Supporting Technical Report for the Public Interest Civil Action

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List of Acronyms

ABC	Agricultura de Baixo Carbono (Low Carbon Agriculture)
ABIOVE	Brazilian Association of Vegetable Oil Industries
AFOLU	Agriculture, Forestry and Other Land Use
ALC	LAC (Latin America and the Caribbean)
ALS	Airborne Laser Scanning
ANEC	National Association of Cereal Exporters
BNDES	National Development Bank
CAR	Rural Environmental Registry
CCST	Centro de Ciência do Sistema Terrestre
CRA	Centro Regional da Amazônia
DETER	Real Time Deforestation Detection System
EBA	Estimating Biomass in the Amazon
EMBRAPA	Brazilian Agricultural Research Company
ENSO	El Niño Southern Oscillation
ET	Evapotranspiration
FLONA	National Forest
FUNAI	The National Indian Foundation
GHG	Greenhouse Gases
GLO	Guarantee of Law and Order
GTE	Specialized Technical Group
GWP	Global Warming Potential
IAM	Integrated Assessment Models
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources
IBGE	Brazilian Institute of Geography and Statistics
ICMBio	Chico Mendes Institute for Biodiversity Conservation
ILPF	Crop-Livestock-Forestry Integration
IMAZON	Institute of Man and the Environment of the Amazon
INCRA	National Institute for Land Reform and Settlement

INPE	National Institute of Space Research
IPCC	International Panel on Climate Change
LCA	Creative Laboratory of the Amazon
LiDAR	Light Detection and Ranging
LPVN	Native Vegetation Protection Law
LULUCF	Land Use, Land Use Change and Forests
MAPA	Ministry of Agriculture, Livestock and Supply
MAS	Satellite Environmental Monitoring of the Amazon Biome
MCTIC	Ministry of Science, Technology, Innovation and Communications
MERCOSUR	Southern Cone Common Market
MMA	Ministry of Environment
MUT	LUC - Land Use and Land Cover Changes
NDC	Nationally Determined Contributions
PADDD	Protected Area Downgrading, Downsizing and Degazettement
PNMC	National Climate Change Plan
PPCDAm	Action Plan for the Prevention and Control of Deforestation in Legal Amazonia
PPCerrado	Action Plan for the Prevention and Control of Deforestation and Burning in the Cerrado
PRA	Environmental Regularization Program
PRODES	Project for Satellite Monitoring of Deforestation in the Legal Amazon
PRONAF	National Family Agriculture Program
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SAD	Deforestation Alert System
SAF	Agroforestry Systems
SEEG	Greenhouse Gas Emissions Estimation System
SICAFI	Integrated System of Registration, Tax Collection and Supervision
SIRENE	National Emissions Registration System
TAC	Conduct Adjustment Agreement

TI	Terra Indígena (IT - Indigenous Territory)
UC	CU - Conservation Unit
UHE	HPP - Hydropower Plant

Set of Questions and Answers

1. Explain the relationship between forests and climate change, including the functioning of forests as a carbon sink, GHG emissions caused by deforestation and any other aspect you consider relevant.

According to the *International Panel on Climate Change* (IPCC), climate change is characterized as changes in the state of the climate that can be identified through changes in the average and/or by the variability of its properties (such as temperature and rainfall regimes) that persist over a long period of time, usually decades or more (IPCC, 2012). Climate change has gained global visibility since the middle of last century given the evidence of intensifying extreme weather events such as forest fires and heat waves, with disastrous consequences for human populations in different regions of the planet (AHIMA, 2020; ARRIAGADA et al., 2020; HULME, 2020; MOSER, 2020). In Latin America and the Caribbean (LAC), for example, records show that the temperature has increased around 1ºC (LI et al., 2015; MAGRIN et al., 2007, 2014). Climate change projections for this region point to a temperature increase of around 7°C by 2100 (MARENGO et al., 2012a). Drier climates have been recorded in western Central America and northern South America, covering northern Brazil, southern Peru, Chile, southwestern Argentina, the Peruvian Amazon and the Andes (HAYLOCK et al., 2006; MAGRIN et al., 2014). Projections also point to intensification of droughts, heat waves and tropical cyclones (REYER et al., 2017). These climate trends pose a major risk to human livelihoods and the economies of countries in various parts of the world, which must seek plans for mitigation and adaptation to their effects (HERRON et al., 2014; MAGRIN et al., 2014).

Scientific observations, local perceptions and model predictions indicate that gradual and extreme climate changes, in particular global warming, are mainly generated by greenhouse gas emissions (GHG) related to fossil fuels, energy production and land use (REBOITA et al., 2014; SALAZAR et al., 2015). Global emissions reached 39.4 $GtCO_2eq$ in 2014. LAC countries were responsible for 12.4% (3.9 Gt) of this total (CAIT, 2017). In LAC, activities with potential to generate emissions include the production of agricultural commodities for export, land use change and the forestry, energy and agriculture sectors. Among the tropical LAC countries, Brazil's GHG emissions are the highest, reaching 1,730 $MtCO_2eq$ in 1990, and the highest in 2004 (at the peak of deforestation in the Amazon) with 3,959 $MtCO_2eq$, decreasing to 1,929 $MtCO_2eq$ in 2018 (SEEG Data. Access: 03-Jul-2020).

Wet forests in LAC are estimated to cover 817 Mha (41%), most of which in South America (40%), including the floodplain forests of Central America, the Amazon Basin, Guyana, the northern half of the Atlantic Forest, and rain and cloud forests found on the western slopes of the Andes (EVA et al., 2004). Humid tropical forests play a crucial role in climate change mitigation and adaptation, maintaining ecosystem functions and ensuring essential services for human survival and well-being, such as climate regulation, shelter for biodiversity and the provision of goods (BUSTAMANTE et al., 2016; MEIGS; KEETON, 2018; ZHU et al., 2020). On a global scale, the tropical forests of LAC contribute to the dynamic balance of biogeochemical and hydrological cycles, critical to the sequestration and storage of large amounts of carbon from the atmosphere and to provide moisture across the South American continent (BRANDO et al., 2008; HOUGHTON et al., 2012). At local and regional scales, LAC forests provide climatic comfort through the cooling effect (BAKER; SPRACKLEN, 2019; LI et al., 2015) and provide greater resilience to extreme climatic events by mitigating climatic episodes such as extremes of high surface temperatures, droughts and floods (GALEANO et al., 2017; MARTIN; WATSON, 2016). The tropical forests of LAC remove large amounts of carbon dioxide from the atmosphere (CO_2) (1.2 ± 0.4 Gt $C.year^{-1}$) (PAN et al., 2011) and store it in their plant biomass, above ground and in the roots and soil. The carbon stocks in this region represent ~ 49% of the total above ground carbon in the tropics, equivalent to about 93 – 120 GtC (GIBBS et al., 2007; MALHI et al., 2006; SAATCHI et al., 2011) and 16.5 – 30 GtC below ground (FAO, 2015; GUEVARA et al., 2019).

LAC contains a large proportion of protected areas, most of which in Brazil (56% of the territory), while at the same time presenting the highest deforestation rates in the world (HANSEN; STEHMAN; POTAPOV, 2010). About 24% of the global forest loss between 2000 and 2017 took place in LAC, totaling 120 million ha

(HANSEN; STEHMAN; POTAPOV, 2010). In addition to the high deforestation rates, evidence has shown that much of the forest in LAC is already experiencing different levels of forest degradation (ARMENTERAS et al., 2017). Forest degradation consists of the partial deforestation of the forest, leading to loss of biomass diversity and density, and affecting the capacity of the forest to provide natural resources, as well as compromising the functioning and regeneration capacity of ecosystems after disturbances (GHAZOUL et al., 2015; HOUGHTON et al., 2012; SASAKI; PUTZ, 2009). Approximately 2.4 Mkm² of tropical forests in LAC are estimated to be in a critical state of degradation (ARMENTERAS et al., 2017), while in protected areas this number exceeds 1 Mha (LEISHER et al., 2013). In LAC, the impacts of land use change on GHG emissions are largely associated with the net conversion of forests to other uses, particularly agricultural crops and livestock (ARMENTERAS et al., 2017; FAO, 2017). 24% of global emissions attributed to land use change (22% of total emissions from 2007 to 2016) (IPCC, 2019) come from LAC countries (CAIT, 2017). The main net carbon emission from deforestation comes from biomass burning and soil carbon loss (heterotrophic respiration) (VAN DER WERF et al., 2010). Forest conversion is followed mainly by biomass burning, which can represent 11-70% of the values of emissions from deforestation, released mainly during the southern dry season (ARAGÃO et al., 2018; VAN DER WERF et al., 2010). Rising carbon emissions from forest areas have also been linked to forest fragmentation, due to increased forest edges vulnerable to sources of ignition and fire dispersal (ARAGÃO et al., 2018; BRANDO et al., 2020).

It is estimated that an average of 443.4 x 10^6 tC.year^{-1} was lost to deforestation and degradation in South and Central America between 1990 and 2000. This value built up to an average of 464.8 x 10^6 tC.year^{-1} between 2000 and 2010 (ACHARD et al., 2014). This forest loss heightened the release of CO_2 into the atmosphere to levels above the total sequestered (loss = 516.0 ± 69.5; gain = 191.2 ± 18.2; net 324.8 ± 73.5 Tg C.year^{-1}) (BACCINI et al., 2012), effectively converting the forest from a CO2 sink to a CO_2 source (GATTI et al., 2014; HOUGHTON et al., 2012; PEARSON et al., 2017).

Reducing emissions from deforestation and forest degradation (REDD+) is considered a relatively low cost measure (SOARES-SILHO et al., 2016; STERN et al., 2006) that is essential to keep global warming below 1.5°C (IPCC, 2019). In addition, natural forest regeneration or active restoration of degraded and unproductive land is an ecological and natural solution to current and future climate change challenges (REID et al., 2018). The potential for restoration of almost 1 billion hectares of suitable areas in the world and about 17 million hectares of unproductive and degraded land in the Brazilian Amazon offers a great opportunity for carbon storage (BRANCALION et al., 2019), while also adding socioeconomic value to the environment and permanent forest, including sustainable forest management (NOBRE, 2019). In LAC, such initiatives have been developed in tropical rainforest zones, focusing on restoration, regeneration and reduction of community vulnerability to climate change (COPPUS et al., 2019).

2. Explain the relationship between forests and climate change, specifically with respect to the Amazon rainforest

Gradual and extreme climate changes have been recorded in recent decades in the Amazon. The temperature has increased by 0.6-0.7°C in the last 40 years (MARENGO et al., 2018) and monthly maximum temperatures have increased by 0.04-0.06°C in most of the Amazon region (DA SILVA et al., 2019). Long-term observations (over the last 20 years) indicate that the atmosphere over the Amazon forest is becoming drier due to global warming, biomass burning and changes in land use (such as replacing forests for livestock grazing), with a reduction in the humidity produced by the forest, especially in southeastern Amazonia, and increasingly more severe drought and fire events (including in northwestern Amazonia) (BARKHORDARIAN et al., 2019). In addition to gradual events associated with global warming, the Brazilian Amazon has faced historically intense droughts, such as those recorded in 1906, 1912, 1926, 1964, 1986, 1992, 1998, 2005, 2010 and 2015 (NOBRE et al., 2016).

The Amazon Forest plays a key role in the mitigation and adaptation to climate change, especially in Brazil, due to biochemical and biophysical processes resulting from the interaction between the forest and the atmosphere. The 5.3 million km² of Amazon Rainforest act as a large carbon sink, storing on average 60 $t.ha^{-1}$ of carbon above the ground, and sequestering between 430 million to 2 gigatons of carbon annually (BRIENEN et al., 2015). The absorption of large amounts of carbon by the forest is responsible for reducing the country's net emissions at relatively low costs (SOARES-FILHO et al., 2016) in the Amazon region, where 43% of the territory is under some form of protected status (SOARES-FILHO et al., 2010). The protected areas or conservation units, in addition to the indigenous territories of the Brazilian Amazon, hold 58% of the total carbon stock of the Amazon Region and account for a significant proportion of the carbon sequestration occuring in the region (SOARES-FILHO et al., 2010; WALKER et al., 2019).

Carbon emissions in the tropics are strongly associated with deforestation for conversion of natural forests into agricultural uses. The National Emissions Registration System (SIRENE - *Sistema de Registro Nacional de Emissões*), based on official data developed by the Ministry of Science and Technology and Innovations (Decree No. 9,172 / 2017), revealed that between 1994 and 2010 changes in land use and land cover (LUC) in the Amazon biome were the main cause of about 74% of national emissions (results still in public consultation, MCTI, 2019). In percentage terms, the deforestation of the Amazon was responsible for 25.7% of the country's total annual GHG emissions in 2018, and 59% of emissions driven by LUC.

Extreme weather events, such as severe droughts associated with *El Niño*, are linked to the increase in forest fires in southeastern Amazonia and increased tree mortality and GHG emissions into the atmosphere (BRANDO et al., 2014). Although in general not included in national carbon emission inventories, emissions caused by forest fires contribute substantially to GHG emissions (ARAGÃO et al., 2018). During a year of severe drought, (El Niño-Southern Oscillation - ENSO) 1998, for example, the area of forest burned by forest fires (3.9×10^6 ha) was 13 times greater than the area burned during a year of average rainfall (0.2×10^6 ha), and twice the area of annual deforestation, resulting in a total of 0.049 to 0.329 Pg of dead tree biomass (ALENCAR; NEPSTAD; DEL CARMEN VERA DIAZ, 2006). Similarly, the incidence of wildfires during the 2015 drought increased by 36% compared to the previous 12 years, resulting in gross emissions of 989 ± 504 Tg CO_2/year^{-1} (ARAGÃO et al., 2018). Aerosols produced by burning biomass at the end of the dry season influence the formation of precipitation and may delay the rainy season in the Amazon Region (ANDREAE et al., 2015).

Besides combatting deforestation, preserving the natural forests within private properties and Conservation Units is fundamental to reduce the country's net emissions at low costs (SOARES-FILHO et al., 2016; STERN et al., 2006), given their role as carbon sinks (PHILLIPS et al., 2017). In the period 1990 to 2002 the carbon removal by the forest amounted to 3 Gt CO_2eq, a little more than one third of the total removed in the following 15 years. This new trend has meant that land-use change and forestry are no longer the main economic sectors responsible for net GHG emissions since 2009 (316 Mt CO2eq in 2018), giving way to the agricultural sector as the main net GHG emission sector in Brazil (492 Mt CO2eq in 2018).

In addition to its role in regulating climate on a global scale, the Amazon rainforest plays an essential role in mitigating the effects of climate change at local and regional levels by producing moisture and cooling the earth's surface. Services carried out by the forest, such as recycling rain and maintaining moisture production in dry periods, are important mechanisms that regulate the seasonality of rains. The huge quantities of water pumped from the soil into the atmosphere through Amazonian tree roots help maintain air humidity during the dry season of the year and mitigate the impacts of prolonged droughts associated with climatic anomalies, both by moistening and cooling the earth's surface, and by controlling the discharge regime and the flood pulse of rivers (MARENGO et al., 2018; SORRIBAS et al., 2016). This precipitation recycling process guarantees 35 to 80% of rainfall within the forest (MARENGO et al., 2018), and creates conditions for the entry of moisture into the Atlantic Ocean, triggering the rainy season (FU et al., 2013b; WRIGHT et al., 2017). Deforestation can amplify the impacts of climate change extremes, as modeled in eastern Amazonia, resulting in warming above 3°C, and a 40% reduction in rainfall from July to November, causing a delay in the onset of the rainy season of 0.12 to 0.17 days for every 1% increase in deforestation (LEITE-FILHO; SOUSA PONTES; COSTA, 2019).

The interaction of climate and the Amazon rainforest is, therefore, an essential mechanism of climate mitigation for the Planet, maintaining a large carbon stock in the forest and sequestering carbon from the atmosphere, helping to keep the temperature below 2ºC, and for Brazil, mitigating the impacts of global warming by cooling the earth's surface and producing humidity.

3. How is the Brazilian government measuring the deforestation of the Legal Amazon Region and which institutions are responsible for collecting and releasing this data? Explain what the PRODES and DETER systems are and comment on the suitability, technical quality and degree of accuracy of the data obtained through these systems.

Deforestation in the Brazilian Amazon has been monitored by the National Space Research Institute (INPE) since 1988 through the Project for Satellite Monitoring of Deforestation in the Legal Amazon (PRODES). INPE discloses the annual increase of deforestation in the region, that is, the area deforested without considering the deforestation of previous years. This rate is calculated by analyzing satellite images for the period from August 1 of the previous year to July 31 of a given year (PRODES year). For example, the deforestation rate for the year 2019 was calculated on deforestation data obtained between 01/08/2018 and 31/07/2019.

PRODES adopts remote sensing methods to interpret images from the American satellite LANDSAT-5TM and other satellites whose images support deforestation analysis, such as Landsat-8, SENTINEL-2 and CBERS-4, the latter resulting from a technical partnership between Brazil and China (INPE/CRESDA).[1] All images used in the deforestation analysis process can be freely accessed in INPE's own website.[2] The spatial resolution of the satellite images used by PRODES to calculate deforestation is 20 to 30 meters, allowing the system to monitor areas with a minimum size of 6.25 hectares for clear cutting, that is, where the vegetation has been completely removed.[3] To prevent an area deforested in previous years from being counted again, PRODES applies a “mask” over the images, corresponding to the areas deforested in previous years. This way PRODES only calculates the year-on-year increment of deforestation.

Other initiatives created with the objective of monitoring deforestation in the Amazon should be mentioned here: the Deforestation Alert System (SAD), from IMAZON (*Instituto do Homem e do Meio Ambiente da Amazônia*) and MapBiomas,

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[1] http://www.cbers.inpe.br/

[2] http://www.dgi.inpe.br/catalogo/

[3] http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes/pdfs/Metodologia_Prodes_Deter_reviewed.pdf

the result of a partnership between several research institutions and universities. However, what is unique about PRODES is its photointerpretation, the analysis of deforestation polygons by specialists and the validation of that analysis of satellite images through field work. By means of this rigorous methodology the PRODES system provides an accurate analysis of Amazonian deforestation, with an error estimate of only 5 to 6%, which is considered very low for this type of analysis.

While PRODES provides annual results, the Real Time Deforestation Detection System (DETER) provides daily deforestation alerts that support the surveillance actions of the Brazilian Institute of Environment and Renewable Natural Resources - IBAMA. DETER was created in 2004 as one of the main measures of the Federal Government to halt deforestation in the Amazon and improve the surveillance systems so as to bring punitive measures against offenders. Until 2015, DETER issued clear-cutting deforestation alerts for areas larger than 25 hectares. However, with improved methodology and the availability of CBERS-4 satellite images, DETER not only reduced its minimum analyzed area to 5 hectares, but also began to make available important information on forest degradation, which involves partial removal of vegetation. DETER classifies forest degradation in three categories: selective logging, degradation resulting from timber extraction and forest fires. The deforestation detected by DETER corresponds to around 60 to 70% of the deforestation mapped by PRODES (see figure 1). In the same manner as PRODES, DETER does not take into account any previously recorded deforestation.

In late 2019, DETER started integrating satellite images with higher spatial resolution to radar images, thereby allowing more detailed analysis of deforestation. Called DETER Intenso,[4] this system has been applied since February 2020 in regions where deforestation has reached a critical state, and is currently concentrated in five Amazonian municipalities: Anapú and Novo Progresso in the state of Pará, Apuí in the Amazon, Candeias do Jamari and Extrema in Rondônia.

[4] http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/deter

Both the consolidated deforestation data provided by PRODES and the alerts provided by DETER are freely accessible to anyone on the terrabrasilis[5] platform.

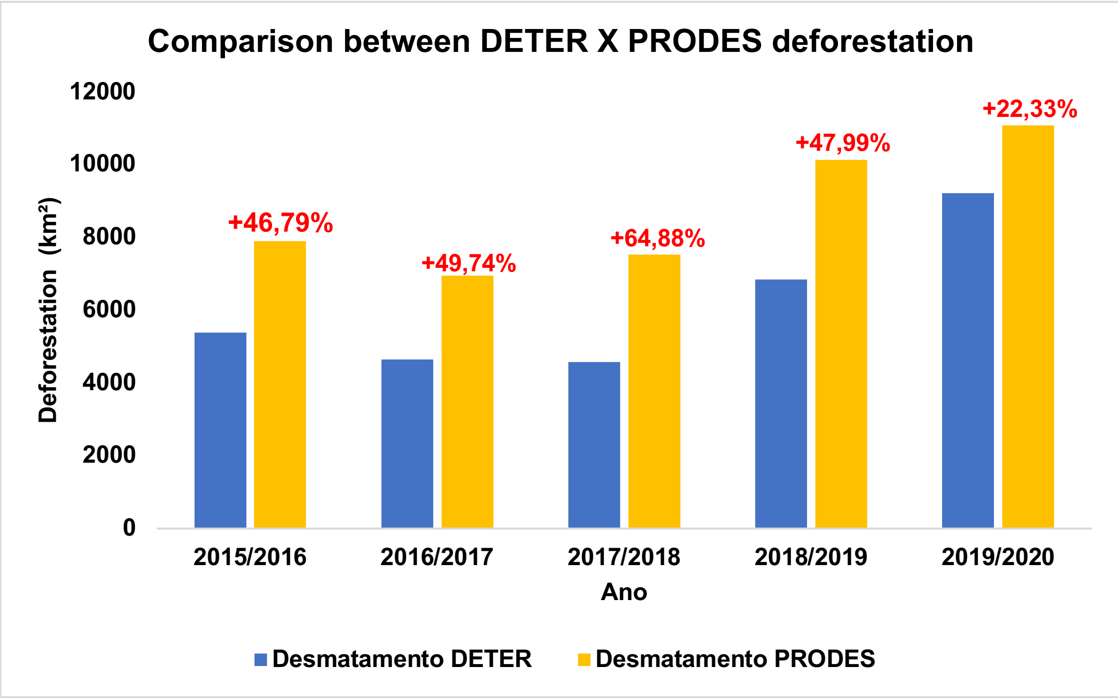


Figure 1: comparison between deforestation areas measured by the PRODES and DETER systems from 2015 to 2020. The reference year 2015/2016 is measured from August 2015 to July 2016. Notice that the PRODES figures are always higher than those consolidated by DETER (% difference indicated in red). Deforestation data from the PRODES and DETER systems are available at http://terrabrasilis.dpi.inpe.br/.

