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Payments for Environmental Services and environmental regularization: analysis of rural properties in southern Amazonas for the Floresta+ Amazônia Project

Pagamentos por Serviços Ambientais e regularização ambiental: análise de propriedades rurais no sul do Amazonas para o Projeto Floresta+ Amazônia

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Abstract
With global temperatures rising and deforestation advancing in the Amazon, viable strategies such as Payment for Environmental Services (PES) are essential for climate change. We analyzed the environmental situation of rural properties in the southern region of Amazonas (Apuí, Borba, Boca do Acre, Canutama, Humaitá, Lábrea, Manicoré, Novo Aripuanã, Pauini and Tapauá) during 2020 and 2021. We consulted the Rural Environmental Registry System (SICAR) platform to identify properties with surplus native vegetation in Legal Reserve (RL) areas and areas with altered vegetation cover in Permanent Preservation Areas (APP). Of the 77 rural properties, 50 did not meet the requirements of the Forest + Conservation and Forest + Recovery modalities due to irregularities in registration or ownership. In the Forest+ Conservation modality, 11 had a surplus RL area, totaling 92 hectares conserved, while 16, classified in the Forest+ Recovery modality, had changes to the APP, totaling 84 hectares to be recovered. There is a need to improve SICAR's verification mechanisms for the inconsistencies declared by landowners. The intense agricultural, livestock and extractive activities in the region reinforce the importance of monitoring to combat deforestation. The Floresta+ Amazônia Project is an initiative to regularize rural properties and conserve biodiversity in the region.

Keyword: SICAR, degraded areas, Amazon rainforest

Resumo
Com aumento global da temperatura e do avanço do desmatamento na Amazônia, estratégias viáveis como o Pagamento por Serviços Ambientais (PSA) são essenciais na mudança do clima. Analisamos a situação ambiental das propriedades rurais da região sul do Amazonas (Apuí, Borba, Boca do Acre, Canutama, Humaitá, Lábrea, Manicoré, Novo Aripuanã, Pauini e Tapauá) durante os anos de 2020 e 2021. Consultamos à plataforma do Sistema de Cadastro Ambiental Rural (SICAR) para identificar propriedades com excedente de vegetação nativa em áreas de Reserva Legal (RL) e áreas com alteração de cobertura vegetal em Áreas de Preservação Permanente (APP). Das 77 propriedades rurais, 50 não atendiam aos requisitos das modalidades Floresta+ Conservação e

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Floresta+ Recuperação devido a irregularidades no registro ou na propriedade. Na modalidade Floresta+ Conservação, 11 apresentaram excedente de área de RL, totalizando 92 hectares conservados, enquanto 16, classificadas na modalidade Floresta+ Recuperação, apresentaram alterações de APP, totalizando 84 hectares a serem recuperados. Evidenciamos a necessidade de aprimoramento dos mecanismos de verificação do SICAR, as inconsistências declaradas pelos proprietários. As intensas atividades agrícolas, pecuárias e extrativistas na região reforçam a importância da fiscalização para combater o desmatamento. O Projeto Floresta+ Amazônia surge como uma iniciativa para a regularização de propriedades rurais, para a conservação da biodiversidade na região.

Palavra-chave: SICAR, áreas degradadas, Floresta Amazônica

1. Introduction

The global climate change has led to an increase in extreme events worldwide, such as a significant rise in average temperatures, periods of intense rainfall and devastating floods, prolonged droughts severely impacting ecosystems and communities, and a range of other extreme climatic phenomena (Covey et al., 2021; Silva et al., 2023). This scenario poses a significant challenge to the resilience and adaptation of societies to climate change, demanding the urgent implementation of effective strategies and policies to mitigate negative impacts and promote environmental sustainability (Ferrante & Fearnside, 2021; Fremout et al., 2022; Silva et al., 2023).

The global temperature increase is considered the most significant environmental concern for the coming decades. Therefore, the climate change situation poses a challenge in addressing illegal deforestation (Fearnside, 1996; Reisch, 2021), a challenge imposed not only on the government but also on Brazilian society, encompassing the international community due to the contribution of reducing deforestation and degradation of tropical forests to global warming (Fearnside, 2000; Barni *et al*., 2021). In addition, extreme events have increased even more in recent years, for example, the Amazon droughts of 2015-2017, which were exacerbated by the El Niño event, as well as the recent changing in the process precipitation in southern tropical Amazon forest (Segura et al., 2020), may reduce forest net primary productivity by increasing mortality of canopy trees, thereby altering both the short-term and long-term forest carbon balance (Leitold et al., 2018).

