v. 67, p. 1-25, Jan./Jun. 2026 http://doi.org/10.5380/dma.v67i.95400 e-ISSN 2176-9109

DMA Desenvolvimento e Meio Ambiente

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Challenges and opportunities for environmental regularization in southeastern Pará, Amazon, based on local actors' perception

Desafios e oportunidades para a regularização ambiental no sudeste do Pará, Amazônia, baseado na percepção de atores locais

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Article received on **May 6, 2024**

Final version accepted on **September 18, 2025**

Published on **April 16, 2026**

Abstract: Effective implementation of the Native Vegetation Protection Law is crucial for reconciling agricultural activities with environmental preservation. In this study, we analyzed the environmental compliance of 26,703 rural properties in 10 municipalities of the Itacaiúnas River Basin (BHRI, in Portuguese) located in southeastern Pará, and investigated the perceptions of 19 rural landowners and 46 environmental professionals regarding environmental regularization. By December 2021, the majority (99%) of the registrations analyzed in the BHRI had pending issues related to property registration in the Rural Environmental Registry (CAR). Only a small portion (1%), representing 107 analyzed registrations, was eligible to join the Rural Environmental Regularization Program (PRA). The results revealed that most properties eligible for PRA have not yet initiated the environmental regularization process (78%). Respondents demonstrated knowledge of CAR (84.2%) and recognized the importance of understanding environmental protection laws (94.7%). The identified challenges include high costs associated with environmental liability recovery, lack of economic incentives to motivate forest restoration, and low owner awareness of the PRA. The research also highlighted divergent perceptions among environmental professionals, emphasizing the importance of coordination between state and municipal agencies to support environmental regularization activities. The challenges identified in this study provide valuable recommendations for public policies aimed at scaling up forest restoration in Pará, Brazil. The main drivers of PRA adoption were economic advantages, such as access to rural credit and market demand for production commercialization. Recommendations include expanding financial incentives, facilitating credit access, investing in environmental awareness, decentralizing restoration actions, providing training for municipal technicians, promoting greater coordination between state and municipal agencies, and offering more effective communication channels for environmental regularization. These measures are essential for effectively achieving the conservation and environmental restoration goals in the state of Pará.

Keywords: forest code; private rural properties; deficit; environmental perception.

Resumo: A efetiva implementação da Lei de Proteção da Vegetação Nativa é fundamental para conciliar atividades agropecuárias com a preservação ambiental. Neste estudo, analisamos a conformidade ambiental de 26.703 propriedades rurais em 10 municípios da Bacia Hidrográfica do Rio Itacaiúnas (BHRI), localizada no sudeste do Pará, e investigamos as percepções de 19 proprietários rurais e 46 profissionais da área ambiental sobre a regularização ambiental. Até dezembro de 2021 a maioria (99%) dos cadastros analisados na BHRI apresentavam pendências relacionadas ao registro do imóvel no Cadastro Ambiental Rural (CAR). Apenas uma pequena parcela (1%), representando 107 cadastros analisados, está apta para aderir ao Programa de Regularização Ambiental (PRA). Os resultados revelaram que a maioria das propriedades aptas

ao PRA ainda não iniciaram o processo de regularização ambiental (78%). Os entrevistados demonstraram conhecimento sobre o CAR (84,2%) e reconheceram a importância das leis de proteção ambiental (94,7%). Os desafios identificados incluem altos custos para recuperação de passivos ambientais, falta de incentivos econômicos para motivar a recomposição florestal e baixo conhecimento dos proprietários sobre o PRA. A pesquisa também destacou percepções divergentes entre os profissionais da área ambiental, enfatizando a importância da articulação entre os órgãos estaduais e municipais para apoiar as atividades de regularização ambiental. Os desafios identificados neste estudo fornecem recomendações valiosas para políticas públicas visando aumentar a escala da recomposição florestal no Pará. Os principais motivadores para adesão ao PRA foram vantagens econômicas, como acesso a crédito rural e exigências do mercado para comercialização da produção. Recomendações incluem ampliação de incentivos financeiros, facilitação do acesso ao crédito, investimento em conscientização ambiental e descentralização das ações de restauração, capacitações para técnicos municipais, promover maior articulação entre órgãos estaduais e municipais, e disponibilizar meios de comunicação mais eficazes para a regularização ambiental. Estas medidas são essenciais para se alcançar efetivamente os objetivos de conservação e restauração ambiental no estado do Pará.

Palavras-chave: código florestal; propriedades rurais privadas; passivo; percepção ambiental.

1. Introduction

The Native Vegetation Protection Law (LPVN) *Lei nº 12.651*, 2012), also known as the Forest Code, was designed to strike a balance between agricultural production and the conservation of native vegetation. The LPVN establishes rules for the protection and restoration of native vegetation in public and private areas, introducing significant innovations through the establishment of important instruments for monitoring and environmental regularization of rural properties. Among these instruments, the Rural Environmental Registry (CAR) stands out, a mandatory public registry for all rural properties that integrates environmental information about the properties, including Permanent Preservation Areas (APP), Legal Reserves (RL), and consolidated areas. In addition, the law established the Environmental Regularization Program (PRA) and the Project for the Recovery of Degraded and Altered Areas (PRADA), which provide guidelines and restoration actions for private properties, aiming at their environmental regularization. However, it is important to note that the legislation reduced the obligation to recover areas illegally deforested before July 22, 2008, known as consolidated areas, which may limit the restoration of lost biodiversity ((Brancalion et al., 2016; Rodrigues & Matavelli, 2020).

According to Federal Decree No. 7,830/2012, environmental regularization occurs when vegetation maintenance and recovery activities are implemented in areas illegally degraded in APPs and RLs (*Decreto nº 7.830*, 2012). After registering their rural property in the CAR, producers who illegally deforested before July 22, 2008, can voluntarily join the PRA to inform the environmental agency of their vegetation restoration actions. By joining, producers can regularize their properties and suspend any proceedings resulting from the deforestation of these areas (*Instrução Normativa SEMAS nº 01*, 2020). Despite the advantages of joining the PRA, the effective regularization of environmental liabilities remains a distant reality and largely depends on the interest of rural producers and the incentives that

drive environmental regularization (Costa, 2020). In this paper, we refer to environmental liabilities as the deficit of native vegetation in APPs and RLs that needs to be regularized by law, according to the regularization alternatives defined in the LPVN. Environmental regularization on private lands is crucial, as 44% (375 million hectares) of Brazil's territory is covered by these lands, with 70% of this area represented by medium- and large-sized properties (Sparovek et al., 2019).

The implementation of the LPVN also plays a crucial role in Brazil's achievement of its climate goals (Chiavari & Lopes, 2015). During the 21st Conference of the Parties (COP21) of the UNFCCC, held in 2015 in France, Brazil made a commitment to reduce greenhouse gas emissions (Government of Brazil, 2015). The current goal is to reduce emissions by 48% by 2025, which is expected to be achieved through actions aimed at ending illegal deforestation and reforesting and restoring 12 million hectares of forests by 2030. However, the implementation of the LPVN remains a challenge, as even a decade after its publication, the law is still far from being effectively implemented in all Brazilian states (Lopes et al., 2024).

Pará has stood out as the most proactive Brazilian state in applying strategies to monitor vegetation liabilities on private properties, aligning the Forest Code with other environmental policies (Lopes et al., 2024). In 2021, Pará launched the Amazon Now State Plan (PEAA), which aims to promote actions to reduce deforestation and increase forest cover, with a goal of restoring 5.6 million hectares by 2030 (*Decreto nº 941*, 2020). It was also the first and only Brazilian state to publish its plan for restoring native vegetation in 2023, one of the key instruments for meeting the PEAA goal (Secretaria de Estado de Meio Ambiente e Sustentabilidade [SEMAS], 2023). Among the initiatives taken by the state are the increase in technical analysis teams, the adoption of automated CAR analysis tools, the adoption of remote sensing monitoring of high-resolution images, providing updated information and promoting online data transparency, as well as mechanisms to reduce overlap and cancel overlapping registrations (Lopes et al., 2024). However, even with these efforts, Pará remains one of the largest deforesters in the Amazon (Instituto Nacional de Pesquisas Espaciais [INPE], 2024) and has low adherence to the PRA by landowners, with scattered and small-scale restoration initiatives covering an area of only 110,000 hectares in the process of recovery (Lopes et al., 2024).

Knowledge about the motivations of landowners and rural producers to adopt conservation practices is essential to drive efforts to address environmental challenges (Thompson et al., 2015). As rural producers are primarily responsible for conservation decisions, understanding how they perceive the requirements of legislation and how their attitudes are shaped by these requirements is critical to the effectiveness of conservation policies (Celio et al., 2014; Pacheco et al., 2021). Studies on environmental perception provide valuable information for monitoring, evaluating, and adapting conser-

vation programs, as well as helping to identify the needs of those involved and optimize the strategies implemented (Bennett, 2016, Fernandes et al., 2025). According to Aronson et al. (2010), only 3% of studies on forest restoration analyze the perceptions of stakeholders regarding the benefits of ecosystem services and the effectiveness of restoration actions. For example, although several studies address the perceptions of rural producers on conservation practices and environmental policies (Pacheco et al., 2021), the integrated analysis of the different actors involved in implementing environmental regularization of environmental liabilities in the Amazon is limited.

