analysis ³⁹	Status i	1	rrent submission	
	О	Phas e 1	eba_cagb	71.74
	Р	Phas e 1	eba_cbgb	7.17
	Q	Phas	eba_cdw	5.81
	R	e 1 Phas	eba_clitter	4.14
		e 1 Phas		
	S	e 1	eba_ctotal	88.86
	Т	Phas e 1	area_ha	3.83
	U	Phas e 2, Step 1	Total carbon stock (t C) - t0	340.18
	v	Phas e 2, Step 1	Total aerial carbon stock (t C) - t0	312.73
	w	Phas e 2, Step 1	Above ground living carbon stock (t C) - t0	274.64
	x	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tC)	115.09
	Y	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tCH4)	1.67
	z	Phas e 2, Step 2	Emissions due to fire in 2017 in managed lands (tN2O)	0.05
	AA	Phas e 2, Step 2	Emissions due to selective logging in 2017 (tC)	0.00
	АВ	Phas e 2, Step 2	Carbon stock decrease due to fire in unmanaged lands in 2017 (tC)	0.00
	AC	Phas e 2, Step 2	Carbon stock decrease due to selective regular logging in 2017 (tC)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	AD	Phas e 2, Step 3	Total carbon stock (t C) - t1	225.10
	AE	Phas e 2, Step 3	Total aerial carbon stock (t C) - t1	197.65
	AF	Phas e 2, Step 3	Above ground living carbon stock (t C) - t1	101.07
	AG	Phas e 2, Step 4	Emissions due to deforestation in 2017 (tC)	0.00
	АН	Phas e 2, Step 4	Emissions due to post-fire deforestation in 2017 (tCH4)	0.00
	AI	Phas e 2, Step 4	Emissions due to post-fire deforestation in 2017 (tN2O)	0.00
	ĄJ	Phas e 2, Step 5	Total aerial carbon stock (t C) - t2	197.65
	AK	Phas e 2, Step 5	Above ground living carbon stock (t C) - t2	101.07
	AL	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tC)	72.73
	AM	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tCH4)	1.05
	AN	Phas e 2, Step 6	Emissions due to fire in 2018 in managed lands (tN2O)	0.03
	AO	Phas e 2, Step 6	Emissions due to selective logging in 2018 (tC)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status i	n the cu	rrent submission	
	AP	Phas e 2, Step 6	Carbon stock decrease due to fire in unmanaged lands in 2018 (tC)	0.00
	AQ	Phas e 2, Step 6	Carbon stock decrease due to selective regular logging in 2018 (tC)	0.00
	AR	Phas e 2, Step 7	Total carbon stock (t C) - t3	152.36
	AS	Phas e 2, Step 7	Total aerial carbon stock (t C) - t3	124.91
	AT	Phas e 2, Step 7	Above ground living carbon stock (t C) - t3	37.19
	AU	Phas e 2, Step 8	Emissions due to deforestation in 2018 (tC)	0.00
	AV	Phas e 2, Step 8	Emissions due to post-fire deforestation in 2018 (tCH4)	0.00
	AW	Phas e 2, Step 8	Emissions due to post-fire deforestation in 2018 (tN2O)	0.00
	АХ	Phas e 2, Step 9	Total aerial carbon stock (t C) - t4	124.91
	AY AY AY Step 9		Above ground living carbon stock (t C) - t4	37.19
	AZ	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tC)	45.97
	ВА	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tCH4)	0.67