Regarding the trustworthiness of the PRODES system, its data is widely used by the scientific community. As of June 29, 2020, the system had been cited in 1,221 scientific articles in 411 journals,[6] which speaks of a high level of reliability. An article published by Rajão et al. (2017) reaffirms the importance of the systems developed by INPE, clarifying the scope, resolution, frequency and type of detection developed by the institute and emphasizing the existence of complementary systems also developed by INPE, such as DETER B, which maps fires, selective logging and forest degradation,

[5] http://terrabrasilis.dpi.inpe.br/
[6] http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes/citacoes-ao-prodes

and TerraClass, which analyzes land use classes in deforested areas in the Amazon and Cerrado. Additionally, a recent paper has brought further evidence for the quality of the system. By comparing data from the PRODES and MapBiomas systems, Maurano and Escada (2019) identified that Mapbiomas data had underestimated deforestation by 36% until 2017 in relation to PRODES. In other words, areas that were classified as deforested by the PRODES system were still considered forested by Mapbiomas (MAURANO; ESCADA, 2019).

In August 2019, the DETER system was harshly criticized by the Federal Government, specifically by President Jair Bolsonaro, due to the 88% increase in deforestation registered in the Amazon. The criticism of the results published by INPE culminated in the resignation of the institute's director, Ricardo Galvão, who in December of the same year was chosen as one of the 10 leading scientists of the year by Nature magazine, a highly prestigious publication in the scientific community. During the same period, several press articles were published on the reliability, importance and detailed operation of the PRODES and DETER systems (G1, 2019a; GAZETAWEB, 2019; JOVEM PAN, 2019). Again, the main role of the DETER system is to detect deforestation and issue a real-time alert, and not to measure the deforested area. However, since its beginning (2015), the PRODES system has always confirmed the trends identified by DETER, even though the DETER system generally tends to show smaller areas of deforestation due to its lower spatial resolution (G1, 2019b).

4. Is it correct to say that the main emitter of GHG in the Brazilian economy is the deforestation of the Amazon? Why? Comment with the help of data.

Carbon emissions in the tropics are strongly associated with deforestation for conversion of natural forests to agricultural uses (FLEISCHER et al., 2019). More than 80% of the expansion of agriculture and cattle raising in Brazil between 1990 and 2011 occurred in the Amazon and Cerrado (LAPOLA et al., 2014), which directly, through deforestation, or indirectly, through agricultural practices, resulted in high greenhouse gas emissions rates. When the forest is converted into agricultural areas, the burning of trees after the forest is cleared and the decomposition of the forest biomass left in the soil release carbon dioxide and other greenhouse gases. In the agricultural sector, emissions occur mostly due to enteric fermentation by the cattle and to agricultural soil management practices (BRAZIL, 2015a).

Unlike the rest of the world, the GHG emissions trajectory of Brazil, the 7th largest global emitter (2.9% of the world total), mainly occurs in response to variations in deforestation rates caused by changes in land use and land management practices (LUC), while the rest of the world shows a general trend of increasing emissions driven by the energy sector (SEEG, 2018).

Brazil emitted a total of 63 billion tCO_2eq (GWP) between 1990 and 2018 (gross emissions). Almost two-thirds of this total (63%) was generated by land use changes (ANGELO; RITTL, 2019). The LUC sector's main source of emissions is deforestation, representing 93% of the sector's total for the period 1990 to 2018 (SEEG, 2020). The trajectory of emissions in Brazil was marked by ups and downs, with highs of 2.8 $GtCO_2eq$ in 1995 and 3.9 $GtCO_2eq$ in 2004, of which 75% (2 $GtCO_2eq$) and 77% (3 $GtCO_2eq$) were attributed to LUC, respectively; and the historical low of 1.8 $GtCO_2eq$ in 2012, of which 41% (767 $MtCO_2eq$) were attributed to LUC (Figure 2).

In 2018, emissions of 1.9 $GtCO_2eq$, albeit not the highest since 1990, represent a 1.4% increase compared to 2017, in line with a surge in deforestation (Figure 3).

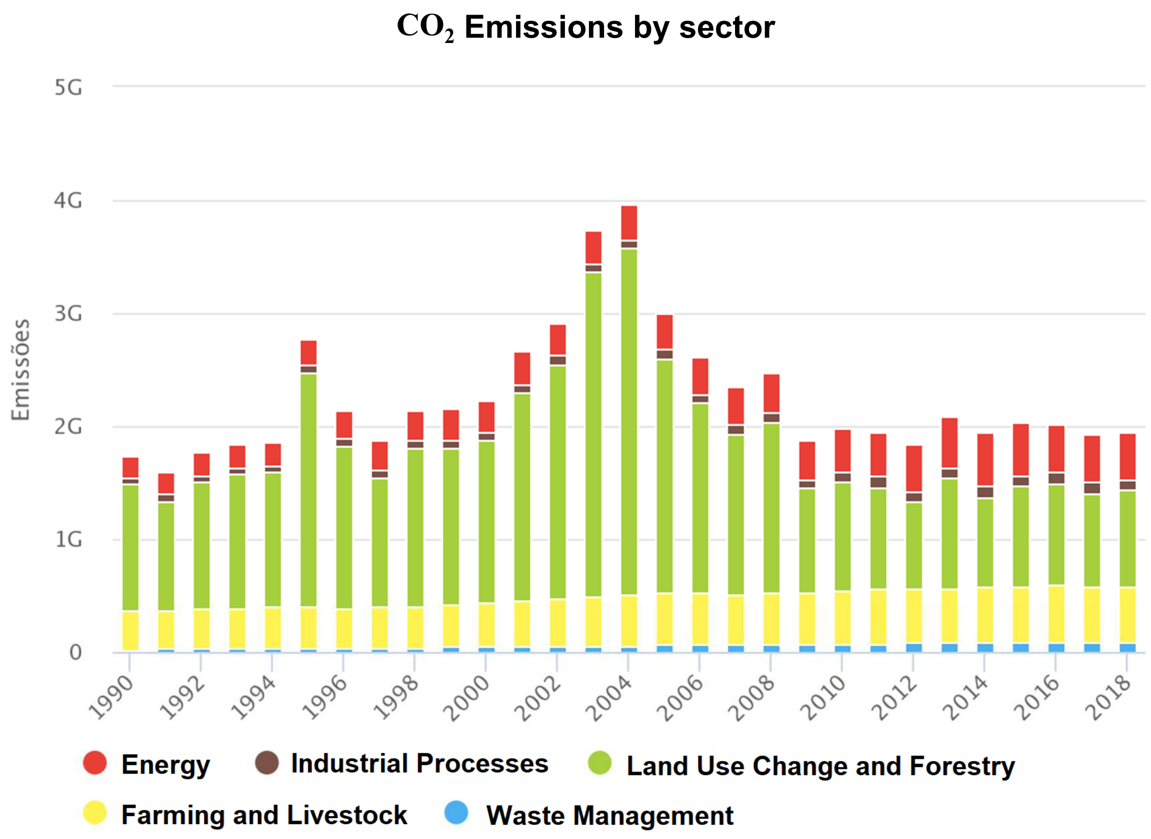


Figure 2: Gross Greenhouse Gas Emissions (CO_2 and other gases) in $GtCO_2eq$ (GWP-100; IPCC AR5) from five sectors of the Brazilian economy, as indicated in the legend, from 1990 to 2018 (SEEG Data, http://plataforma.seeg.eco.br/sectors/).

Comparing deforestation rates in the Amazon from 1990 to 2016 with total GHG emissions and changes in land use, the predominant role of deforestation in the Amazon on GHG emission rates in Brazil becomes clear (Figure 3). The years of greatest deforestation in the Amazon, between 1995 and 2004, when the rate reached 28 and 29 thousand km², respectively, were associated with the highest emission rates in the Land Use Change sector (2.1 $GtCO_2eq$ in 1995 and 3.1 $GtCO_2eq$ in 2004). The decline in deforestation rates in the Amazon in 2012 to 4,600 km² resulted in emission reductions of 767 $MtCO_2eq$ for the LUC sector. Increased gross emissions between 2017 and 2018 showed a strong relationship with the high deforestation rate in the Amazon, 8.5% higher than in the year 2017, increasing the biome's emissions by 44.5 million tons, although this increase was partially offset by a 10.9% drop in deforestation of the Cerrado (ANGELO; RITTL, 2019). From a total of 845 $MtCO_2eq$ generated in 2018 by land use changes, the deforestation of the Amazon alone was responsible for 499 $MtCO_2eq$, more than the entire agricultural sector, which generated

492 $MtCO_2eq$ in the same period. In percentage terms, deforestation in the Amazon was responsible for 25.7% of the country's total annual GHG emissions in 2018, and 59% of emissions by LUC. This value was 0.3% higher than in 2017 (ANGELO; RITTL, 2019).

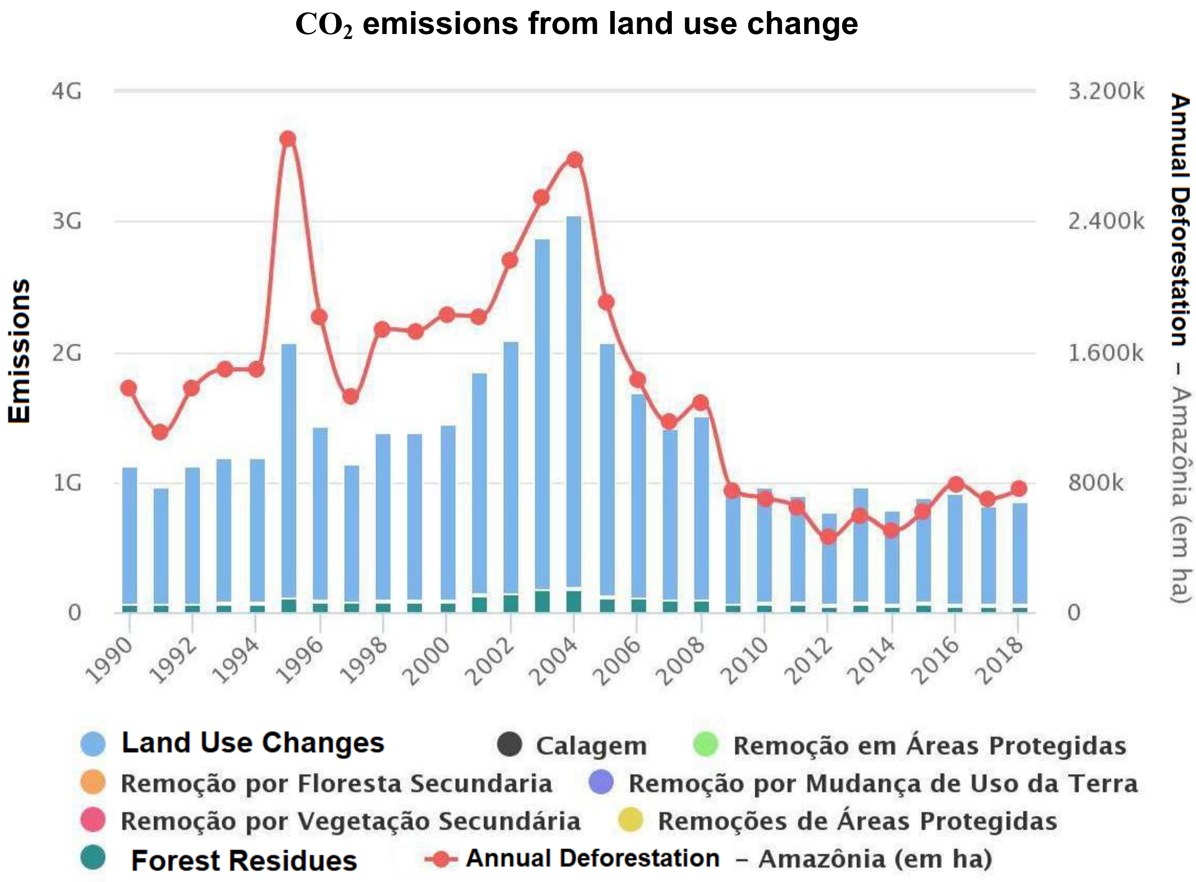


Figure 3: Gross Greenhouse Gas Emissions (CO_2 and other gases) in $GtCO_2eq$ (GWP-100; IPCC AR5) caused by land use and forestry changes, liming of agricultural soils and forest residues, in the period from 1990 to 2018 (SEEG Data, http://plataforma.seeg.eco.br/sectors/).

The reduction of deforestation in the Amazon and its influence on emissions, as evidenced after 2004, are attributed to conservation policies in Brazil in the form of expanded protected areas and deforestation control plans in the Amazon (PPCDAm), which were initiated in the second half of 2000 (ASSUNÇÃO; GANDOUR; ROCHA, 2015; INPE, 2013; SANQUETTA et al., 2020). The strengthening of environmental governance in this period is considered the main reason for decoupling the agricultural commodities market from deforestation in the Amazon (LAPOLA et al., 2014), also contributing to the conservation of primary forests, especially within protected areas, and the expansion of secondary forests resulting from the conversion of agricultural areas into secondary forests. This change in land use dynamics contributed significantly to reduce the impact of gross emissions from the LUC sector, removing 8 Gt CO_2eq in the period 2003 to 2018 (Figure 4).

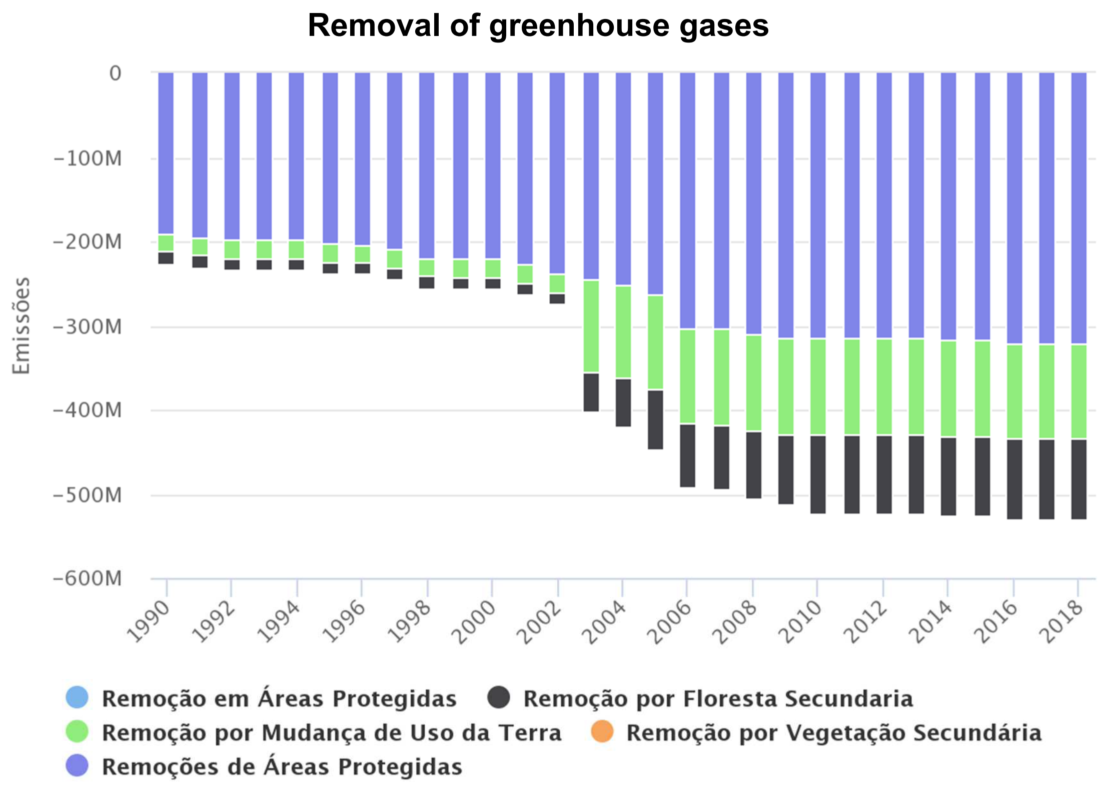


Figure 4: Removal of Greenhouse Gases (CO_2 and other gases) in GtCO_2eq (GWP-100; IPCC AR5) through land use changes (e.g., conversion of pastures and secondary forests) and maintenance of natural forest areas in protected areas (Conservation Units and Indigenous Lands), from 1990 to 2018 (SEEG Data, http://plataforma.seeg.eco.br/sectors/). Net GHG emissions within the biome result from subtracting the sequestered amount – in particular, by primary and secondary forests – from the gross emissions (total emissions).

From 1990 to 2002 the removal of CO_2eq totaled 3 Gt, just over a third of the amount removed in the following 15 years. This new trend has meant that since 2009 LUC is no longer the main cause of net GHG emissions (316 MtCO_2eq in 2018), giving way to the agricultural sector, which took the lead in net GHG emissions in Brazil (492 MtCO_2eq in 2018) (Figure 2). The analysis of net emissions in the IV emission inventory of SIRENE, the National Emissions Registry System, consisting of official data from the Ministry of Science and Technology and Innovations (Decree No. 9,172 / 2017) (MCTIC, 2018), indicated that between 1994 and 2010 changes in land use and land cover in the Amazonian biome were the main drivers of about 74%

of national emissions (results still in public consultation, MCTI, 2019). This shows that the reduction of Brazilian GHG emissions depends significantly on actions to combat illegal deforestation in the Legal Amazon, stimulated by national policies and governance within a long-term project.

The recent weakening of environmental policies by the current Brazilian government, especially in the area of climate change, in terms of command, control and land regularization, may put in jeopardy the national and international commitments signed by Brazil to reduce emissions, as well as the national and global climate balance (ANGELO; RITTL, 2019).

5. What is the importance of Amazonian deforestation control for climate stability in Brazil and the Planet?

The IPCC's fifth report on climate change published in 2014 (IPCC, 2014) drew the attention of the world community to the need for immediate action to keep the global temperature below 2ºC from the temperature recorded in the pre-industrial period. Beyond this limit, it is claimed, the climate system would be affected by a growing number of extreme weather events, such as prolonged droughts and heavy rainfall, bringing irreversible impacts to the economy, health, and quality of life for human populations and for biodiversity.

According to pessimistic GHG emission scenarios (SRES A2, RCP8.5), Brazil is expected to warm up by more than 4ºC by the end of the century. The average global temperature increased by about 0.85°C [0.65<1.06] during the period 1880-2012, and different parts of the world already feel the consequences of climate warming, especially countries with high socioeconomic vulnerability in Latin America (DA SILVA et al., 2019; IPCC, 2014; MAGRIN et al., 2014). Accumulated GHG emissions since 1980 have reached a critical point and challenge keeping the temperature below a tipping point that would lead to an irreversible state of global climate instability (IPCC, 2014). This calls for an abrupt reduction of emissions in the next 40 years, investments in a low-carbon economy, creation of carbon sinks on a massive scale, and increased resilience of the biosphere in order to mitigate the effects of ongoing climate change (PEREIRA; VIOLA, 2018; ROCKSTRÖM et al., 2016; VIOLA; BASSO, 2015).

In this scenario, the Amazon Forest plays a key role in the mitigation and adaptation to climate change, especially in Brazil, due to biochemical and biophysical processes resulting from the interaction between the forest and the atmosphere. The 5.3 million km^2 of the Amazon rainforest act as a large carbon sink, storing on average 60 t ha-1 of carbon above the ground, and sequestering 430 million to 2 gigatons of carbon annually (BRIENEN et al., 2015; PHILLIPS et al., 2017). The removal of large quantities of carbon by the forest is responsible for reducing the country's net emissions at relatively low costs (SOARES-FILHO et al., 2016). In addition, the Amazon rainforest, by pumping water from the soil and releasing it into the atmosphere (evapotranspiration) increases cloud production and ensures 35% to 80% of precipitation within the ecosystem (MARENGO et al., 2018), cooling the earth's surface and minimizing the effects of inter-annual droughts and heat waves (ARIAS et al., 2018; LLOPART et al., 2018; PAVÃO et al., 2017). This moisture produced by the forest is transported to the southern and northern hemispheres, ensuring precipitation in remote regions and contributing to regulate atmospheric circulation on a continental scale, mitigating the effects of global warming.

Carbon emissions in the tropics are strongly associated with deforestation for conversion of natural forests into agricultural uses. The National Emissions Registration System (SIRENE) (MCTIC, 2018), with official data developed by the Ministry of Science and Technology and Innovations (Decree No. 9,172 / 2017), has indicated that between 1994 and 2010, land use and land cover changes in the Amazon biome were the leading cause of about 74% of national emissions (results still in public consultation, MCTI, 2019). From a total of 845 Mt CO_2eq generated in 2018 by land use changes, the deforestation of the Amazon alone was responsible for generating 499 MtCO_2eq, more than the entire agricultural sector, which generated 492 MtCO_2eq in the same period. In percentage terms, deforestation of the Amazon was responsible for 25.7% of the country's total annual GHG emissions in 2018, and 59% of emissions by LUC. This value was 0.3% higher than in 2017. In addition to its effects on GHG emissions, deforestation may amplify the impacts of climate extremes resulting from climate change. The eastern Amazon, for example, may warm up by more than 3°C, while rainfall from July to November may decrease by as much as 40%, causing a delay in the beginning of the rainy season of 0.12 to 0.17 days for every 1% increase in deforestation (LEITE-FILHO; SOUSA PONTES; COSTA, 2019). The interaction of the climate and the Amazon rainforest is, therefore, an essential mechanism of climate mitigation for the planet, storing large amounts of carbon in the forest and sequestering carbon from the atmosphere, thus helping to keep the temperature below 2º C, and for Brazil, mitigating the impacts of global warming by cooling the earth's surface and producing humidity.