The Itacaiúnas River Basin (BHRI), in southeastern Pará, exemplifies this challenge well, having lost 51% of its forests and generated an environmental liability of 328,000 hectares, which needs to be recovered where deforestation occurred Nunes et al., 2019a). This loss has negative impacts on the connectivity of ecological corridors, biodiversity, and the provision of ecosystem services for the region (Silva et al., 2025). This study is based on the premise that experiences and knowledge about environmental legislation can influence the perception of different groups regarding environmental regulation. The central questions of the study are:

(i) How have CAR and PRA adherence progressed in the study area?

(ii) What is the environmental liability of properties eligible for the PRA?

(iii) How do perceptions of the implementation of environmental regularization vary among rural landowners, environmental professionals, and technicians from the Pará State Secretariat for the Environment and Sustainability (SEMAS) in Pará, especially in relation to the benefits, challenges, and limitations of the CAR and PRA?

We expect rural landowners to focus more on economic issues and access to credit. On the other hand, environmental professionals, who have technical training, may have a more critical and scientific view of policy implementation, while SEMAS technicians may focus on the operational and structural limitations of the implementation process (Brancalion et al., 2016). Therefore, we observe significant differences in perceptions among these three groups, and these differences may be influenced by factors such as technical knowledge, previous experience with CAR and PRA, and direct involvement with public policies. This approach aimed not only to highlight ongoing efforts but also to identify challenges and opportunities to improve conservation and environmental recovery practices in the region.

2. Materials and methods

2.1. Study area

The study area comprises 10 municipalities that make up the Itacaiúnas River Basin (BHRI), located in the southeast of the state of Pará, covering

an area of approximately 41,300 km² (Figure 1). The municipalities analyzed were: Água Azul do Norte, Canaã dos Carajás, Curionópolis, Eldorado dos Carajás, Marabá, Parauapebas, Piçarra, São Geraldo do Araguaia, Sapucaia, and Xinguara (Figure 1). The total estimated population in the area is 714,230 people, with a total Gross Domestic Product (GDP) of R$ 49 billion (Instituto Brasileiro de Geografia e Estatística [IBGE], 2019), which represents 27.5% of the GDP of the state of Pará.

The predominant vegetation in the basin is tropical forest, with patches of ferruginous fields (savanna) in the higher areas, with much of the remaining vegetation located in conservation units and indigenous lands (Nunes et al., 2019a). The opening of the Trans-Amazonian Highway in the early 1970s caused drastic changes in the land cover of the BHRI (Souza-Filho et al., 2016). The construction of unofficial roads to establish agrarian reform settlements and pastures, which also facilitate timber extraction in the southeastern Amazon, was a primary cause of deforestation in the region (Uhl & Buschbacher, 1985; Laurance et al., 2009). The basin has already lost 51% of its forests, resulting in an environmental liability of 328,000 hectares that must be recovered by law (Nunes et al., 2019a).

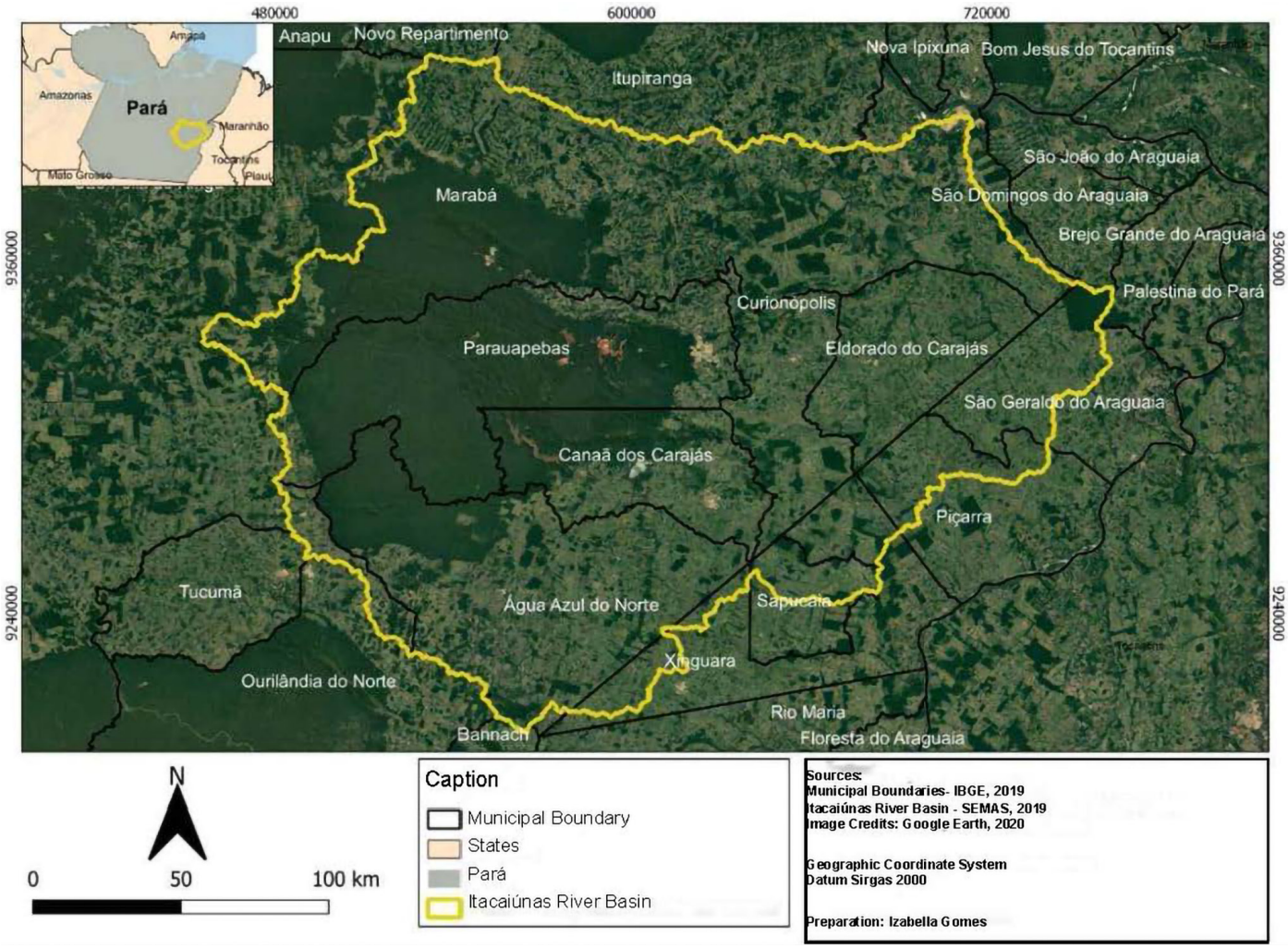


Figure 1

Study area, Itacaiúnas River basin, located in the state of Pará, southeastern Brazilian Amazon.

2.2. Survey of the CAR and PRA situation in the BHRI

The survey of CAR registrations potentially eligible for PRA membership in the BHRI was conducted by analyzing the CAR database in the 10 municipalities of the BHRI, through the Brazilian Forest Service (SFB) website, with data available until December 2021. According to IN No. 01/2020, joining the PRA can only be done after the CAR has been analyzed by the responsible environmental agency: if the property is eligible, the CAR will show the registration status as "analyzed, awaiting environmental regularization" (*Lei nº 12.651*, 2012). As a result, only those registered in the 10 municipalities that fit this situation were selected. Next, the information for each selected CAR was accessed on the PRA portal of the Secretariat of Environment and Sustainability (SEMAS, 2022), and the situation in relation to environmental regularization, environmental restrictions on properties, and the description of the areas to be regularized, with data up to January 8, 2022.

2.3. Perceptions of rural landowners and environmental professionals on the implementation of environmental regularization in Pará

Interviews were conducted with BHRI rural property owners and environmental professionals working in the state to collect and systematize data on their perceptions of the progress of the PRA in Pará, as well as the main challenges and opportunities identified by these actors in relation to this program. The data were collected in five stages:

1) structured interviews with 31 questions with rural landowners in the municipalities of Canaã de Carajás and Parauapebas (Supplementary Material 1);
2) an *online* form with 15 questions for people with professional training related to the environment or with professional occupations in the environmental field in Pará (Supplementary Material 2);
3) an *online* form with 20 questions for SEMAS technicians (Supplementary Material 3);
4) tabulation and database creation; and
5) descriptive statistical analysis of the data collected, based on the frequency of responses.

The sampling of interviews and forms was conducted using a non-probabilistic method (Santos, 2007). Data collection was reduced due to the COVID-19 pandemic and consequent restrictions on field trips.

Interviews with rural landowners were conducted during a field visit to the municipalities of Canaã de Carajás and Parauapebas on October 5 and 6, 2021, with 19 landowners participating in an event on agroforestry systems. Data were collected on the characteristics of the property owner, knowledge of environmental legislation and environmental regularization,

the implementation of environmental regularization in Pará and the municipalities of Canaã de Carajás and Parauapebas, and perceptions of the performance of municipal and state environmental agencies.