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	BB	Phas e 2, Step 10	Emissions due to fire in 2019 in managed lands (tN2O)	0.02
	BC	Phas e 2, Step 10	Emissions due to selective logging in 2019 (tC)	0.00
	BD	Phas e 2, Step 10	Carbon stock decrease due to fire in unmanaged lands in 2019 (tC)	0.00
	BE	Phas e 2, Step 10	Carbon stock decrease due to selective regular logging in 2019 (tC)	0,00
	BF	Phas e 2, Step 11	Total carbon stock (t C) - t5	106.39
	BG	Phas e 2, Step 11	Total aerial carbon stock (t C) - t5	78.95
	ВН	Phas e 2, Step 11	Above ground living carbon stock (t C) - t5	13.69
	BI	Phas e 2, Step 12	Emissions due to deforestation in 2019 (tC)	0.00
	BJ	Phas e 2, Step 12	Emissions due to post-fire deforestation in 2019 (tCH4)	0.00
	ВК	Phas e 2, Step 12	Emissions due to post-fire deforestation in 2019 (tN2O)	0.00
	BL	Phas e 2, Step 13	Total aerial carbon stock (t C) - t6	78.95
	BM	Phas e 2, Step 13	Above ground living carbon stock (t C) - t6	13.69

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir	n the cu	rrent submission	
	BN	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tC)	29.05
	во	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tCH4)	0.42
	BP	Phas e 2, Step 14	Emissions due to fire in 2020 in managed lands (tN2O)	0.01
	BQ	Phas e 2, Step 14	Emissions due to selective logging in 2020 (tC)	0.00
	BR	Phas e 2, Step 14	Carbon stock decrease due to fire in unmanaged lands in 2020 (tC)	0.00
	BS	Phas e 2, Step 14	Carbon stock decrease due to selective regular logging in 2020 (tC)	0.00
	ВТ	Phas e 2, Step 15	Total carbon stock (t C) - t7	77.34
	BU	Phas e 2, Step 15	Total aerial carbon stock (t C) - t7	49.89
	BV	Phas e 2, Step 15	Above ground living carbon stock (t C) - t7	5.04
	BW	Phas e 2, Step 16	Emissions due to deforestation in 2020 (tC)	0.00
	BX	Phas e 2, Step 16	Emissions due to post-fire deforestation in 2020 (tCH4)	0.00
	BY	Phas e 2, Step 16	Emissions due to post-fire deforestation in 2020 (tN2O)	0.00

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status ir		rrent submission	
	BZ	Phas e 2, Step 17	Total aerial carbon stock (t C) - t8	49.89
	СА	Phas e 2, Step 17	Above ground living carbon stock (t C) - t8	5.04
	СВ	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tC)	18.36
	сс	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tCH4)	0.27
	CD	Phas e 2, Step 18	Emissions due to fire in 2021 in managed lands (tN2O)	0.01
	CE	Phas e 2, Step 18	Emissions due to selective logging in 2021 (tC)	0.00
	CF	Phas e 2, Step 18	Carbon stock decrease due to fire in unmanaged lands in 2021 (tC)	0.00
	CG	Phas e 2, Step 18	Carbon stock decrease due to selective regular logging in 2021 (tC)	0.00
	СН	Phas e 2, Step 19	Total carbon stock (t C) - t9	58.98
	CI	Phas e 2, Step 19	Total aerial carbon stock (t C) - t9	31.53
	СЈ	Phas e 2, Step 19	Above ground living carbon stock (t C) - t9	1.85
	СК	Phas e 2, Step 20	Emissions due to deforestation in 2021 (tC)	58.98

