Government policies endanger the indigenous peoples of the Brazilian Amazon

Abstract

The Brazilian Amazon rainforest deforestation rate increased by 34.1% between 2018 and 2019, reaching even protected areas, such as Indigenous Lands (ILs). In particular, Ituna/Itatá IL, in the state of Pará, restricted to the study of Igarapé Ipiaçava isolated indigenous people, has experienced a 654% deforestation rate increase during the same period. The mainstream deforestation analysis explains it as a struggle between conservation and development, which is commonly typified by large-scale producers who replace natural vegetation with pasturelands and crop fields, especially in agricultural frontiers, as ILs are barriers for protecting forests. In this work, we expose a devised and underlying deforestation process in Ituna/Itatá, and argue that land grabbers and squatters have promoted this boom by moving in, clearing, subdividing, and occupying this IL as if it were real estate. Such process mischaracterizes it and obstructs the demarcation process, in the expectation of a land regularization law that authenticates selling the land in the future. This process seems to be promoted by the Brazilian Federal Government rhetoric and mediated by local politicians, somewhat passing on the message of feeble repression against invasions of public lands. Our results evidence a process of IL mischaracterization, with primary forests converted to pasturelands, and a 1,994.30 ton $year^{-1}$ increase of annual estimates of fine particulate matter ($PM_{2.5}$) associated with fires. Also, 94% of Ituna/Itatá has been claimed in the Brazilian Rural Environmental Registry, resembling a city allotment process, with a road network conditioning and suggesting axes of deforestation expansion. Measures to prevent deforestation are vital not only to sustain land demarcation processes but also to stop it from spreading to other ILs.

Keywords: Ituna/Itatá Indigenous Land, Isolated people, Deforestation, Land use change.

1. Introduction

According to data produced by the Brazilian National Institute for Space Research (INPE), at least 20% of the Brazilian Amazon rainforest has already been lost (INPE, 2019). Market forces guide the main drivers of this deforestation: the increasing global need for agricultural, livestock, and timber products, and local infrastructure projects required to sustain it, including roads, dams, and ports (Nepstad et al., 2014; Artaxo, 2019; Rajão et al., 2020). Furthermore, from 2018 to 2019, the deforestation rate increased by 34.41%, reaching 1,012,900 ha (INPE, 2019) due to a recent deforestation trend in the Brazilian Legal Amazon which may have been triggered by the Brazilian Federal Government (BFG), given a weakening of its policies that protect native vegetation (Barlow et al., 2019; IMAFLORA, 2021; Vale et al., 2021).

Many studies have shown that since 2019, the government has reduced environmental protection in four main ways, thus dismantling the environmental regulatory framework. The first one is deregulation, which weakens environmental law and standards (Ferrante and Fearnside, 2019; 2020; Vale, 2021) and supports law amendments that downplay indigenous rights, such as mining authorization within ILs (Rorato et al., 2020; Siqueira-Gay et al., 2020) and the use of an occupation timeframe for their demarcation (Begotti and Peres, 2020). The second is the dismantling of environmental institutions in charge of field actions for deforestation control, which merges environmental agencies, reducing their budget, relaxing regulations, removing head positions and substituting them by non-technical staff (Gonçalves et al., 2020), discouraging fines (Vale, 2021), hindering the investigation of environmental administrative infractions (IBAMA, 2021), and supporting the transfer of ILs administration to the Ministry of Agriculture (Artaxo, 2019; Carvalho et al., 2019). This dismantling also concerns environmental commissions, in which civil participation has decreased (Vale, 2021) or extinguished altogether. The third is socio-cultural, which downplays indigenous peoples' rights to land, encouraging non-conservationist acts on the premise of equal opportunities for

natives and settlers (Artaxo, 2019), especially by using social media (Caetano, 2021). Finally, other environmental protection actors have been affected by historical budget cuts, and their credibility undermined by creating suspicions on land cover monitoring programs and scientific results and by questioning the way Non-Governmental Organizations and external funds such as the Amazon Fund use their budgets to monitor and fight deforestation (Trancoso, 2021; Vale et al., 2021).

The mainstream analysis of deforestation explains this process as a struggle between conservation and development, represented by conflicting interests among indigenous peoples, farmers, and landowners (Nepstad et al., 2014; Artaxo, 2019; Barlow et al., 2019). A process commonly typified by large-scale producers who replace natural vegetation with pasturelands and crop fields (Jusys, 2016), especially in agricultural frontiers (Le Tourneau, 2016; Rajão et al., 2020). This paper presents underlying reasons driving deforestation at a local scale in the Brazilian Amazon. We believe there is a regional background-running deforestation process, which is exemplified in the Ituna/Itatá IL, located between the municipalities of Altamira and Senador José Porfírio, Pará.

The hypothesis raised in this study is that the deforestation in Ituna/Itatá is being driven by land grabbers and squatters moving in, clearing, subdividing, and occupying land as real estate inside this IL. It aims to mischaracterize it in order to obstruct its demarcation process, awaiting land regularization that would authenticate profiting from future land sales. In addition, we argue that the deforestation booming in Ituna/Itatá - which increased about 654% between 2018 and 2019 - may have been permeated by the BFG's rhetoric that legal protections are too restrictive and stifle economic development, which is mediated by regional politics. This immediate human action resulted from underlying driving forces, including economic, political, and cultural factors derived from a demographic increment in Altamira coincident with the construction of the Belo Monte hydroelectric dam, in 2011.

2. Background

Brazil is recognized as one of the world's most biodiverse countries (Ferreira et al., 2014) and one of the largest food producers (Soterroni et al., 2018). Because of the Brazilian Amazon rainforest extraordinary ecological significance, international concerns have focused on reducing deforestation in this region (Zalles et al., 2018). An expansion of the deforestation frontier leads to significant changes in the regional landscape, even in protected areas such as ILs, affecting biodiversity and sustainability at local and global scales (Ferreira et al., 2014; Barlow et al., 2016; Abessa et al., 2019). Between 2004 and 2012, the deforestation reduction policies of the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm) decreased deforestation rates (Kalamandeen et al., 2018; Tacconi et al., 2019; Pereira et al., 2020). According to INPE, the annual deforestation rate decreased from a record 2,777,200 ha in 2004 to 457,100 ha in 2012 (INPE, 2019). In addition to the PPCDAm, other initiatives (such as the soy and the meat moratoriums) contributed to making the coexistence of market interests and conservation objectives possible (Gibbs et al., 2015; Soterroni et al., 2018).

Besides environmental agreements and policies, on-field operations and fines issued by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) were valuable tools to reduce forest loss during this period (Börner et al., 2015). However, sustainable and socially equitable development in Brazil depends crucially on efforts to tackle land tenure insecurity (Sparovek et al., 2019; Yanai et al., 2020). After 2012, the Amazon deforestation rates increased again, especially during the last five years; those coincided with a period of economic crisis, changes in political forces, and a weakening of environmental regulation in Brazil (Azevedo-Santos et al., 2017; Freitas et al., 2018), factors that have caused the instability exploited by deforestation drivers (Geist and Lambin, 2002). Under such circumstances, environmental agency budgets decreased, the number of fines issued dropped, and on-field operations collapsed, threatening their deterrence effects on forest loss

(Magnusson et al., 2018; Tacconi et al., 2019; Pereira et al., 2020). The dismantling of environmental policies reflects the loss of inspection force (Figure 1).

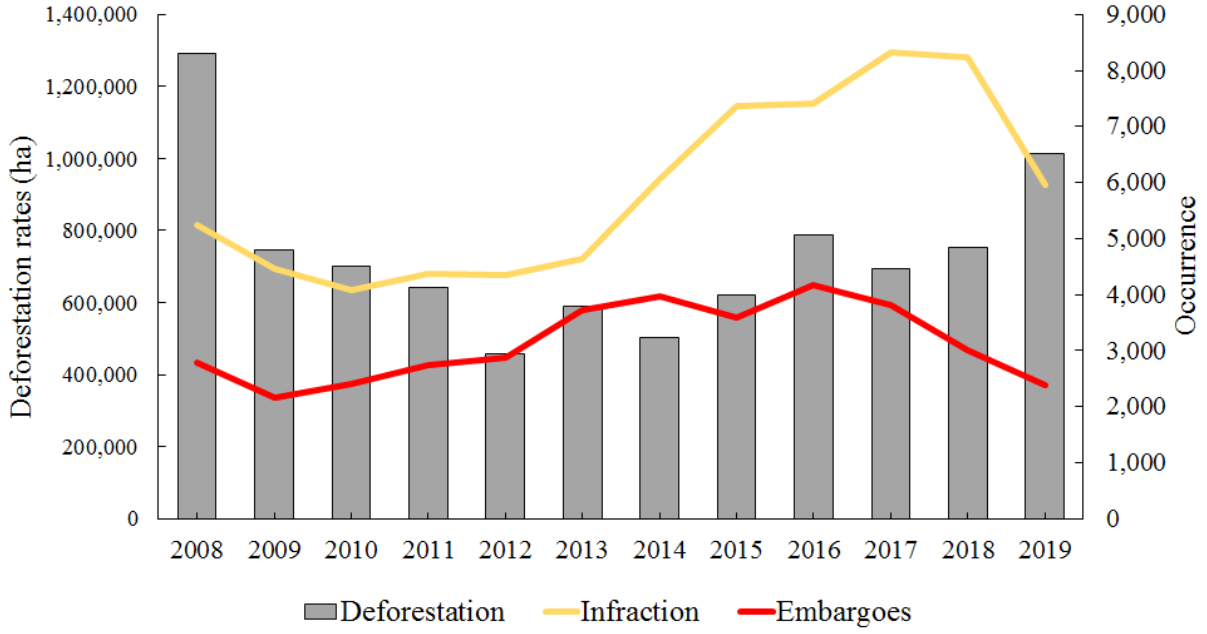

Figure 1. Relation between deforestation rates registered by INPE and the infractions and embargoes enforced by IBAMA in the Brazilian Legal Amazon, from 2008 to 2019.