The form for environmental professionals was sent by email and the LinkedIn platform and completed by 30 professionals between November 16 and December 28, 2021. The form for SEMAS technicians was answered by 16 professionals between February 2 and 5, 2022. These questions addressed the profile of the interviewees and their area of expertise, perceptions about the behavior of landowners in implementing Environmental Regularization in Pará, actions, resources, and accessibility of the CAR and PRA systems, training, and challenges for implementing the PRA in Pará.

3. Results and discussion

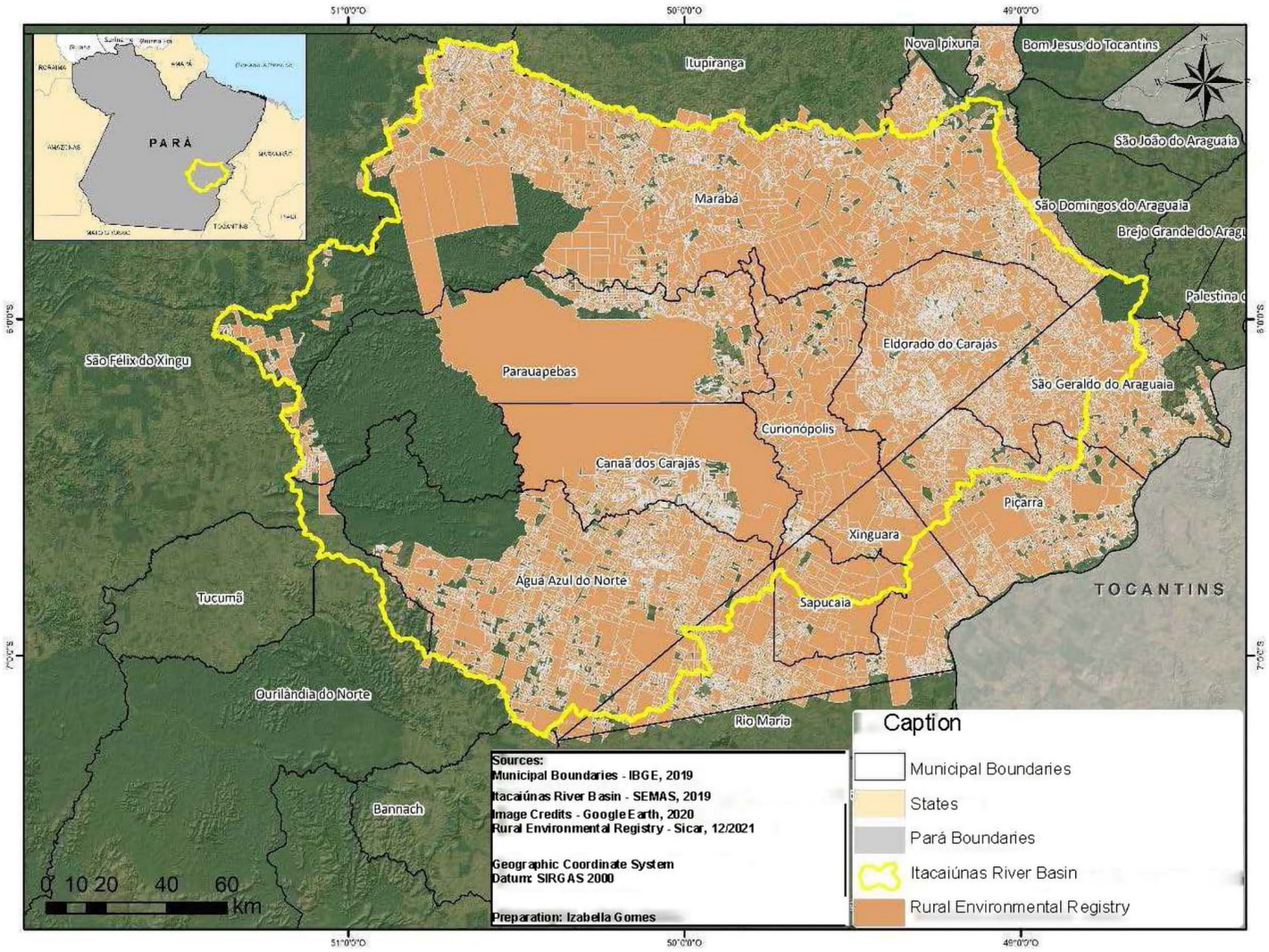
3.1. CAR status in BHRI

The total registrable area in the 10 municipalities of BHRI covers 3.65 million ha, with a total of 26,703 properties registered in CAR by December 2021 (Figure 2). The high registration rate (91% of the total registrable area)

Figure 2

Location of CARs registered in BHRI municipalities.

SOURCE: Authors (Modified from Serviço Florestal Brasileiro, 2021).



reflects the effectiveness of government initiatives, which, in collaboration with institutions such as EMATER and the granting of authorizations to municipal Environment Secretariats to conduct CAR analyses, have been driving registrations since 2015 (Lopes et al., 2024). Registration in the CAR is a crucial step toward environmental regularization, as it is the first requirement for the regularization of native vegetation areas and a fundamental component for implementing the PRA.

Despite the high number of registrations, only 46.3% of these registrations had been analyzed by 2021. All municipalities in the basin were authorized to analyze and validate the CAR between 2019 and 2022, as part of the actions of the Regulariza Pará Program (*Decreto nº 2.745*, 2022) to accelerate environmental regularization, with the exception of Curionópolis. When compared to the state of Pará, this number already indicates good performance in 2021, given that the state had less than 63,000 CARs analyzed (SEMAS, 2023). In the following years, the state made progress in its verifications, reaching a 56% analysis of the 329,298 CARs registered throughout the state by the end of 2024 (SEMAS, 2024).

Of the registrations analyzed in the basin, the vast majority (99%) have pending issues. Only 0.1% ($n = 11$) of the registrations analyzed had no pending issues, and a small portion, 0.9% ($n = 107$), are eligible to join the Environmental Regularization Program (PRA), with the condition of CAR "analyzed, awaiting environmental regularization" (Table 1). It is essential to note that most pending issues stem from poorly prepared registrations, primarily due to the declaratory nature of the records, which often lack accurate information regarding the property's location (Lopes et al., 2024). These figures underscore the complexity and urgency of the situation, ne-

Table 1 Number of CAR registrations and status in BHRI municipalities.

Municipalities	Total CARs	Awaiting analysis	Analyzed with pending issues	Analyzed with no pending issues	Analyzed, awaiting environmental regularization	Under review	Canceled
Água Azul do Norte	2,575 (10%)	1,907	622	1	11 (0.4%)*	6	28
Canaã dos Carajás	1,444 (5%)	347	954	-	2 (0.1%)	7	134
Curionópolis	561 (2%)	343	185	-	19 (3.4%)	1	13
Eldorado dos Carajás	4,897 (18%)	2,363	2,516	-	3 (0.1%)	3	12
Marabá	8,659 (32%)	3,742	4,734	7	35 (0.4%)	29	112
Parauapebas	1,021 (4%)	620	372	1	5 (0.5%)	13	10
Gravel	2,845 (11%)	1,411	1,398	-	12 (0.4%)	6	18
São Geraldo do Araguaia	2,708 (10%)	1,721	980	-	4 (0.1%)	-	3
Sapucaia	205 (1%)	156	40	-	4 (2%)	-	5
Xinguara	1,788 (7%)	1,255	450	2	12 (0.7%)	2	67
Total	**26,703**	**13,865**	**12,251**	**11**	**107**	**67**	**402**

SOURCE: Serviço Florestal Brasileiro, 2021.

* Percentage in relation to the total number of CAR registrations per municipality.

cessitating the implementation of effective measures to address outstanding issues and ensure compliance with current environmental legislation.