nts from previous technical analysis ³⁹	Status ir		rrent submiss	ion					
	CL	Phas e 2, Step 20	Emissions du	ue to post-d	leforestatior	n fire in 2	021 (tCH4)) 0.17	7
	CM Phas e 2, Step 20 Emissions due to post-deforestation fire in 2					021 (tN2O) 0.00	D	
			17 queimada e (tCH4) ARE4 MANEJADA	m 2017 quei S 2017	C a de EM por mada em (tN2O) AREAS IEJADAS 13,78	CS em 20	EM por desn 17 (tC) 2017	E a de EM por Sa natamento d (tC) e 0.871.135,25	
	Figure	s/activ	Emission ities in the				017 acc	ording to	o the
		on, addea	are converted to the other o	-	· ·	ige net en	nission for ti		nal
	Figure	49 prese	into un exampi	e of CO2 eq e	emissions by R	EDD+ act	ivity for the		iome.
	A 2 2016-2017 3 2017-2018 4 2018-2019 5 2019-2020 6 2020-2021 7 2010-2021	8 Emissões Con- desmatamento (tC) 10.871.135,25 11.349.332,44 15.341.770,94 19.565.811,53	C D Emissões CH4 por desmatamento (tCH4) 47.440,38 1.995,31 50.022,04 1.477,30 58.8495,81 1.773,70 67.855,58 1.995,74 86.566,70 2.546,08	E F por Área de	G H Periodo Emissõe: Cpa dumada en dumada e	I Fr Emissões CH4 por a queimada em	J Emissões N2O por queimada emida (tN2O) 13,78 5: 2,67 8: 6,02 5: 8,69 4.1	k L M	N Emissões O corte selei irregular (1.523,8 355,76 4.672,0 3.861,9 4.171,8
	A Periodo 1 2 2016-2017 3 2017-2018 4 2018-2019 5 2019-2020 6 2020-2021	8 Emissões C por desmatamento (tC) 10.871.135,25 11.349.332,44 13.418.112,34 15.341.770,94 19.565.811,53	C D Emissões CH4 por desmatamento (tCH4) Emissões N20 desmatamento desmatamento desmatamento 1 (N20) 47.440,38 1395531 50.024,04 1.471,30 58.945,81 1.733,70 67.855,28 1.995,74	E F por Arce desmotamento (ba) 94.237,38 97.057,75 113.352,39 129.559,16 129.559,1	G H Emissões C pa queimada em área manejada (C) 2015-2017 2237637 2017-2018 6.273.09 2018-2019 14137,42 2019-2020 20.431,50	I Emissões CH4 por queimodo em órea manejado (tCH4) 468,42 90,76 204,54 295,60 26,12 207 Emissões CH4 por queimodo em	3 Emissões N20 por queimodo emi farea manejado (N20) 13,78 5,2,67 8,69 4,1 0,77 6 Emissões N20 por queimodo emi (KC026) 5,50,95 707,39 1,594,22 2,30,38	k L M quelinodo (htt) Período Período 177,04 2016-2017 2017-2018 251,09 2018-2019 2019-2020	N Emissões C corte selei irregular (1.523,8 355,76 4.672,0 3.861,9

nts from previous technical analysis ³⁹	Status in the curren				
	Source: own elabord	ıtion			
	_	put – Amazon biom	ie		
	PHASE 1 – GIS opei	ations			
	consolidate all different the information present polygons with the same represents the sum of amount of data.	es several "georeferenced of at degradation activity data inted in Table 49 . Each lin the characteristics, with the the individual polygons. Su	a. As result, a spread ine of the spreadshee exception of the area ich aggregation was i	sheet was obtain t represents a gr n (hectares). The necessary due to	ned, containing roup of area
	Variable name	Description	Unit	Spreadsheet column	Source
	Biome				
		Biome classification: Amazon	n/a	A	IBGE, 2019
	Main_class	Amazon REDD+ activity classification: "DEGRAD" meaning	n/a n/a	1	
	Main_Class deter2017	Amazon REDD+ activity classification: "DEGRAD"		A	2019
		Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in	n/a	AB	2019
	deter2017	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding	n/a n/a	A B C	2019
	deter2017 deter2018	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding year:	n/a n/a n/a	A B C D	2019
	deter2017 deter2018 deter2019	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in classification in corresponding year: - Fire ("burn	n/a n/a n/a n/a	A B C D E	2019
	deter2017 deter2018 deter2019 deter2020	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding year:	n/a n/a n/a n/a n/a	A B C D E F	2019
	deter2017 deter2018 deter2019 deter2020	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding year: - Fire ("burn scar")	n/a n/a n/a n/a n/a	A B C D E F	2019
	deter2017 deter2018 deter2019 deter2020	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding year: - Fire ("burn scar") - Disordered logging ("CS") - orderly logging	n/a n/a n/a n/a n/a	A B C D E F	2019
	deter2017 deter2018 deter2019 deter2020 deter2021	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding year: - Fire ("burn scar") - Disordered logging ("CS")	n/a n/a n/a n/a n/a	A B C D E F G	2019
	deter2017 deter2018 deter2019 deter2020	Amazon REDD+ activity classification: "DEGRAD" meaning "degradation" Degradation classification in corresponding year: - Fire ("burn scar") - Disordered logging ("CS") - orderly logging	n/a n/a n/a n/a n/a	A B C D E F	2019