Brazil could better manage the situation in this region driven by social inequality (Nobre et al., 2016; Pereira et al., 2020) by adopting an environmental agenda (Brito et al., 2019; Rajão et al., 2020) focused on sustainable development. Nowadays, policies that were initially created for environmental protection have been used for land regularization instead of their original purpose (Benatti and Fischer, 2017; Brito et al., 2019), stressing the environment (Rochedo et al., 2018; Azevedo-Ramos et al., 2020). In April 2020, IBAMA Environmental Protection Director, the General Coordinator of Environmental Inspection, and the Inspection Operations Coordinator were exonerated after performing inspection operations to remove illegal loggers and miners from ILs in Southern Pará (Ministry of Environment, 2020a, 2020b, 2020c). This action took place during the fight against the spread of COVID-19 among indigenous people. During these operations, IBAMA staff burned machinery (e.g., tractors) to curb illegal deforestation. Another example is the Decree

9.760/2019 (Brazil, 2019a), which severely disabled IBAMA's ability to impose fines on illegal deforestation as of October 2019 (Human Rights Watch, 2020).

The BFG's rhetoric and its weak environmental regulations (Artaxo, 2019; Barlow et al., 2019; Pereira et al., 2020), that is, scarce inspection funds as well as unfavorable policies for protected areas (Brazil, 2019b; Lopes et al., 2019; Pereira et al., 2019), may have been encouraging and increasing land speculation and cattle ranching in deforested public lands (Brito et al., 2019; Azevedo-Ramos et al., 2020). This scenario has generated uncertainties about protecting indigenous peoples, mainly the isolated ones, such as the Igarapé Ipiaçava, who live in the Ituna/Itatá IL (FUNAI, 2019; Potter, 2019).

3. Material and Methods

3.1 Study area

With approximately 142,402 ha, Ituna/Itatá is an IL in the process of legal demarcation located between Altamira and Senador José Porfírio municipalities, Pará. It was created in 2011 by the National Indian Foundation (FUNAI) to respond to the construction of the Belo Monte dam in the Xingu River Basin (FUNAI, 2011). In Brazil, as this procedure is declaratory, ILs are not created by law. Instead, they are recognized based on technical and legal requirements under the Brazilian Federal Constitution of 1988 (Brazil, 1988).

Since its creation, the Ituna/Itatá IL is exclusively reserved for studying isolated indigenous peoples, as the Igarapé Ipiaçava, recently observed in local field campaigns (FUNAI, 2019). Therefore, the law forbids the use of natural resources by non-indigenous and the admission, locomotion, and permanence of people other than FUNAI staff. However, this regulation has been breached and the indigenous people have been struggling to keep their way of life. The location of this IL, near Belo Monte and the Volta Grande Gold Project (an open pit mining project led by the Canadian company Belo Sun Mining Corporation), is a contributing factor since it can attract people to the border and to the interior of Ituna/Itatá as

well as to neighboring ILs (Figure 2). The surrounding Mocotó village, where hundreds of people live, clearly illustrates the point.

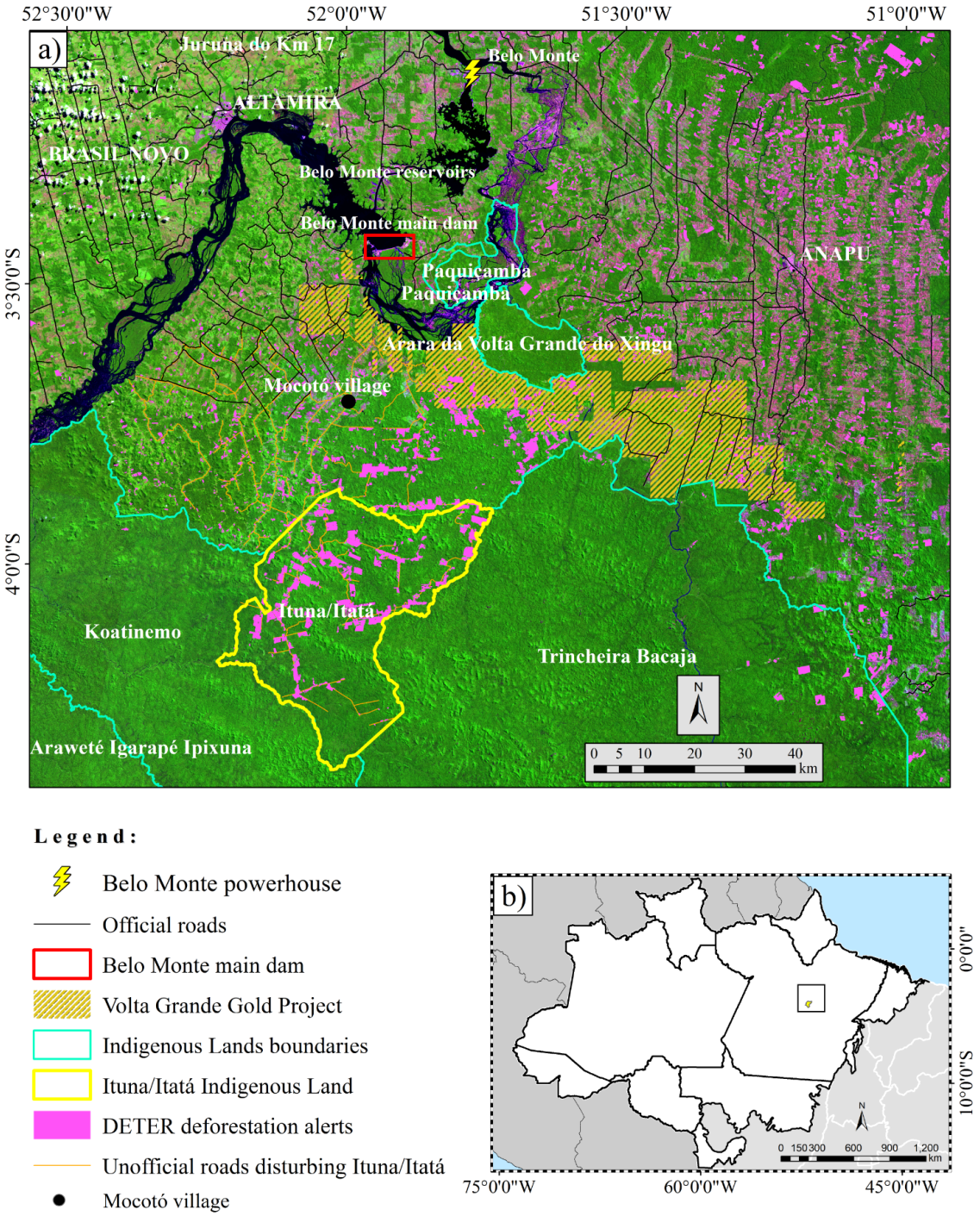

Figure 2. Location of the Ituna/Itatá IL and its proximity with the Belo Monte dam and the Volta Grande Gold Project (a) and spatial location of this area in the Amazon biome (b). The base map is Landsat 8 OLI path/rows 225/62, 225/63, 226/62, and 226/63, color composite R6G5B4 for 2019.

3.2 Land cover transition: categorization of deforested areas in Ituna/Itatá

To assess land cover transition during the same period of the deforestation boom in Ituna/Itatá (2018-2019), we used information processed by the Brazilian Amazon Deforestation Satellite Monitoring Project (PRODES), which INPE operates. PRODES has monitored clear-cut deforestation and provided annual accurate official deforestation rates of the Brazilian Legal Amazon since 1988 (INPE, 2019). We categorized land use in the deforested areas mapped by PRODES in 2017 and 2019, following TerraClass Project interpretation key (Coutinho et al., 2013; Almeida et al., 2016); since the deforested area in 2017 (1,339 ha) was similar to that of 2018 (1,589 ha), we avoided using data from 2018 owing to dense cloud coverage. TerraClass biannually produces Land Use and Land Cover (LULC) information for the deforested areas mapped by PRODES based on visual interpretation of 11 LULC classes using imagery from Landsat, Sentinel-2, and CBERS satellites. This project has already produced free of charge LULC maps for 2004, 2008, 2010, 2012, and 2014 (INPE, 2020b, 2020c).