In the face of these circumstances, viable alternatives such as Payment for Environmental Services (PES) emerge to contribute to climate change mitigation. PES has become an excellent alternative and solution for incentivizing preservation and protection activities (Lopes, 2017; Viguera et al., 2024; Huang et al., 2024). Among these activities, the Reduction of Greenhouse Gas Emissions from Deforestation and Forest Degradation (REDD+) promotes the transition from a predatory exploitation economy to a low-carbon economy.

The Forest+ Amazonia Project arises from the national PES policy as a form of recognition for the environmental services provided by small farmers, indigenous peoples, and traditional communities, allowing them to maintain, manage, and restore their territories in the Legal Amazon. Through the received economic incentives, it also contributes to innovation in the forestry sector (UNDP, 2020). In this context,

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environmental institutions' concern about compliance with environmental legislation is growing.

The national legislation contains, among the main instruments to ensure forest conservation, the Permanent Preservation Area (PPA) and the Legal Reserve (LR). Both aim to maintain and preserve natural resources covered by preserved native vegetation or recovered by rural property owners, and these are conditions for participation in the Project. In the Rural Environmental Registry System (SICAR), the declared LR may be in a situation such as "proposed," "registered," "approved and not registered," or "linked to the compensation of another property" (IDESAM, 2016).

The Forest+ Amazonia Project uses information from rural properties presented through the Rural Environmental Cadastre (CAR, in Portuguese) to demonstrate compliance with the legislation, allowing the verification of forest liabilities and assets. CAR is an environmental management tool created based on the New Forest Code Law No. 12,651 published in 2012 for the electronic registration of georeferenced information (Brasil, 2012).

Given this, the new legislation exposed the need to identify and characterize rural properties, making it extremely important to diagnose environmental irregularities and regularities, proposing methodologies suitable for reality (Souza, 2019). In terms of regularization, farmer participation is essential to restore forest environments, a necessary action of the legal instrument to facilitate the adoption of more environmentally sustainable practices.

In this context, the primary objective of this research is to analyze information from the Rural Environmental Cadastre (CAR) of rural property owners who sought licensing through rural technical assistance. The analyses cover a database for the years 2020 and 2021, especially focused on Legal Reserve (LR), Permanent Preservation Areas (PPAs), and remnants of native vegetation, also regulated by the Law No. 12,651/2012. The obtained results aim to provide subsidies for the qualification of beneficiaries in accessing the Forest+ Amazonia Project.

2. Materials and Methods

2.1 Data and study area

The study was based on the southern region of the state of Amazonas, a territory comprising 10 municipalities, formed by the cities of Apuí, Boca do Acre, Borba, Canutama, Humaitá, Lábrea, Manicoré, Novo Aripuanã, Pauini, and Tapauá (Figure 1). The region has an area of approximately 392,210.00 km², representing about 25% of the total state area (Silva & Pereira, 2005). The precipitation of the southern mesoregion of Amazonas can vary from 37 to 88 mm in the dry season and from 190 to 292 mm in the wet season. The temperature ranged from 25°C to 28°C in the wet season, and in the dry season from 31°C to 32°C (Souza et al.,2022). The classification of each municipality climate according to Thornthwaite and Matter is characterized in Table 1 (Martins et al., 2019).

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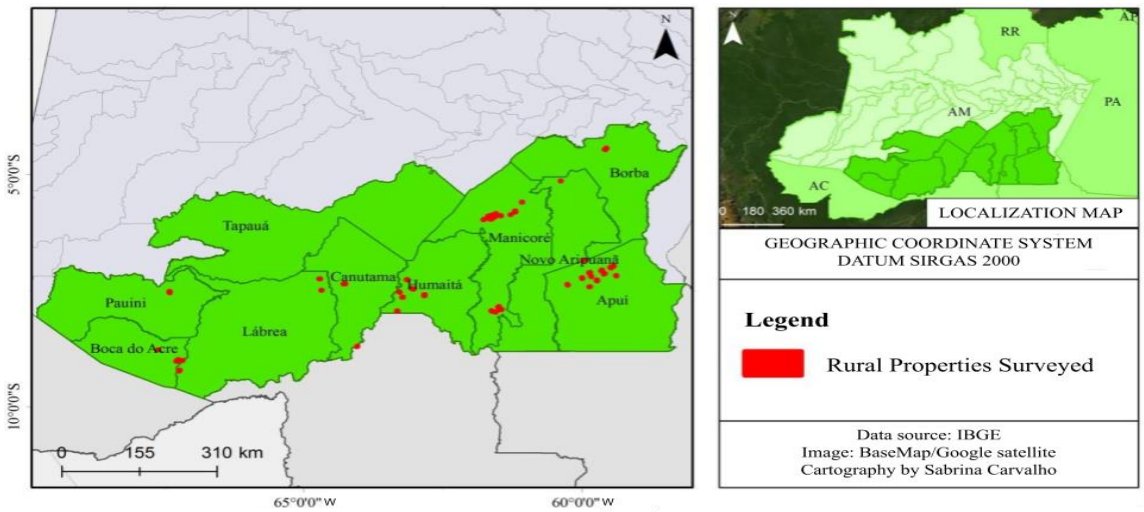
Table 1. Municipalities, geographical coordinates, Thornthwaite and Matter climatic classification, precipitation (mm) and annual average air temperature (ºC) according to the Climatological Normal (CN) of each municipality in the southern mesoregion of Amazonas.