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	National			4th GHG
	Inventory			National
Phytophysiognomy	Ancient vegetation	n/a	J	Inventory
	phytophysiognomies			
category	Vegetation	n/a	К	
	category: Forest (F)			
Managed_land	indicates whether		L	
	the polygon iS			
	situated in a			
	managed area			
	("t" = true) or			
	not ("f" = falsa)			
EBA cagb	Carbon content –	tC/ha	М	EBA
_ 0	above ground			
	biomass carbon			
	pool			
EBA_cbgb	Carbon content –	tC/ha	Ν	
	below ground			
	biomass carbon			
	pool			
EBA_cdw	Carbon content –	tC/ha	0	
	dead wood			
	carbon pool			
EBA_clitter	Carbon content –	tC/ha	Р	
	litter carbon pool			
EBA_ctotal	Total carbon	tC/ha	Q	
area_ha	Polygon area	ha	R	Own
				estimates

- Source: Electronic spreadsheet "1c_Amazon_Emissions_Output_Degradation.xls"
- 0
- PHASE 2 Emissions calculations
- Emissions calculations were performed in chronological order, according to the occurrence of degradation processes (fire and/or disordered logging). The following steps have been followed:

Step **1**: Calculation of carbon stocks available in *t0* (tons of C, i.e., tC/ha stock values already multiplied by areas (in ha)) by total and carbon pools: Column S: total C stock *t0*

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Column T: aerial C stock t0
	Column U: above ground C stock t0
	Step 2: Calculation of C, CH_4 and N_2O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2017:
	Column V: C emissions due to fire in managed lands Column W: CH4 emissions due to fire in managed lands Column X: N2O emissions due to fire in managed lands
	Column Y: C emissions due to disordered logging (CS)
	Column Z: C loss due to fire in unmanaged lands
	Column AA: C loss due to orderly logging (CSR)
	Step 3: Calculation of remaining carbon stocks after degradation processes in 2017, definining the carbon stocks available for potential degradation in 2018:
	Column AB: aerial C stock t1
	Column AC: above ground C stock t1
	Step 4: Calculation of C, CH ₄ and N ₂ O emissions from degradation due to fire in managed forest areas or disordered logging (CS) in 2018:
	Column AD: C emissions due to fire
	Column AE: CH ₄ emissions due to fire
	Column AF: N2O emissions due to fire
	Column AG: C emissions due to disordered logging (CS)
	• Column AH: C loss due to fire in unmanaged lands
	Column AI: C loss due to orderly logging (CSR)
	Step 5: Calculation of carbon stocks available after <i>degradation processes in 2018, definining the carbon stocks available for potential degradation in 2019:</i>
	Column AJ: aerial C stock t2