For 2017, we used data from 2017 PRODES consolidated deforestation increment, categorizing the polygons based on Landsat 8/OLI image path/row 225/63, of 07-20-2017. For 2019, we repeated the same process using 2019 PRODES consolidated deforestation increment, and Landsat 8/OLI image path/row 225/63 of 08-11-2019. Both were the same images used by PRODES.

3.3 Comparing deforestation/degradation alerts and official infraction and embargoes data

Since 2004, the Near Real-time Deforestation Detection System (DETER) has warned Brazilian authorities about deforestation in the Amazon, presenting a high linear correlation with the deforested areas detected by PRODES (Diniz et al., 2015). The data are publicly available online at the TerraBrasilis website (http://terrabrasilis.dpi.inpe.br/app/dashboard/alerts/legal/amazon/daily/), which INPE

administers. We downloaded the DETER alerts which occurred in the Brazilian Amazon rainforest during 2018 and 2019, and selected those overlapping the geographical delimitation of Ituna/Itatá.

IBAMA provided the official inspection data and included infraction and embargo records. We downloaded these data from two online public databases: (i) the Brazilian portal for official data access (http://www.dados.gov.br/dataset/autos-de-infracao), and (ii) the GeoNetwork opensource platform (http://siscom.ibama.gov.br/geonetwork/srv/por/main.home). We selected only the registries overlapping Ituna/Itatá during the 2018-2019 period.

3.4 Analysis of the Rural Environmental Registry (CAR) data

The Rural Environmental Registry (Cadastro Ambiental Rural, CAR in Portuguese) is a self-declaratory registry introduced in 2012 by the new Brazilian Forest Code (Law 12.651/2012) to enhance law enforcement. There is evidence that the CAR has significantly influenced anthropized land use by expanding pasture areas into natural vegetation (Jung et al., 2021). Therefore, we downloaded the land requests in the Altamira and Senador José Porfírio municipalities (where Ituna/Itatá is located) from the CAR official registry (http://www.car.gov.br/publico/municipios/downloads?sigla=PA). Then, we merged and clipped these records using the ILs' geographical delimitation extracted from TerraBrasilis website and analyzed the documentation of all the self-declared CAR registries found.

3.5 Analysis of the illegal transportation' infrastructure causal effect

The distance to road infrastructures facilitates the logistics of deforestation and timber flow. There are no official roads within Ituna/Itatá, but a network of unofficial roads which greatly contribute to the Amazonian illegal deforestation (Nascimento et al., 2021). Therefore, we analyzed the distance between deforestation polygons estimated by PRODES and the unofficial roads within Ituna/Itatá to evidence how this illegal network affects the distribution pattern of CAR registries and/or deforestation expansion. To this end we used the road dataset

made available by the OpenStreetMap project (Geofabrik, 2021), which contains unofficial roads within our study area. We calculated deforestation polygon percentages within two distinct buffer sizes created around the roads (1 km and 2 km) because the smaller the distance to infrastructures the higher the probability of deforestation (Barber et al., 2014; Grinand et al., 2020; Saha et al., 2020).

3.6 Annual estimates of fine particulate matter ($PM_{2.5}$) associated with fires in Ituna/Itatá

As a proxy for forest fire emission evaluation, we obtained the annual estimates of $PM_{2.5}$ using the Brazilian Biomass Burning Emission Model with Fire Radiative Power (3BEM FRP) (Pereira et al., 2016), which is available on the PREP-CHEM-SRC emissions pre-processing tool version 1.8.3. This model is more appropriate for studying fire emissions in South America than for global biomass burning inventories due to its specificity (Mataveli et al., 2019).

Moderate Resolution Imaging Spectroradiometer (MODIS) active fire products MOD14 and MYD14 (Giglio et al., 2016) were considered as inputs in the 3BEM FRP model. Fires were the only active source of emission in PREP-CHEM-SRC. The model outputs consisted of daily emissions of several species associated with fires for South America, including the $PM_{2.5}$, at the spatial resolution of 0.1º. The daily $PM_{2.5}$ estimated emissions inside the Ituna/Itatá IL were selected and then converted into annual estimations, following the procedure described in Mataveli et al. (2019).

4. Results and Discussion

4.1 Land use change within Ituna/Itatá

The deforestation rates within the Ituna/Itatá IL have increased from 1,589 ha in 2018 to 11,985 ha in 2019 (Figure 3). The year 2019 set the highest deforestation rate of an IL ever registered in PRODES history (INPE, 2019).

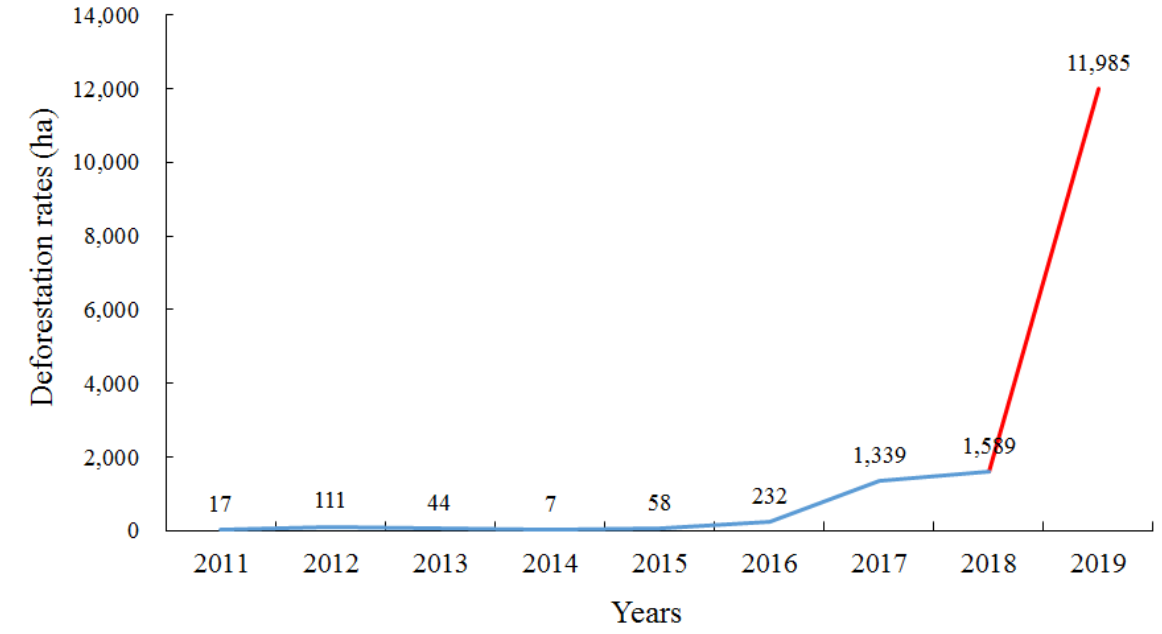

Figure 3. Deforestation rates detected by PRODES Project (INPE) for the Ituna/Itatá IL between 2011 and 2019.

The deforestation rates normalized per area show that the forest loss within the IL were higher than that of Altamira, Pará, and the entire Brazilian Legal Amazon since 2016 (Figure 4).