3.2. Status of PRA adherence in BHRI

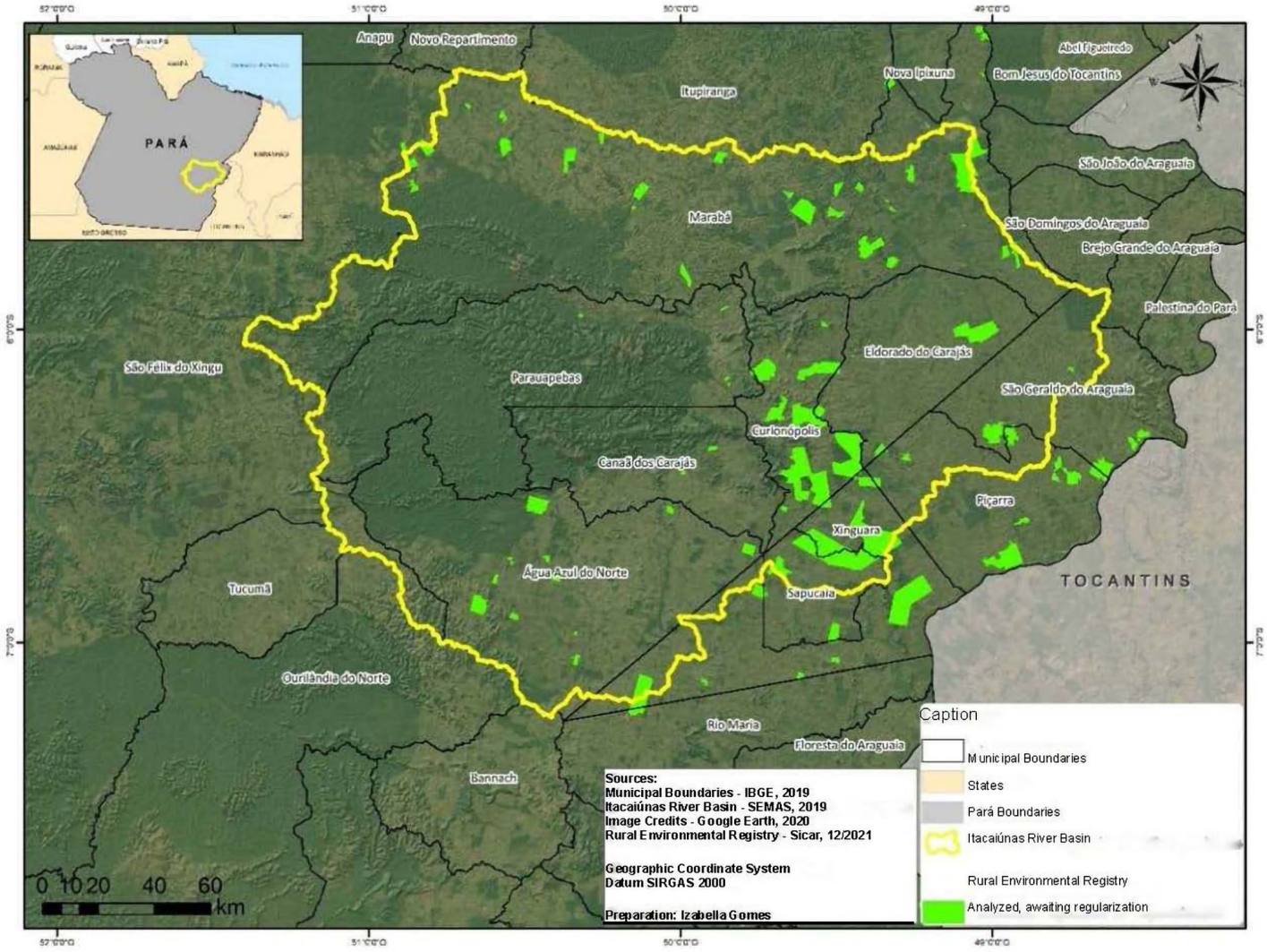
The analysis of compliance with the PRA reveals a worrying scenario regarding adherence to and implementation of BHRI environmental regularization processes. Although the CAR has been widely implemented, effective adherence to the PRA is still very low. Of the 107 properties eligible for PRA adherence (comprising 200,217.83 hectares), 78% of landowners have not yet initiated the environmental regularization process, indicating resistance or a lack of motivation to implement the necessary actions for the recovery of native vegetation (Figure 3; Table 1). Of this total, most are large rural properties (90%; > 10 fiscal modules (FM)), 8% are medium-sized properties (> 4 and < 10 FM), and only 1% are small properties (< 4 FM).

In the BHRI, the municipality of Marabá has the highest number of properties eligible for PRA membership (33%; Table 1), while Canaã dos Carajás has the lowest number of eligible properties, with only 2% of the properties analyzed in the basin. In addition to the significant disparity between the broad coverage of the CAR in the municipalities analyzed

Figure 3

Location of CARs "analyzed, awaiting environmental regularization (Law 12.651/12)" until December 2021.

SOURCE: Authors (Modified from Serviço Florestal Brasileiro, 2021).



and the relatively low number of properties eligible for the PRA, an even smaller number of landowners have actually implemented the PRAs. Only 10% of eligible landowners took concrete steps toward environmental regularization, such as hiring a technical manager to develop a project for the restoration of degraded areas (PRADA), reflecting a low level of engagement with public regularization policies. The lack of knowledge about current environmental legislation, combined with the absence of economic incentives, appears to be one of the primary obstacles that landowners face in implementing regularization actions. Nunes et al. (2016) emphasize that compensating for deforested areas through financial incentives, such as payments for environmental services (PES), could play a key role in overcoming these challenges by encouraging adherence to the PRA.

In addition, the process of signing the Term of Commitment (TC), which is essential to formalize the recovery of environmental liabilities, has low adherence, with only 20% of validated registrations advancing to this stage (Lopes et al., 2024). This shows that, although landowners recognize the importance of regularization, structural and economic barriers prevent these actions from being implemented. The lack of clear regulations, an efficient management system, and technological resources also aggravates the situation, preventing the PRA from being a viable solution for most landowners (Reis et al., 2017, Pacheco et al., 2021).

3.3. Status of environmental liabilities of properties eligible for the PRA in BHRI

The analysis of the 107 properties eligible to join the PRA revealed an environmental liability of 15,993 hectares, representing 8% of the total area of the properties analyzed. Most of this liability is concentrated in APP areas, accounting for 60.5% (9,673.6 ha), while RL represents 39.5% (6,319.40 ha). The largest environmental liability (57.2%; 9,154.1 ha) is located in APPs that were deforested before 2008, representing old, illegal deforestation (Figure 4). This is because most properties are larger than 10 MF (54 properties, representing 90% of the area analyzed), and for this class, there is a greater requirement for APP restoration compared to small and medi-

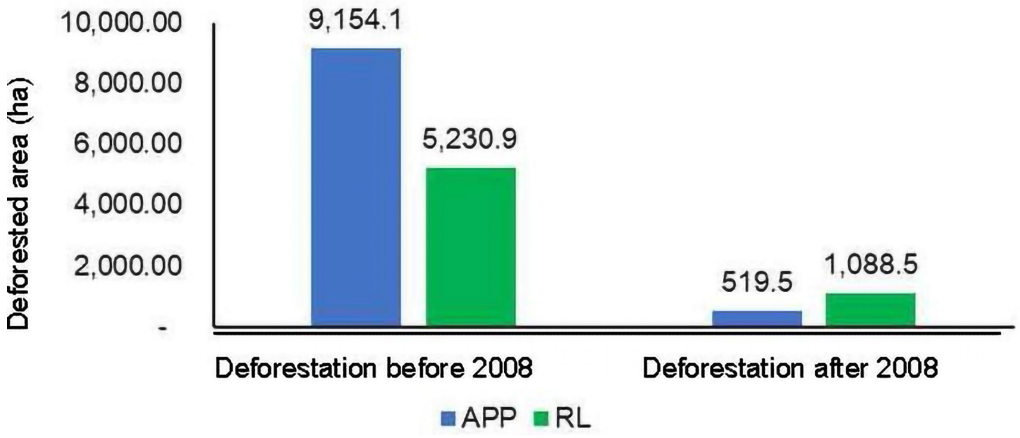


Figure 4

Area of environmental liabilities in APPs and RLs in hectares of properties registered in the CAR with the status "Analyzed, awaiting environmental regularization (Law 12.651/12)" in municipalities located in the BHRI.

SOURCE: SEMAS, 2022.

um-sized properties. This predominance can be attributed, in large part, to the historical and cultural need for cattle and people to access water bodies, resulting in the degradation of riparian APPs, which correspond to most of the APPs in the region (Nunes et al., 2019b). These data corroborate the results of previous studies, which show that APPs in the state of Pará and in the Itacaiúnas basin are more impacted than RLs, even with more restrictive legislation on their use (Nunes et al., 2015; Nunes et al., 2019b).

Another important point to highlight is that, although RLs represent 80% of the area of properties in the Amazon, for restoration purposes, RLs can be reduced to 50% in the municipalities of the basin, considering the percentage of conservation units and ecological-economic zoning (*Decreto nº 7.830*, 2012: Art. 4, 5, and 13). In addition, on small properties, RL corresponds to the area of native vegetation on July 22, 2008 (*Decreto nº 7.830*, 2012: Art. 67). This possibility of reduction has a direct impact on the recovery process of the areas, since the RL can be compensated with areas of native vegetation or natural regeneration, which offers a viable alternative for restoration (Nunes et al., 2019a).

However, even with this possibility of reducing the RL area to be restored, restoration actions have not yet been implemented on most properties, which highlights a critical gap in the implementation of regularization policies. The lack of effective actions may be related to a combination of factors, such as the absence of economic incentives, a lack of knowledge about the benefits of restoration, and a lack of technical support for small landowners, who represent a significant portion of the properties in the basin. As pointed out by Nunes et al. (2015), the development of detailed information on the dynamics of deforestation in APPs and the strengthening of financial incentives are crucial steps to drive the implementation of large-scale restoration actions.