The interactions of large-scale environmental factors such as deforestation, global warming, extreme drought events and the associated higher frequency of forest fires (NOBRE et al., 2016; NOBRE; BORMA, 2009) may lead the Amazon rainforest to an inflexion point, initiating a savannization process where the vegetation takes on characteristics of a degraded savannah (NOBRE; SELLERS); SHUKLA, 1991), which may occur until the middle of this century (NOBRE et al., 2016). Projections indicate that this transition in the forests of central, southern and eastern Amazonia may be reached when the temperature rise approaches 4º C, as a result of reduced rainfall, longer and much more severe dry seasons, or when deforestation reaches 40% of the total forest area in the Amazon basin (NOBRE et al, In a business-as-usual *(*current pattern) scenario of human influence on the climate, the deforestation of 20-25% of the Amazon would be enough for an abrupt transition of the biome, culminating in the reduction of up to 60% of the forest area by 2050 (NOBRE et al., 2016). This massive forest loss will bring irreversible impacts to climate and hydrological regulation services at local, regional and continental scales, essential for human well-being (e.g., water security, food security) and biodiversity conservation.

6. What is the importance of the Amazon rainforest for the occurrence of rain in Brazil?

The Amazon rainforest plays an essential role in regulating the hydrological cycle and rainfall production in Brazil. High rates of rainforest evapotranspiration (ET) are fundamental for the surface energy balance. The water that reaches the root system of the plants, either from rain intercepted by the tree canopy, or accumulated in the water table, returns to the atmosphere through water evaporation processes from surfaces and plant transpiration. This process, known as evapotranspiration, is one of the main cloud and rain formation processes in forested regions. The moisture transpired by the plants precipitates and evapotranspires repeatedly in the forest, thereby recycling rain water (A B ELTAHIR; BRAS, 1994).

The service of recycling the rain and the continued production of humidity by the forest in dry periods are important mechanisms that regulate the seasonality of rains. The deep root system of the Amazonian trees helps trees capture water stored in the deepest levels of the soil, guaranteeing the production of humidity and its release into the atmosphere (BRUNO et al., 2006; JIPP et al., 1998; NEPSTAD et al., 1994). In most of Amazonia, evapotranspiration continues even during the dry season, and may even be higher than the rainy season in some situations (MARENGO et al., 2018). Studies have shown that this process is fundamental for the seasonal dynamics in the region, because during the dry season (FU et al., 2013a) the water vapor produced by the forest creates conditions for the entry of moisture into the Atlantic Ocean, initiating the rainy season (FU et al., 2013a; WRIGHT et al., 2017).

This precipitation recycling process is responsible for 35% to 80% of the rainfall within the forest (MARENGO et al., 2018). Studies suggest that the large amount of water vapor released by the forest is able to transport moisture to the southwest and southern Amazon, as well as the River Plate Basin, contributing to precipitation in Brazil and other regions, as a series of cascading events (ZEMP et al., 2017). About 70% of the forest evaporation in the Guianas and Amazon region is transported by wind to the River Plate, thus representing an essential exogenous water resource (ARRAUT et al., 2012; VAN DER ENT; SAVENIJE, 2011). The humidity from the Amazon may contribute 9 to 10% of the rainfall of South America and 17 to 18% in the region of the River Plate Basin. In terms of total contribution to the River Plate Basin, the Amazon may increase precipitation by 6% during the rainy season (ZEMP et al., 2014).

7. What would be the consequences of increased Amazon deforestation at the pace observed in recent years for the climate stability in Brazil?

The Amazon rainforest plays an essential role in mitigating the climate change by regulating the hydrologic cycle and by cooling the earth's surface, while maintaining a milder climate. High rates of evapotranspiration (ET) from the rainforest are fundamental for the surface energy balance, regulating global and local warming (DAVIDSON et al., 2012; ELLISON et al., 2017) and guaranteeing rainfall recycling in several areas of the South American continent (COE et al., 2017; ELLISON et al., 2017). In other words, the Amazon produces rain and transfers it to other regions of South America. The humidity within the forest is always high, with average values varying from 15.8 $g.kg^{-1}$ in the dry season to 17.5 $g.kg^{-1}$ in the rainy season (VON RANDOW et al., 2004), preventing the soil-plant system from heating the air, by moistening and cooling the microclimate (ROCHA et al., 2017; SATYAMURTY et al., 2010). Studies suggest that the atmosphere at the forest surface may be 2º C colder and more humid than the deforested areas (ARIAS et al., 2018; LLOPART et al., 2018; PAVÃO et al., 2017).

The deforestation of the Amazon might cause its eastern region to heat up more than 3° C, causing up to 40% less rainfall from July to November, and a delay in the beginning of the rainy season (0.12 to 0.17 days per cent for every 1% increase in deforestation) (LEITE-FILHO; SOUSA PONTES; COSTA, 2019). With a deforested are corresponding to 40% of the Amazon, annual rainfall would be reduced by between 5% and 10% in the Amazon basin (ZEMP et al., 2017). The reduction of moisture recycling after the removal of the forest leads to longer dry seasons in southern Amazonia and reduces the flow of moisture to the east of the region (AGUDELO et al., 2019).

The air cooling mechanism is more efficient in tropical forests compared to other land cover, such as grasses, shrubs and non-irrigated crops (VON RANDOW et al., 2004). The duration of the dry season can be a determining factor for the savannization of Amazonia, i.e., the replacement of a humid tropical forest by more drought-resistant vegetation with distinct functionality (NOBRE et al., 2016; NOBRE; SELLERS; SHUKLA, 1991). One of its functions is to regulate the flow of rivers, increasing the capacity of the basin to store water and control the release of water through atmosphere-biosphere interactions, thus avoiding extremes of precipitation leading to stronger river flows and more frequent flooding (FERNANDO SALAZAR et al., 2018). Deforestation can compromise the ecosystem's water balance, an example of which can be found in the Xingu headwaters in the Amazon, where high rates of deforestation have caused several springs to dry up (DURIGAN; GUERIN; DA COSTA, 2013). The interaction of climate and forest is therefore an essential mechanism of climate mitigation that reduces the economic and environmental impacts of global climate change (COE et al., 2017; DAVIDSON et al., 2012).

8. If the deforestation of the Amazon continues to increase at the current rate, can this impact be offset by reducing GHG emissions in other sectors of the economy without jeopardizing climate stability? What would be the costs of such compensation?

The Amazon Forest plays a key role in the mitigation and adaptation to climate change, especially in Brazil, due to biochemical and biophysical processes resulting from the interaction between the forest and the atmosphere. The 5.3 million km^2 of the Amazon Rainforest act as a large carbon sink, storing on average 60 t ha^{-1} of carbon above the ground (RÖDIG et al., 2019), and sequestering between 430 million to 2 gigatonnes of carbon annually (BRIEN et al., 2015; PHILLIPS et al., 2017). The removal of large amounts of carbon by the forest is responsible for reducing the country's net emissions, that is, the total emissions less the carbon sequestered from the air by forests located in protected and regenerating (i.e., secondary) areas, at relatively low costs (SOARES-FILHO et al., 2016). Furthermore, the Amazon rainforest, by pumping water from the soil and releasing it into the atmosphere (evapotranspiration) increases cloud production and ensures 35% to 80% of precipitation within the ecosystem (MARENGO et al., 2018), cooling the earth's surface and minimizing the effects of inter-annual droughts and heat waves (ARIAS et al., 2018; LLOPART et al., 2018; PAVÃO et al., 2017). This moisture produced by the forest is transported to the southern and northern hemispheres (DIRMEYER; BRUBAKER; DELSOLE, 2009; STAAL et al., 2018; ZEMP et al., 2014), ensuring precipitation in remote regions (NOBRE et al., 2009) and contributing to regulate atmospheric circulation on a continental scale (BARKHORDARIAN et al., 2019; MARENGO et al., 2018), thus mitigating the effects of global warming (ELLISON et al., 2017).

Deforestation and forest degradation reduce the cooling effect, as well as the cloud formation, precipitation and climatic seasonality provided by the humid tropical forest (ELLISON et al., 2017; LANGENBRUNNER et al., 2019). Their effects increase the risks related to extreme climate changes (droughts, flooding, storms) leaving the Brazilian population more vulnerable to socio-environmental disasters (BIRKMANN, 2007; IPCC, 2019). In this sense, if deforestation in the Amazon continues on an upward path, as evidenced by the 34% increase in deforestation from 2018 to 2019, the reduction of emissions by other sectors of the national economy, especially the energy and agriculture sectors, will not offset the impacts caused by the loss of ecosystem services such as forest climate regulation, nor by the emissions caused by converting forests to other land uses, due to the magnitude of emissions generated by the Land Use, Land-Use Change, and Forestry (LULUCF) sector.

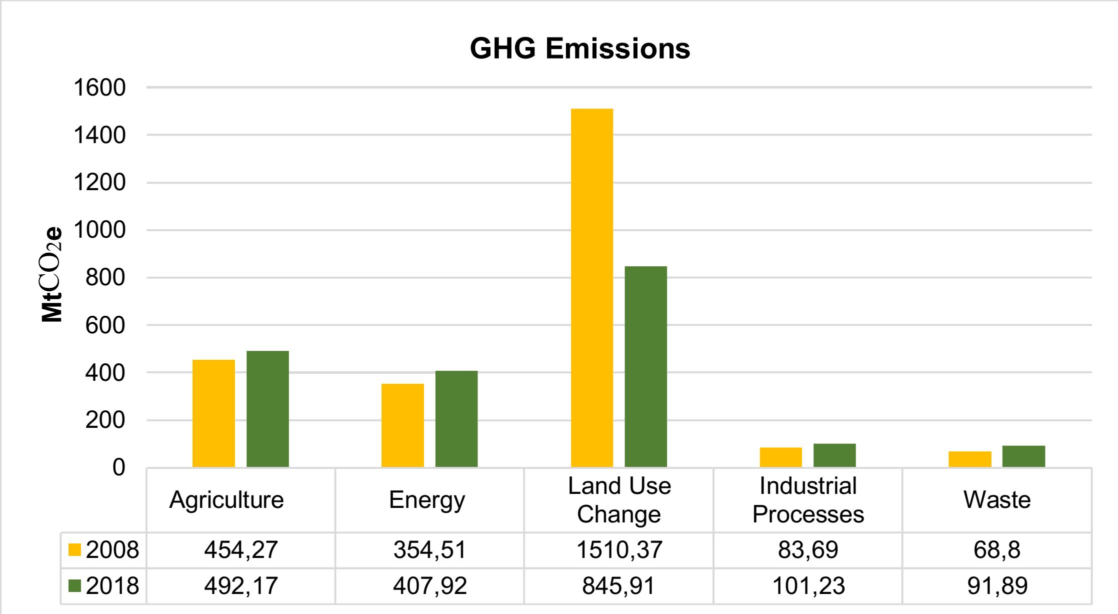
Brazil's greenhouse gas (GHG) emissions were about 1.34 million Gt of CO_2eq in 1990 and decreased to 1.27 million Gt of CO_2eq in 2010. The largest GHG emissions recorded in the historical series, from 1990 to 2010 (IPCC, 1995), occurred in 2004 (3.4 million Gt CO_2eq) (MCTI, 2016). In 2005, the GHG emissions caused by the LULUCF sector represented 70% of the country's emissions, followed by the Agribusiness and Energy sector, which contributed with 14% and 11%, respectively. In 2010, emissions from the Agriculture and Livestock sector represented 32%, while the LULUCF and Energy sectors emitted, respectively, 28% and 29% of the country's GHG (MCTI, 2016).

The LULUCF sector is extremely promising from the point of view of carbon sequestration from the atmosphere, mainly because it demands less investment in technologies to obtain medium and long term results in GHG emissions (LA ROVERE et al., 2016; MCTIC, 2017a). In addition, Brazil has the advantage of being a country with continental dimensions and possessing a vast territory well-suited to forest restoration and to the establishment of more sustainable agricultural systems, such as the Crop-Livestock-Forestry Integration System (ILPF) and the Agroforestry Systems (SAF), both included in the goals of the Sector Plan for Mitigation and Adaptation to Climate Change for the Consolidation of a Low Carbon Economy in Agriculture – ABC Plan (MAPA, 2012). Also highlighted is the possibility of using degraded pastures, which in 2018 represented an area of 94.9 Mha, or 11.16% of the country (LAPIG, 2020), and which would enable the removal of between 3.79 and 5.507 Mg CO_2eq per ha/year if recovered (BUSTAMANTE et al., 2006; MAPA, 2012). These initiatives, along with the reduction of deforestation and the protection of natural vegetation within Conservation Units and Indigenous Territories, would not only allow the reduction of GHG emissions in the country, but also turn it into a carbon sink.

The project "Options for the Mitigation of Greenhouse Gas Emissions in Key Sectors in Brazil", led by the Ministry of Science, Technology and Innovation (MCTI), has explored different low carbon scenarios for several sectors (industry); energy;

transportation; buildings; agriculture, forestry and other land uses and waste management) and analyzed their economic impacts for the period between 2020 and 2050 (MCTIC, 2017a). The vulnerability identified in the scenarios addressed in the project highlight the benefits an integrated analysis of the sectors could bring to bear on the formulation of public policies to reduce emissions, whereby convergence between the objectives of environmental, economic, energy, science and technology, industrial and transportation policies is of fundamental importance. Furthermore, such scenarios reinforce the importance of formulating mitigation policies that follow a rationale of minimizing costs for the energy system and the Agriculture, Forestry and Other Land Use (AFOLU) sector (MCTIC, 2017a). As identified in this project, the measures with the greatest potential for cutting emissions in the AFOLU sector are those with the highest cost: intensification of livestock (1.99 US$/t$CO_2$e), reduction of deforestation (1.24 US$/t$CO_2$e) and forest restoration (9.22 US$/t$CO_2$e). At any rate, these costs are very low, with the exception of forest restoration. In addition, the importance of a coordinated and integrated implementation of measures related to livestock and deforestation reduction is highlighted (MCTIC, 2017a). Schaeffer and Szklo (2009) also reinforce the interdependence between mitigation measures and the different sectors, that is, results partially achieved in one sector influence another. Even though this analysis indicates some paths to reduce emissions, it is important to emphasize the long-term basis of their implementation, which require articulation between the different sectors of the economy.

If we compare the distribution of emissions among the LULUCF, energy and agricultural sectors in 2008, when deforestation reached 12,911 km^2, and 2018, when deforestation was reduced to 7,536 km^2, we notice that the sector of land use change, given its capacity to bring about a substantial reduction of emissions, ensures that the increased emissions from other sectors do not greatly impact the total GHG emissions of the country (Figure 5).



	Agriculture	Energy	Land Use Change	Industrial Processes	Waste
2008	454,27	354,51	1510,37	83,69	68,8
2018	492,17	407,92	845,91	101,23	91,89

Figure 5: Distribution of total gross carbon equivalent emissions by the LULUCF, Energy and Agriculture sectors in the years 2008 and 2018 (SEEG data, access: 03-Jul-2020).

Thus, national investments in reforestation and deforestation control can alleviate mitigation efforts in the energy system, reducing investments in carbon capture and storage technology in the industrial and energy sector (GARCÍA KERDAN; GIAROLA; HAWKES, 2019). The energy sector in the country has the potential to reduce its emissions to zero given its vocation for renewable energy sources, such as hydroelectric, wind and solar. However, recent changes in pricing rules for solar microgeneration and wind power contracting, as well as attempts to expand coal production and use (ANGELO; RITTL, 2019), coupled with the lack of national investments to increase energy efficiency and the rise in non-renewable energy production from 52.1% in 2008 to 59.5% in 2017 (BEN, 2018), along with the continued interest in manipulating oil prices as a political tool to maintain artificially higher rates of economic growth (VIOLA; BASSO, 2015) all point to a dystopian future.

While the development and adoption of modern agricultural management practices that improve productivity and reduce deforestation (e.g., Plan ABC) continue at a slow pace (GARCÍA KERDAN; GIAROLA; HAWKES, 2019), the expansion of pasture areas into the forest continues to be the largest cause of deforestation in the Amazon, representing 64% of gross carbon emissions from 2010 to 2016 (SIRENE data). In this scenario, mechanisms for offsetting GHG emissions in different sectors are unlikely to be feasible. The rhetoric of compensation between sectors reveals the dissonance between the supposed national interest of reduced GHG emissions and the implementation of actions and incentives for decarbonization in the Brazilian economy (VIOLA; GONÇALVES, 2019). Progress towards decarbonization should focus on short-term strategies to reduce emissions and strengthen low-carbon growth advocacy (URPELAINEN, 2017).

Based on Integrated Assessment Models (IAMs), Rochedo et al. (2018) drew up three scenarios of environmental governance. The first is one of weak governance, referring to the neglect of deforestation control and the stimulus to predatory farming. The intermediate governance scenario entais maintaining deforestation control policies while simultaneously supporting predatory practices. The third scenario, one of strong environmental governance, involves the expansion of preservation policies and enforcement of current legislation. For the authors, Brazil's environmental governance is divided into three periods: i) pre-2005, a period with weak governance and high deforestation rates; ii) 2005 to 2011, which saw a decrease in deforestation, associated with stronger governance; and iii) 2012 to 2017, when governance was eroded by the revision of the new Forestry Code. The results show that the financial impact of the first scenario (weak governance) would lead to a loss of 5 trillion dollars to the country until 2050, compared to the strong governance scenario, taking into account the average price for carbon estimated in the literature, projected at 370 dollars for 2050. The authors conclude that abandoning environmental policies leads to an increase in deforestation and, consequently, to greater GHG emissions. To deal with this increase, the country would need to invest heavily in high-cost, cutting-edge technologies, making it unlikely to meet the targets pledged in the PNMC and the Paris Agreement. Therefore, reducing deforestation is certainly the least costly option for Brazil to meet its national and international targets (ROCHEDO et al., 2018).

9. Do you consider as adequate the goal established in the Brazilian legislation of reducing, by the year 2020, the annual deforestation rates in the Legal Amazon region to 80% of the average in the years 1996 to 2005 (19,625 $km^{2)}$, which means that by the year 2020 the deforestation in the Legal Amazon should not exceed the annual rate of 3,925.06 km^2 ?

10. Do you consider as adequate the projection of greenhouse gas (GHG) emissions for the land use change sector of 1,404 million tonCO2eq in 2020, as set forth in article 18 of Decree Law 9578/2018? Why?

(Questions 9 and 10 complement each other, so the answer below applies to both).

The National Policy on Climate Change (PNMC) was established by Law No. 12.187/2009 and edited by Decree No. 9.578/2018. The goals proposed under the PNMC in 2009 were to reduce greenhouse gas (GHG) emissions in the country between 36.1% and 38.9% in relation to projected emissions by 2020 (3,236 million tCO_2eq), based on the 1st National Inventory of Greenhouse Gases Emissions and Removals. For the LULUCF sector, the projection until 2020 was 1,404 million tCO_2eq, an estimate referring to the annex of Law No. 12,187/2009 and Decree No. 7,390/2010 (revoked) and No. 9,578/2018 (replacing the previous one), which regulates the PNMC.

Within the LULUCF sector, the mitigation actions related to these plans were: i) an 80% reduction in annual deforestation rates in the Legal Amazon calculated on the average rates between 1996 and 2005; ii) a 40% reduction in annual deforestation rates in the Cerrado biome in relation to the pattern confirmed between 1999 and 2008; iii) recovery of 15 million hectares of degraded pastures; iv) expansion of the Crop-Livestock-Forestry Integration (ILPF) system by 4 million hectares; v) expansion of no-till farming practice by 8 million hectares; vi) increase of forest planting by 3 million hectares.

The goal of reducing deforestation in the biomes, especially in the Amazon and Cerrado, is the main mechanism for reducing emissions in the sector, serving as the axis on which to trace the trajectory of emission reductions until 2020. The projected emission of 1,404 million tCO2eq resulted from adding up the projections for these two biomes, corresponding to 91% of the emissions for LULUCF, plus the emissions of the

Atlantic Forest, Pantanal and Caatinga biomes. The calculation of the projected emissions from deforestation in the Legal Amazon resulted from the convention that, in 2020, the deforestation rate (measured in square kilometers) would be equivalent to the average deforestation rate verified in the biome between 1996 and 2005, that is, 19,535 km^2, as measured by Project PRODES (Decree No. 7,390, December 9, 2010), which in association with the average carbon stock of 132.3 tC/ha would result in an emission of 947.6 million tCO_2eq in 2020. It should be noted that emissions caused by forest degradation are not included in this calculation (including those caused by forest fires). When considering the average 10-year variation in deforestation rates, an Amazon with deforestation rates ranging from 13,227 km^2 to 27,772 km^2 was intended. In relation to the Cerrado, the projected deforestation rate was 15,700 km^2, representing the average from 1999 to 2008, which associated with a carbon stock of 56.1 tC/ha would result in an emission of 322.95 million tCO_2eq.

With an 80% reduction in deforestation as a 2020 target for the Legal Amazon (3,925 km^2), emissions would be reduced by 761.8 million tCO_2eq to a total of 190.5 million tCO_2eq for the Amazon biome in 2020. Considering the 40% reduction in deforestation for the Cerrado biome in 2020 (9,420 km^2) and, consequently, associated emissions of 193.77 million tCO_2eq, this would represent a reduction of 129.18 million tCO_2eq compared to those projected. This represents 43% of the projected removals for Brazil by 2020. It is worth noting that this analysis does not consider the removal (or sequestration) of carbon by reforestation and other mitigation actions under the ABC Plan (net emissions).