Municipalities	Geographical Coordinates	Climate	Precipitation	Temperature
Apuí	07º 11’ S, 59º 53’ W, 135m	B2rB’4a’	1589,0	25,8
Boca de Acre	08º 45’ S, 67º 23’ W, 116m	B3WA’a	2078,3	25,9
Canutama		N.a	N.a	N.a
Humaitá	06° 32’ S, 64° 22’ W, 55m	B4WA’a	2079,9	26,4
Lábrea		B2WA’a	2099,8	26,4
Manicoré	07º 30’ S, 63º 01’ W, 58m	AWA’a’	2946,2	26,5
Novo Aripuaña		N.a	N.a	N.a
	07º 15’ S, 64º 47’ W, 75m			
	05° 48’ S, 61° 18’W, 45m			
	05° 07’S, 60° 22’ W, 20m			

Source: Souza et al. (2022). N.a: Not available.

Figure 1. Study Area Location: Southern Region Amazonas State



Source: the authors.

In the environmental context, two forest typologies stand out: the dense ombrophilous forest, characterized by trees between 40 and 50 meters in height, surrounded by shrubs, with wet or waterlogged areas, and the open ombrophilous forest, characterized by palms, bamboo, and lianas, forming a kind of border with the vegetation of the Brazilian Midwest (Magnusson et al., 2016).

The definition of the study area took into account deforestation as well as a large amount of information regarding land use and occupation. The data investigated based on

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CAR declarations included specific details characterizing properties according to their location.

To build the database, the Forest+ Conservation and Forest+ Recovery modalities were selected, with the criterion being active rural property owners. Therefore, the data for the research foundation were provided by the Geoprocessing Unit (NUCGEO) of the Institute of Agricultural, Forestry, and Sustainable Development of the State of Amazonas (IDAM). The data corresponded to the years 2020 and 2021, referring to the preliminary CAR database of properties up to 04 (four) fiscal modules, and where family farmers and rural producers had electronic registration for access to rural credit. A total of 800 documents were analyzed, classified into situations such as registered, rectified, and consulted. The classification observed properties with any pending and/or irregularities in the CAR, such as overlaps in agrarian reform settlements, conservation units, or other CAR registrations. Rectified properties needed adjustments to their declared environmental data, while registered properties were the first entries to regularize the property's status in the CAR.

CAR information is publicly available in the SICAR (Rural Environmental Cadastre System) module, showing the property's perimeter, location of the headquarters, areas occupied by native vegetation, consolidated rural areas, fallow areas, areas of administrative servitude, PPAs, and LRs.

In the consultation of each property, using the CAR registration number, it was possible to view the CAR status, including whether it was active, suspended, or pending, the size in hectares, and any restrictions on the property, such as embargoed areas or overlaps with other properties. The overlap with other records makes rectification impossible, so those classified as overlapped are only consulted. However, in cases without the CAR registration number, SICAR allowed the download of raw declared data.

In this research, only proposed LRs in the "not analyzed" situation were presented. Therefore, as a criterion for accessing the Project, it is necessary to have the LR approved. Thus, the surveyed rural properties become potential beneficiaries of the Project. The materials used for the analysis of the environmental situation were digital documents acquired in vector format through the SICAR portal, only from properties classified as "rectified" and "registered." The information consisted of georeferenced polygons of the declared areas.

From the individual analysis of rural properties, those with surplus native vegetation and altered areas in PPA were identified, facilitating the quantification of potential properties that met the requirements of the Forest+ Amazonia Project. For data processing, ArcGIS version 10.3, a licensed multiplatform Geographic Information System (GIS) tool, was used. Google Earth Pro version 7.3.2.5776 was also used, a program for three-dimensional visualization of the Earth built from a mosaic of satellite images and aerial images from various sources. In addition, QGIS version 3.16 - Hannover, an open-source, multiplatform GIS software offering functionalities for visualization, editing, and analysis of georeferenced data, was incorporated. Additionally, Microsoft Power Business Intelligence (BI) was employed.