3.4. Perceptions of rural landowners or squatters, environmental professionals, and SEMAS technicians on the implementation of environmental regularization in Pará

Interviews were conducted with 19 rural landowners or squatters, 30 environmental professionals, and 16 SEMAS technicians. The complete profile of these actors (e.g., gender, location, profession, activity, municipality) is available in MS 1, 2, and 3. Most of the landowners interviewed, 94.7%, own small rural properties (up to 4 fiscal modules), as this was the focus of the audience at the event where the interviews were conducted; and 47.4% are located within an Environmental Preservation Area or settlement. The main source of income for 79% of respondents comes from activities carried out on their properties, and 57.9% do not yet have definitive land titles, being classified as rural squatters.

Regarding knowledge of environmental regularization, 84.2% of respondents recognize the importance of the CAR, but 79% remain unaware

of the PRA, an essential component for the effective regularization of environmental liabilities. This data suggests that, although there is recognition of laws aimed at protecting forests and native vegetation (94.7% of respondents), communication and knowledge about environmental regularization and recovery programs are still limited. Pacheco et al. (2021) emphasize that the lack of knowledge about the legislation and the bureaucracy associated with joining the PRA represents a significant barrier. Often, geoprocessing specialists and employees of rural unions or non-governmental organizations fill out CAR forms on behalf of farmers, which may indicate a lack of knowledge among farmers themselves about the process and its implications. This scenario underscores the importance of increased engagement by rural landowners in the regularization process, with greater transparency and the dissemination of information, to ensure the effectiveness of public policies and the effective implementation of environmental restoration and recovery actions.

The percentage of farmers with knowledge about the CAR was very close to the percentage who reported having CAR for their property obtained in another study in Pará (Castro & Ramos, 2023), with a larger number of respondents. Although knowledge about the PRA was not analyzed, the study revealed that information regarding the function and use of the registry for rural properties remains unclear among producers.

Notably, all respondents claim to have no environmental liabilities in RL. Regarding deforestation in APP, only 10.5% ($n = 2$) admit to having carried out such activities, and 15.8% ($n = 3$) indicate that they have paid fines related to deforested areas. Most respondents (84.2%; $n = 16$) cite the high costs associated with recovering deforested areas as one of the biggest obstacles to implementing environmental regularization in municipalities. However, it should be noted that the responses may be influenced by a lack of understanding of the terms “Legal Reserve” and “Permanent Preservation Area”.

The lack of knowledge about the PRA can be a significant obstacle to its implementation, particularly given that federal and state environmental agencies have given little priority to regulating, implementing, and disseminating information about the program. Landowners’ attention has primarily focused on the CAR, as it is necessary for accessing rural credit and is the first step toward regularization; however, it does not guarantee the implementation of restoration actions (Celio et al., 2014). To reverse this scenario, it is imperative that environmental agencies intensify their efforts to actively and effectively disseminate the PRA, highlighting its advantages and importance for environmental regularization (Pacheco et al., 2021). In addition, it is necessary to expand incentives for forest restoration (e.g., payments for environmental services, carbon credits), facilitate access to credits for restoration, and invest in environmental awareness initiatives aimed at property owners, with a view to changing their perception and

encouraging adherence to more comprehensive environmental policies (Celio et al., 2014, Nunes et al., 2019a).

Regarding the interviewees' perceptions of the implementation of environmental regularization in Pará, the three main reasons identified for registering property in the CAR, as assessed by all stakeholder groups, were:

(iii) obtaining advantages such as access to rural credit and other financing,

(ii) legal obligation, and

(iii) market requirements as a criterion for marketing production.

In contrast, advertising and news reports about CAR deadlines were considered to have less influence by all participants (Figure 5). This result was expected, as in Pará, the main motivations for regularization appear to be economic (access to rural credit and market requirements) and legal. This suggests that, in addition to comprehensive legislation, further incentives are necessary for landowners to undertake vegetation restoration actions. The planting of agroforestry systems emerges as an economically viable option for environmental regularization, especially for small producers, with average returns estimated at R$ 2,000 per hectare (Nunes et al., 2017).

Regarding the perception of landowners' adherence to the PRA, the main reasons for adherence that lead these landowners to adhere, according to those interviewed, were: identified among the profiles interviewed were:

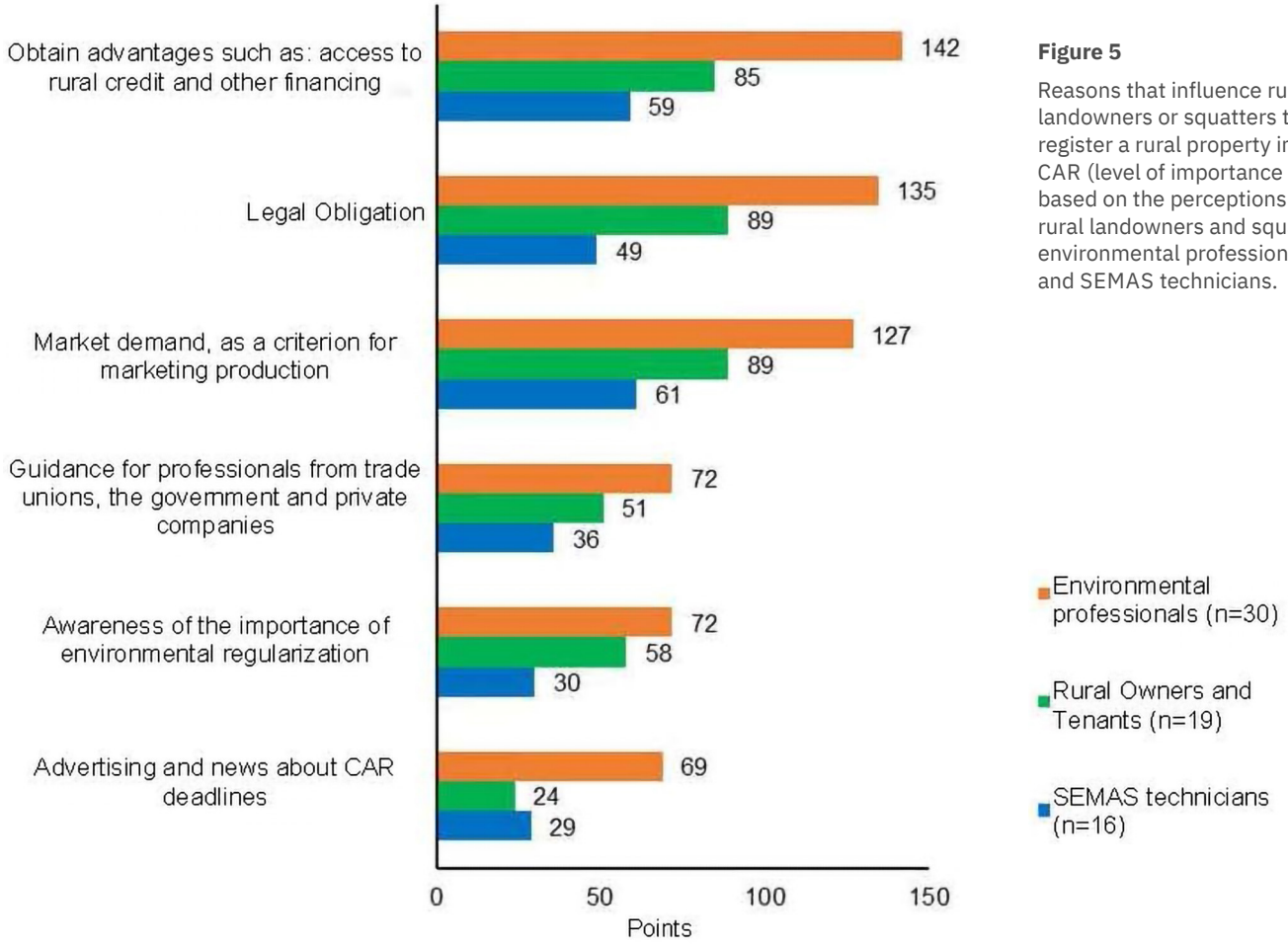


Figure 5

Reasons that influence rural landowners or squatters to register a rural property in the CAR (level of importance 1 to 6), based on the perceptions of rural landowners and squatters, environmental professionals, and SEMAS technicians.

(i) obtaining economic advantages, such as access to rural credit, suspension of fines and administrative sanctions, continuity of economic activities in APPs and RLs; and

(ii) market requirements, as a criterion for marketing production.

These results show that, for all groups analyzed, the main motivator for joining the PRA is related to economic incentives and market pressure. However, the least influential reason varies among the profiles of those interviewed. For environmental professionals and SEMAS technicians, the least relevant reason was "awareness of the importance of recovering degraded areas", while for rural landowners and squatters, the least influential factor was "advertising and news reports about PRA deadlines" (Figure 6).