Brazil's voluntary commitment, pledged at the 2009 Climate Conference (COP15), was considered important because a developing country was proposing to overcome the development-versus-conservation dichotomy on which several countries relied in order not to commit to major goals. It was also considered feasible at the time, in light of the country's experience of deforestation reduction, which reflected the results of the first phase of the PPCDAm (2004 - 2008). This achievement spurred Brazil to set its goals and contributed to the formulation of a series of political mechanisms that associated the fight against deforestation with actions to combat climate change. After continuous drops in deforestation rates, the Amazon reached the lowest area of 4,571 km^2 in 2012, which made it seem very likely that the 3,925 km^2

goal would be met by 2020. After 2012, however, rates fluctuated considerably, reaching 7,536 km^2 in 2018, 92% above the target. In 2019, with governance undermined by policies and government declarations encouraging illegal deforestation, along with weakened command and control mechanisms, deforestation rose to 10,129 km^2, definitively moving Brazil away from the PNMC target.

As for emissions, a projection based on the average annual variation from 2015 to 2018 – the year the law was regulated, which included an estimated 30% increase in Amazon deforestation in 2019, was developed by the Climate Observatory (ANGELO; RITTL, 2019) with the objective of assessing whether Brazil would meet the emission targets by 2020. This projection showed that Brazil would be emitting 2.039 billion tons of CO_2 equivalent by that year, and therefore 3% above the most ambitious limit of the PNMC (38.9% reduction, or 1.977 $GtCO_2e$), but within the less ambitious limit (2.068 $GtCO_2e$). In 2018, driven by increased deforestation of the Amazon (7,536 km^2), emissions from the LULUCF sector increased 3.6% compared to 2017, reaching 845 $MtCO_2e$, 40% below the projected target of reducing 1404 $MtCO_2e$. Deforestation in the Amazon alone led to gross emissions of 499 $MtCO_2e$ in 2018, against 454 $MtCO_2e$ in 2017. In the Cerrado, emissions were 168 $MtCO_2e$, compared to 186 $MtCO_2e$ in the previous year (ANGELO; RITTL, 2019). In 2019, with increased deforestation to 10,129 km^2, emissions would reach about 671 $MtCO_2e$, or 72% above the reduction target for the biome (190.5 million tCO_2eq).

In this analysis of data since 2009, the year when the emission and deforestation targets were determined, we can establish that i) Brazil had all the political and technological tools to meet the self-determined targets, especially in terms of reducing deforestation; ii) the non-fulfillment of national commitments was influenced by political scenarios of instability and the strengthening of conservative economic sectors of society that benefit from weakened environmental governance; iii) the continued preservation of climate change mitigation plans and actions should be the main effort of Brazil toward climate stability, natural ecosystems integrity and comprehensive social welfare; and iv) with reference to a time frame, the adoption of multiple periods as a way to monitor the mitigation actions and their results, as suggested in the report on the Civil Society Participation in the NDC[7] preparation process, would make it possible to review the goals and adjust the proposed actions, avoiding deviations from the proposed goals.

[7] https://www.mma.gov.br/images/arquivos/clima/convencao/indc/Relatorio_MRE.pdf

11. What are the main causes of deforestation in the Legal Amazon? Comment on the most recent deforestation data, its distribution by states in the Legal Amazon and distribution by land category (indigenous lands; conservation units; land reform settlements; environmental protection areas; private property; government lands; and other categories without information).

a) Comments on area and distribution of deforestation by states

Amazonia, an area that holds the three largest states in Brazil, presents hotspots of deforestation throughout the region, with specific causes and dynamics. Historically, deforestation has been concentrated along the “Arc of Deforestation” region, also known as “Arc of Fire”, which corresponds to an area of 256 municipalities (33% of the 772 municipalities that make up the legal Amazon) that concentrate around 75% of all Amazonian deforestation. A region of intense agricultural expansion, the Arc of Deforestation starts at the border of Pará and Maranhão and forms an arch that follows the border of Pará with Tocantins and Mato Grosso, until it reaches the state of Rondônia. In addition to high rates of deforestation and forest fires (INPE, 2019), the municipalities located within the Arc of Deforestation are also characterized by large beef cattle herds (IBGE, 2019) and agrarian conflicts (CPT, 2019).

In the period 1999 to 2004, deforestation rates were on the rise, peaking at 27,772 km^2 of deforested area in 2004. Of the nine states that make up the Legal Amazon, four recorded their highest rate on record that year: Mato Grosso (11,814 km^2), followed by Pará (8,870 $km^{2)}$, Rondônia (3,858 km^2) and Acre (728 km^2). Total deforestation in the region fell by 31% (19,014 km^2) from 2004 to 2005, and by another 33% in the following year (2005 to 2006, 14,286 km^2). Until 2006, Mato Grosso was the leading state in deforestation in the Amazon, followed by the states of Pará and Rondônia (INPE, 2020). Most deforestation in Mato Grosso was concentrated in the central and extreme north of the state, following northward along highway BR-163, starting from the region of intense agricultural activity, especially soybeans (MORTON et al., 2006, 2016). Between 2004 to 2005, the deforestation rate in Mato Grosso fell by 39.5%. In the following year, that rate decreased a further 39.3%. This means that in the course of only two years, the deforested area in Mato Grosso fell from

11,814 km² to 4,333 km², a figure that significantly contributed to the decrease of the deforestation rate in the whole Amazon region.

In addition to reducing its deforestation rate, the state of Mato Grosso also changed the spatial distribution of deforested areas, now increasingly concentrated in the northwest of the state, especially in the municipality of Colniza, one of the main logging centers in the Amazon (IBGE, 2019), which has been in the ranking of the largest deforesters in the region since 2010, and in the municipalities of Aripuanã, Cotriguaçu and Machadinho do Oeste (all of which were ranked as municipalities with the largest increases in deforestation in Mato Grosso in 2019). However, after successive declines in the deforestation rate, the state of Mato Grosso has again showed small increases in deforestation rates since 2015. In 2019, the deforestation rate grew more than 12.5% (1,702.00 km²) compared to the previous year, and more than 3.5% in 2020, reaching an area of 1,767.00 km². A higher figure than 2020 had only been recorded in 2008 in the state.

Starting in 2006, with the sharp decrease of deforestation in Mato Grosso, the state of Pará took the lead in deforestation in the Amazon and has remained in that position ever since. The most recent PRODES data shows that in 2019 six out of ten municipalities with the highest deforestation in the Amazon region were in the state of Pará. Deforestation in Pará is concentrated along its main highways, BR- 010 (Belém-Brasília), BR-155 (Marabá - Redenção), BR-163 (Cuiabá- Santarém) and BR- 230 (Transamazônica). The main deforestation hotspot in Pará is in the southeastern region of the state, characterized by intense livestock activity and land conflicts (JUAN, 2015; SCHMINK et al., 2019). In this region, the municipality of São Félix do Xingu has for years stood at the top of municipalities with the highest deforestation rate in the Amazon, as well as that with the largest cattle herd in Brazil (IBGE, 2019). This is also the municipality where the Conservation Unit with the highest deforestation rates in the Amazon is found, the Triunfo do Xingu Environmental Protection Area, which for more than a decade has led the ranking of deforested CUs in the region (INPE, 2020). This is also the region where the leading Amazonian deforestation municipality is located: Altamira, whose deforestation rates have been on the rise since 2012, when the municipality reached the top stop on the list of the main deforesters in the Amazon. The municipality was responsible for over 15% of all deforestation recorded in the state in 2020, equivalent to an area of 798.20 km². For decades, Altamira has been the object of extensive environmental and social controversy due to the implementation of the Belo Monte hydroelectric plant, whose construction began in 2011 and operations started in 2016.

The southwest region of the state of Pará also presents intense deforestation dynamics, especially the municipality of Novo Progresso, on the border with Mato Grosso and crossed by the BR-163 highway. Since the end of the 1990's, the city has been among the ten most deforested municipalities in the Amazon (INPE, 2020). Novo Progresso recently received media attention due to the "Day of Fire", promoted in August 2019, when landowners in the municipality organized to collectively burn pastures and the forest (KLINGLER; MACK, 2020; MACHADO, 2019), significantly raising the fire alerts in the municipality (INPE, 2019). Another episode that highlighted the municipality was the significant increase in deforestation in the Jamanxim National Forest. Created in 2006 under the PPCDAm, the Jamanxim National Forest has been one of the most intensely deforested Conservation Units (CUs) in the Amazon since its creation. From 2017 to 2019, deforestation in the UC increased from 25.09 km² to 100.82 km², a growth of 75 percentage points. Similar deforestation had only been recorded a decade earlier, when the Jamanxim National Forest lost 100.33 km² of its forests.

The most recent PRODES data not only points to more intensified deforestation in the municipalities included in the list with the highest expansion of deforested areas in the Amazon, or those located in the Arc of Deforestation, but also warns of the spread of deforestation to adjacent municipalities. In southwest Pará, municipalities north of São Félix do Xingu and Marabá, such as Pacajá, Novo Repartimento and Anapú, have been listed among the ten municipalities with the greatest rise in deforestation in the Amazon since 2015. Likewise, municipalities along BR-163 and north of Novo Progresso, such as Jacareacanga, Trairão and Rurópolis, have recently also recorded the largest increases in deforestation in the state. The aggravating factor in this scenario is that municipalities not located along the Arc of Deforestation, or not on the list of priority municipalities (BRAZIL, 2007), do not have any priority in receiving coordinated actions to combat deforestation. The intensification of deforestation in Pará became clear following the release of PRODES data for the year 2020, which indicated that approximately 47% of all deforestation in the Amazon in this period occurred in the state, totaling an area of 5,192.00 km². A higher deforested area had last been recorded in the state in 2008.

Considering the total deforestation in the Amazon region, Rondônia is the third state that most contributed with deforested area, concentrating approximately 14% of all deforestation in the region until 2020. In 2011, 2013 and 2017, the state capital, Porto Velho, was the municipality with the greatest increase in deforestation in the entire Amazon (with 318.63 km², 304.64 km² and 341.81 km² of deforested area, respectively) and is currently the third municipality with the greatest increase in deforestation in the Amazon. Since 2015, the state had been recording annual deforestation rates of more than 200 km², concentrated along highway BR-364. The deforested area in the municipality in 2020 added up to 449.66 km².

Since 2019, the PRODES results have also highlighted three important aspects at state level: i) the state of Amazonas took on the third position among the states with the highest increases in deforestation in the Amazon, breaking its own record of deforested area, ii) the state of Acre recorded an increase of approximately 55% over 2018, with a deforested area close to its 2004 record and iii) the state of Roraima broke its own deforestation record with an increase of 216% over 2018. In 2020 the pattern remained the same, although with a decrease in most states and continued absolute growth in the state of Pará.

In the case of Amazonas, the deforestation rate increased by 36% from 2018 to 2019 and the state began to contribute approximately 15% of all deforestation that occurred in the Amazon in this period (Figure 6). Starting in 2013, municipalities in southern Amazonas assumed the leading positions in terms of deforestation, while at the same time the deforestation rates throughout the Amazon rose by 29% over 2012 (Figure 6). Two municipalities stand out in this context: Lábrea, on the border with Rondônia, and Apuí along the BR-230 highway. The municipality of Lábrea is on the border of the states Amazonas and Rondônia (near Porto Velho) and has been the stage of bitter land conflicts, mainly between traditional sustainable extractivists and ranchers who have implemented an intense process of converting the forest into extensive pastures (COSTA, 2016a; MONTEIRO, 2020), which contributed to Lábrea taking the lead in the ranking of municipalities with the largest area deforested in 2017, and staying at the top ten since then.

The most recent PRODES data also highlights the municipalities in southeastern

Amazonas, along highways BR-230 and BR-319, where expanding livestock production has taken place in a scenario of intense agrarian conflict. A further aggravating factor is the paving of highway BR-319 (Manaus - Porto Velho) (the bidding for surfacing the highway was published in the Federal Official Gazette on June 24, 2020), a development viewed with concern by local leaders and scientists (FEARNSIDE; FERRANTE; ANDRADE, 2020; FERRANTE; GOMES; FEARNSIDE, 2020).

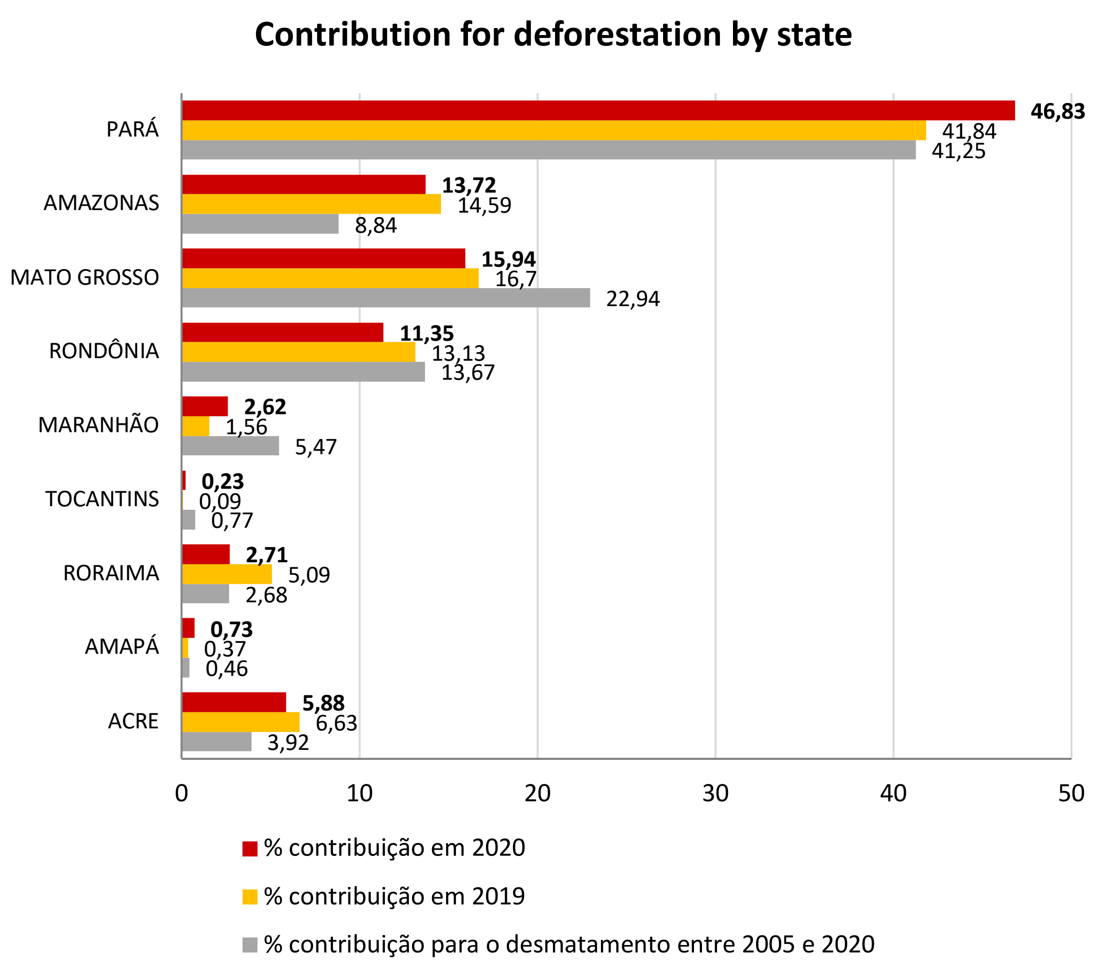


Figure 6: Contribution of deforestation by state. Source: Prepared by the author based on PRODES data

In the state of Acre, the area deforested in 2019 was 682 km². Although the area deforested in the state decreased in 2020 (682.00 km²) in relation to 2019, a higher figure had only been recorded in 2003 and 2004, when deforestation peaked with an area of 1,078.00 km², reaching 728 km² the following year. Though its municipalities are not at the top of the list of those that clear the most forests, the municipalities with the highest deforestation rates in the state reported a significant increase in deforestation rate, such as Feijó (48%), Sena Madureira (57%) and Rio Branco (68%), whose deforested areas are are concentrated along the BR-364 highway.

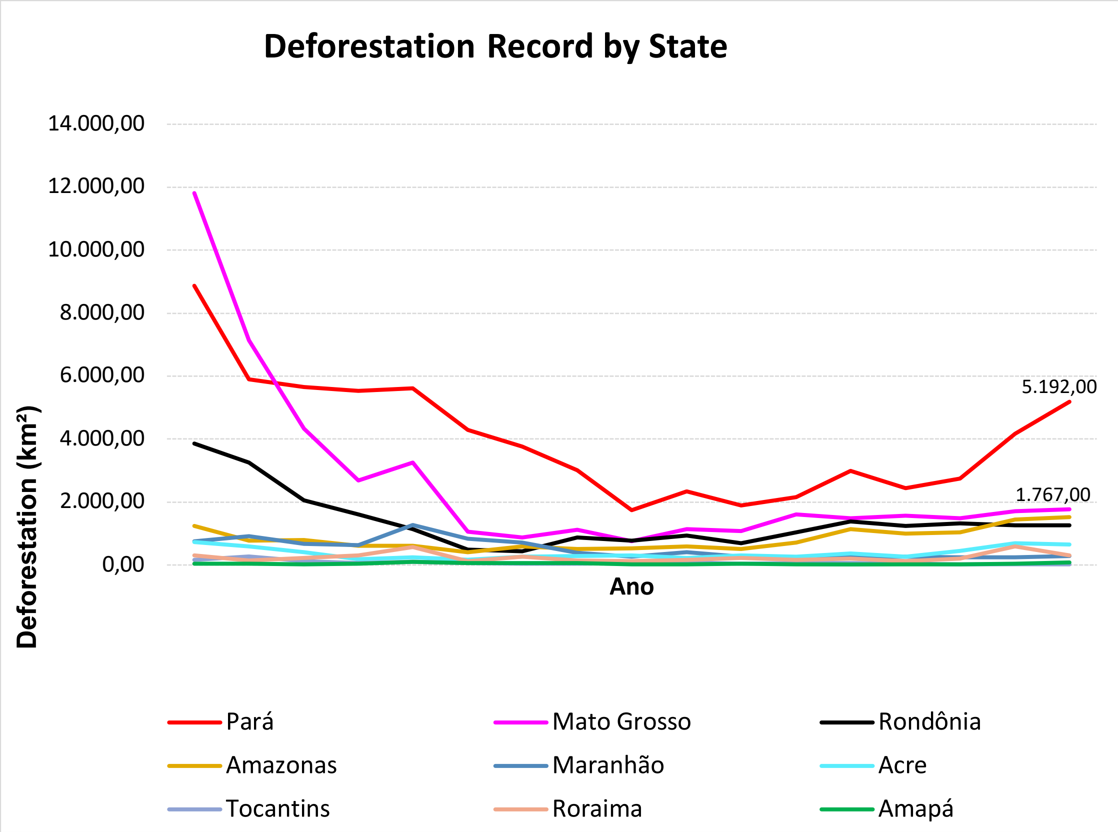


Figure 7: Deforestation in km² per state in the Legal Amazon, between the years 2004 and 2020. Source: INPE/PRODES; data available at http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/rates.

Roraima reached its deforestation record with an area of 590 km². On the border with Venezuela, the state has 65% of its territory occupied by indigenous lands, the remaining distributed among land reform settlements and undesignated lands. The state has seen a constant increase of deforested area, with intense land conflicts, mainly in the interior of indigenous lands (TIs) (CPT, 2019), concentrated in the municipalities along the BR-210 and BR-174 highways, in the municipalities of Caracaraí, Rorainópolis and Mucajaí. In 2019, the Yanomami Indigenous Land assumed the fifth position among the most deforested TIs in the Amazon.

According to the matrices of land use and land cover changes produced under the Third Brazilian Inventory of Greenhouse Gas Emissions and Removals not Controlled by the Montreal Protocol, between 1994 and 2002 transitions from natural vegetation[8] to pasture represented 96.7% of land use changes in the Amazon, while between 2002 and 2005 these changes represented 91.5%, followed by conversions to agriculture (8%). Between 2005 and 2010, transitions to pasture represented only 2.6% of converted areas, while transitions from natural vegetation to agriculture represented 96.6% of conversions. It is worth noting that the converted areas for the periods 1994 to 2002, 2002 to 2005 and 2005 to 2010 were 15,249,225 ha, 9,613,937 ha and 5,945,788 ha, respectively (BRAZIL, 2015a).

The TerraClass project is developed and executed by the Amazon Regional Center (CRA) of INPE, in partnership with the Brazilian Agricultural Research Company (Embrapa), and qualifies deforestation in the Brazilian Legal Amazon, previously mapped and published by the PRODES Amazonia project (INPE, 2014). TerraClass classified the deforested areas in the Legal Amazon for the years 2004, 2008, 2010, 2012 e 2014. The results show that between 2004 and 2014, pasture areas increased from 422,036 to 479,760.00 km2, representing 63% of the Biome's deforested areas in 2014. Annual agriculture also increased from 18,354 to 45,050 km2 in the period evaluated, representing 5.9% of the deforested areas in 2014. The areas occupied by secondary vegetation are also worth mentioning, as they increased from 100,674 to 173,387 over the period, representing 22.8% of deforested areas in 2014.