For the environmental analysis of each property, only the categories "PPA," "Area_Property," "Legal_Reserve," and "Native_Vegetation" were considered relevant.

After uploading the files into the ArcGIS program, it was possible to perform visual analyses, layer organizations, and calculations regarding vegetation indices and their comparisons, as well as the storage of georeferenced information. Subsequently, the accuracy of the declared data concerning the actual existence of native vegetation within

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the defined boundaries in the current period was verified, and the LR declared correctly from July 2008 was examined. To analyze LR areas, the "date regulator" tool of the Google Earth Pro software was used to observe the declared area according to the law. To verify declared native vegetation, Sentinel-2 satellite images acquired from the SentinelHub plugin installed in the QGIS software were used. This plugin allows for the practical monitoring of changes in land cover. Thus, native vegetation was considered areas that had not been altered based on periodic visualization in the software used.

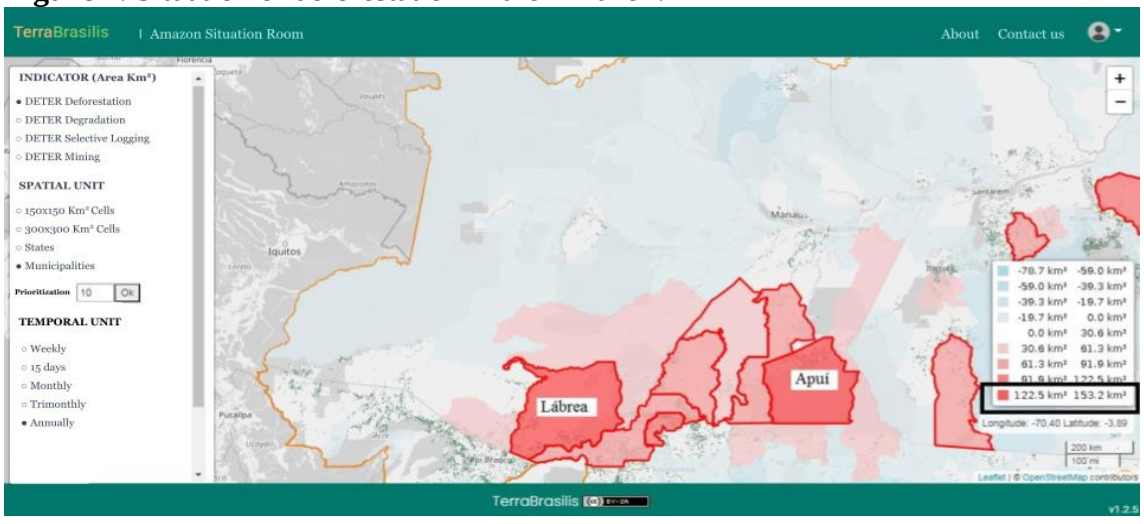
After applying the mentioned techniques, the data were systematized, demonstrating two situations for each modality of the Forest+ Amazonia Project, according to the study's objectives.

3. Results

The region belongs to the "deforestation arc", considered by the federal government as a critical area for preventing, combating, and controlling deforestation (Santos, 2010). It is also associated with the advance of the agricultural frontier due to access by highways that cover the municipalities in the region. The environmental impacts are linked to social, environmental, and economic factors, resulting in activities of varying degrees of impact.

The advancement of deforestation in the study area can be observed through data collected by General Coordination of Earth Observation (DETER-INPE). DETER is a rapid survey of alerts for evidence of changes in forest cover in the Amazon, conducted by National Institute for Space Research (INPE) to support monitoring and control of deforestation and forest degradation by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA) (INPE-DETER, 2021). Therefore, aggregating annual data up to the period of 2021 and focusing on the 10 municipalities in the deforestation filter in the Amazon, Figure 2 indicates, with shades of red, the municipalities in the southern state of Amazonas with the advance of deforested areas in km². Lábrea and Apuí stand out as municipalities in a critical situation regarding the size of deforested areas.

Figure 2. Situation of deforestation in the Amazon.



Source: TerraBrasilis (INPE-DETER), 2022.