During interviews conducted in the municipalities of Canaã de Carajás and Parauapebas, respondents highlighted the high costs associated with recovering environmental liabilities as one of the main obstacles to environmental regularization. The lack of environmental regulation of rural properties can result in substantial risks, as pressure on natural resources

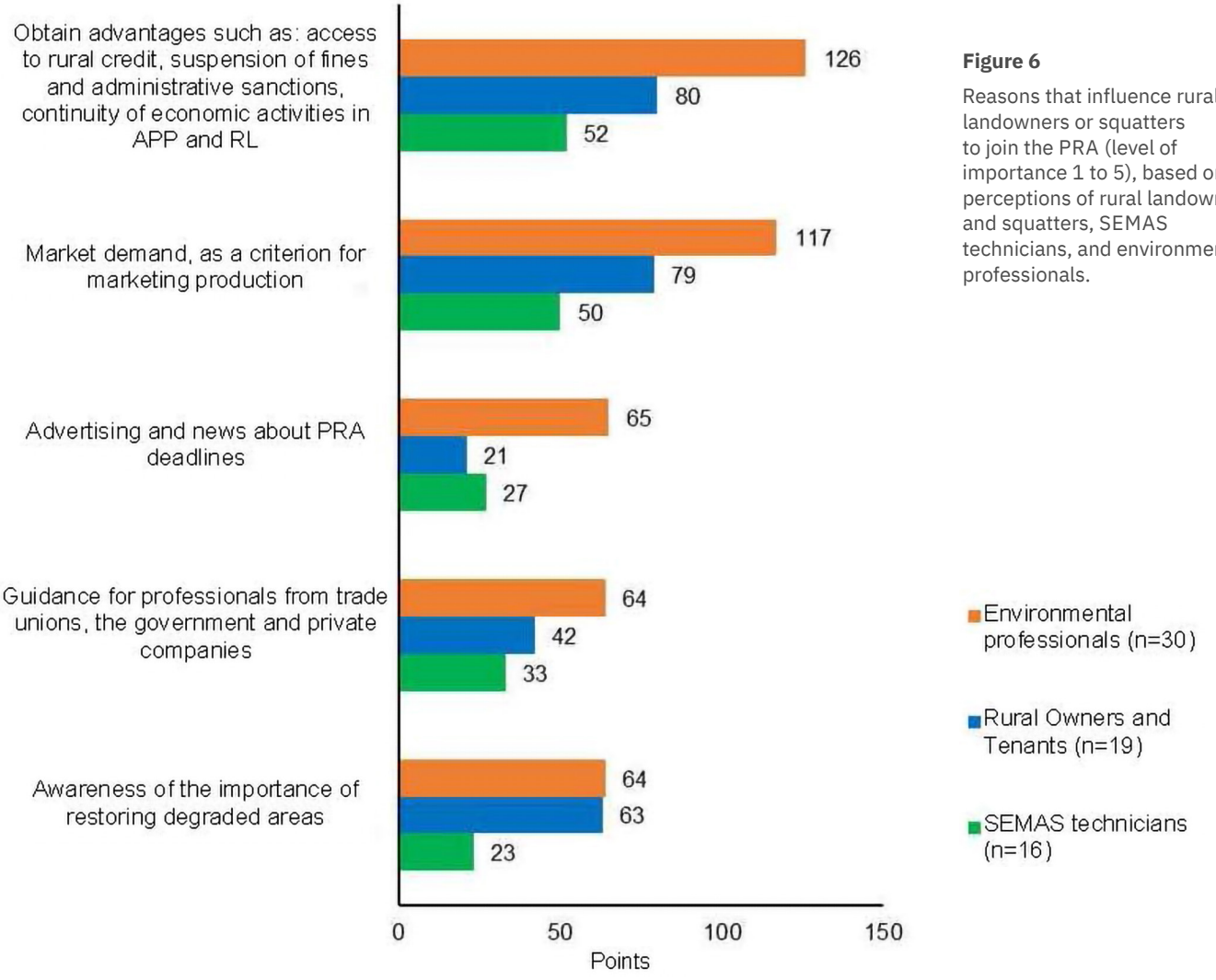


Figure 6

Reasons that influence rural landowners or squatters to join the PRA (level of importance 1 to 5), based on the perceptions of rural landowners and squatters, SEMAS technicians, and environmental professionals.

and ecosystem services can compromise productive activities, with negative impacts on profitability and market access (Federação Brasileira de Bancos [Febraban], 2017). Although the natural regeneration of the Amazon rainforest is a viable alternative for reducing these costs (Pinto et al., 2021a), there is still a significant need for resources to finance the environmental liabilities to be restored.

In this context, Silva et al. (2020) indicate that the average costs of implementing forest restoration in southeastern Pará vary between R$ 4,810 and R$ 26,845 per hectare, depending on the recovery method adopted. These figures pose a significant challenge, particularly for small and medium-sized rural producers, who often face substantial financial constraints when investing in the restoration of degraded areas (Soares-Filho et al., 2013). However, the public sector alone does not have sufficient resources to finance all the necessary demand, which implies the need for greater involvement from the private sector (Febraban, 2017; World Business Council for Sustainable Development [WBCSD], 2024).

In this sense, increasing the flow of capital for large-scale forest restoration in Brazil can benefit both the private sector, which has the opportunity to reduce its risks by contributing to the maintenance of the land's productive capacity in the long term through climate regulation services, soil erosion control, nutrient loss, and water provision, as well as family farmers, who can access financing to implement restoration actions (Nasi et al., 2002; Grimaldi et al., 2014; Food and Agriculture Organization [FAO], 2017). The challenge, therefore, is to create conditions that enable financial operations for both producers and the private sector, thereby contributing to the development of a sustainable production model in Brazil that aligns with the principles of sustainability and environmental conservation (Pinto et al., 2021b; WBCSD, 2024).

It is essential to recognize that the implementation of economic incentives, such as payment for environmental services (PES), can significantly influence the behavior of rural landowners and squatters. Such incentives can reduce or eliminate actions that lead to forest degradation (Nogueira & Borges, 2012). A successful example of a PES program is the "Conservador das Águas" (Water Conservator), created in 2005 in the municipality of Extrema, Minas Gerais. This program aims to preserve the quality of water sources and promote environmental adaptation, serving as a model that can be replicated in other regions.

Additionally, respondents indicated that EMATER (47.4% of landowners and 25% of SEMAS technicians) is the primary source of information for environmental regularization. For 30% of environmental professionals, federal, state, or municipal environmental agencies are the main points of consultation (Figure 7). The prominence given to EMATER reflects its presence with local offices in the municipalities of Pará, which facilitates direct service to small rural producers. This scenario highlights the impor-

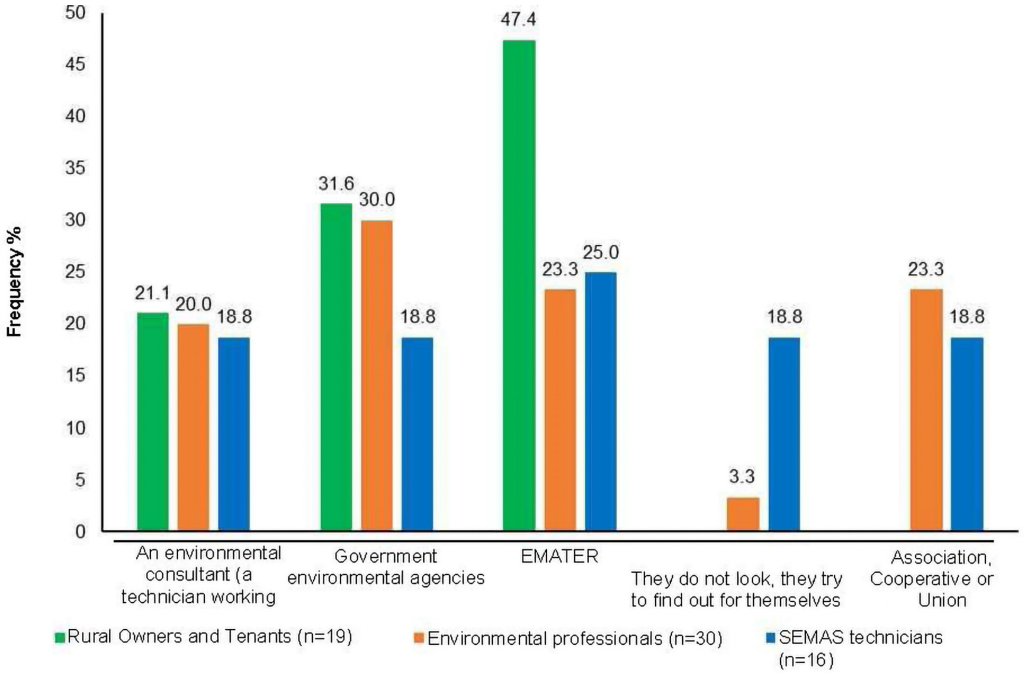


Figure 7

Places where rural landowners or squatters seek information on environmental regularization in Pará, based on the perceptions of rural landowners and squatters, SEMAS technicians, and environmental professionals.

tance of decentralizing state agency restoration actions to municipalities, which are better positioned to address the needs of landowners. The decentralization of environmental management favors the democratization of environmental policy, increases society's participation, and accelerates the response to local demands ((Guimarães et al., 2013, Pacheco et al., 2021).