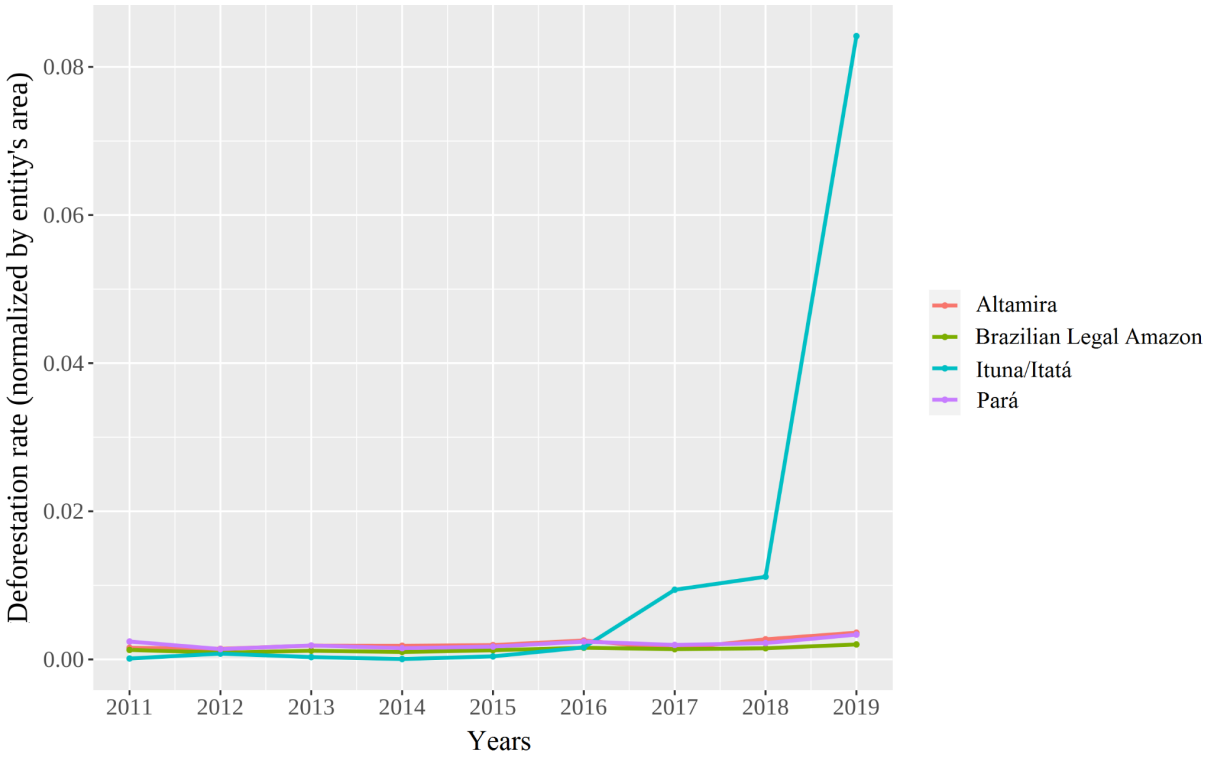

Figure 4. Deforestation rates normalized by the entity area of the Ituna/Itatá IL, the Altamira municipality, the state of Pará, and the Brazilian Legal Amazon.

The deforestation rate registered in 2019 in Ituna/Itatá was superior to that of neighboring ILs, such as Koatinemo and Trincheira/Bacajá, probably due to the fact that the former ones have already been demarcated, which makes the selling of land forbidden. Different studies showed a causal relation between collective property rights, such as ILs demarcation, and the prevention of forest loss in high-pressure regions when compared to that of other categories of protected areas (Nolte et al., 2013; Jusys, 2018; Baragwanath and Bayi, 2020; Begotti and Peres, 2020). Environmental inspection shortcomings also contribute to this rampant deforestation. Scarcity of funding prevents IBAMA not only from keeping a permanent post in Ituna/Itatá and its surroundings but also from promptly responding, rendering it a deforestation hotspot in the Brazilian Amazon rainforest.

The categorization of PRODES polygons within this IL show that deforested areas in Ituna/Itatá are being converted especially to herbaceous (5,310.00 ha) and shrub pasturelands (4,737.50 ha) (Figure 5).

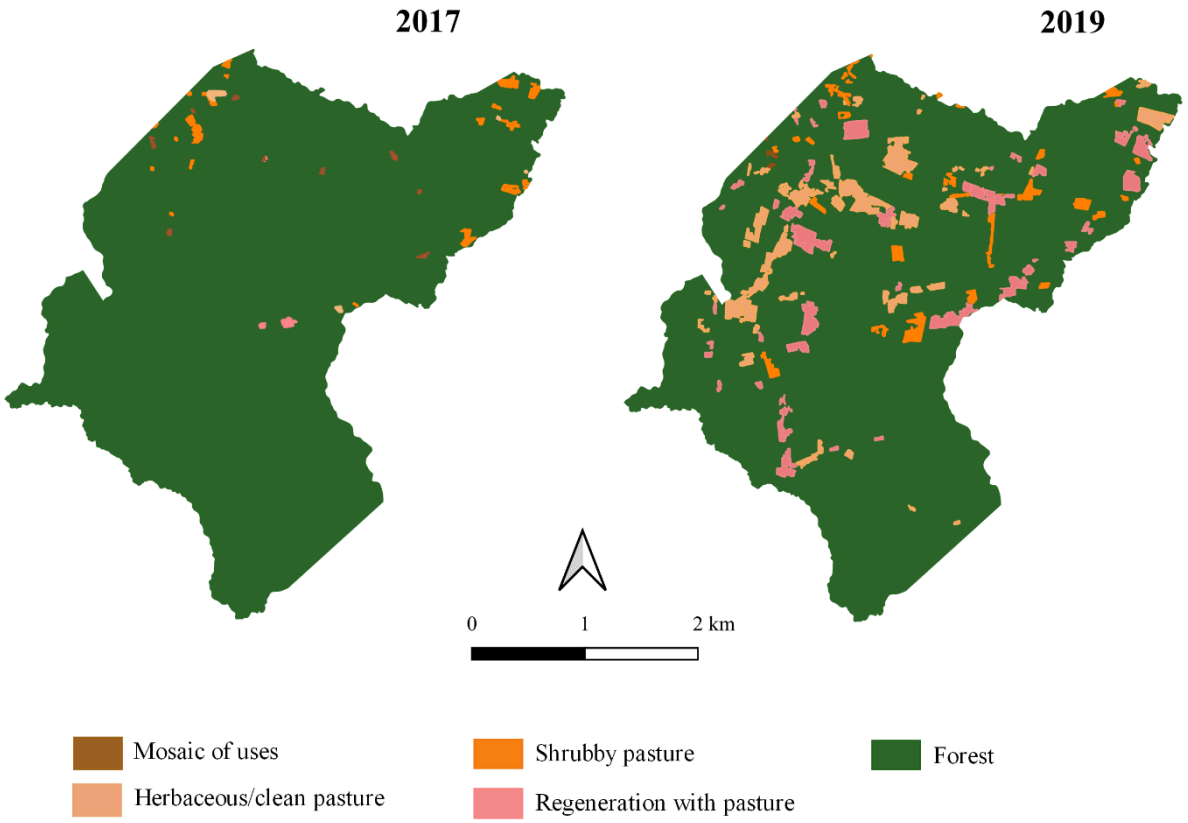

Figure 5. Categorization of the deforestation polygons mapped by PRODES in the Ituna/Itatá IL for 2017 and 2019, considering the TerraClass interpretation key.

Abrupt changes have been occurring in Ituna/Itatá; the most notorious being a herbaceous and shrub pasture increase (Table 1). IBAMA inspections have found that this pasture is predominant because it grows fast, suffocating native species, and can be easily dispersed and cultivated for cattle feed - 2,000 cattle heads have been found within the IL. Moreover, pasture gives the area the appearance of an old occupation and the successive burning and planting can definitively consolidate the area, hindering or preventing natural regeneration (Loss et al., 2020). We have observed mosaics of use and large clearings, suggesting a variety of actors - such as migrant farmers and loggers - whose action may be complementary in the land appropriation process.

Table 1. Categorization of the deforestation polygons mapped by PRODES in the Ituna/Itatá IL for 2019.

LULC classes	Area (ha)
Mosaic of uses	42.00
Herbaceous pasture	5,310.00

Shrub pasture	4,737.50
Regeneration with pasture	1,895.50
Total	11,985.00

Additionally, 94% of this IL has been claimed by landowners as parcels in the CAR registry system. Some parcels within Ituna/Itatá have been claimed by up to five distinct owners, creating overlays. A total of 229 CAR registries have been found in the analysis, and 77 (33.62%) correspond to parcels larger than 1,000 ha - which suggests a process made by large landowners, considering the current legislation (Brazil, 2012; INCRA, 2013). More specifically, the parcels can be divided into three types: (i) small, 19 CAR registries until 300 ha, (ii) medium, 147 between 300 and 1,125 ha, and (iii) large, 63 above 1,125 ha, of which 47 are smaller than 1,500 ha, indicating a fraction of large areas divided in equivalent parcels. When these CAR registries were created, lands with up to fifteen fiscal modules of extension - about 1,500 ha - could be regulated without the need for bidding (Brazil, 2009). After, it was extended to 2,500 ha (Brazil, 2016; 2017). This situation makes the CAR registries' spatial pattern in Ituna/Itatá resemble an allotment within a city.

This division into similar parts that form large parcels gives scope to suppose that large landowners may be registering estates over the upper legal limit via the registration of multiple parcels, owned by small squatters (Vurdubakis and Rajão, 2020). While CAR should serve environmental regularization, it is increasingly applied in this region as a key instrument to secure private land claims through georeferenced property demarcation and evidence of rural use, specifically with cattle pastures (Klingler and Mack, 2020). The situation of Ituna/Itatá corroborate the discussion that many Amazonian public areas under the responsibility of the BFG still lack effective planning and are often disregarded by state-level efforts against widespread land grabbing and illegal deforestation (Alix-Garcia et al., 2018; West and Fearnside, 2021). The vast majority of the CAR registries are waiting for analysis, even though they are inappropriate since it is an IL.

This absence of juridical security is causing deforestation. Considering 2018 and 2019, 471 deforestation/degradation alerts were emitted within Ituna/Itatá by DETER. In contrast, IBAMA registered only 14 infractions during this period, all of them resulting in embargoes (IBAMA, 2019). An infraction can correspond to several DETER alerts that present equivalent illicit actions arising from the same individual responsible. However, we analyzed the IBAMA database. As each infraction report shows the deforested area, the location of the polygons by geographical coordinates and the date of its formulation, it was possible to identify a lag between deforested polygons and documented infractions. These infractions are distributed over the polygons, which are, in many cases, spatially dispersed and do not pertain to the same deforestation process (Figure 6).