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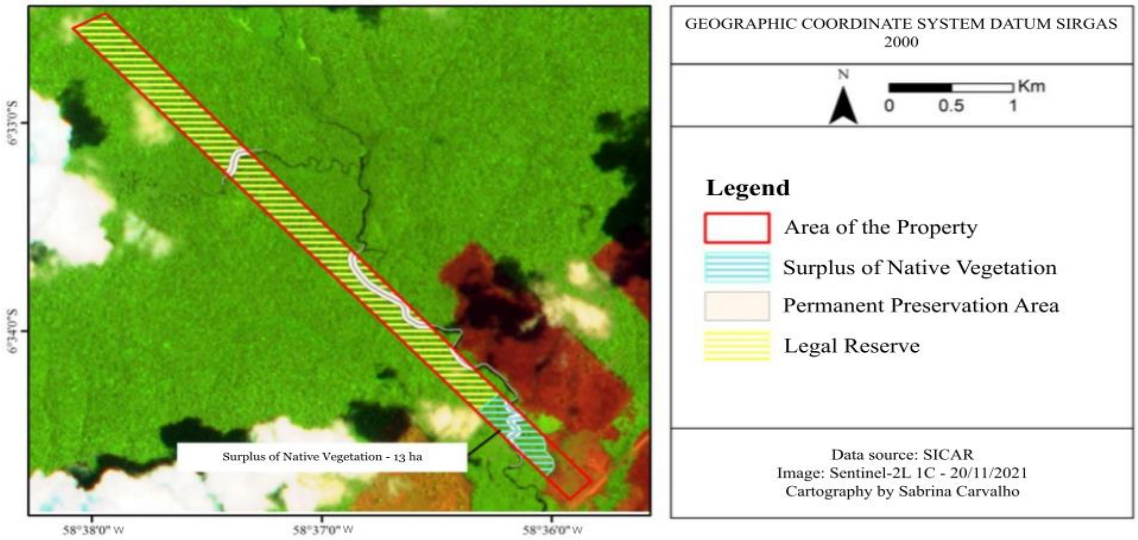
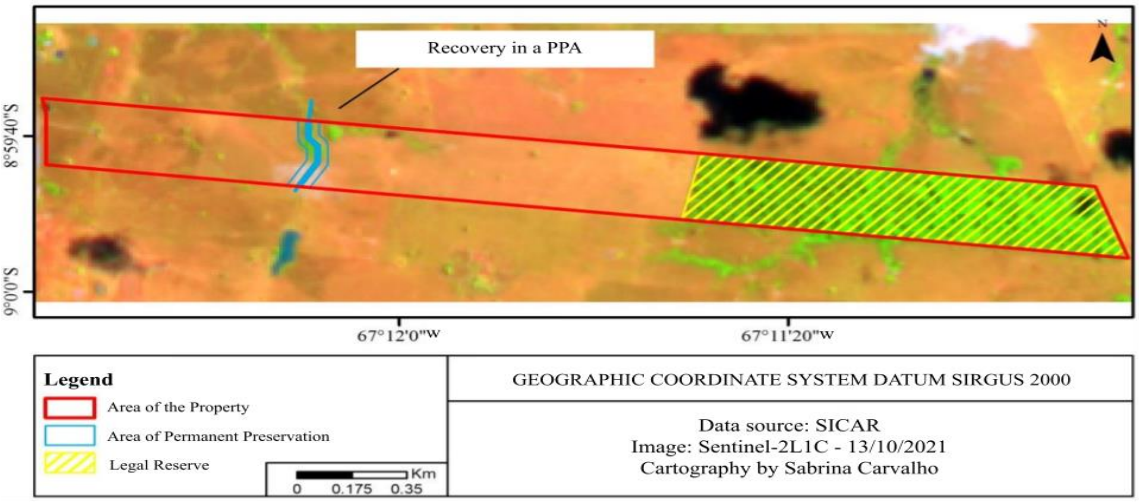
In the southern region of the Amazonas, located within the so-called "deforestation arc," 77 rural properties were identified in the database, whose owners requested licensing for obtaining rural credit in the years 2020 and 2021. The analysis of CAR resulted in the classification of 38 properties as "Consulted," 32 properties as "Rectified," and 7 properties as "Registered." Figure 3 is an example of a conserved rural property, with a focus on the Forest+ Conservation modality. Figure 4 exemplifies a rural property that had its area deforested in PPA and LR, thus with a perspective for the Forest+ Recovery modality.

Figure 3. Example of the analysis of a rural property located in the municipality of Apuí/AM with potential for the Forest+ Conservation modality.



Source: the authors.

Figure 4. Example of the analysis of a rural property located in the municipality of Boca do Acre/AM with potential for the Forest+ Recovery modality



Source: the authors.