The Brazilian Institute of Geography and Statistics (IBGE), through its land cover and land use monitoring program, has developed maps for the years 2000, 2010, 2012, 2014, 2016 and 2018 (IBGE, 2020). When specifically evaluating the state of Pará, we can see that between 2000 and 2018 grasslands went from 6% to 13% of the state area. In Mato Grosso, besides the increase of pastures from 16 to 21%, there was also an increase in the agricultural area, from 8 to 13% between 2000 and 2018. In Rondônia, the pasture areas went from 16 to 30% in the evaluated period. In Maranhão, pasture areas occupied 19% of the State territory in 2018, 8% higher than the area occupied in 2000.

b) Deforestation by land categories

It is estimated that more than 60% of all deforestation in the Amazon has occurred within private properties and land reform settlements (Table 1), with a growing contribution from Protected Areas.

[8] Represented in the matrices of land use and land cover changes by FM/FNM/GM/GNM/OFLM and OFLNM.

Table 1. Contribution to deforestation by land category. Source: adapted by the author from MMA data.

	Private Area / Others	Land reform settlement	Public Land	Indigenous Land	Conservation Unit	
					Integral Protection	Sustainable Use
2004	46,9%	18,0%	26,3%	2,2%	1,8%	5,1%
2005	46,9%	20,5%	25,4%	1,9%	1,1%	4,2%
2006	36,6%	22,4%	31,3%	1,8%	2,1%	9,0%
2007	35,2%	22,1%	30,5%	2,0%	1,0%	11,8%
2008	37,8%	24,0%	28,8%	3,0%	0,9%	5,4%
2009	29,5%	28,3%	28,3%	5,0%	0,8%	8,2%
2010	33,1%	25,6%	28,6%	4,2%	0,8%	7,9%
2011	32,6%	28,1%	28,9%	3,7%	0,5%	5,5%
2012	34,0%	27,4%	27,7%	3,3%	0,6%	6,9%
2013	34,9%	27,0%	26,6%	3,0%	0,5%	8,0%
2014	32,6%	23,2%	22,0%	1,6%	0,3%	7,7%
2015	36,1%	27,4%	25,1%	1,2%	0,8%	9,3%
2016	32,4%	29,9%	24,5%	1,3%	0,7%	11,3%

Based on the PRODES results, both CUs and ITs have increased their participation in deforestation in the region. In the period from 2008 to 2019, 9% of total deforestation in the Amazon took place in CUs and 3% in ITs. However, in 2019 this percentage increased to 10.5% in CUs and 4.5% in ITs. The location of the CUs with the highest deforestation rates is in zones of intense deforestation. The leading CU in deforestation in the Amazon is the Triunfo do Xingu Environmental Protection Area, in southeast Pará, which lost 436.13 km² of forest in 2019 and in 2020 broke its own record with a total of 436.28 km² of deforested area. The second place in this ranking is the Jamanxim National Forest, located in another deforestation hotspot in Pará, in the southwestern region of the state, in the municipality of Novo Progresso. In 2020, the deforested area in this National Forest exceeded the 100.81 km² reported in 2019, reaching 436.28 km².

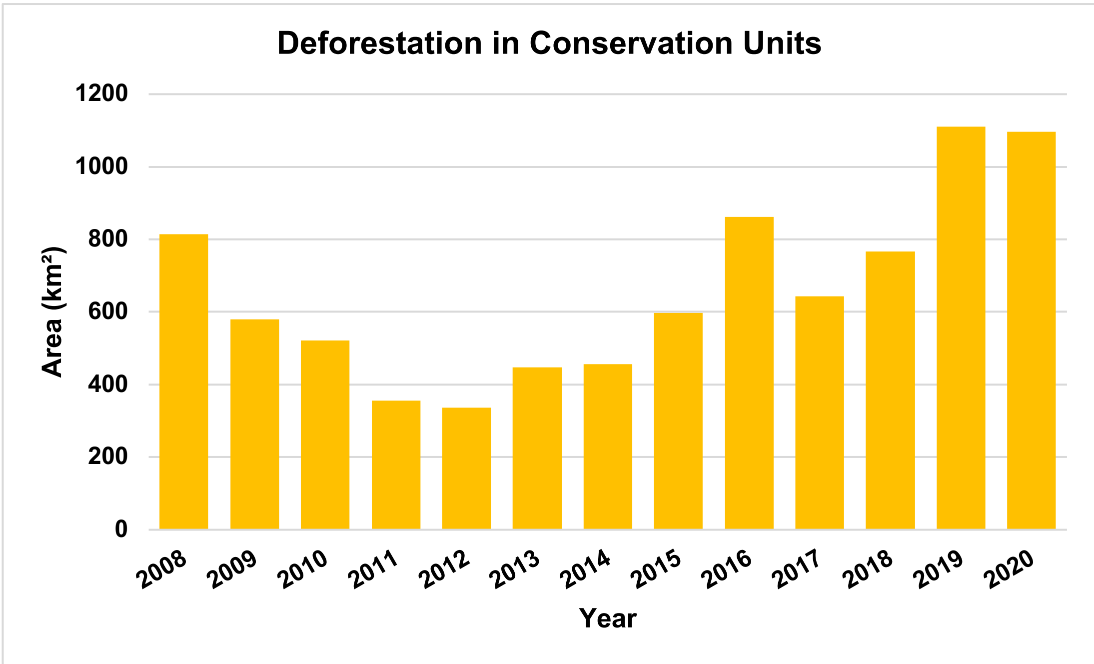


Figure 8: Deforestation, in km², in Conservation Units in the period 2008 to 2020. Source: PRODES/INPE; data available at: http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/increments

The four ITs with the largest areas deforested in the Amazon in 2019 lie in Pará, in the southeast of the state. The ITs Ituna/Itatá (119.85 km² deforested), Apyterewa (85.26 km² deforested), Cachoeira Seca (61.28 km² deforested) and Trincheira Bacajá (34.59 km² deforested) are on the outskirts of the municipalities Altamira and São Félix do Xingu, currently the leaders in deforestation in the Amazon. Deforestation in these Protected Areas was intensely reported by the media between 2018 to 2020 (FANTÁSTICO, 2019, 2020; JORNAL NACIONAL, 2020). The data released by

PRODES in 2020 indicates a drop of more than 23% in deforestation in indigenous lands, with an area of 381.4 km². However, the same ITs from previous years continue to lead in terms of deforested area: Cachoeira Seca, which had an increase in deforested area compared to the previous year (72.44 km² deforested), Apyterewa (63.27 km² deforested) and Ituna/Itatá (61.62 km² deforested), which saw a sharp reduction compared to the area deforested the previous year.

c) Deforestation drivers

In all states of the Amazon, deforestation is concentrated along the main highways and expands from them by way of secondary roads, cities and small towns (VILELA et al., 2020). The opening of roads was one of the most important governmental initiatives to occupy the region during the 1970s (BECKER, 2001; COY; KLINGLER, 2014). Since then, road axes have been determinant for the pattern and distribution of deforestation in the Amazon and, for this reason, any projects for paving older roads or opening new ones, or for developing infrastructure such as hydroelectric plants, railroads, and waterways, are viewed with concern by local communities and scientists (FEARNSIDE, 2020a; PFAFF et al., 2018; WALKER; SIMMONS, 2018).

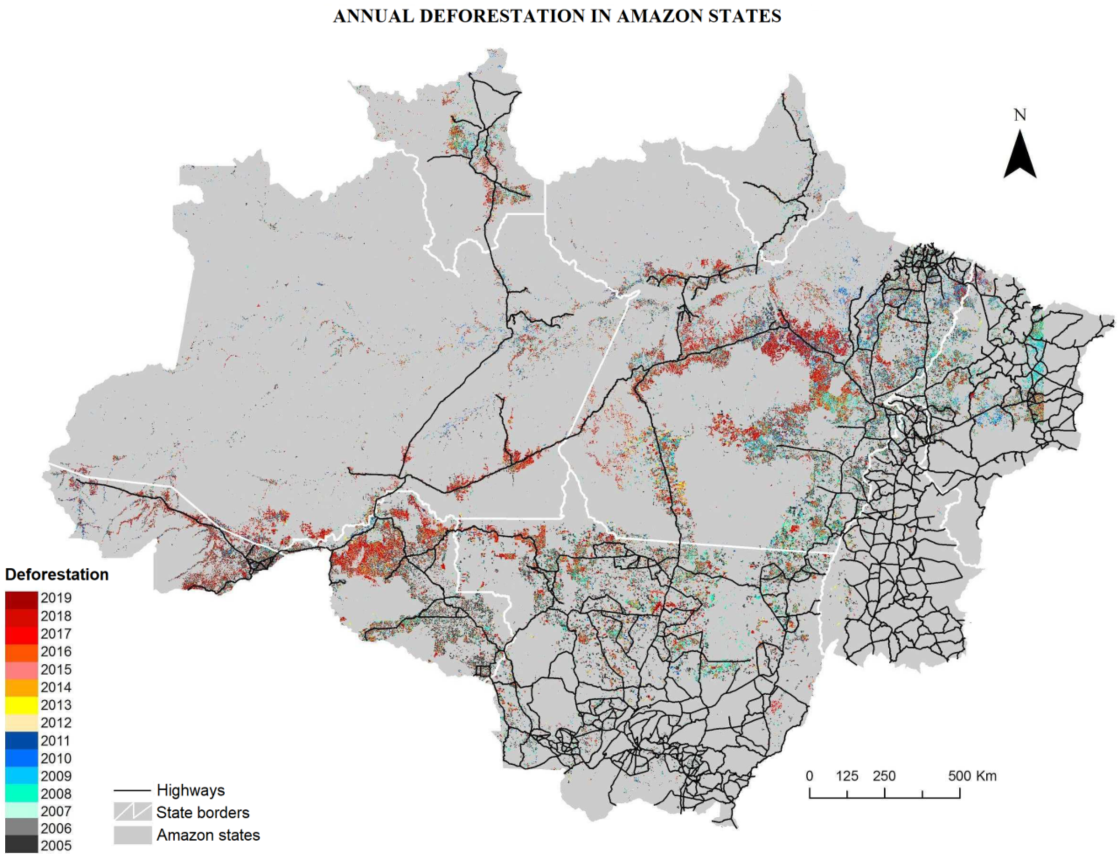


Figure 9: Map of annual deforestation in the states of the Amazon. Source: Produced by the author

High deforestation rates in areas close to infrastructure reflect regional problems that stimulate deforestation practices, such as gaps in land-use planning and land regularization, difficulties in environmental enforcement and lack of concrete instruments to encourage and benefit those who practice sustainable activities in the region. These aspects were the main lines of action of the PPCDAm, which planned to combat deforestation, acting systematically to address its main causes.

One of the most complex causes of deforestation in the Amazon lies in its agrarian structure. The lack of land regularization stimulates the land market, squatting, occupation of public lands and conflict in areas previously designated for conservation that hold natural resources of high economic value (e.g., timber and mineral resources) (ALDRICH et al., 2012; ALSTON; LIBECAP; MUELLER, 2000; BRITO et al., 2019). Aside from the relatively low price of Amazonian lands (when compared to the south and southeast of the country) and the intense activity of illegal land occcupation, the region also has problems due to its vast extension of public lands without designation. A study by Azevedo-Ramos et al. (2020) has pointed out that most of the undesignated lands in Brazil are in the Amazon region, adding up to a total area of 49.8 million hectares (37.2 Mha state and 17.1 Mha federal land). The deforestation of these areas in the period 1997 to 2018 totaled more than 2.6 Mha. Most of this deforestation (56.5%) is concentrated in the state of Pará. Another important piece of data raised by this study is that 23% (11.6 Mha) of the entire undesignated area in the Amazon was registered in the Cadastro Ambiental Rural (CAR, a land registry that is part of the Brazilian Forestry Code) as private property, clear evidence of the irregular occupation of public lands. In addition, these declared properties concentrate more than 80% of the total deforestation of the forests without designation in the region. Deforestation on public lands and exploitation of natural resources, especially timber, are particularly complex to be punished, because unless the perpetrators are caught in the act, it is almost impossible for inspection agents to find those who are legally responsible for environmental crimes.

The creation of public and private mechanisms to combat deforestation (among them the PPCDAm, the Soy Moratorium and the so-called Meat Conduct Adjustment Agreement) have created a demand for regularization of properties in the Amazon (BENATTI; DA CUNHA FISCHER, 2018), culminating in the creation of the Legal Land Program in 2009, and the Rural Environmental Registry in the same year (Decree No. 7.029/2009), which was later unified in a single system and made mandatory by the Brazilian Forestry Code (Law nº 12.651/2012). Despite the attempts to move forward, two recent measures have strongly impacted the land context in the Amazon, Law No. 13.465/2017 and Provisional Measure 910/2019 (both of which will be dealt with in the following questions), which were meant to facilitate land regularization, but in practice created loopholes that benefit landowners who occupied land illegally.

Another important factor in the deforestation dynamics in the Amazon is associated with the command and control actions in the region. From the 90's until the beginning of the 2000's, the variation in deforestation rates in the Amazon was strongly associated with market variations and the economic context. The economic recovery of Brazil from 1994 onwards, for example, has been considered one of the leading causes for the peak of deforestation reached in 1995 and its fluctuations since then (ALENCAR et al., 2004; FEARNSIDE, 2020a). However, since the mid-2000s, variations in deforestation rates seem to have become dissociated from economic fluctuations, to the point that even in booming economic times, especially for trade in agricultural commodities, deforestation has continued to decline. Research has associated this new dynamic with public policies to combat deforestation, especially the actions of the PPCDAm directed at improving environmental monitoring and enforcement in the region (ASSUNÇÃO; GANDOUR; ROCHA, 2015; SOARES-FILHO; RAJÃO, 2018). The year 2005 saw the launch of the satellite-based monitoring system DETER, which allowed daily deforestation alerts to be issued that have been used from then on by IBAMA. These alerts increased the odds for IBAMA to crack down on offenders.

Studies of deforestation dynamics have shown strong evidence for a direct effect of command and control actions on Amazon deforestation. To this end, in addition to analyses of deforestation rates and the frequency of environmental enforcement, certain theories have been explored in order to contribute to a better understanding of the behavior of deforestation agents, such as the theory of deterrence and the economic theory of crime (BÖRNER et al., 2015; NASCIMENTO, 2019; PFAFF et al., 2018; SCHMITT, 2015). Basically, these studies have shown that in making the decision to clear a forest, the violator takes into account the risk of being punished and the economic cost of punishment. In practice, violators consider the likely risk of being fined in an inspection operation and the consequences of that notification, which could take the form of penalties and seized property (NASCIMENTO, 2019; SCHMITT, 2015). Whenever the frequency of inspections decreases, or the defendant does not feel an obligation to pay fines or comply with mandatory provisions, the tendency is for deforestation practices to increase. Another important aspect brought up in these studies concerns the benefits obtained by a notice of violation issued for an amount lower than the value of the illegal cargo, a situation where the violation generates profit in spite of the fine, thereby reaffirming the idea that in practice it pays to clear forests. Based on this logic, the current context of budgetary cuts for inspection agencies and administrative changes in the way deforestation is punished has serious consequences.

Cattle raising is currently the activity with the greatest impact on deforestation in the Amazon. More than 60% of all deforested area in the region is estimated to have been converted to pasture (INPE/EMBRAPA, 2018). And although there are mechanisms to regulate market access, such as the Meat Conduct Adjustment Agreement and the Soy Moratorium, a study by Garcia et al. (2020) for Chain Reaction Research has produced compelling evidence that the dynamics of deforestation and forest fires in the Amazon are more intense near slaughterhouses and soybean silos. In this sense, studies have emphasized the need to support value chains for socio-biodiversity products, promoting the inclusion of local communities and adding value to nature-sourced products that can compete with agribusiness practices (ABRAMOVAY, 2018).

12. Which public policies have demonstrably contributed to the reduction of deforestation in the Amazon? What public policies and other governmental actions were most relevant in reducing deforestation in the Amazon between 2005 and 2016? Why?

From 2004 to 2012 deforestation rates in the Amazon fell by 84% (INPE, 2020). During this period, a series of public policies and private sector measures to combat deforestation were directed towards solving key problems that encouraged deforestation practices in the region (SOARES- FILHO; RAJÃO, 2018). In this context, the creation of PPCDAm is considered a milestone in public policies for the Amazon, converting in its first phase (2004-2008) alone more than 25 Mha of land in federal Conservation Units and approving more than 10 Mha of Indigenous Lands. At the same time, the improvement and creation of instruments for monitoring deforestation, as well as greater investment in enforcement initiatives, were not only crucial for the protection of the forest and punishment of environmental offenders, but also transmitted the message that the Brazilian state was taking on the fight against deforestation as one of its priorities (ASSUNÇÃO; GANDOUR; ROCHA, 2015; REYDON; FERNANDES; TELLES, 2020; SOARES-FILHO; RODRIGUES; FOLLADOR, 2013).

In a scenario of intense discussion about deforestation and an increasingly evident focus on its causes, the publication of the Greenpeace report *Eating up the Amazon* (GREENPEACE, 2006), which directly associated a large fast food network with deforestation in the *Amazon,* increased pressure on sectors associated with agribusiness. In 2006, the Brazilian Association of Vegetable Oil Industries (ABIOVE) and the National Association of Cereal Exporters (ANEC), which together controlled 92% of all soybean production in Brazil, launched the Soy Moratorium, closing the market to grain producers with records of environmental violations. The success of the Soy Moratorium in reducing deforestation rates, especially in the state of Mato Grosso, was highlighted by Gibbs et al. (2015), who stressed the importance of the mechanism as a complementary tool to public sector initiatives, as it was able to keep in check an important sector with deforestation potential that was beyond the control of the state.

In 2007, Decree No. 6,321 created the List of Priority Municipalities, a measure widely considered as the most significant within the PPCDAm (ARIMA et al., 2014; BIZZO; DE FARIAS, 2017). The list records municipalities based on their total deforested area and their increased deforestation rates over the previous three years, thus encompassing the municipalities with the highest contributions to deforestation in the Amazon (BRAZIL, 2007). According to the decree, those municipalities included in the list would be subject to priority actions for land regularization, intensive monitoring of deforestation and prohibition of rural credit to producers with records of environmental infractions. To get off the list, 80% of the properties in the municipality had to be regularized and had to demonstrate reduced deforestation rates (based on ordinances from the Ministry of the Environment). In 2008, two important operations led by IBAMA were carried out in the municipalities that made up the list, the “Arc of Fire” and “Guardians of the Forest” operations, which had the support of the Federal Police and the Brazilian Army, and culminated in over R$ 361 million issued in fines.

2008 also saw the creation of another measure with great impact. Central Bank Resolution 3545 started requiring proof of environmental regularity as a condition for granting rural credit throughout the Amazon, immediately preventing access to credit lines by violators. In the following year, Decree No. 7,029/2009 extended the Rural Environmental Registry to the entire country, strengthening the land regularization initiatives already implemented by the Amazon states. In the same year, the Public Prosecution Office of Pará launched the Meat Conduct Adjustment Agreement (TAC da Carne), a mechanism similar to the Soy Moratorium, but focused on the meat production chain, with the important difference of being an agreement which slaughterhouses could join voluntarily.

This set of governance to combat deforestation started applying pressure on the productive sector to adapt to the legal norms imposed on agricultural production in the Amazon. The effectiveness of the public and private mechanisms to combat deforestation in this period was confirmed when increased agricultural commodity prices, even in an economic context favorable to producers, did not strongly affect deforestation rates in the region, emphasizing the importance of consolidated governance instruments to combat deforestation and deal with market pressures (ASSUNCĄO; GANDOUR; ROCHA, 2015; FEARNSIDE, 2020a; MACEDO et al., 2012; NASCIMENTO et al., 2019b).

In 2019, with the creation of the National Policy on Climate Change (PNMC) through Law No. 12.187/2009, the PPCDAm became one of the main instruments for combatting climate change in Brazil, acting directly in the sector of Land Use Change (LUC). The PPCDAm is oriented towards achieving the goals set out by the PNMC, which foresees the continuous reduction of deforestation to 80% by 2020, aiming to reach a target of 3,925 km² in that year, and zero illegal deforestation in 2030.

From 2013 onwards, deforestation rates in the Amazon have once again been on the rise. Studies have shown a strong association between changes in the Brazilian Forestry Code (BRAZIL, 2012a) and the resumption of deforestation in the Amazon (MOUTINHO; GUERRA; AZEVEDO-RAMOS, 2016; SOARES-FILHO et al., 2014). The illegally deforested area that has to be restored is estimated to have been reduced from 50 to 21 Mha by these changes, with 78% of these areas within legal reserves and 22% in Permanent Conservation Areas (SOARES-FILHO et al., 2014). The changes meant that deforested areas over and above the quota allowed within the properties and in environmentally sensitive areas were exempt from the obligation to restore the forest. Another controversial point in the legislation, and a target of strong criticism, was the amnesty extended for any deforestation having taken place prior to July 22, 2008. In practice, this also meant the cancellation of all fines for deforestation applied until July 2008 if the producer joined the Environmental Regularization Program (PRA). These changes strengthened the perception among landowners that laws can be changed at any time, and deforestation forgiven (NASCIMENTO, 2019; SOARES-FILHO et al., 2014).

From then on, a series of specific measures began to undermine the political structure of the initiatives created to combat deforestation. In 2012, MP 558 reduced the area of eight CUs in the Amazon, part of them created under the PPCDAm in areas of intense deforestation dynamics, such as around BR-163 in Pará, Lábrea in Amazonas and Porto Velho in Rondônia (BRAZIL, 2012b). Actions to combat deforestation in the Amazon have also had their budgets reduced.

A survey conducted by InfoAmazonia highlights that between 2007 and 2010 the Federal Government invested R$ 6.36 billion in actions to combat deforestation. This amount was reduced by 72% from 2011 to 2014, when the government invested only R$ 1.77 billion in the same actions. The most affected sector was the incentive for sustainable activities, which suffered the biggest budget reduction (INFOAMAZONIA, 2015). In addition, the growth of ruralist representation in Congress and the political instability that culminated in the impeachment of President Dilma Rousseff also contributed to the resumption of deforestation in the region (FEARNSIDE, 2020b).