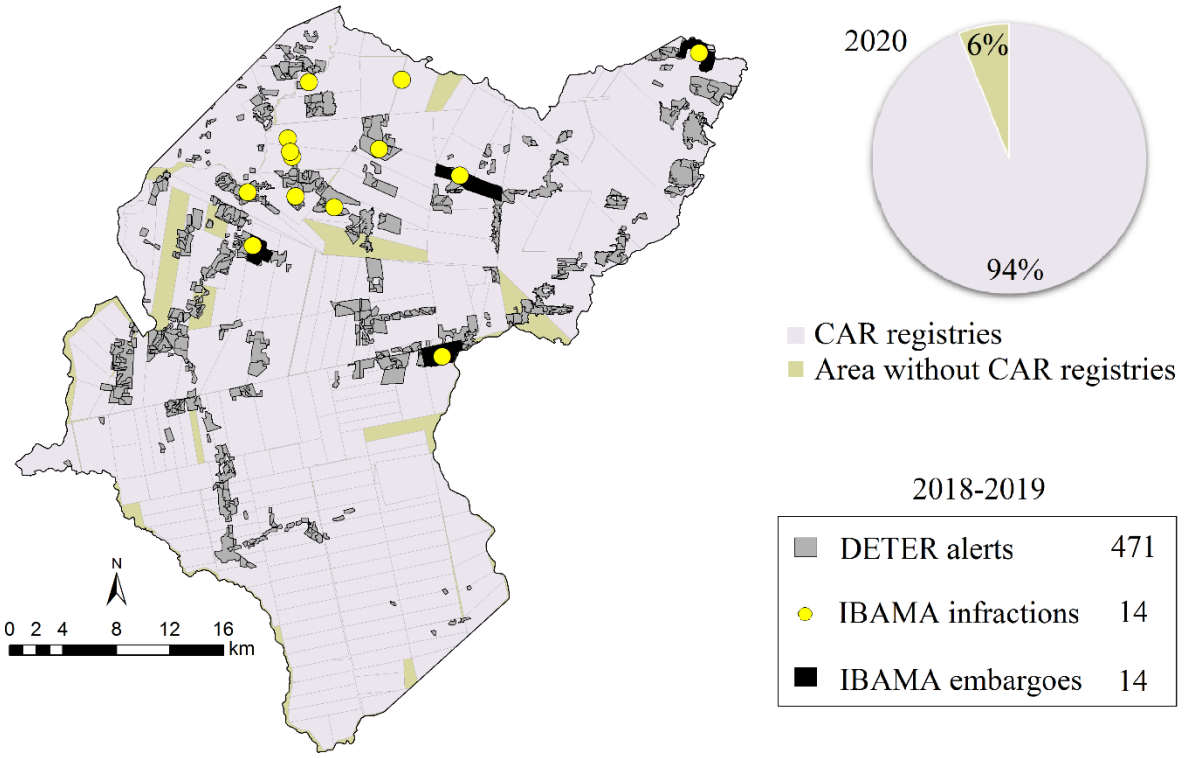

Figure 6. Relation among DETER alerts, IBAMA infractions, and IBAMA embargoes within the Ituna/Itatá IL between 2018 and 2019, and total and geographical location of CAR registries in 2020.

The discrepancy can be explained by the limitation of effective human effort for inspection. IBAMA's workforce has been limited recently, and this situation has reduced the capacity to stay and to go frequently to the field (ASCEMA, 2021; IBAMA, 2021). Then,

IBAMA staff may not be able to identify, *in loco*, those responsible for other deforestation detected by DETER, as seems to be the case. Despite the use of remote sensing technologies for remote inspection purposes, this solely does not guarantee juridical security and does not enable to identify land conflicts, that are observed only in field inspections. This situation highlights how IBAMA should be reinforced with funds. While deforestation alerts occur in near real-time, inspection operations are punctual (less frequent) due to budget, planning, the actual number of qualified staff, and the absence of political disposition for full inspection, among other issues.

This unprecedented number of illegal CAR registries and DETER alerts demonstrate that land grabbers have been occupying this IL not only accelerating deforestation and mischaracterizing Ituna/Itatá but also preventing its legal demarcation. Such practices force its incorporation into the real estate market, allowing them to become the owners of portions within this IL on the grounds that a political act will support it (Moutinho et al., 2016; Azevedo-Ramos and Moutinho, 2018; Sparovek et al., 2019; Stabile et al., 2020). Illegal land grabbers expect an ordinance revocation which restricts access to Ituna/Itatá, or a legislation amendment which determines land tenure regularization in public areas. Such act would authenticate the process devised to reverse profit at the expense of forest and national heritage and appropriate the surplus-value due to the land speculation from the dam construction and the requested Volta Grande Gold Project implementation, in Altamira, designed to be the largest gold mine in Brazil (Bratman and Dias, 2018).

Allocated infrastructure further evidences this process. Results suggest the emergence of a village within the IL and of an unofficial road network connected to nearby official highways. This conditions allotment spatial distribution, indicating expansion axes, which facilitate deforestation and timber flow logistics (Figure 7).

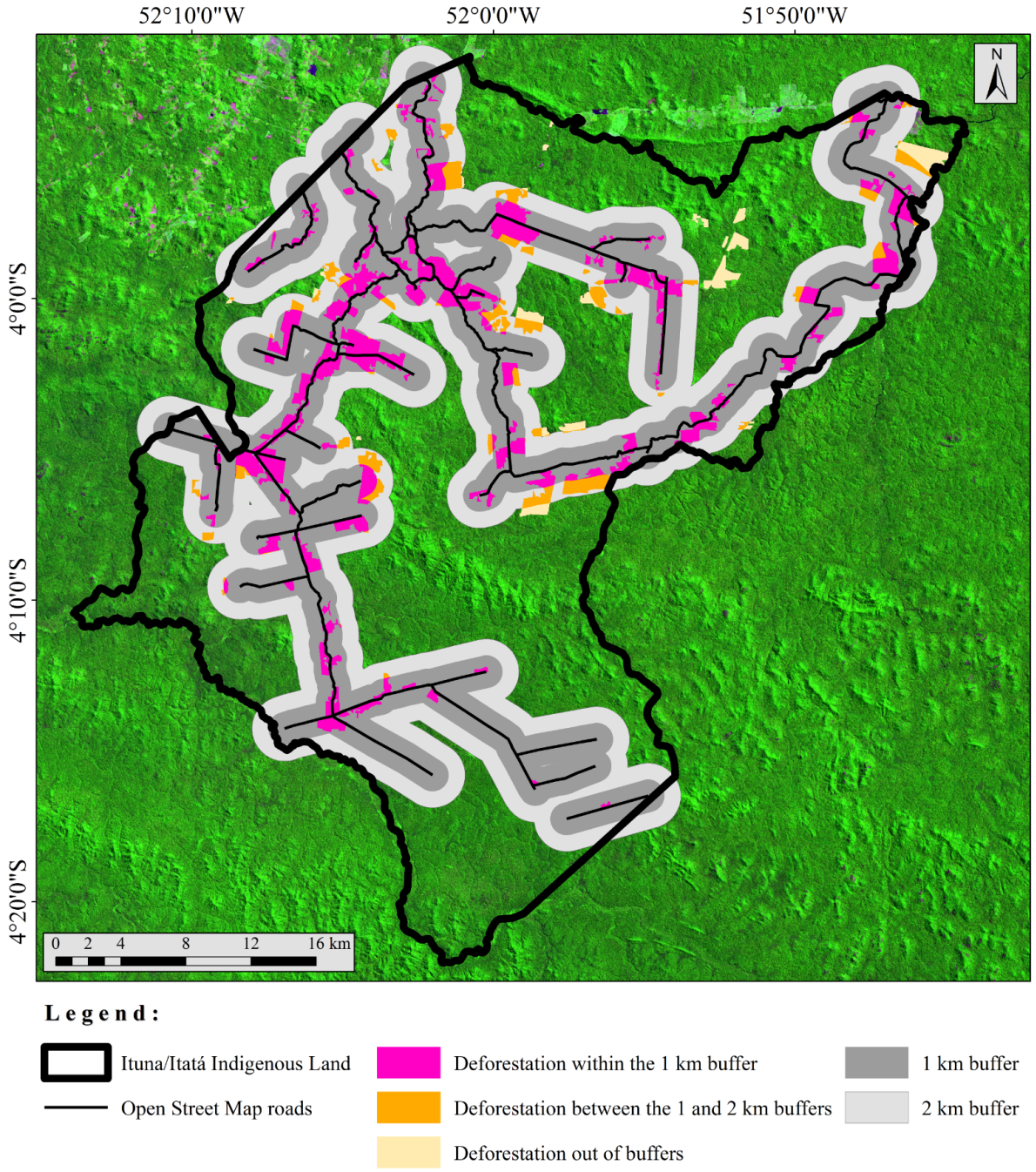

Figure 7. Relation between PRODES deforestation polygons and road infrastructure within the Ituna/Itatá IL.