The perception of SEMAS's performance in implementing environmental regularization actions in Pará varies significantly among the various groups interviewed. The majority of rural landowners and squatters (42.1%) evaluated SEMAS's performance as poor or very poor, while environmental professionals (40%) assessed it as good. Conversely, the majority of SEMAS technicians (56.3%) evaluated the performance as either excellent or good (Figure 8). This divergence in perceptions is likely related to the respondents' location, as most (73.3%) of the professionals and all SEMAS technicians reside in the metropolitan region of Belém, which allows them greater contact with the Secretariat's headquarters. Conversely, rural landowners and squatters residing in more distant municipalities, such as Canaã de Carajás and Parauapebas, maintain more direct contact with the Municipal Environment Secretariats, which frequently possess more limited resources and structure (Reis et al., 2017).

Regarding the performance of the Municipal Environment Secretariats in Pará, variations in perceptions were observed among the profiles interviewed. For 47.4% of rural landowners and squatters, the performance of the Municipal Secretariats was rated as excellent or good. However, 60% of environmental professionals and 68.8% of SEMAS technicians assessed their performance as average (Figure 9). This phenomenon can be attributed to the close proximity of rural landowners and squatters to the Municipal Secretariats, which, due to their enhanced accessibility, are regarded more

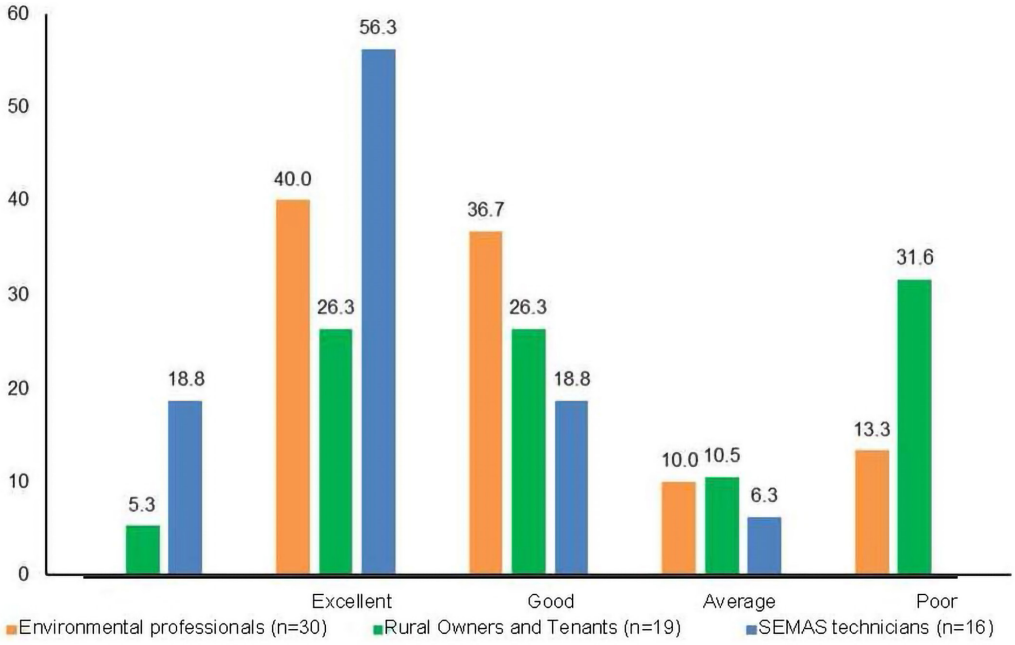


Figure 8

Perceptions of rural landowners and squatters, environmental professionals, and SEMAS technicians on SEMAS's role in implementing environmental regularization in municipalities and in Pará.

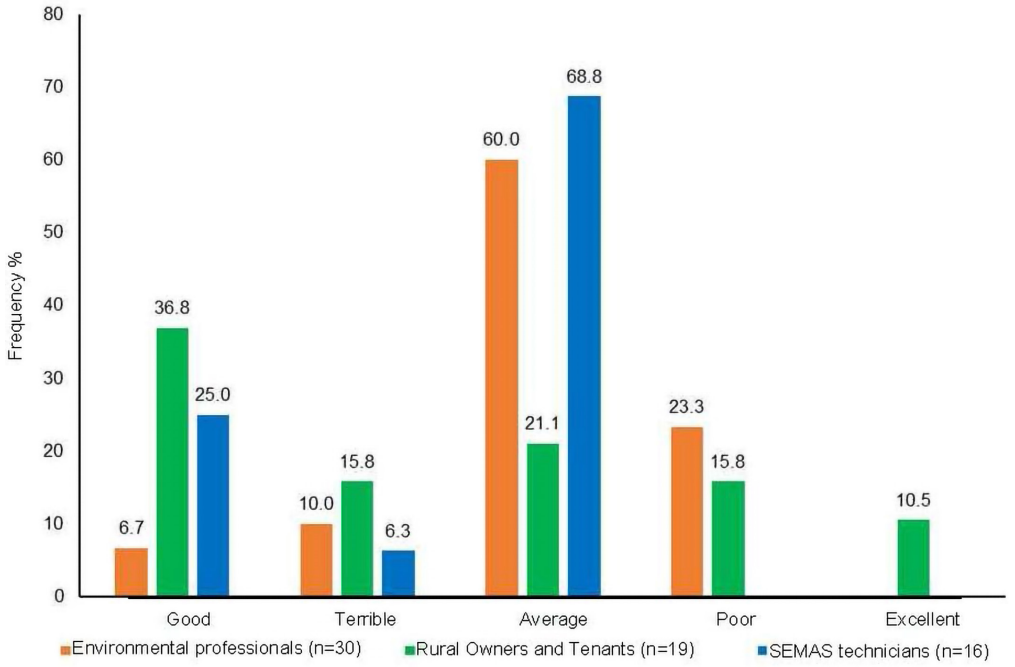


Figure 9

Perceptions of rural landowners and squatters, environmental professionals, and SEMAS technicians on the performance of Municipal Environment Secretariats in implementing environmental regularization in municipalities and in Pará.

favorably by local actors. On the other hand, professionals and technicians, with a more critical view of the operational and structural limitations of municipal secretariats, tend to evaluate the performance of these institutions less optimistically. The discrepancy in perception between the groups interviewed underscores the importance of decentralizing environmental management to municipalities.

The decentralization of environmental management is a critical process, as it enables local governments, which possess a more profound understanding of societal needs and the distinct environmental characteristics of their regions, to formulate and implement more suitable and effective policies (Andersson et al., 2006; Reis et al., 2017). In Pará, there has been

a notable increase in environmental decentralization processes in recent years, with the implementation of public policies that have allocated subsidies for the development and reinforcement of municipal environmental systems (Silva et al., 2019). Local environmental management would benefit from the implementation of sustainable and technological practices, as well as adequate environmental planning, secure land tenure, and the restoration of deforested areas. However, the viability of decentralized regimes is contingent upon the presence of adequate institutional conditions, capacities, and resources (Reis et al., 2017). The failure to provide local governments with incentives for sustainable economies can have deleterious consequences, further exacerbating their already considerable challenges.

Respondents indicated several factors that hinder or prevent the implementation of the PRA in Pará. Among rural landowners and squatters, the three main reasons were:

(i) lack of action and investment by the Government of Pará (22.8%),

(ii) difficulty accessing SEMAS and municipal departments for clarification of doubts and guidance (15.8%),

(iii) the high costs of implementing environmental regularization initiatives on rural properties (14%), and

(iv) lack of clear regulations and instructions (14%).

These factors reflect landowners' perception of the lack of support and the complexity involved in the regularization process.

Among environmental professionals, the most frequently mentioned reasons were:

(i) lack of additional staff at SEMAS to advance the analysis of the CAR and implementation of the PRA (23.6%),

(ii) lack of interest on the part of landowners or squatters in environmental regularization (16.7%), and

(iii) lack of coordination between state and municipal agencies to support implementation activities in the municipalities of Pará (16.7%).

These factors reveal a critical view of operational limitations and the lack of incentives for landowners to become actively involved in regularization.

Finally, SEMAS technicians highlighted similar reasons, with

(i) the lack of interest of landowners or squatters in environmental regularization (25%) as the main obstacle, followed by

(ii) the lack of more SEMAS employees to advance the CAR analysis and PRA implementation (16.7%).

(iii) the high costs of implementing environmental regularization initiatives on rural properties (16.7%) and

(iv) the lack of clear regulations and instructions (16.7%) (Figure 10).