13. What factors can be attributed to the 29.5% increase in Amazon deforestation from 2018 (August 2017 to July 2018) to 2019 (August 2018 to July 2019) registered by PRODES, when the annual deforestation of the Amazon increased from 7536 km² to 9762 km²?

In June 2020, PRODES published the consolidated deforestation rate in the Amazon, an area 3.7% higher than the 9,762 km² estimated and published in 2019. The spike to 10,129 km² represents an increase of 34% over 2018. A higher figure had not been registered since 2008, when the deforested area in the Amazon totaled 12,911 km². With a rising trend since 2017, deforestation in the Amazon seems like a response to proposed changes in land policies, budgetary cuts for actions to combat deforestation, and the dismantling of agencies responsible for environmental inspection and land demarcation in the Amazon (JOHNSON DE AREA et al., 2019). In addition, the constant signals from the Brazilian government, especially from the President of the Republic, in support of actors that deforest the forest, along with attacks on the agencies responsible for monitoring and inspecting deforestation in the region, as well as the lack of support to traditional communities in the Amazon, can also be understood as stimulating deforestation and conflicts in the region. The most recent case occurred in early August 2020, in the southwest region of Pará, in the municipality of Jacareacanga, when an operation to combat illegal mining was suspended by the Minister of the Environment, Ricardo Salles, strengthening the debate regarding permits for mineral exploration in indigenous territories (G1, 2020; ESTADO DE MINAS, 2020).

Issues related to land property have historically been one of the main drivers of deforestation in the region and they are also one of the issues that has been undergoing most changes in legislation (BRITO et al., 2019; ROCHEDO et al., 2018). In July 2017, Law No.13,465 extended an amnesty for the irregular occupation of public lands until 2008, allowed the regularization of areas up to 2,500 ha, and set low values for selling the land, which could be negotiated at a value between 10% and 50% of the tariff values stipulated by INCRA. In 2019, MP 910, also known as the "*MP da Grilagem*" (Land-grabbing Decree), proposed further changes to the land regularization rules, suggesting the regularization of illegally occupied land up to 2014, and in residential properties up to 2018. The Decree also aimed to extend the benefits of self-declaration of property, waiving prior inspection by INCRA for regularization of property up to 15 fiscal modules, as well as doing away with the obligation of declarations from the occupant that the property is not under environmental embargo, that is, has not been fined by environmental agencies. Although the Decree was not approved, it created great expectation for the possibility of amnesty and regularization of land illegally occupied in recent years in the Amazon. A survey conducted by Estadão in July 2020 (ESTADÃO, 2020) denounced a renewed attempt to facilitate the remote regularization of properties in the Amazon by simple cross-checking of databases, and (once again) proposing to waive local inspections in areas of intense conflict and deforestation, such as the Transamazon highway region.

The situation of the Indigenous Lands in the Amazon also deserves to be highlighted. In 2017, Ordinance No. 68 of the Federal Government added additional layers to the bureaucracy of demarcating Indigenous Lands by creating a Specialized Technical Group (GTE) that would be responsible for the analysis and approval of the demarcations. The ordinance was repudiated by representatives of indigenous groups across the country, who declared it unconstitutional and an affront to their original land rights. In 2019, the Report of the Indigenous Missionary Council (CIMI, 2019) showed that in addition to the freezing of IT demarcations, deforestation had skyrocketed within ITs in the Amazon, increasing by more than 50% from 2017 to 2018, as did the number of cases of IT invasions. According to PRODES, in 2019 deforestation within ITs reached 490.8 km^2, with the Ituna/Itatá Indigenous Land as the IT recording the largest deforested area in the Amazon. It is worth mentioning that in April 2020, after a reporting team from the weekly news program *Fantástico* followed an IBAMA operation into IT Ituna/Itatá, which revealed intense mining activity in the area, the IBAMA agent in charge of the operation was fired by the Minister of the Environment.

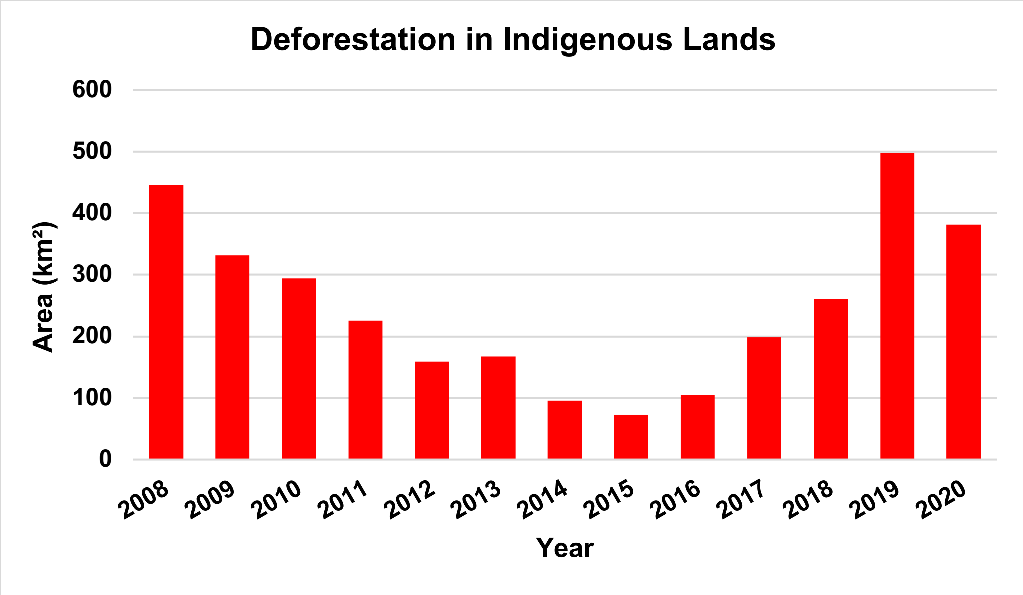


Figure 10: Deforestation (in km²) on indigenous lands, between the years 2008 and 2020. Source: PRODES/INPE; data available at: http://terrabrasilis.dpi.inpe.br/app/dashboard/deforestation/biomes/legal_amazon/increments.

Another measure of great impact was MP 886/2019, which transferred responsibility for demarcation of indigenous lands from FUNAI to the Ministry of Agriculture. In addition, pressures to open ITs to external economic activities have intensified. In early 2020, Draft Bill PL 191/2020 was introduced in Congress, which foresees the creation of standards for surveying potential mining activities and hydroelectric exploitation within ITs.

Another highly relevant aspect that may have influenced deforestation concerns IBAMA's budget and its administrative infrastructure and personnel shortages. Since 2017, IBAMA has suffered a reduction in its budget[9] that directly affects its capacity to carry out inspection operations (CASTELO et al., 2018). The situation worsened after the transfers of the Amazon Fund ceased, which financed more than 450 IBAMA operations in two years (2016-2018). In addition, infrastructure and personnel shortages compromise the normal operations of the agency. An analysis by the Federal Accounting Court has shown that a significant portion of the fines are not processed due to limitations of document scanners (TRIBUNAL DE CONTAS DA UNIÃO, 2017). In mid-2019, IBAMA agents released an open letter demanding a solution to fundamental problems in the organ, such as imposing a requirement for technical

[9] http://portaltransparencia.gov.br/

qualification in appointments to management positions in the agency, urgently dealing with staff shortage, and securing budgetary resources to ensure the continuity of inspection operations, among others. According to the letter, from 2010 to 2019 the institute's inspection personnel fell by 45%, and 189 of the current 780 inspectors are about to retire.

Data on IBAMA's fines show that although the number of fines has decreased since 2017 (which may be related to the decrease in the number of operations and not to the decrease in the occurrence of infractions), the total annual value of fines has increased, which may indicate the intensification of environmental infractions.

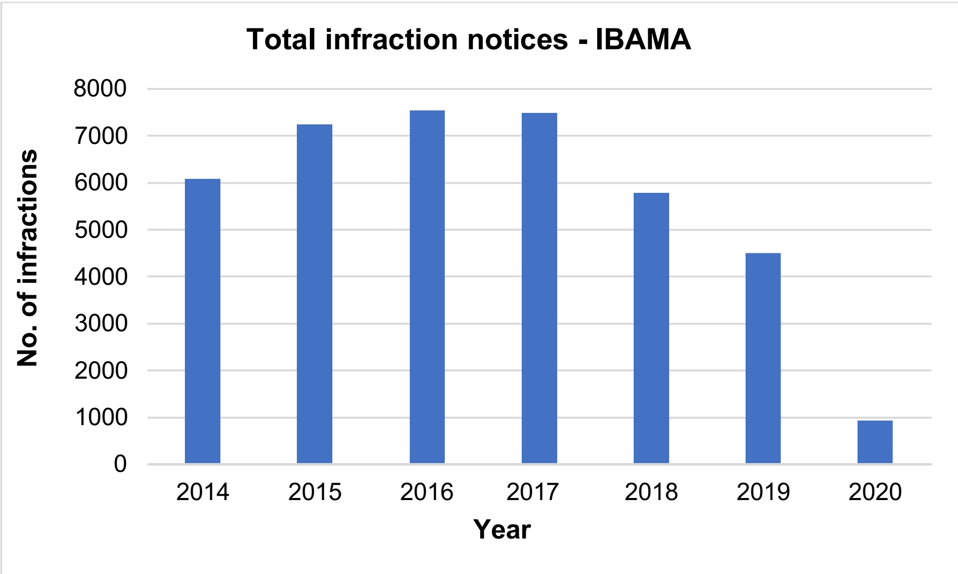


Figure 11: Total infraction notices issued by IBAMA in the states that form the legal Amazon, from 01/01/2014 to 25/06/2020. Source: IBAMA; data available at: https://servicos.ibama.gov.br/ctf/publico/areasembargadas/ConsultaPublicaAreasEmbargadas.php

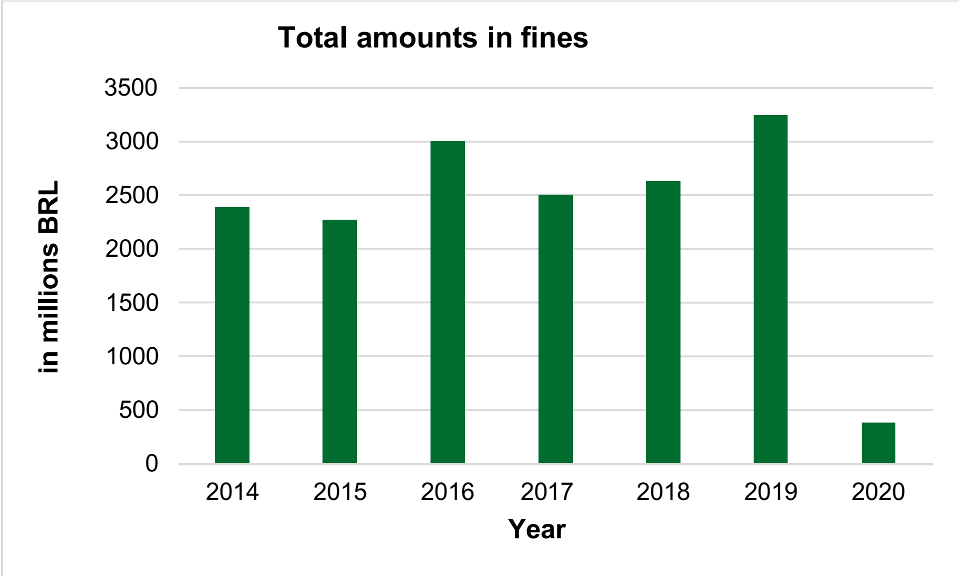


Figure 12: Total amounts of fines, in millions of R$, in the period from 01/01/2014 to 25/06/2020. This figure reflects the sum of fines in all the states in the Legal Amazon. Source: IBAMA; data available at: https://servicos.ibama.gov.br/ctf/publico/areasembargadas/ConsultaPublicaAreasEmbargadas.php

The creation of mechanisms to increase bureaucratic steps and make it more difficult to impose fines, such as the creation of conciliation hearings (Decree 9,760/2019), which require a hearing between inspectors and offenders to negotiate the fines, tends to diminish the effect of environmental inspection penalties. This is due to IBAMA's own administrative limitations in holding such hearings and the characteristics of the fine enforcement process, which may remain pending until the end of negotiations, without affecting the benefits obtained by the offender for the crime committed. In this context, it is also important to point out the existence of a series of legal appeals that are generally adopted by the offender to prolong the proceedings, which, in addition to the administrative incapacity of the agency to deal with the fines, contribute to the fines being time-barred (after three years without legal action) (CGU, 2019). An analysis by the Office of the Comptroller General (2019) shows that the number of fines paralyzed by structural and personnel constraints in the agency total R$ 20.8 billion. In addition, the low payment ratio of the fines also undermines the deterrent effect of environmental inspections. An analysis made by the Federal Accounting Court estimated that only 6% of the fines issued between 2011 and 2014 were actually paid (TRIBUNAL DE CONTAS DA UNIÃO, 2017).

The problems in environmental inspection set off a cascading effect that affects several governance mechanisms. For example, the Soy Moratorium, the Meat Conduct Adjustment Agreement and Resolution 3545/2008 (which prevents banks from granting rural credit to producers with environmental irregularities) all have to access the Integrated Registration, Collection and Inspection System (Sicafi) to enforce their rules. In June 2020, a lawsuit was filed by deputies in the federal court against the Minister of the Environment, Ricardo Salles, the president of IBAMA, Eduardo Bim, and the federal government for omitting data in Sicafi since October 2019. Besides providing support to the current governance mechanisms, inspections are also crucial to prevent initiatives meant to improve agricultural productivity and stimulate different production chains end up resulting in more deforestation (e.g. Jevons Paradox, Rebound effect, for example). Thus, it is fundamental for all initiatives to combat deforestation and encourage sustainable production in the region to count on the strong support of monitoring and inspection mechanisms (ASSUNÇÃO; GANDOUR; ROCHA, 2015; CARVALHO et al., 2019; NASCIMENTO et al., 2019; THALER, 2017).

14. What public policies or other governmental actions contribute to the increase of Amazon deforestation? Why?

Government policies and actions that can stimulate deforestation are those that reinforce the root causes of deforestation, such as ignoring lacunae in legislation that deal with the regularization and concession of illegally occupied land; extending amnesty for illegal deforestation; granting exemption from restoration of deforested areas; deallocating protected areas; dismantling inspection agencies; approving large infrastructure projects in the Amazon without carrying out impact mitigation plans; reducing the budget of environmental agencies; and destructuring programs and plans aimed at combatting deforestation (Figure 13). Details of such actions are detailed in the answers to questions 13, 14 and 15.

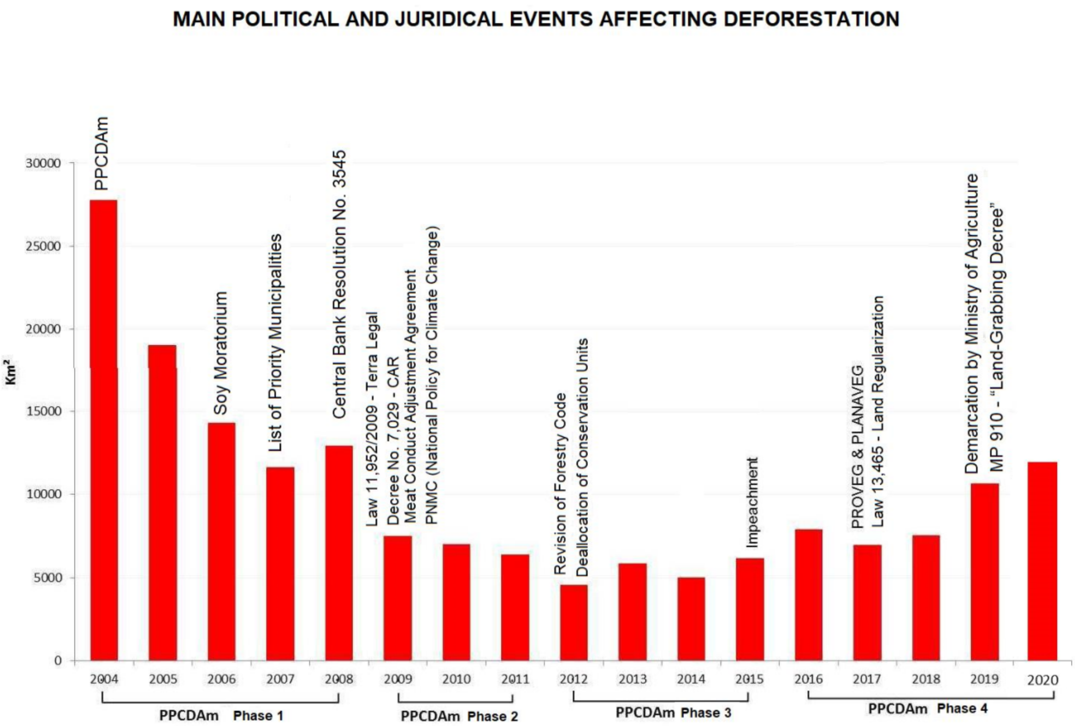


Figure 13: Deforestation rates and major political events. Source: prepared by the author.

The alarming number of forest fires and the high deforestation rate in 2019 led to pressure from other countries on the Brazilian government to take measures to reduce deforestation. In August 2019 the Government initiated a Law and Order Guarantee (GLO) operation to reduce fires and deforestation in the Amazon. Nevertheless, the DETER system has been showing higher numbers in 2020 than those observed in the same period a year ago (this will be further explored in question 15),
suggesting that the Amazon deforestation rate will be higher than in 2019 and, consequently, higher than the target forecast for 2020.

The disclosure of data from the DETER system has brought pressure on the government. In June 2020, a group of 29 European investors, with total assets of US$ 3.6 trillion, threatened to withdraw investments from Brazil if the government did not adopt firm measures to combat deforestation. In July 2020 the letter “Convergence for Brazil” was signed by 17 former Finance Ministers and the President of the Brazilian Central Bank, calling for urgent changes in the Brazilian economic growth pattern, which should be based on a low carbon economy, focused on reducing deforestation in both the Amazon and the Cerrado, raising Brazil's resilience to climate change and encouraging low carbon technologies.

In April 2020, Vice President Hamilton Mourão restarted the activities of the Amazon Council, created in 1995 by Decree No. 1,541 with the objective of planning actions to combat deforestation (but this time not including representatives of FUNAI and IBAMA, and excluding the governors of the Amazon states). With the new DETER results pointing to new record deforestation rates for June, combined with further pressure from the foreign market and threats to boycott Brazilian products, the Vice President convened the Council of the Amazon in July 2020 to discuss actions to combat deforestation, emphasizing the importance of land regularization and increased personnel at FUNAI and IBAMA.

15. What data is available on the deforestation of the Amazon from January 2018 to the current date and what can be concluded from the analysis of this data?

At the moment we have PRODES data recorded at the end of 2019 and updated in June 2020, referring to deforestation in the period from August 2018 to July 31, 2019, and DETER data released in August. Looking at previous DETER figures for the period 2016 to 2020 and the months with larger year-on-year deforestation, a sharp increase in deforested areas can be observed starting in July 2018, which culminated in 10,129 km² of deforestation in 2019.

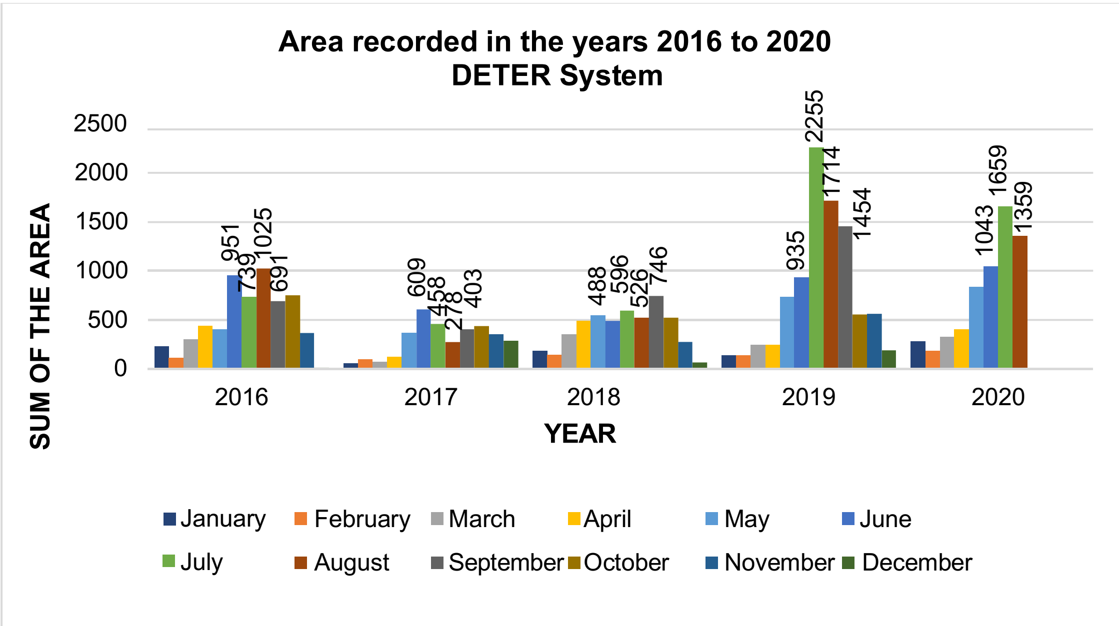


Figure 14: Deforestation data (in km²) registered by the DETER system, between the months of January and December, starting in 2016. Source: DETER / INPE.