About 91% of the deforestation estimated by PRODES in 2019 occurred within a 1 km buffer of distance to roads, and 96% within a 2 km buffer. This highlights the causality between road infrastructure and deforestation. Smaller distances to infrastructures increase the probability of deforestation (Grinand et al., 2020; Saha et al., 2020). In this region, the routes of migration and encroachment of land grabbers are dictated by accessibility (Jusys, 2016;

West and Fearnside, 2021). Road infrastructure has been favoring colonization, logging, mining, and land speculation (Barber et al., 2014; Schielein and Börner, 2018). This often spurs a large network of clandestine roads due to concurrent interests of a variety of actors to expand over forest frontiers (Jusys, 2016; Busch and Ferretti-Gallon, 2017). Barber et al. (2014) showed that the rapidly growing unofficial road network, built with or without government oversight or incentives, is a key deforestation driver in the Amazon and that protected areas have had a strong mitigating effect on that risk. However, Ituna/Itatá has not been as successful, maybe for having its 'default protection' threatened due to its remoteness and resilience which has been under the influence of different primary deforestation drivers, such as its proximity to transportation networks. This situation has also been detected in other protected areas over the Amazon (Barber et al., 2012; 2014).

Such evidence shows how land grabbing is articulated and oriented to consolidate possession over the territory. The migration of people into Ituna/Itatá, driven by real estate speculation fostered by land grabbers, generates social problems that justifies future occupation regularization by the BFG. The low price of land and the promise of land ownership attract hundreds of people to illegally divided areas, leading to the opening of lots without infrastructure, assistance, or government control. Due to impunity, CAR ownership may give the feeling of legality to land clearing, contributing to the expansion of pasture areas. Jung et al. (2021) found a similar circumstance assessing the impacts of CAR registries on land use conversion. These circumstances divide responsibility and hide the identity of the group that articulates and profits from illegal occupation and deforestation. This situation in Ituna/Itatá is unique since there are no records of ILs becoming unviable during their demarcation process in Brazil.

4.2 Ituna/Itatá underlying deforestation drivers

In a regional context, the Northern portion of the Xingu River basin is rich in socio-biodiversity, archaeology, and endemic species (Bratman and Dias, 2018), besides being home to over 26 indigenous peoples (Schwartzman et al., 2013). However, given its vastness of relatively untapped primary resources, it is vital for infrastructure development and for the energy sector modernization (Schwartzman et al., 2013; Bratman and Dias, 2018). Consequently, cattle ranching and land speculation have been growing and expanding in this region due to infrastructure development, weak governance, and uncertainties in land tenure rights (Begotti and Peres, 2020). Therefore, the underlying driving forces of the alarming deforestation in Ituna/Itatá can be attributed to regional socio-economic and socio-environmental factors. The precursor was the Belo Monte dam, close to Altamira. The announcement of its construction in 2010 increased local actors interest in this region, which not only resulted in an abrupt population growth (Jiang et al., 2018; Li et al., 2018) but also triggered indirect deforestation to meet local demands, affecting protected areas surrounding the dam (Bratman and Dias, 2018).

As a consequence, the population of Altamira increased 15% from 2010 to 2019, while the Brazilian population increased 9% during the same period (IBGE, 2020). This demographic boom boosted the local economy. The construction sector absorbed the largest contingent of new inhabitants, but new hirings also took place in other economic sectors (industry, trade, and services) (Calvi et al., 2020). Data from the General Registry of Employed and Unemployed (CAGED) database (Ministry of Labour and Employment, 2018) revealed an increase in formal employment rates between 2011 and 2014, peaking at 43,207 registered employees.

Although the dam generated new jobs, the average monthly salary did not increase substantially – it went from 1.8 to 2.5 minimum wages between 2010 and 2017 (IBGE, 2020). Furthermore, 24.3% of people have inadequate water supply and sanitation, and 18.1% of the

population between the age of 15 and 24 do not study or work and are vulnerable to poverty (Cerqueira et al., 2019). As a consequence, violence has risen. Altamira is the second most violent municipality in Brazil, with a homicide rate of 133.7 per 100,000 inhabitants (Cerqueira et al., 2019). This can be explained by the intense agrarian conflicts on land ownership involving several actors, such as landowners, land grabbers, squatters, settlers, gold-diggers, extractive riverine communities, artisanal fishermen, Pará nut harvesters, and indigenous peoples (Marin and Oliveira, 2016; Bratman and Dias, 2018). Therefore, poverty, inequality, and conflict sustain the land speculation scenario and the natural resources exploration (Azevedo-Ramos et al., 2020), leading to the increase of Altamira's accumulated deforestation over primary forest monitored by PRODES, which went from 672,600 ha in 2010 to 973,730 ha in 2019, representing an increase of 44.77% (INPE, 2021).

4.3 Potential threats for land use change in Ituna/Itatá

4.3.1 Threats from policies

The abrupt deforestation, land speculation, and cattle ranching in ILs demand urgent law enforcement. As previously mentioned, the substantial weakening of policies to combat illegal activities, the worsening of a culture of impunity as well as the dismantling of the environmental surveillance agencies (IBAMA, ICMBIO, and FUNAI) are key deforestation drivers (Rorato et al., 2021). For example, in December 2019, the BFG announced the Provisional Measure 910/2019 (Brazil, 2019c) regarding land regularization, a legal instrument to ease land claims and to restrict on-field inspections. Land tenure regularization, previously for those who occupied the land before 2008, would extend until 2014 (Azevedo-Ramos et al., 2020; Brito and Barreto, 2020). If approved, it would allow an amnesty for crimes of public land invasion practiced between December 22, 2011, and December 10, 2018 (Brito, 2020).

In Ituna/Itatá, all CAR declared areas were registered between November 17, 2015, and February 4, 2020. 82% of them would benefit from this amnesty, rendering the IL

unviable by the action of land grabbers who registered these areas on the CAR database platform. The Brazilian House of Representatives did not vote in favor of this Provisional Measure. It was proposed as the bill 2633/2020 (Brazil, 2020) in May 2020, maintaining land tenure regularization for those who occupied the land before 2008. However, extending property size from 4 to 6 fiscal modules without inspection prior to obtaining land title and without reinforcing inspection measures increasing the risk of holding public areas under conflict or with other priority regularization demands, such as territories not yet recognized by traditional communities (Brito, 2020). According to this regulation, the CAR registry is one of the most important documents required from the alleged owner to regularize occupied land. The land occupier is responsible for informing the extent and limits of his property. The National Congress needs to approve it so that it becomes a law yet; land grabbers in Ituna/Itatá expect its approval by the end of the IL interdiction, even after FUNAI demarcation Ordinance n. 38 (FUNAI, 2011) was extended for three years (FUNAI, 2019). Although the BFG considers the 2633/2020 bill an advance, titling not integrated with other policies will not yield environmental benefits (Probst et al., 2020). Furthermore, it may bring negative economic impacts to the country since Brazilian commodities are threatened by international market sanctions if non-environmental planned measures are approved (Harris, 2020).

Other land regularization bills are under analysis, without defined promulgation. The Normative Instruction n. 09/2020 seeks to determine the exclusion of all ILs that are not in the last stage of state recognition of the national Land Management System (SIGEF) database, making these territories invisible (FUNAI, 2020). The Normative Instruction n. 01/2021 aims to establish procedures to be adopted during the environmental licensing process for projects or activities located or developed within ILs (FUNAI and IBAMA, 2021). This act seeks to institutionalize rural leasing in ILs, which violates the constitutional clause of the reserve for

the exclusive use of natural resources existing in ILs by indigenous peoples. Bill 510 (Brazil, 2021) aims to postpone the so-called timeframe for land legalization, from December 2011 to December 2014. Moreover, it allows large areas (up to 2,500 hectares) to be titled without inspection. Recently approved in the Senate, Bill 4,348, which will once again be considered by the House of Representatives (Brazil, 2019d), expands the possibility of applying rules to land tenure regularization of public lands.

If approved, such rules will ease the criteria for privatizing public lands that have been illegally deforested (Brito, 2021), violating Brazilian's constitutional rights to an ecologically balanced environment, posing a serious threat to all Amazonian ILs and to indigenous peoples, and directly impacting the demarcation process of Ituna/Itatá. A recent report produced by the NGO OPI (Observatory for the Human Rights of Isolated and Recent contact Indigenous Peoples) reveals that FUNAI, after protests by local political leaders and the imminent approval of bills (OPI, 2020), has been working on the possibility of halving the area. The reduction would represent a crime according to the Rome Statute of the International Criminal Court, made law in Brazil by presidential decree in 2002, since it would represent intentional subjection to living conditions, such as deprivation of access to food or medicine (OPI, 2020).

4.3.2 Threats from the Volta Grande Gold Project

Besides land grabbing practices, the state of Pará concentrates diverse mining activities, and resource exploitation plans in the Amazon, mostly inside ILs, have increasingly been supported by the BFG's rhetoric (Araújo and Vieira, 2019; Diele-Viegas and Rocha, 2020; Pereira et al., 2020). Another regulation proposed by the BFG, bill 191/2020, can benefit deforestation drivers if approved, as it regularizes mining activities in ILs. Rorato et al. (2020) evaluated the impact of this new proposed mining regulation. They considered all mining license requests registered with Brazil's National Mining Agency that overlap with

ILs. The authors noted that the existing mining requests cover 176,000 km² of ILs, equivalent to 3,000 times more than the current illegal mining area.