Present the circumstances of rural properties and their status in CAR (Figure 6), making it possible to identify potential beneficiaries in the Forest+ Amazonia Project. A total of 24 private rural properties and 3 properties in settlements were identified as

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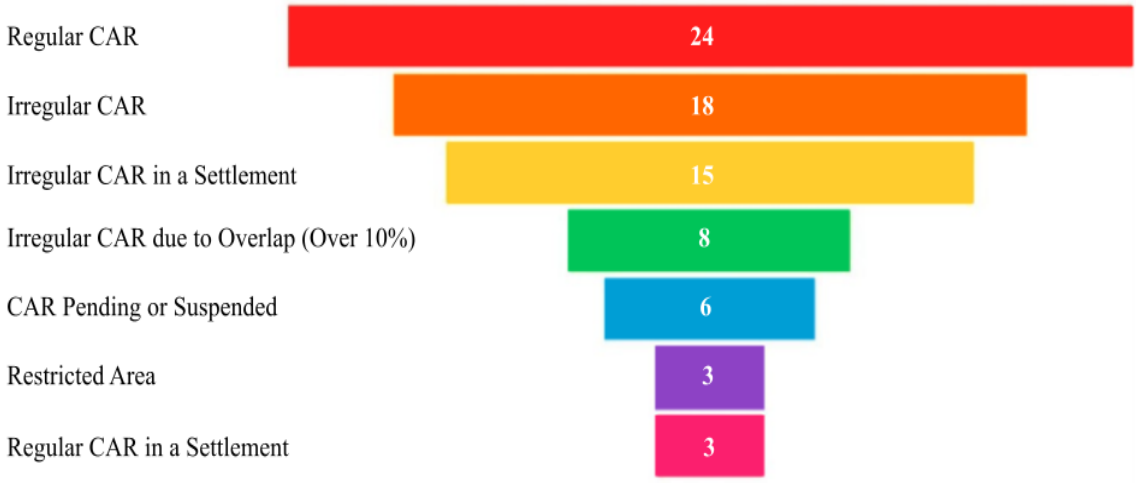
meeting the project's requirements. On the other hand, 18 private properties were found to be in irregular and/or unstable situations regarding declarations in SICAR.

However, the irregular rural properties showed changes in land cover in LR areas, categorizing them as an environmental liability for the owner. Consequently, this becomes a concerning factor given the increase in deforestation in the Amazon in 2021. Data generated by PRODES showed that in the Amazonas, between 2020 and 2021, there was a 55% variation in deforestation contribution (INPE-DETER, 2021). Regarding the data from this research, the municipalities that showed high changes in land cover were Apuí, Manicoré, and Boca do Acre.

In the SICAR platform, some registrations of rural properties analyzed by the environmental agency IPAAM in 2021 were in a "Pending" or "Suspended and Embargoed Area" situation (Figure 6), indicating that the process requires a review of the analysis(IPAAM, 2021). This situation arises from a judicial or administrative decision of the competent authority that deemed the declarations incorrect, notifying the owners of rural properties of their irregularities and deadlines to address them.

Figure 6. Conditions of CAR Analyzed, years 2020 and 2021.



Source: the authors.

This study highlights the number of overlaps detected between rural properties, specifically for "Irregular CAR in settlements" (15) and "Irregular CAR due to Overlap above 10%" (8), totaling 23 overlaps (Figure 6). One of the main reasons for these overlaps is that the SICAR system does not impose restrictions on the user in the property delimitation procedures. In other words, at the time of property registration, the system does not make any reference or consultation with the confronting registrations, allowing free registration (Dantas, 2020).

However, SICAR allows a tolerance of overlaps up to 0.1 ha (10%) for properties with up to 4 fiscal modules (FAEP, 2017), as they are considered insignificant in terms of influencing the results concerning the spatial reality of occupation. However, of the rural properties that showed overlaps above 10%, 15 rural properties are listed as 100% overlapping areas in agrarian reform settlements (Figure 7). This condition of irregularity hinders the follow-up of technical assistance via IDAM; therefore, the owner must

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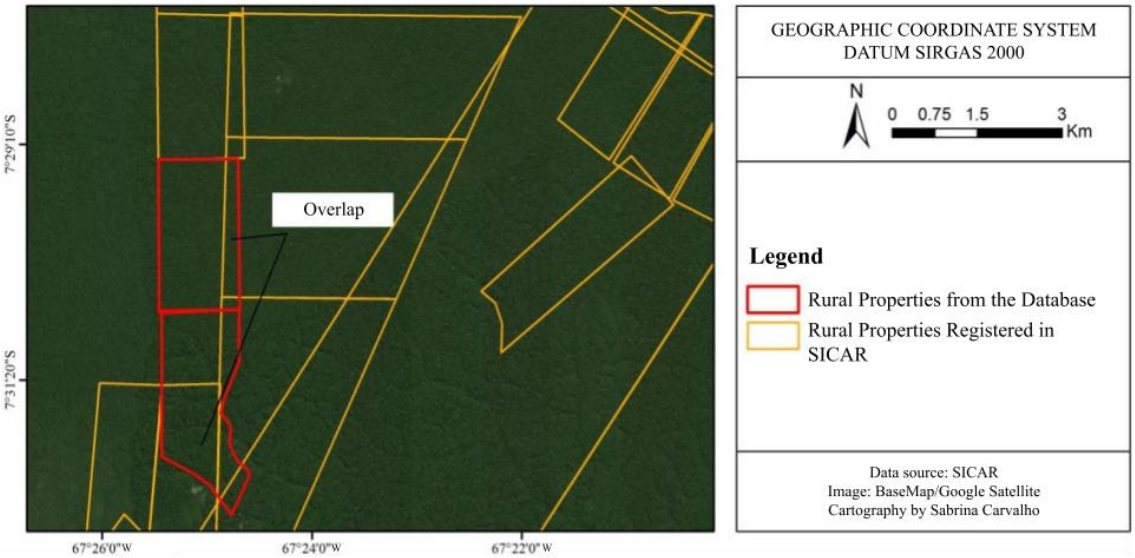
regularize their situation with INCRA and meet the requirements of the institution. For properties that had partial overlaps, the owners must submit land documents and address irregularities with IPAAM, through rural technical assistance provided by IDAM.