Based on the data, we can conclude that the trend for the year 2020 is to see an increase in deforestation rates to an area greater than that of 2019. In other words, for the second consecutive year deforestation is expected to exceed 10,000 km² in the Amazon. To provide stronger evidence for this observation, we need only compare the historical series of deforestation rates measured by the DETER and PRODES systems (Figure 15, also present in question 3). The PRODES data is more accurate than that provided by the DETER system, and over the last few years (2015/2016 until 2018/2019) the deforestation rates of the PRODES system have been on average 52,35% higher than those measured by the DETER system. For the year 2019/2020 it is still not possible to know the deforestation value measured by the PRODES system, but with only one and a half months left to close the reference year (mid-July and August), the trend is for the consolidated deforestation to exceed that measured in the period 2018/2019, which was of 10.129 km², as the deforestation measured by the DETER system until July was already higher than the one measured in 2018/2019.

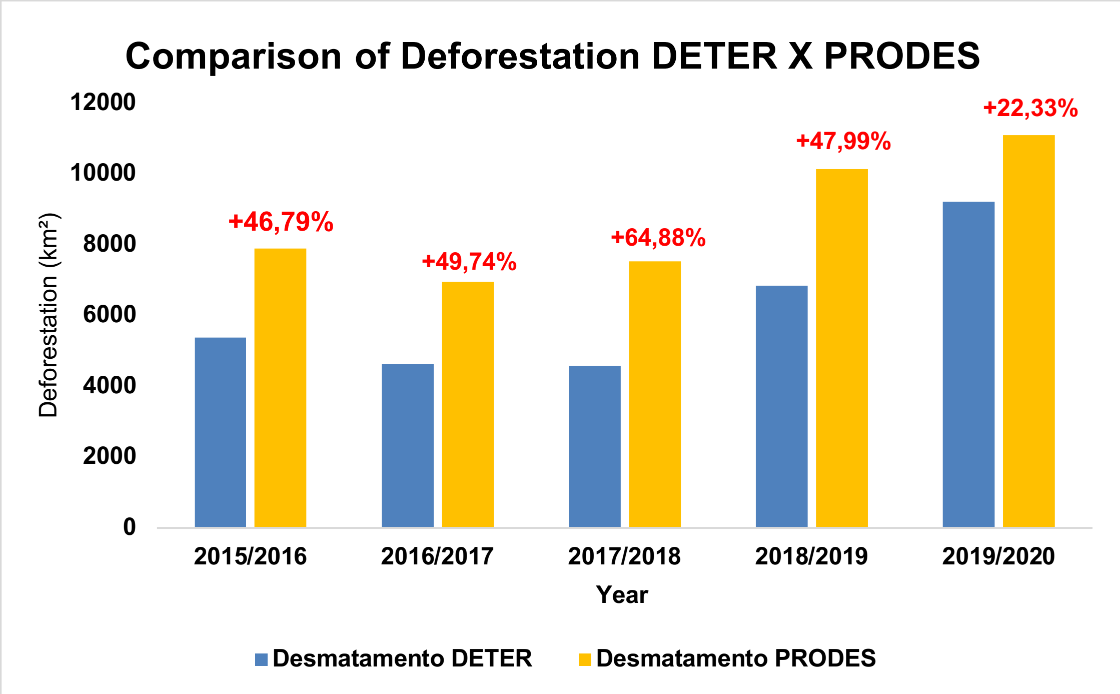


Figure 15: Comparison between deforestation values measured by the PRODES and DETER systems in the period from 2015 to 2020. The reference year 2015/2016, for example, starts in August 2015 and ends in July 2016. Notice that the values consolidated by the PRODES system are always higher than those of the DETER system (% difference indicated in red). Deforestation data from the PRODES and DETER systems are available at http://terrabrasilis.dpi.inpe.br/.

16. What public policies should be implemented today to contain, mitigate and reduce deforestation in the Legal Amazon in order to meet the 2020 target of not exceeding the annual rate of 3,925.06 km² of deforested area?

According to the latest trend in deforestation rates and the most recent DETER data, Brazil is not expected to meet the target set in the PNMC for 2020. The lowest deforestation rate ever recorded was in 2012, with an area of 4,571 km², in a context where the overall pattern of deforestation was declining. Furthermore, aside from the PNMC goals, Brazil also has to meet the commitment of its NDC (Nationally Determined Contribution) target, ratified by the Paris Agreement in 2016: reducing emissions by 37% by 2025, compared to 2005 levels, and 43% by 2030. Given Brazil's global commitment, and considering the imminent risks of irreversible climate change, with impacts on the economy, quality of life, and the integrity of natural ecosystems, mitigation actions are urgent.[10]

This indicates that in the current context, with all the legal changes and budgetary problems already highlighted in our answer to the previous questions, a strong commitment on the part of the Brazilian government would be needed to combat deforestation in the Amazon. First of all, it would be necessary to strengthen the actions on all PPCDAm axes, especially providing immediate support to inspection actions and improving the administrative infrastructure and personnel shortages for inspection agencies such as IBAMA and ICMBIo, as well as the agencies responsible for land regularization, such as INCRA and FUNAI.

In the medium term, the government could act to implement compensation instruments that encourage the conservation and restoration of deforested and degraded areas. The Brazilian Forestry Code itself created new mechanisms that allow for environmental compensation and the negotiation of environmental reserve quotas (AZEVEDO et al., 2017), which could serve not only as a stimulus for conservation, but also as a way to benefit landowners who have complied with legislation, keeping intact the forest area required by law.

Studies have also emphasized the importance of encouraging sustainable production chains, not only to ensure reduced deforestation, but also to encourage a

[10] https://www.mma.gov.br/images/arquivos/clima/convencao/indc/Relatorio_MRE.pdf

change of behavior on the part of producers in the region (MOUTINHO; GUERRA; AZEVEDO-RAMOS, 2016; STABILE et al., 2020). Even though the incentive to sustainable practices is one out of four PPCDAm's axes of action, it has been the one on which the least progress has been made. Moreover, the incentives stimulated by political instruments in the region have focused on credit grants that do not put forward proposals for a change in production practices in the Amazon. In fact, the PPCDAm Phase 4 operational plan itself emphasizes that only 14.5% of all rural credit extended between 2013 and 2015, was granted to the National Program for Family Agriculture - Pronaf, with the Eco, Forest and Agroecology line representing only 0.07% of grants. Furthermore, only 1.86% of all the credit granted by Pronaf was obtained by municipalities on the list of priority municipalities in the Amazon.

Promoting productive practices by extending credit lines, technology transfer and technical assistance aimed at increasing agricultural productivity would be fundamental to guarantee the income of lawful local producers, thus providing alternatives of sustainable practices in a context of intense monitoring and inspection. Complementary policies to stimulate sustainable production chains could be created to ensure economic return. In this sense, the government could also strengthen economic instruments such as credit lines and mechanisms to facilitate market access and marketing of non-timber forest products produced by local communities, strengthening sustainable production chains and contributing to income generation in small communities. The creation of instruments that benefit sustainable practices in the Amazon, as well as the lawful producers who have complied with environmental legislation, would be a game changer in the public policies developed for the Amazon, which have had a record of regularizing offenders and granting amnesty to illegal practices.

Another important aspect would be to designate public lands as yet without designation in the Amazon. A survey by Azevedo-Ramos et al. (2020) shows that undesignated lands have been feeding the land market and illegal occupation in all regions of the Amazon. Stabile et al. (2020) suggests that an immediate solution for these areas would be their destination as conservation areas, allowing for sustainable use by local communities. In such a scenario, intensifying inspections and promoting sustainable production initiatives within these units would be fundamental to avoid deforestation and strengthen local sustainable production chains.

In addition, the federal government could invest in restoring degraded pastures and implementing incentive instruments for reforestation that are already provided for in the Forestry Code, the ABC Plan and the National Policy for Recovery of Native Vegetation (PROVEG), which could become an additional carbon sink and contribute to Brazil reducing its GHG emissions.

17. What parallels can be made between the simulations in the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon - PPCDAm and the factual reality of deforestation in the Legal Amazon?

The simulations for deforestation in the Amazon proposed by the PPCDAm are in line with the targets set out in the National Policy on Climate Change (PNMC), which establishes an 80% reduction in deforestation in the Amazon by 2020 (equivalent to 3,925 km²). By 2016, the year when phase 4 of the PPCDAm kicked off, newly deforested areas had been reduced by 59% in relation to the reference deforestation area of 19,625 km². From then on, meeting the target would have required a sharp drop in deforestation, similar to the figures achieved in the first years of the PPCDAm. The PPCDAm simulations suggest that a decrease of approximately 1000 km² per year from 2016 to 2020 would have been necessary.

Despite a short-lived decrease in deforestation rates in 2017, the Amazon has seen a new rising trend since then, jeopardizing the Brazilian commitment to reduce its deforestation rates and CO_2 emissions. In 2019, the deforestation of 10,120 km² was the highest in the preceding decade, and was accompanied by high rates of forest degradation and fires. The difference between the deforestation rate simulated by PPCDAm and that recorded for the year 2019 is more than 5,000 km², i.e., the difference between the simulated and observed rate is greater than the reduction target for a four-year interval (2016 to 2019) (Figure 16).

As explained above, not only is it higly unlikely that Brazil will meet its 2020 target, but the deforestation rate in 2020 is also expected to exceed the rates of the last 11 years.

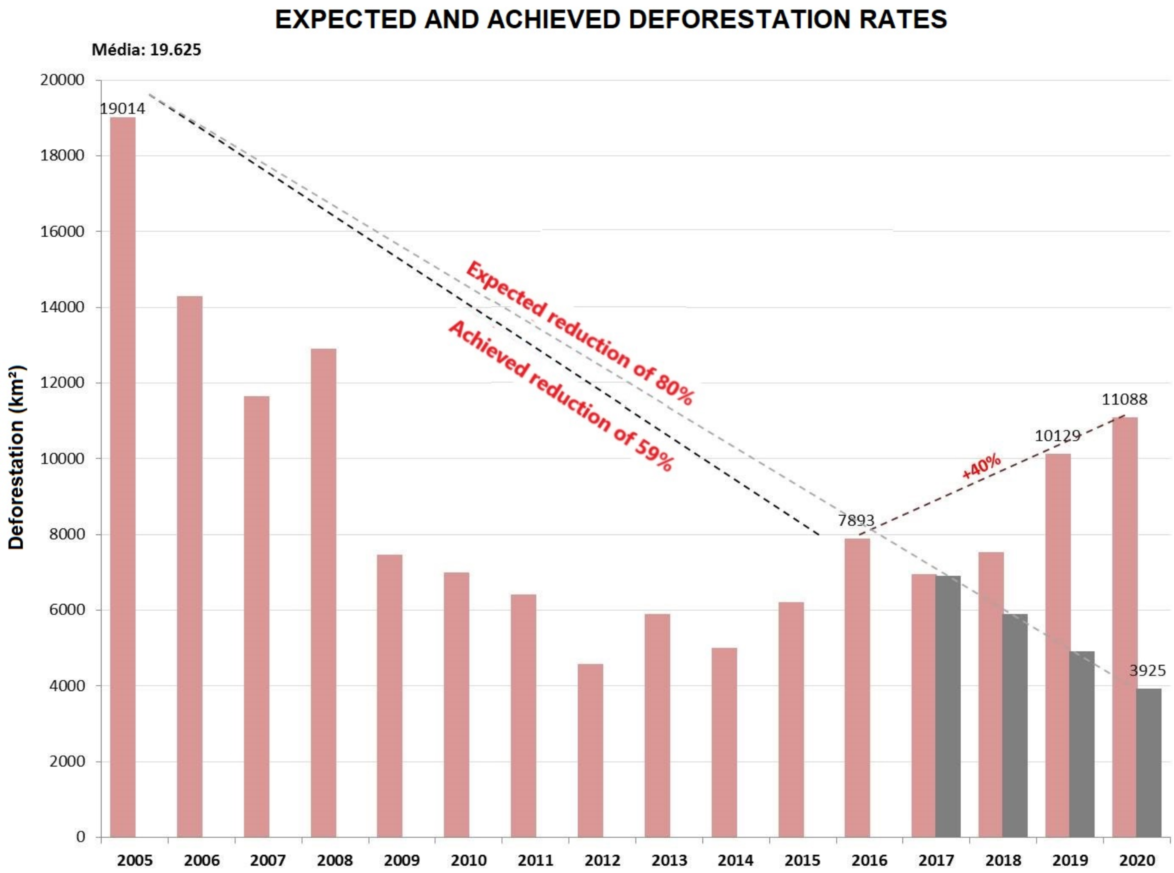


Figure 16: Actual and simulated deforestation rates and defined targets. Source: prepared by the author.

18. Is it possible to identify failures or omissions in the PPCDAm that demonstrate the inefficiency of the federal government, either in the construction of the plan or in its execution (in other words, were the means used by the government adequate to achieve the result)?

The construction of all phases of the PPCDAm took into account the suggestions of scholars on the dynamics of deforestation in the Amazon. The conception of the program axes, for example, was based on historical contradictions in terms of policies, for example between conservation policies and land ownership policies, and in the type of economic incentive for activities in the region, which in the PPCDAm sought to differ from the old model that encouraged activities which promoted deforestation. Beginning with phase II, more care was taken to address the suggestions made by evaluators of each previous phase and to consider the context behind the deforestation trend.

Below we highlight some shortcomings in the PPCDAm that have affected the development of the plan and that can serve as points of questioning and discussion by the Public Interest Civil Action:

- The need to include the CUs and ITs in all the axes of the PPCDAm as targets of continuous priority both for inspection mechanisms and actions to encourage sustainable production initiatives for their inhabitants. Since 2012, several CUs created under the PPCDAm have undergone deallocation processes and change of protection status in favor of infrastructure projects, such as the construction of hydroelectric power plants (MP 558/2012) and railroads to export agricultural commodities (MP 758/2016). Another aggravating factor is the high number of properties in the CAR Registry System that are located inside protected areas (MARTINS; NUNES; SOUZA, 2018). An additional complexity in these cases results from the low proof of land titles in the Amazon. In 2019, the Minister of the Environment, Ricardo Salles, suggested using the Amazon fund to reimburse and relocate landowners from the interior of protected areas, which generated a strong backlash from the fund's financing countries (Germany and Norway).
- Absence of actions to combat deforestation in land reform settlements. Although they are among the landholdings that have deforested the most, land reform settlements have not received much attention from inspection actions within the PPCDAm. In 2012, the revision of the Brazilian Forestry Code exempted the settlements from restoring their illegally deforested areas. Studies

in areas of agricultural expansion have also revealed the intense land trade in land reform settlements involving rent and illegal property sales (COSTA, 2016b; VALADÃO, 2019).

- Lack of continuous monitoring of municipalities after they leave the list of priority municipalities. Studies by Arima et al. (2014) and Bizzo and Farias (2017) show that municipalities follow different patterns of deforestation after leaving the list, which may be due to a number of factors, ranging from government signaling of looser environmental standards to regional socioeconomic contexts. This behavior highlights the need to create monitoring mechanisms for these municipalities, as they are located in areas of intense deforestation dynamics and, therefore, more likely to resume high rates of deforestation.
- Focus on sustainable productive chains. PPCDAm actions of incentives to sustainable activities have been mainly based on granting credits and adopting technologies aimed at increasing the productivity of traditional agricultural practices. Less attention has been given to creating instruments to add value to forest products of great commercial potential, such as seeds, grains, roots and leaves that can be transformed into food products for the cosmetics and pharmaceutical industries.
- Technical assistance must go beyond agricultural and livestock production. It is urgent to promote the professionalization of local actors, especially those linked to sustainable production chains, so that they acquire technical expertise and business acumen to transform forest products and even raw materials already inserted in the transformation market, into final products, thereby ensuring employment, income generation and quality of life for communities in the Amazon.

19. Could the means adopted in the PPCDAm, if they had been effectively implemented, have led to the reduction of deforestation in the Legal Amazon to the level of 3,925.06 km^2 by 2020?

Yes, in all its phases the PPCDAm sought to design action plans adapted to the deforestation context. However, budgetary limitations and priority changes in the execution of the plans undermined the effectiveness of the PPCDAm over time. In addition, political measures contrary to the actions of the PPCDAm (already explained in the previous questions) have also affected the Plan's goals along all its axes.

In its first phase, the PPCDAm created more than 25 million hectares of federal Conservation Units and designated more than 10 million hectares of Indigenous Lands. It also improved the mechanisms for monitoring and controlling deforestation and encouraged (albeit to a lesser degree than on the other axes) activities that adopted sustainable practices. According to Fearnside (2006), the actions implemented in the first phase of the PPCDAm showed that political will is fundamental in order to change the dynamics of deforestation in the Amazon. Once a government takes on the fight against deforestation as a goal to be achieved, it can adapt its actions to a changing context that requires adjustments and refinements in its regularization and monitoring systems, as well as innovative instruments that stimulate a market for forest goods produced in a sustainable way.

According to the PPCDAm evaluation report, from 2012 to 2015 all axes experienced a reduction in their response rates, which fell from 98% to 76%. Analyzing all activities that were not carried out, 45% of them were found on the axis of support for sustainable activities, 30% in monitoring and inspection and 25% in land and property registration. From 2013 to 2016, more than 40% of the budget allocated to environmental inspection was reduced.[11] The effects of this started to be seen in 2017 already, when the number of fines issued by IBAMA fell in all the states of the Amazon, in spite of increased deforestation rates (Figure 17).

[11] https://auditoria.cgu.gov.br/download/9752.pdf

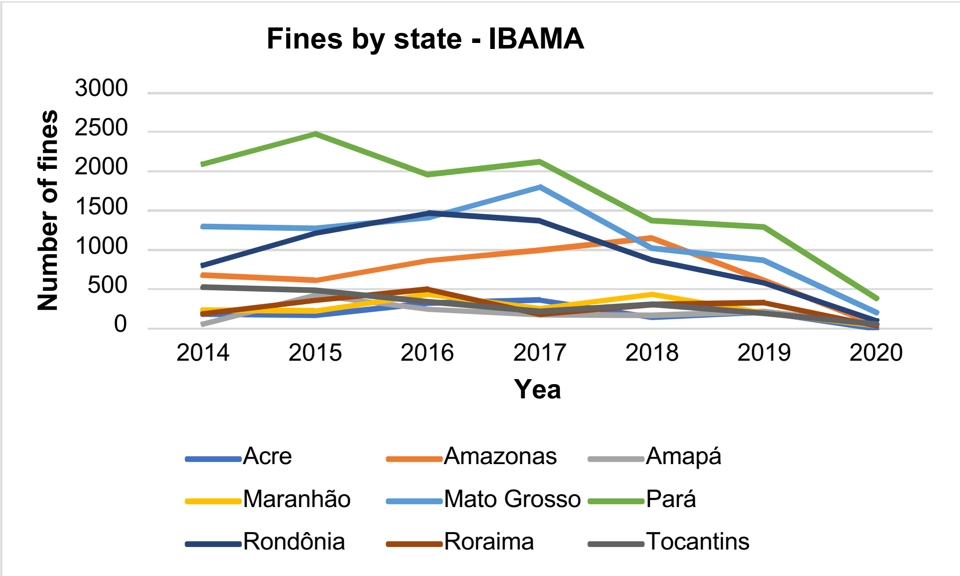


Figure 17: Number of IBAMA fines from 01/01/2014 to 25/06/2020 in the states of the Legal Amazon. Source: IBAMA; data available at https://servicos.ibama.gov.br/ctf/publico/areasembargadas/ConsultaPublicaAreasEmbargadas.php

What makes the PPCDAm unique is the interconnection between its actions and axes. Thus, for the plan to work, it is fundamental that all its axes have the resources and infrastructure to operate properly, and that the land registration agencies, as well as those agencies that deal with monitoring, inspection and technology transfer and development are fully operational. An aggravating factor caused by the dismantling of the plan at the federal level is that state-level plans created as part of the PPCDAm's action plans depend on federal PPCDAm's monitoring activities to guide and evaluate their own actions.

20. Could the deforestation rate projected for 2020 have been reached in the period 2009 to 2020? If so, how could it have been achieved?

21. Were there any external constraints unrelated to the federal administration that prevented the results from being achieved?

(Questions 20 and 21 are similar, so the answer below applies to both).

Deforestation rates may be influenced by the economic context, either by market demand, which determines the prices of agricultural commodities, or by the appreciation of the dollar, which in turn influences the prices of commodities and agricultural inputs, especially imported fertilizers essential for soy cultivation. As previously mentioned, until the mid-2000s a strong connection could be identified between changes in agricultural prices and deforestation rates in the Amazon, but with the development of governance mechanisms, both public or private, aimed at conservation and regulation of productive sectors, there has been a noticeable decoupling between market variations and deforestation rates (ASSUNÇÃO; GANDOUR; ROCHA, 2015). Although much emphasis has been placed on the role of the market in deforestation, as an element over which the government is seen to have no control, the market more recently seems to have taken on a secondary role. Between 2010 and 2012, for example, even with the rise in soy and beef prices, deforestation reached its lowest value in 2012. On the other hand, in 2019, in spite of a retraction in the market, deforestation reached the largest area of the last decade. Taking into account the changes in deforestation combat initiatives, the most recent rates seem to be more responsive to actions taken by the Brazilian government than to any other variable.

22. Are there any other points/issues that can be taken from the Plan which may be of interest to the public interest civil action?

In recent years there have been a series of changes in the management structure of the agencies responsible for key actions in the PPCDAM axes, such as the demarcation of Indigenous Lands being transferred to the Ministry of Agriculture; in land registry legislation, such as increasing negotiable areas to 2,500 ha, thus allowing land trading at negliglible prices; in budget cuts throughout the Ministry of the Environment, which affect not only the inspection capacity, but also a series of other initiatives, such as actions directed at mitigating climate change, as well as the National Policy on Climate Change. This weakening of environmental policies underlines the importance of an in-depth analysis of the actions on each axis of the PPCDAm, of the time required to carry out each action while taking into account the available budget and the operational capacity of each agency, the impact that the most recent legal and budgetary changes have had on each action, and the development of a plan aimed at restructuring the agencies responsible for these actions. As explained above, the PPCDAm puts forward some innovative, comprehensive and interconnected measures, but there seems to be no administrative structure, legal collaboration and budgetary support to implement these actions.