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Column AK: above ground C stock t2
	8.13.2. Step 6: Calculation of C, CH ₄ and N ₂ O emissions due to degradation by fire in managed forest areas or disordered logging (CS) in 2019:
	 Column AL: C emissions due to fire Column AM: CH₄ emissions due to fire Column AN: N2O emissions due to fire Column AO: C emissions due to disordered logging (CS) Column AP: C loss due to fire in unmanaged lands Column AQ: C loss due to orderly logging (CSR)
	 Step 7: Calculation of the remaining carbon stocks available after degradation in 2019, defining the carbon stocks available for potential degradation in 2020: Column AR: aerial C stock t3 Column AS: above ground C stock t3
	Step 8: Calculation of C, CH₄ and N₂O emissions due to degradation by fire in managed forest areas or disordered logging (CS) in 2020: Column AT: CO₂ emissions due to fire Column AU: CH4 emissions due to fire
	Column AV: N ₂ O emissions due to fire
	Column AW: C emissions due to disordered logging (CS)
	Column AX: C loss due to fire in unmanaged lands Column AY: C loss due to orderly logging (CSR)
	 Step 9: Calculation of carbon stocks available after degradation processes in 2020, defining the carbon stocks available for potential degradation in 2021: Column AZ: aerial C stock <i>t4</i> Column BA: above ground C stock <i>t4</i>

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current su	bmission	
	due to fire i 2021: Column E Column E C		d logging (CS) in ng (CS) 5 emissions were cons of C, CH ₄ and CO2 equivalent. and added to the the biome. ut – Amazon G tools, with the ty data. As result, resented in Table olygons with the ctares). The area
		secondary vegetation output main pa	
	Variable name	Description	Source
	Biome class_2014	Biome classification: Amazon Secondary vegetation class for year 2014	TerraClass
	class_2014	Secondary vegetation class for year 2020	i ci i aciass
	phytophysiognomy	Ancient vegetation phytophysiognomies	
	category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)	4th GHG National Inventory

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the curren	nt submission	
	area_ha	Polygon area	Own estimates
	• PHASE 2 – Re	emovals calculations	
		Calculation of the total area of na (2014 and 2020)	itural forest regeneration
	-	alculation of C removals by natura 14 and 2020) considering factor of	•
	o Step 3 : C	onversion of tonnes of C tonnes to	o CO ₂ equivalent
	 Step 4: ((tC/yr) 	Calculation of the average annu	ial removal average rate
	• Step 5: reference	Application of the value obtain e period	ed for each year of the
	8.13.4.	Net GHG emission – /	Amazon biome
	• PHASE 3 – Co	onsolidation of results	
	GHG emi	Calculation of the annual net GH ssions by deforestation and degra orest regeneration in each annual	dation minus removals by
		Detailed description for est ons/removals in the Cerra	<u> </u>
	described in pag and removals fr	I procedures, based on the n e 56, used to estimate GHG emis om growth of natural forest reg nted in sequence.	sion due to deforestation

Status in the current submission

8.14.1. Deforestation output – Cerrado biome

• PHASE 1 – GIS operations

The 1st phase involves several spatial operations using GIS tools, with the aim to consolidate all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in **Table 51**. Each line of the spreadsheet represents a single deforestation polygon.

Variable name Description		Unit	Spreadsheet column	Source	
fid		n/a	А		
Biome	Biome classification: Cerrado		В	IBGE, 2019	
State	Brazilian political- administrative state	n/a	С		
Main_class	REDD+ activity	n/a	D		
Class_name	REDD+ activity/year classification		E		
Year	Mapping year	n/a	F	PRODES	
Image_date	Image date of each polygon	n/a	G		
source_inv	Corresponding biome classification in the 4th GHG National Inventory	n/a	Н		
phytophysiognomies	Ancient vegetation phytophysiognomies	n/a	I		
Category	Land use category: Forest (F)	n/a	J	4th GHG National	
rr_cagb	Above ground carbon stock	tC/ha	К	Inventory	
rr_cbgb	Below ground carbon stock	d carbon tC/ha L			
rr_cdw	Dead wood carbon stock	tC/ha M			