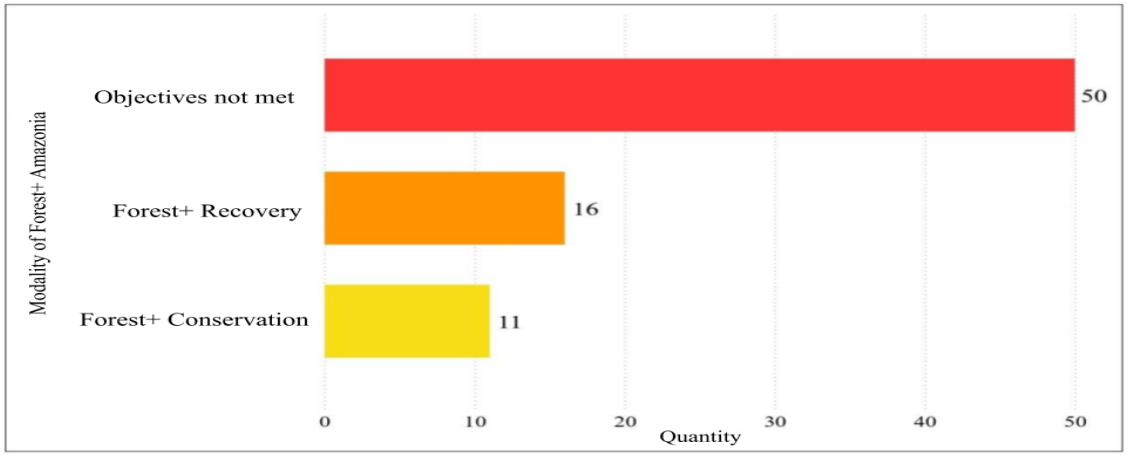
Figure 7. Overlap of two rural properties from the IDAM database with other records from SICAR.



Source: the authors.

In this study, 50 rural properties were identified with irregularities in their declarations, consequently not meeting the objectives of the Forest+ Amazonia Project. On the other hand, it was confirmed that 16 rural properties fit into the Forest+ Recovery modality, and 11 rural properties in the Forest+ Conservation modality. In this way, the owner can engage in the Project (Figure 8).

Figure 8. Situation of analyzed properties concerning the modalities of the Forest+ Amazonia Project.



Source: the authors.

Based on the data cross-referencing between IDAM and SICAR records, rural properties with environmental liabilities in PPA areas requiring recovery were observed.

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These areas are protected by law and are sensitive in terms of ecological aspects, soil protection, water resource protection, and overall biodiversity. In this study, rural properties indicating any irregularities regarding deforestation in PPAs reveal the degree of disturbance in these areas. Such deforestation in PPAs occurs nationwide; according to the Ministry of the Environment (MMA) in 2005, more than 40% of PPAs were degraded in seven states of Brazil (MMA, 2015), mostly occupied by agribusiness activities (Mendes, 2006).

Considering only rural properties that qualify for the Forest+ Amazonia Project, Table 2 presents the areas in hectares that each modality could address. Thus, of the total of 92 hectares, 11 rural properties had surplus conserved native vegetation, becoming important areas in the face of advancing deforestation in the region. Regarding the recovery of PPA areas, it was approximately 84 hectares of areas to be restored.

Table 2. Quantity of accumulated areas according to each modality of the Forest+ Amazonia Project.

Modalities	**Nº of Rural Properties**	**Area (ha)**
Forest+ Recovery	16	84
Forest+ Conservation	11	92

Source: the authors.