Mining pollutes rivers with mercury and silt, erodes riverbanks, clears trees, and creates large pools of stagnant water — a breeding ground for mosquitoes (The Lancet, 2019). In the Brazilian Amazon rainforest, mining activities drive deforestation far beyond operational mining sites, yet the full extent of these impacts can be immeasurable during environmental licensing (Sonter et al., 2017). Therefore, the advance of mechanisms for legitimizing mining activities surrounding and within ILs is one of the most threatening issues which could lead to irreversible consequences for the environment and for the indigenous peoples of this region (Abessa et al., 2019; Diele-Viegas and Rocha, 2020; Rorato et al., 2020). Therefore, the so-called Volta Grande Gold Project in Altamira can produce environmental and social impacts similar to those caused by the Belo Monte dam (Bratman and Dias, 2018; Emerman, 2020). Located between Belo Monte and Ituna/Itatá, this mining field, led by the Canadian company Belo Sun Mining Corporation, potentially attracts workers and land grabbers to the boundary and to the interior of Ituna/Itatá and neighboring ILs (Tófoli et al., 2017; Bratman and Dias, 2018; Diele-Viegas and Rocha, 2020).

The licensing process was interrupted in 2019 due to problems in public land acquisition, removal of the local population, and flaws in assessing impacts on indigenous peoples (Tófoli et al., 2017). However, the Belo Sun company submitted a report to FUNAI, approved in November 2020, regarding the impacts of the mining project implementation on the indigenous peoples. The Company will now present a study complying with health and safety protocols to the indigenous peoples. The complete process will then be filed with the Federal Court of Brasilia (Belo Sun Mining Corporation, 2020).

The possibility of legalization and the company's expansion plans have already caused a boom in the local land market (Bratman and Dias, 2018). The expectation of substantial

compensation at the time of the project implementation led many local actors to occupy and deforest large areas in this region. Similar to what occurs within Ituna/Itatá, the occupation strategy includes using the CAR to legitimize recent occupations and claim compensations (Araújo and Vieira, 2019). The mining project foresees the construction of a tailings dam classified as a high disruption risk (Emerman, 2020). Additionally, the cyanide and mercury – traditionally used in gold mining (Zolnikov and Ortiz, 2018) – may affect local biodiversity, water quality, and environmental/human health which has already taken place in other Amazonian sites (Asner and Tupayachi, 2016; Tófoli et al., 2017). Both disruption and biodiversity degradation would severely affect the entire region (Fitzgerald et al., 2018). Furthermore, the relatively short distance to Ituna/Itatá (less than 50 km) exposes the Igarapé Ipiaçava indigenous people to elevated health risks because of their low immunity (Coimbra et al., 2013; Walker et al., 2016; Ellwanger et al., 2020). Mine workers and land grabbers can transmit diseases like malaria and hantavirus (MacDonald and Mordecai, 2019; Souza et al., 2019; Terças-Trettel et al., 2019; The Lancet, 2019). This condition also affects peoples of neighboring ILs, such as Koatinemo, Paquiçamba, and Trincheira/Bacajá.

4.4 Consequences for indigenous peoples

The role of tropical forests is crucial for environmental sustainability and for the future of our planet, owing to their remarkable carbon storage capacity as well as their ecological services (Antonelli et al., 2018). In this process, ILs are fundamental as a refuge for biodiversity, protecting 36% of the world's intact forest landscapes and being essential to mitigate climate change impacts (Fa et al., 2020). The indigenous peoples' knowledge, culture, and practices are also contributing factors (Begotti and Peres, 2020; Walker et al., 2020; FAO and FILAC, 2021). In Brazil, since the 1990s, the traditional peoples of the Amazon, including indigenous peoples, whose subsistence historically depends on non-timber forest products (e.g., rubber-tappers), have recognized collective land rights on a portion of their ancestral territories (Tritsch and Arvor, 2016). Specifically, they have the Constitutional

right to remain isolated and the original right to the lands they traditionally occupy (Art. 231, Federal Constitution) (Brazil, 1988). Nevertheless, the situation in Ituna/Itatá shows that, even though it is located in a region that is considered the cradle of the Xingu indigenous ethnic groups (Tófoli et al., 2017), the forest and the indigenous peoples are not being protected. The alarming deforestation rate increase and the expectation of grabbed land legitimization within this area can bring about serious consequences for other ILs, especially for those which already face this problem at a minor scale, such as Apyterewa and Cachoeira Seca. In these two ILs, deforestation increased by 334.78% (from 1,961 ha to 8,526 ha) and 13% (from 5,423 ha to 6,128 ha), between 2018 to 2019, respectively, indicating ineffective actions to combat illegal deforestation in the Xingu River basin, a region with rich and unique biodiversity and a *sui generis* number of ethnic groups (Bratman and Dias, 2018; de Oliveira et al., 2020a, 2020b).

Scientists recommend that the BFG stop road paving, mining regularization, and incentive to agropastoral projects without consulting indigenous peoples in the Brazilian Amazon rainforest. However, rather than addressing deforestation with scientific and sustainable solutions, the BFG tends to favor agribusiness and mining interests (Artaxo, 2019; Rajão et al., 2020), even within ILs, aiming to incorporate them into market practices and opposing the Constitutional right (Art. 231, Federal Constitution) (Brazil, 1988). Moreover, the unprecedented deforestation in Ituna/Itatá may already be causing environmental and health damages to the Igarapé Ipiaçava indigenous people. Possibly, the deforestation clearing within this IL has been occurring with the use of fire, which is widely explored in the Amazonian deforestation process (Davidson et al., 2012; Barlow et al., 2019). The increasing deforestation in Ituna/Itatá has significantly intensified fire emissions in the IL (Figure 8).

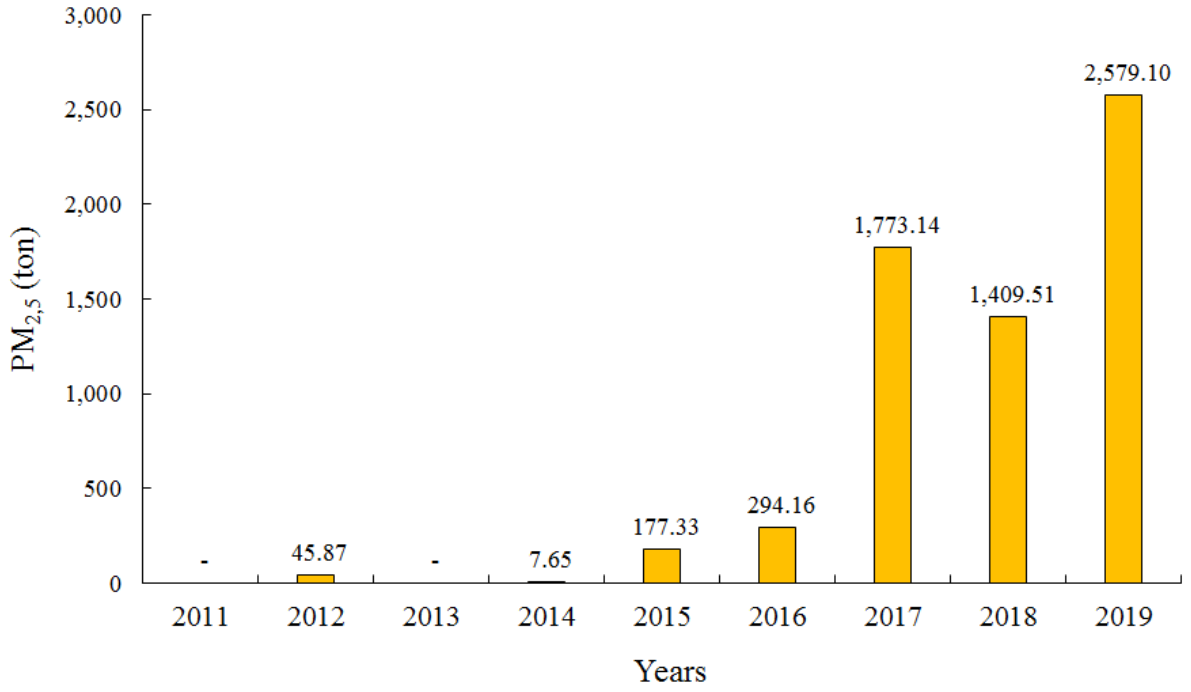

Figure 8. Annual estimates of fine particulate matter ($PM_{2.5}$) associated with fires in the Ituna/Itatá IL.