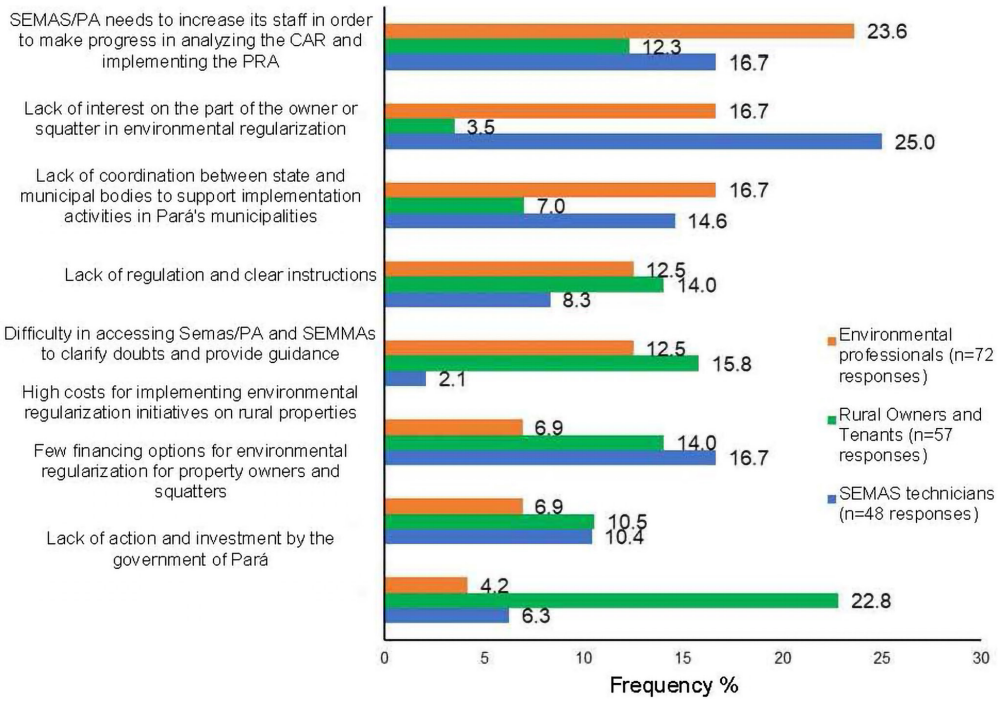


Figure 10

Problems that hinder progress or impede the implementation of the PRA in Pará, based on the perceptions of rural landowners or squatters (*n* = 57 responses), environmental professionals (*n* = 72 responses), and SEMAS technicians (*n* = 48 responses), based on the selection of up to three most important items.

These data indicate that, although there is a general perception that costs and lack of regulation are significant barriers, the lack of interest on the part of landowners and the shortage of human resources in environmental agencies are also recurring challenges. These results are consistent with other studies, which indicate that without external incentives such as fines or market demands, many landowners show little motivation for forest restoration (Azevedo et al., 2017). In addition, the shortage of technicians in environmental agencies is one of the main challenges for the implementation and efficiency of CAR and PRA (Igari et al., 2021, Lopes et al., 2024). The implementation of automated systems for pre-analysis is a solution that has helped to address this limitation (Lopes et al., 2024). Automation has significantly reduced the volume of manual work for technicians, facilitating analysis and ensuring greater agility in the analysis of registrations.

The evaluation of the means of communication provided by SEMAS reveals a discrepancy between environmental professionals and SEMAS technicians. Most environmental professionals considered the means of communication to be average (53.3%), while a significant portion considered them poor (20%), and 13.3% considered them very poor, with only 13.3% rating them as good. On the other hand, SEMAS technicians have a more favorable view, with 68.7% rating the means of communication as excellent, 25% as good, and only 6.3% considering them average and poor (Figure 11). Communication between SEMAS and rural landowners and squatters is identified as a major challenge to be overcome, especially in relation to notifying and engaging landowners in the necessary stages of environmental regularization (Lopes et al., 2024). The system requires that producers be notified for actions such as rectifying their registration, supplementing information, and adhering to the PRA or proposing a PRADA.

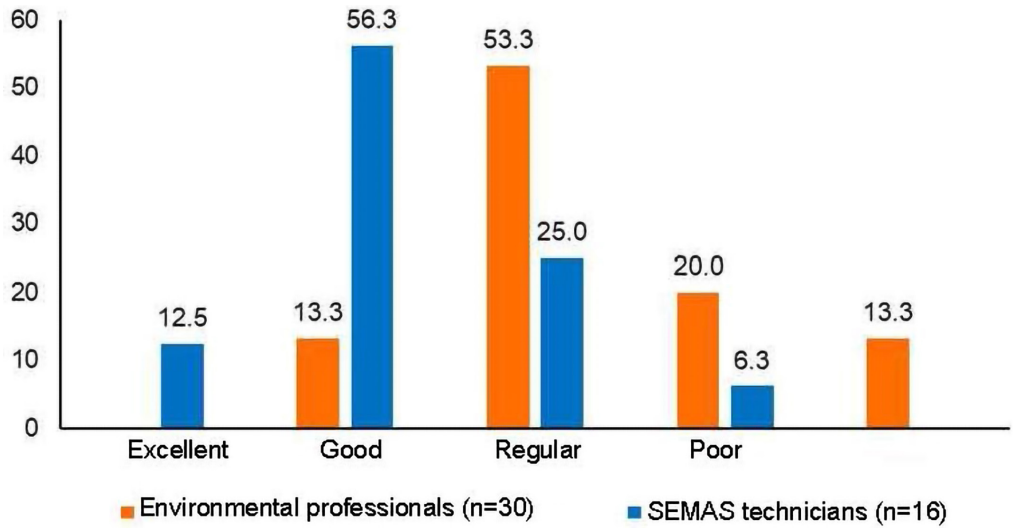


Figure 11

Perceptions of environmental professionals and SEMAS technicians regarding SEMAS's means of communication.

To overcome this difficulty, the state of Pará has initiated regional task forces involving SEMAS technicians, who conduct field visits to contact those responsible and request that notifications be responded to more promptly (Lopes et al., 2024). These regional actions represent a significant effort to overcome communication barriers and ensure the effective implementation of environmental regularization policies.

The results of the study indicate that, in relation to accessibility to the SICAR/PA systems, the majority of respondents consider the system accessible, both among environmental professionals (83.3%) and SEMAS technicians (93.7%) (indicate the percentage, as done in the previous group. It is imperative to standardize the acronym. The PRA portal is also considered accessible by most respondents, with 60% of environmental professionals and 75% of SEMAS technicians expressing this perception. Furthermore, the subject of PRA has been incorporated into the discussion and training agendas promoted by SEMAS in Pará, although it is still regarded as a relatively novel subject.

Regarding the training aspect, all SEMAS technicians interviewed attested to the Secretariat's provision of training for the preparation and analysis of the CAR. Furthermore, a significant majority of respondents, specifically 93.7%, reported the existence of training programs designed to address the PRA. The sole technician (3.7%) who was unaware of this training indicated that his professional activities were unrelated to environmental regularization. However, a salient issue that emerged from the interviews was the perception that the number of SEMAS employees is inadequate to address the mounting demands for environmental regulation in rural properties. This sentiment was expressed by 75% of the respondents. This suggests that the primary challenge faced by SEMAS may not be a lack of training, but rather a shortage of human resources, which compromises the effective implementation of environmental regularization policies.

In view of this, the decentralization of PRADA analyses to the Municipal Environment Secretariats emerges as a crucial measure to en-

hance the efficiency of environmental regulation. Decentralization would facilitate the initiation of activities in municipalities qualified for CAR analysis, thereby optimizing processes and contributing to a more agile response to local needs.

4. Conclusion

The present study analyzed the implementation of the Rural Environmental Registry and adherence to the Environmental Regularization Program in 10 municipalities in southeastern Pará, highlighting the challenges and opportunities for environmental regularization in the state. The findings indicated that, despite the CAR's noteworthy advancements, adherence to the PRA remains a significant challenge, primarily due to a lack of awareness regarding the program and a lack of engagement from rural landowners. The research revealed that, although most rural landowners and squatters recognize the importance of the CAR, most of them are still unaware of the PRA. This indicates that communication about environmental regularization programs is limited. Additionally, while there is an acknowledgement of legislation intended to safeguard forests and indigenous flora, the translation of these legal provisions into tangible actions, such as the PRA, remains underdeveloped.

Regarding the motivations for registering with the CAR, the data indicate that the predominant motivation for rural landowners is economic incentives, including access to rural credit, legal requirements, and market pressures. These results suggest that, in addition to comprehensive environmental legislation, it is essential to provide additional incentives for landowners to implement restoration actions, with a particular emphasis on agroforestry systems, which are economically viable, especially for small-scale producers. The results of the interviews also highlighted the high costs involved in forest restoration as a major challenge for small rural producers. While natural regeneration of the Amazon rainforest is a viable option for reducing these costs, the need for resources to finance restoration is a challenge that requires the involvement of the private sector and the creation of sustainable financing mechanisms.

The decentralization of environmental management was identified as a key strategy for improving the efficiency of the regularization process in Pará. Greater proximity between municipal agencies and rural landowners has been demonstrated to facilitate access to information and the engagement of producers in the regularization process. However, the scarcity of human resources in state and municipal environmental agencies poses a significant obstacle, impeding the effective implementation of policies. It is imperative to enhance the efficacy of the regularization process by augmenting the workforce, leveraging automated systems, and decentralizing CAR and PRA analyses to municipal environmental departments.

Despite the challenges imposed by the pandemic, which resulted in a reduced number of interviewees, the data systematization and analysis of the Rural Environmental Registry (CAR) and the Environmental Regularization Program (PRA) records contribute to understanding the main challenges and opportunities for expanding environmental regularization in Pará. The information obtained is representative at the state level and is aligned with other published studies on the challenges of forest restoration in the Amazon. However, for future research, we recommend increasing the number of interviewees to encompass a larger number of rural landowners of different property sizes and local actors from different regions. This information can guide environmental regularization policies and practices aligned with local needs and realities, effectively promoting sustainable development and environmental conservation.

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