Therefore, Piasentin & Góis (2016) emphasize the importance of conserving forest remnants, as this contributes to the ecological integrity of biomes and enhances the connectivity of ecological corridors. In this regard, several Payments for Ecosystem Services (PES) mechanisms exist to encourage the maintenance, recovery, or improvement of ecosystems. In the state of Amazonas, some PES initiatives and instruments are already making progress in highlighting the importance of standing forests, benefiting numerous family farmers. For instance, the Bolsa Floresta Program incentivizes the conservation of carbon credits and currently benefits over 8,000 families living in Conservation Units in perfect condition (FAS, 2024).

Another notable initiative in the region is the Carbon Neutral Program, developed and monitored by the Institute for the Conservation and Sustainable Development of the Amazon (IDESAM). This program aims to develop strategies for reducing greenhouse gas emissions, compensating through the planting of Agroforestry Systems (AFS). By 2021, more than 45,000 m² had already been reforested, generating income for entrepreneurs (IDESAM, 2022).

4. Discussion

Activities related to valuing environmental services are crucial in this process, involving critical decisions regarding the natural environment. According to Félix & Fontgalland (2021), PES policies increase hope for gradually recovering environmental degradation and provide rewards to property owners who undertake the challenging task of preserving and conserving their forests.

Given that the benefits of PES indirectly and directly impact the entire population of the region, it can serve as a complementary mechanism to command-and-control

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instruments in environmental preservation and conservation, provided that environmental aspects are observed, and there is joint participation from public management and rural landowners (Wegner, 2016; Wunder et al., 2018; Fufu Liet al.,2022; Montero-De-Oliveira et al., 2023)

According to Oliveira & Altafin (2008), Brazil currently has good environmental legislation; however, many rural property owners did not respect PPA limits. This situation may be linked to the lack of information and understanding of environmental laws by property owners (Bley Jr *et al*., 2004), as well as the lack of enforcement on properties in the Amazon (Bonaudo, 2005).

As per the obtained result, the analysis of land use and occupation dynamics indicates intense use, characteristic of small rural producers in the region engaged in agricultural production, livestock farming, and extractivism. The local economy is driven by the presence of roads facilitating the flow of soy crops, livestock, and timber, dominant markets throughout southern Amazonas, with livestock being the most active activity (Reis & Leal, 2020).

The investment in the Forest+ Conservation modality becomes an ideal benefit compared to a scenario without the PES mechanism, as there is the possibility of negotiating surplus areas of Legal Reserve (LR) through compensation via Environmental Reserve Quota (ERQ). However, both mechanisms do not fit into a long-term scenario concerning environmental conservation. Gasparinetti & Vilela (2018) states that incorporating values into these ecosystem services calibrates both the ERQ and PES markets. Such initiatives can prevent legal deforestation through payment, generating economies of scale due to the operational complementarity of the mechanisms.

However, the forest conservation mechanism must take into account rural properties under some degree of deforestation pressure due to higher opportunity costs (agricultural profitability), making it more expensive to make a payment that can change the behavior of the owner in pressured areas.

According to Wunder (2006, 2007), if the opportunity cost of discouraged land use is higher than the incentivized land use, PES programs will not be sufficient compensation, showing limited efficiency. Therefore, viable alternatives for the owner, such as adopting agroforestry systems in PPA areas or enriching and introducing crops, are examples that would provide greater income stability over the years while meeting the initially established requirement, considering strategies according to the characteristics of each location (IDESAM, 2016).

The participation of property owners in the Forest+ Amazonia Project should generate long-term investment and income with the implementation of a PES scheme in the region. This will favor the producer, ensuring conditions for alternative land use, and significantly reducing deforestation (Greiner et al., 2013; Montero-De-Oliveira et al., 2023).

5. Conclusions

The Rural Environmental Registry (Cadastro Ambiental Rural - CAR) emerges as a fundamental tool for managing information on rural properties, enabling environmental, economic planning, and deforestation mitigation. However, the results obtained reveal inaccuracies in the information declared by some landowners, indicating the need for improvement in the verification mechanisms of the Rural Environmental Registry System (SICAR).

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This study identified rural properties that, although in regular CAR status, showed changes in Permanent Preservation Areas and Legal Reserves, contravening environmental legislation in the Amazon. The intensification of agricultural, livestock, and extractive activities in the southern region of the Amazon suggests intensive land use, highlighting the importance of monitoring and information dissemination for regularization purposes.

Furthermore, rural properties with surpluses of conserved native forests were identified, representing a positive contribution against deforestation in the region known as the "arc of deforestation" in the Amazon. Properties falling under the Forest+ Recovery and Forest+ Conservation modalities present opportunities for benefits to landowners, such as access to rural credits and other governmental and non-governmental initiatives, depending on their adherence.

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