Table 51 – Cerrado deforestation output main parameters

Recommendat ions / encourageme nts from previous technical	Status in the current sul	omission				
analysis ³⁹	rr_clitter	Litter carbon stock	tC/ha	Ν		
	rr_ctotal	Total carbon stock	tC/ha	0		
	Area_ha	Polygon area	ha	Р	Own calculations	
	PHASE 2 – Emissions calculations Step 1: Calculation of C and CO ₂ due to deforestation: Column Q: C emissions due to deforestation					
	Column R: CO2 emissions due to deforestation					
	Step 2: Calculation of the mass of fuel available for fire combustion in the "slash and burn" type deforestation Column S: above ground C stock					
	 Step 3: Calculation of CH4 and N2O emissions <i>due</i> to "slash and burn" deforestation: Column T: CH4 emissions due to deforestation Column U: N2O emissions due to deforestation 					
	 Step 4: Through pivot tables, the sum of emissions per year and GHG are calculated. The values obtained at this stage are in tonnes of CO₂, tonnes of CH₄ and tonnes of N₂O. 					
	Step 5: Emissions are converted into tones of CO ₂ equivalent. These values will be used in the final calculation and added to the other outputs, to obtain the average net emission for the biome.					
	Secondary vegetation output – Cerrado <i>biome</i> PHASE 1 – Georeferenced operations					
	SIG tools, activity d the info spreadsh	hase involves several ' , with the aim to cons ata. As result, a sprea rmation presented eet represents a gro ristics, with the excep	olidate idsheet in Table oup of	all different o was obtaine 52 . Each polygons wi	deforestation d, containing line of the th the same	

ions / encourageme nts from previous technical analysis ³⁹	Status in the current sul	bmission			
	aggregati	presents the sum of the individuation was necessary due to the large an errado secondary vegetation output	mount of data.		
	Variable name Description		Source		
	Biome	Biome classification: Cerrado			
	class_2018	Secondary vegetation class for year 2018	TerraClass		
	class_2020	Secondary vegetation class for year 2020			
	phytophysiognomy	Ancient vegetation phytophysiognomies	4th GHG National		
	category	Land use category: Forest (F), Grassland (G), Other Forest Land (OFL) and Dunes (Dun)	Inventory		
	Area_ha	Polygon area	Own calculations		
	 PHASE 2 – Emissions calculations Step 1: Calculation of total area of secondary vegetation per year (2014 and 2020) Step 2: Calculation of C removals by secondary vegetation per year (2014 and 2020) considering factor of 3,03 tC/ha.yr 				
	 Step 3: Conversion of C tones to CO2 equivalent Step 4: Calculation of the annual removal average rate (tC/yr) Step 5: Application of the value obtained for each year of the series Net GHG emission – Cerrado biome PHASE 3 – Consolidation of results 				

ions / encourageme nts from previous technical analysis ³⁹	Status in the current su	bmission			
	 Step 1: Calculation of the annual net GHG emission: sum of gross GHG emissions by deforestation minus removals by secondary vegetation in each period 				
	Step 2: Calculation of average net emissions in the period				
	Detail description for estimating GHG <i>emissions</i> /removals in the Atlantic Forest, Caatinga, Pampa and Pantanal biomes PHASE 1 – GIS operations				
	The 1st phase involves several spatial operations using GIS tools, with the aim to consolidate all different deforestation activity data. As result, a spreadsheet was obtained, containing the information presented in Table 53 . Each line of the spreadsheet represents a single deforestation polygon.				
	 Table 53 – Atlantic Forest, Caatinga, Pampa and Pantanal biomes deforestation output main parameters 				
	deforestation	n output main parame	eters		
	Variable name	n output main parame Description	eters Unit	Spreadsheet column	Source
		· ·			Source
	Variable name	· ·	Unit	column	Source IBGE, 2019
	Variable name fid	Description	Unit n/a	column A	
	Variable name fid Biome	Description Biome classification	Unit n/a n/a	column A B	
	Variable name fid Biome Main_class	Description Description Biome classification REDD+ activity	Unit n/a n/a n/a	Column A B C	IBGE, 2019
	Variable name fid Biome Main_class Year	Description Biome classification REDD+ activity Mapping year Image date of each	Unit n/a n/a n/a n/a	Column A B C D	IBGE, 2019
	Variable name fid Biome Main_class Year Image_date	Description Description Biome classification REDD+ activity Mapping year Image date of each polygon Corresponding biome classification in the 4 th GHG National	Unit n/a n/a n/a n/a n/a	column A B C D E	IBGE, 2019 PRODES 4th GHG National
	Variable name fid Biome Main_class Year Image_date source_inv	Description Biome classification REDD+ activity Mapping year Image date of each polygon Corresponding biome classification in the 4 th GHG National Inventory Ancient vegetation	Unit n/a n/a n/a n/a n/a	Column A B C D E F	IBGE, 2019 PRODES