23. From 2012 to 2019 deforestation in the Legal Amazon has been steadily increasing. Why?

The year 2012 marked the lowest deforestation rate in the Legal Amazon in 30 years, more than 80% lower than the rate of 2004. This reduction reflected the conservation policies implemented in Brazil, especially through increased protected areas, improved monitoring of deforestation, intensified environmental inspections, and the implementation of the Action Plan for Prevention and Control of Deforestation in the Legal Amazon (PPCDAm), initiated in the late 2000s (ASSUNÇÃO; GANDOUR; ROCHA, 2012; INPE, 2013; SANQUETTA et al., 2020).

Land regularization through the registration of properties in the Rural Environmental Registry (CAR), restrictions on rural credit for producers subjected to embargo for deforestation (2006), the soy moratorium and restrictions on trading meat of illegal origin for slaughterhouses (Meat TAC), all these were important measures to discourage illegal deforestation by farmers for fear of legal consequences (ANGELO; RITTL, 2019). The strengthening of environmental governance in this period dissociated deforestation in the Amazon from the market for agricultural commodities and reduced the effect of price oscillations and demands for commodities on the expansion of agricultural areas into natural forests (LAPOLA et al, 2014).

In 2013 the deforestation rate increased by 28% (5,891 km^2) compared to 2012 (4,571 km^2) and continued to fluctuate until 2018 at an average of 6,581 $km^2 \pm 1,081$, with a spike in deforestation in 2019 of 10,129 km^2. The measures that led to this growing trend in deforestation in recent years have been associated with the weakening of environmental policies and inspecion agencies to control and combat deforestation, in conjunction with the government's rhetoric of granting amnesty to actors in society who deforest illegally.

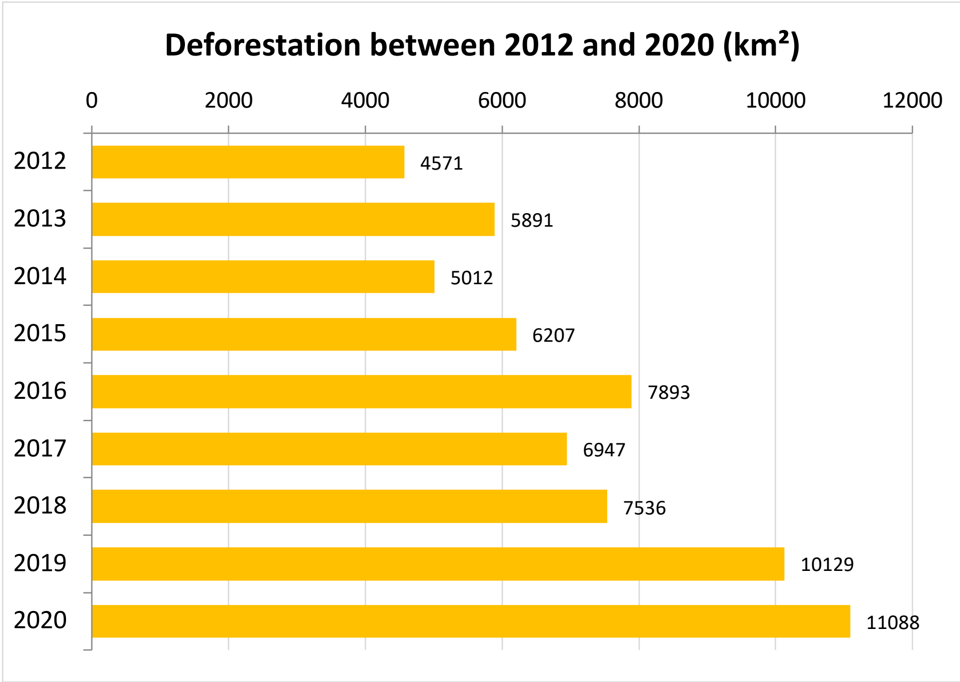


Figure 18: Deforestation rate in the Legal Amazon from 2012 to 2020 (PRODES data).

In 2012, the reformulation of the Forestry Code instituted by Law 12,651/2012 represented a milestone in terms of environmental setback, directly influencing increased deforestation in Brazil by reducing the limits set for areas of permanent protection (e.g, vegetation along water bodies and hilltops), allowing agricultural and cattle raising activities and infrastructure in protected areas, waiving the obligation to restore a deforested Legal Reserve on rural properties up to 4 fiscal modules (corresponding to 20 ha in southern Brazil and 440 ha in the Amazon), and granting amnesty for fines imposed for violation of previous legislation (BRANCALION et al., 2016; FERREIRA COSME; BARBOSA DA SILVA, 2019; SOARES-FILHO et al., 2014).

The enactment of restrictions on the use of remaining natural forests is crucial to reduce deforestation, especially on private rural properties, which constitute 53% of the remaining native vegetation in the country (SOARES- FILHO et al., 2014). In 2012, 28% of deforestation occurred in land reform settlements and 23% in private rural properties. In 2016, private areas took over, representing 36% of deforested areas (Table 2), partially as a result of the increase in properties registered in CAR. In 2019, deforestation in private areas skyrocketed to 67%, indicating that the increased deforestation in these areas did not merely represent a limitation due to uncertainties in land tenure.

Table 2. Deforestation rate in the Brazilian Amazon by land use category between 2010 and 2016 (Source: Greenpeace, 2017)

Land Use Category	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Indigenous Lands	305 (4,7%)	227 (4%)	168 (3,8%)	170 (3.2%)	71 (1,6%)	62 (1,2%)	88 (1,3%)
Protected Federal Areas	179 (2,8%)	131 (2,3%)	175 (4%)	187 (3,5%)	120 (2,8%)	184 (3,5%)	201 (2,9%)
Protected State Areas	126 (1,9%)	150 (2,7%)	117 (2,7%)	175 (3,3%)	174 (4%)	233 (4,4%)	322 (4,6%)
Areas of Permanent Preservation	265 (4,1%)	209 3,7%)	124 (2,8%)	228 (4,3%)	202 (4,6%)	245 (4,7%)	207 (3%)
Land Reform Settlements	1851 (28,6%)	1766 (31,3%)	1239 (28,3%)	1518 (28,7%)	1269 (29,2%)	1437 (27,3%)	1986 (28,6%)
Private Property	1502 (23,2%)	1355 (24%)	986 (22,5%)	1009 (19,1%)	883 (20,3%)	1113 (21,2%)	2462 (35,5%)
Federal Public Lands	690 (10,6%)	698 (12,4%)	574 (13,1%)	743 (14,1%)	584 (12,7%)	670 (12,7%)	855 (12,3%)
State Public Lands	64 (1%)	30 (0,5%)	15 (0,3%)	31 (0,6%)	0	7 0,1%)	59 (0,9%)
Areas without information	1497 (23,1%)	1072 (19%)	982 (22,4%)	1222 (23,1%)	1047 (24,1%)	1306 (24,8%)	758 (10,9%)
TOTAL	6479 (100%)	5638 (100%)	4380 (100%)	5283 (100%)	4350 (100%)	5257 (100%)	6938 (100%)

The existence of large tracts of undesignated public forests (49.8 Mha) constitutes a risk of illegal occupation of public lands associated with deforestation (AZEVEDO-RAMOS et al., 2020). Five percent (5%) of these forests were deforested from 1997 to 2018, indicating that the lack of land regularization in the Amazon continues to be a risk to forest conservation. The bill on land regularization in the Amazon known as the "Land-grabbing Bill" 910/19 MP, signed by President Jair Bolsonaro in 2019, allowed public forests up to 2,500 hectares, as well as those illegally deforested prior to December 2018, to fall into the hands of the people who had occupied them illegally (i.e., land-grabbers), thereby conveying a message of amnesty for environmental crimes that affects the decisions of farmers and opportunists to clear and burn down natural forests (RODRIGUES-FILHO et al., 2015).

Cattle ranching is the activity with the greatest impact on deforestation in the Amazon. More than 60% of all deforested area in the region is estimated to have been converted to pasture (INPE/EMBRAPA, 2018). Although mechanisms to regulate market access do exist, such as the Meat Conduct Adjustment Agreement and the Soy Moratorium, the study by Garcia et al. (2020) for Chain Reaction Research produced compelling evidence that the dynamics of deforestation and forest fires in the Amazon are more intense near slaughterhouses and soybean silos, suggesting that mechanisms to punish companies that buy and finance products from illegally deforested areas are essential to combat deforestation.

Budget cuts in the Ministry of the Environment have had a strong impact on inspection, licensing and environmental monitoring actions. From 2013 to 2016 there was a reduction of about 42% in the budget for environmental inspection, and 15% in the number of environmental inspectors.[12] In 2019, in the name of cost-cutting, Decree 9.741 reduced 17% of the approved 1.1 billion budget of the Ministry of the Environment, representing R$ 187 million reais. Programs and actions essential to combat deforestation were significantly affected by this reduction, in some cases representing almost 70% of their funds (Table 3), leading to a 20% reduction in environmental inspection actions by IBAMA.[13]

[12] https://auditoria.cgu.gov.br/download/9752.pdf
[13] https://auditoria.cgu.gov.br/download/9752.pdf

Table 3. Budget cuts in 2019 for actions attributed to the Ministry of the Environment related to combatting deforestation. (Source: SIOP/PSOL14)

	Cut (R$)	Program Budget
IBAMA		
Sustainable Use of Biodiversity Management	18.747.992	69%
Construction of the Headquarters of the National Center for the Prevention and Combat of Forest Fires - Prevfogo	1.085.000	50%
Environmental Monitoring and Information Management and Environmental Education	4.517.295	50%
Federal Environmental Licensing	3.328.117	43%
Forest Fire Prevention and Control in Federal Priority Areas	17.500.000	38%
Environmental Control and Inspection	24.880.106	24%
Unit Administration	28.655.365	16%
ICMBio		
Support for the Creation, Management and Implementation of Federal Conservation Units	45.065.173	26%
Unit Administration	15.118.383	22%
Environmental Inspection and Forest Fire Prevention and Combat	5.482.012	20%

[14] http://www.psolnacamara.org.br/index.php?option=com_content&view=article&id=3804&catid=17&Itemid=144

The administrative changes in handling penalties for deforestation and negotiating fines (Decree No. 9,760/2019) were another aspect that weakened the environmental policies intended to combat deforestation and compromised the work of Ibama and ICMBio (Chico Mendes Institute for Biodiversity Conservation).

Deforestation in Proctected Areas in Brazil, the so-called Conservation Units (CUs), has been steadily increasing. While in 2012 they represented 5% of total deforestation in the Amazon, this percentage had increased to 7.5% by 2016. These protected areas have become more vulnerable to deforestation and degradation since 2005, due to events known as Protected Area Downgrading, Downsizing and Degazettement (PADDD), which result in scaling back the legal restrictions on the use of such units, reducing their territorial extension or outright canceling them.

Most of the requests for area or status reduction of CUs are related to demands for infrastructure projects, especially the construction of hydro power plants (HPPs) (**Figure 19**). The Amazon biome is the most affected by PADDD events, with a total affected area of 88,341 km^2 (79%) from 1900 to 2014 (PACK et al., 2016). In 2017, federal deputies and senators from the state of Amazonas requested in Congress a reduction of 2.83 million hectares of CUs to 1.78 million hectares, a cut of about 40% in the size of the CUs, in an area near the border that is highly vulnerable to deforestation by land grabbing.[5] In the Tapajós basin, five HPPs are planned to be implemented by 2020, with the potential to generate 10,680 MW. The reduction of CUs was implemented by MP 558, with a projected reduction of more than 1000 km^2 of intact forest that could result in the emission of approximately 152 million tons of CO_2 into the atmosphere if these forests are flooded, deforested or degraded (by predatory logging) (ARAÚJO et al., 2012). The strong agribusiness lobby for the expansion of agricultural and mining activities is a powerful force pushing for the reduction of CUs and Indigenous Lands (MOUTINHO; GUERRA; AZEVEDO-RAMOS, 2016).

[15] https://www.wwf.org.br/?56122

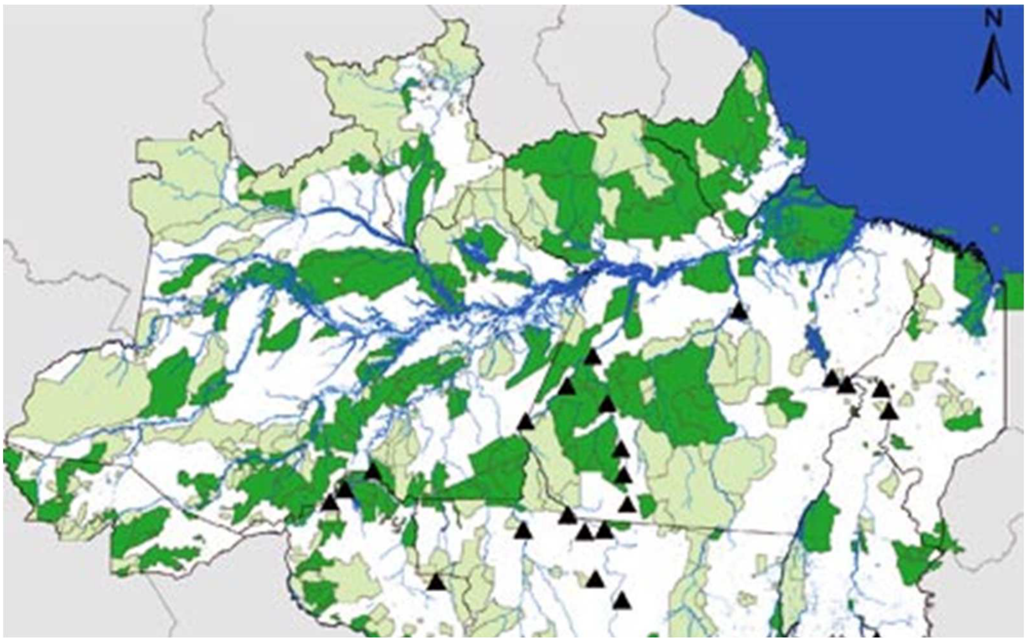


Figure 19: Planned hydroelectric plants in the Amazon until 2020. Source: PAC: http://www.brasil.gov.br/pac/relatorios/pac-2

The Amazon Fund is a relevant instrument for the country to achieve these commitments by chaneling donations into non-refundable investments and directing them to support environmental monitoring projects, implementation of conservation and sustainable development policies proposed by governmental and non-governmental organizations for the Legal Amazon, preventing political interference or government influence. In 2019, Norway suspended the transfer of 155 million to the Amazon Fund after the Minister of the Environment Ricardo Salles questioned its governance. Following the suspension and extinction of committees of the federal public administration (decree nº 9.759/2019) in charge of evaluating projects, the Fund closed the year of 2019 without having approved any project.

The different threats shown above reveal Brazil's great challenge in achieving zero deforestation and mitigating the impacts of climate change. The reduction of deforestation in the next decade will depend on a profound transformation of the country's policies and actions aimed at combatting impunity for environmental crimes, in addition to decarbonizing the economy, and striving for transparency of information.

24. What are the risks to the agricultural production in Brazil caused by the deforestation of the Amazon and the respective climate changes originating from it?

In terms of climate impacts, deforestation in the Amazon may amplify the impacts of climatic extremes resulting from climate change, as modeled for eastern Amazonia, resulting in warming of more than 3° C and up to 40% reduction in precipitation from July to November, delaying the beginning of the rainy season by 0.12 to 0.17 days for every 1% increase in deforestation (LEITE-FILHO; SOUSA PONTES; COSTA, 2019). The contribution of 9-10% of the rainfall in South America and 17-18% in the River Plate Basin caused by moisture recycling of the Amazon rainforest will be jeopardized if more than 40% of the Amazon is deforested and the annual rainfall is reduced by 5-10% throughout the Amazon basin (ZEMP et al., 2017), leading to longer dry seasons in southern Amazonia and reducing the flow of moisture to other parts of Brazil (AGUDELO et al., 2019). Models of vegetation dynamics predict an irreversible savanization process in this region within 30 to 50 years associated with deforestation, climate change, and intensified forest burning, directly affecting economic activities, especially agriculture, and its population (COSTA; PIRES, 2010; NOBRE et al., 2016).

The effects of reduced rainfall and the delay in the beginning of the dry season affect in particular the Southern Eastern Amazon due to the long dry season in a region known as the "arc of deforestation". The Ministry of Agriculture, Livestock and Supply (MAPA) and the OECD/FAO (2015) predict growth in agricultural production in Brazil over the next 10 years in order to meet the growing global demand for food, from 33.9 to 37% of soybeans and 13 to 26.3% of corn. The increased production of these cultivars will be supported by the expansion of planted area and the adoption of double harvest systems, a system favored by the high annual precipitation, long rainy season and low variability of the start of the rainy season, which however will be compromised due to climate change associated with deforestation (ARVOR et al., 2014; PIRES et al., 2016).

Thus, the loss of forests would economically harm agricultural production. Strand et al. (2018), for example, estimate that soy or beef production in some regions may be reduced and lose up to US$ 9 $ha^{-1}.year^{-1}$ as a result of reduced rains. Several studies suggest that productivity losses due to climate change might render some agricultural production systems unfeasible, such as the double cropping systems previously mentioned (ARVOR et al., 2014; PIRES et al., 2016). According to Abrahão e Costa (2018), double cropping systems located in the transition area of Amazonia-Cerrado may suffer a 17% decline by 2050, while in some regions such as MATOPIBA (a region formed by sections of the states of Maranhão, Tocantins, Piauí and Bahia, respectively) the decline may reach 61%, threatening their sustainability (PIRES et al., 2016).

The productive system in Brazil, based on expanding intensive monoculture and cattle-raising into the forest, resulted in more than 45 Mha of degraded agricultural land in Brazil in 2014 (INPE/EMBRAPA, 2018), leading to productivity losses. In Brazil, annual costs for soil erosion in 2002 have been estimated at $4.2 billion, while the additional cost of managing agricultural land due to reduced soil productivity and the consequent increase in demand for fertilizers was estimated at $2.93 billion per year (GUERRA et al., 2014; MANZATTO et al., 2002). Hipólito et al. (2018) estimate that agricultural production of avocado, guava, tomato and other crops in 19 municipalities near the Mata do Jambeiro National Park in Minas Gerais benefit from the pollination services generated by the Park's forest, worth a total of US $246,039. Cost and value estimates clearly indicate that forests and other natural ecosystems located near agricultural production areas provide valuable ecosystem services that contribute economic returns to the sector. The average marginal value of the Brazilian Amazon, according to a vision of benefit transfer through the forest, can vary between 431 and 3,135 US $ ha^{-1} $year^{-1}$ (ANDERSEN et al., 2002; TORRAS, 2000), considering the services of food production, raw materials, climate regulation and greenhouse gas regulation (STRAND et al., 2018). Studies show that European families would be willing to pay $8.4 billion per year to avoid forest losses in Amazonia by 2050 (NAVRUD; STRAND, 2018). Sustainability policies have been adopted by European parliamentarians and investment funds, in defense of the Amazon forest and in fighting climate change. The explosion of deforestation in the Amazon in 2019 and 2020, for example, has led 29 members of the European Parliament, members of committees on agriculture, environment, and foreign trade, as well as 29 investment and pension funds, which together represent US$ 4.1 trillion in assets, to pressure the Brazilian government in relation to its commitments to environmental protection, warning with the withdrawal of investments or the creation of obstacles in the approval of the free trade agreement between the European Union and MERCOSUR (“Funds with US$ 4.1 trillion in assets put pressure on Brazil to combat deforestation - 06/23/2020 - Market - Folha”, 2020).

Indirectly, the loss of river flow control services by the forest will influence the production of energy supplied by hydroelectric plants, which corresponded to 52% of the national power supply from 2017 to 2018, and consequently the supply of power and water to the agricultural sector (CARVALHO et al., 2004; SEEG, 2018). The Xingu and Madeira basins (southern and southeastern Amazonia) have high potential for hydropower production, but its generation at the end of the dry season may be imperiled due to the late start of the rainy season (SUMILA et al., 2017). In addition, this delay may jeopardize the water supply to reservoirs during the most critical period (after the dry season), such as happened in the 2013-2015 drought in São Paulo, which was partially due to low rainfall levels in some River Plate Basin headwaters during the dry to wet season transition (MILANO et al., 2018). The public and private economic benefits of ecosystem services include populations living both near and far from where the ecosystem service is actually provided, which argues for the overall positive aspects of these benefits.

Unfortunately, the monetary evaluation of ecosystem services provided by the forests has not guaranteed their conservation. Brazilian farmers often resist complying with the regulations of the Forestry Code, even though they recognize the importance of ecosystem services (TREVISAN et al., 2016), because they are ruled by the logic of economic returns. Many Brazilian farmers tend to resist legal obligations to maintain native vegetation (i.e., Legal Reserve) on their farms, as this involves lost benefits (e.g., $1.2 billion) from agricultural production (e.g., $15 billion), as well as operating costs for active forest restoration (STICKLER et al., 2013). Given the growing political influence of agribusiness in the national congress in the 2010s (AAMODT, 2018), this logic has become emblematic for the Brazilian environmental policy. The revisions made in the Brazilian Forestry Code in 2012, for example, were largely motivated by the understanding that the high demands for nature conservation (not only Legal Reserves, but also Permanent Preservation Areas, such as riparian forests) on private lands constitute an obstacle to development (SAUER; DE FRANCE, 2012), while similar arguments have resurfaced in recent attempts to completely dismantle the Legal Reserve (METZGER et al., 2019).

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