From 2002 to 2010, the area corresponding to this IL presented an annual average emission of 1.16 ton $year^{-1}$ $PM_{2.5}$ associated with fires. However, considering the period between 2011 – the year of the beginning of the Ituna/Itatá demarcation process declared in the FUNAI's Ordinance n. 38 (FUNAI, 2011) – and 2019, the annual average has increased to 698.53 ton $year^{-1}$. The years 2018-2019, when the deforestation boom occurred, had an average annual emission of 1,994.30 ton $year^{-1}$ of $PM_{2.5}$ associated with fires, that is, an average 285% higher than that found for the 2011-2019 period and higher than 1719% compared with the period of 2002-2010, changing the local air quality and microclimate. Particulate matter emitted from the biomass burning in the Amazon region exposes humans to an increased risk of DNA damage, gene mutations, inflammation, and cancer (de Oliveira Alves et al., 2017; de Oliveira Galvão et al., 2018). Unlike Yanomamis and Pataxós, for example, who have had contact with settlers and consolidated exploitation production modes, indigenous people like the Igarapé Ipiaçava live in voluntary isolationism and are more vulnerable to forest loss and climate changes (The Lancet, 2019). As deforestation occurs,

chances of maintaining the protection status decrease, because FUNAI must find signs of isolated indigenous people still living there to renew the area restriction.

Moreover, in the Brazilian Amazon dry period (from July to October) (Friedman et al., 2021), the smoke from fires that have even reached cities located thousands of kilometers away (Human Rights Watch, 2019; The Economist, 2019) may increase and aggravate respiratory problems (Alencar et al., 2020a; de Oliveira et al., 2020c). In 2019, the incidence of respiratory diseases in the southern portion of the Amazon region substantially increased (Barcellos et al., 2019). August 2019 was a devastating month regarding fires in the Brazilian Amazon when INPE Fire Monitoring Program (INPE, 2020a) reference satellite/sensor (AQUA/MODIS) detected 32,127 active fires, an estimate 61.60% higher than the average for this month during the 2011-2018 period (Figure 9).

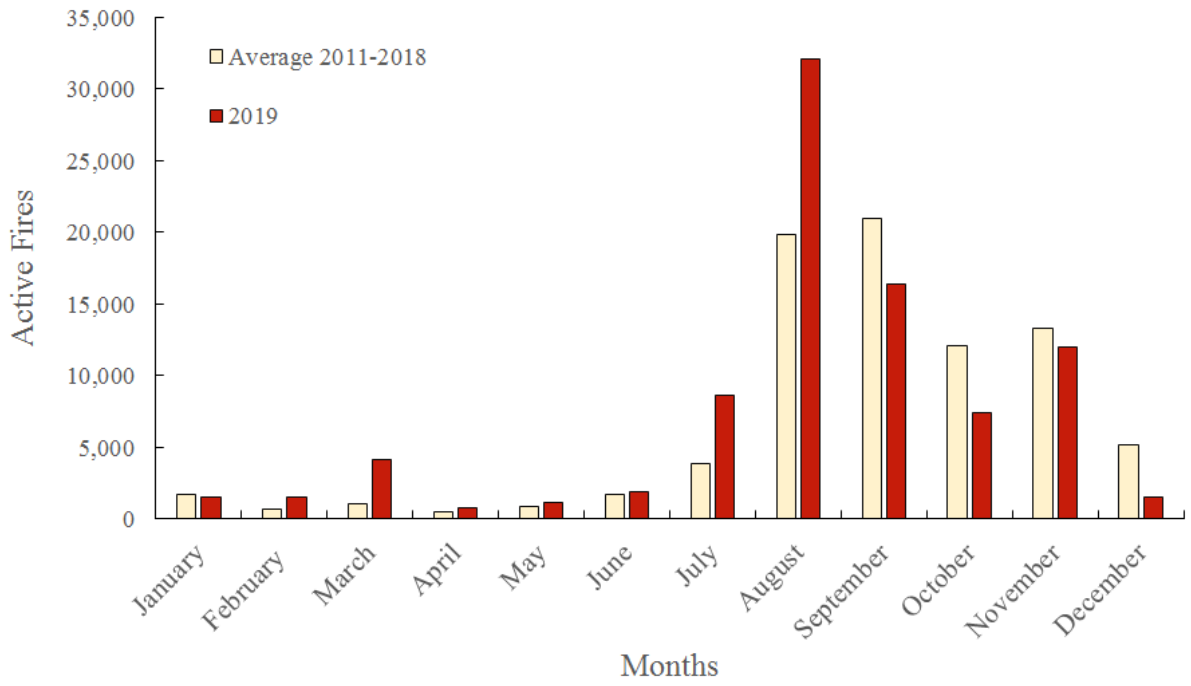

Figure 9. Active fires in the Brazilian Amazon rainforest considering the 2011-2018 monthly average and the total registered in 2019' months.

DETER alerts, MODIS fire products, and precipitation data from Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) evidence the clearing of many trees in the Amazon between 2019 and the first trimester of 2020 that had not been burned, especially

in the state of Pará (Alencar et al., 2020a). This results in an inflammable material that, if burned for land use, may cause emissions and smoke problems greater than those in 2019. This agrees with Kelley et al. (2020), who found a low meteorological influence in the 2019 Amazon rainforest fires and concluded that LULCC or land management were the most probable drivers of such significant increase in the burned area during the early fire of 2019. Besides, it may also explain the higher number of active fires during the rainy season months and the beginning of the dry season of 2019 compared to those of the 2011-2018 period. A recent investigation concluded that 71% of fires in rural properties located in the Brazilian Amazon during 2020 were ignited for land management (Alencar et al., 2020b). This demonstrates how fire is still widely used as a tool for managing pasture and agricultural areas, regardless of the size of the property or lot, the targeting market, as well as the existence of more modern techniques for land management (Alencar et al., 2020b). This scenario shows that land tenure policies should not be unilateral, to avoid the emergence of new deforestation hotspots (Mataveli et al., 2021).

Currently, this situation has been exacerbated due to the COVID-19 pandemic (Zavaleta, 2020; Fellows et al., 2021). Indigenous people, under growing external pressure, are endangered and threatened with extinction, as they have been unable to sustain their lifestyle (CLACSO, 2020). Dozens of ethnic groups have been extinct due to similar factors in the Amazon rainforest (Walker et al., 2016). The Northern region of Brazil is the most affected in the country, registering records of confirmed cases (Ministry of Health, 2020). The virus has already spread and caused deaths in ILs (Amigo, 2020; Kaplan et al., 2020; Socioambiental Institute, 2020) which have no adequate BFG assistance (CLACSO, 2020; Fellows et al., 2021). The Yanomami IL is the most striking example of the environmental and health crisis derived from mining, where the largest group of South American indigenous people that remains isolated from the outside world live. Gold mining covers about 1,000 ha,

destroying the Uraricoera and Mucajaí rivers, trees, and local habitats, with the use of high concentrations of mercury (Hernandez, 2020). Miners' presence has brought COVID-19 to Indigenous People, causing deaths and an alarming number of confirmed cases (Socioambiental Institute, 2020; Fellows et al., 2021).

Conclusion

The cycle of deforestation, degradation, and land use conversion within the Ituna/Itatá IL between 2018 and 2019 threatens the Igarapé Ipiaçava isolated indigenous people. The normalized deforestation rates per area were higher within this IL than in Altamira, Pará, and in the entire Brazilian Legal Amazon. The deforested areas were converted mainly to herbaceous (5,310 ha) and shrub pasturelands (4,737 ha), aiming to consolidate rural use.

The staggering number of 229 illegal CAR registries and 471 DETER alerts demonstrate that land grabbers accelerate deforestation and mischaracterize Ituna/Itatá to avoid its legal demarcation. Another evidence is the emergence of a village and an unofficial road network connected to nearby official ones, indicating axes of expansion and facilitating the logistics for deforestation and timber flow. Possibly, this deforestation clearing has been attributed to burnings, as corroborated by the exponential increase in the annual average emission of $PM_{2.5}$ associated with fires, which reached 698.53 ton $year^{-1}$ between 2011 and 2019, and 1,994.30 ton $year^{-1}$ in 2018-2019, amid the deforestation boom.

Our results show how land grabbing is articulated and oriented to consolidate possession over the territory and how the process may already be causing environmental and health damages to the Igarapé Ipiaçava indigenous people. A situation justified by BFG rhetoric and mediated by regional politics, as proven by the environmental regulatory framework dismantling which results in the contrast between the deforestation/degradation alerts and the total number of infractions and embargoes during this period.

This situation demands urgent actions to make Ituna/Itatá less vulnerable. The conclusion of its demarcation process, which has persisted since 2011, is essential. The delay is exposing the IL to illegal occupation and stimulating property rights conflicts. It is also essential the nullification of all CAR registries within the IL, the prosecution of the responsible for this land grabbing scheme, and the creation of a buffer zone to prevent effects from the installation of high-impact enterprises. Moreover, political willingness is essential to carry out full inspections, with compatible staff and public investment, as well as engagement of all competent bodies and effective operational strategies. Protecting Ituna/Itatá and ensuring the Igarapé Ipiaçava rights may signal a change of mind in the way Brazil acts towards ILs and ethnocultural integrity, honoring the commitments on climate change and biodiversity protection.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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