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current s	ubmission				
	rr_cbgb	Below ground carbon stock	tC/ha	J		
	rr_cdw	Dead wood carbon stock	tC/ha	К		
	rr_clitter	Litter carbon stock	tC/ha	L		
	rr_ctotal	Total carbon stock	tC/ha	Μ		
	Area_ha	Polygon area	ha	Ν	Own calculations	
	 PHASE 2 – Emissions calculations Step 1: Calculation of C and CO2 due to deforestation: Column Q: C emissions due to deforestation Column R: CO2 emissions due to deforestation 					
	Step 2: Through pivot tables, the sums of emissions per year and GHG are calculated. The values obtained at this stage are in tons of CO2, tons of CH_4 and tons of N_2O .					
	 Step 3: Emissions are converted into tones of CO2. These values will be used in the final calculation, added to the other outputs, to obtain average net emission from the biome. 					

0

PHASE 3 – Consolidation of results

Step 1: Calculation of the *gross* CO₂ emissions per period as the sum of individual emissions per polygon

Step 2: Calculation of average gross emissions in the period and biome

- **Detail description** for estimating the national FREL
- \circ Step 1: regrouping the emissions for each biome and year
- 0

0

• Step 2: calculation of the net emissions balance per year

Recommendat ions / encourageme nts from previous technical analysis ³⁹	Status in the current submission
	Step 3: calculation of the average net emission in the period 2016/2017-2019-/2021, considered as the National FREL Quality control and quality assurance procedures"
lu alcala a an	Quality control and quality assurance procedures
Include non- CO ₂ gases to improve consistency with the GHG inventory included in the national communicatio n	Non-CO ₂ gases have been included in the estimates for: 1) Deforestation in the Amazon and Cerrado biomes 2) Degradation by forest fires in the Amazon biome Nevertheless, due to current limitations non-CO ₂ gases that may occur in other biomes have not yet been included – refer to Box 6

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Table 62 – Status of recommendations/encouragements from previous technical analysis FREL Cerrado⁴⁰

Recommendations / encouragements from previous technical analysis ⁴¹	Status in the current submission
Estimate emissions from net deforestation	Net deforestation has been estimated for the Amazon and Cerrado biomes – refer to section "Additional information"
Include emissions from forest degradation by forest fires	GHG emission from forest degradation by forest fires in the Amazon biome have been included – refer to section "Gross emissions due degradation" Nevertheless, due to current limitations GHG emission from forest degradation by forest fires in the Cerrado biome have not yet been included – refer to Box 5
Quantify uncertainties associated with the FREL	Uncertainties have been estimated – refer to section "Accuracy"
Explore the possibility of including the soil organic carbon pool	Due to current limitations soil organic carbon pool have not yet been included – refer to Box 8

⁴⁰ Available at: <u>https://redd.unfccc.int/files/frelcerrado_en_20170629_br_v.2.pdf</u>

⁴¹ Paragraph 35 of the "Report of the technical assessment of the proposed forest reference emission level of Brazil submitted in 2017" (FCCC/TAR/2017/BRA). Available at: <u>https://unfccc.int/sites/default/files/resource/bra.pdf</u>