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Challenges and perspectives of the rural environmental registry: a look at the Cachoeira river basin, Bahia, Brazil

Desafios e perspectivas do cadastro ambiental rural: um olhar sobre a bacia hidrográfica do rio Cachoeira, Bahia, Brasil

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Abstract: The Rural Environmental Registry (CAR) and the Environmental Regularization Program (PRA), established by the Forest Code (Law No. 12,651/2012), are critical tools for environmental management of rural properties in Brazil. Despite advances in their implementation, the CAR faces challenges such as property overlaps, data inconsistencies, and discrepancies in the declarations of Permanent Preservation Areas (APPs) and Legal Reserves (RLs). This study analyzed the effectiveness of the CAR in the Cachoeira River Basin, southern Bahia, Brazil, by comparing its graphical and declaratory data with other existing cadastral systems. The results revealed deficiencies in database integration, technical errors, and gaps in environmental compliance. The study suggests creating standardized protocols for CAR validation, as well as implementing the Land Administration Domain Model (LADM) in Brazil to harmonize systems and ensure cartographic accuracy. Furthermore, it is essential to promote producers' awareness of legal obligations and environmental conservation practices. The proposed standardization could mitigate conflicts, improve environmental regularization, and strengthen public policy implementation.

Keywords: Environmental Regularization; Land Cadastre; CAR.

Resumo: O Cadastro Ambiental Rural (CAR) e o Programa de Regularização Ambiental (PRA), instituídos pelo Código Florestal (Lei nº 12.651/2012), são ferramentas críticas para a gestão ambiental de propriedades rurais no Brasil. Apesar de avanços em sua implementação, o CAR apresenta desafios como sobreposição de imóveis, inconsistências de dados e discrepâncias nas declarações de Áreas de Preservação Permanente (APPs) e Reserva Legal (RL). Este estudo analisou a eficácia do CAR na bacia do rio Cachoeira, sul da Bahia, Brasil, comparando seus dados gráficos e declaratórios com sistemas de cadastro existentes. Os resultados revelaram deficiências na integração entre bases de dados, erros técnicos e lacunas na conformidade ambiental. Sugere-se a criação de protocolos padronizados para validação do CAR, além da implementação do modelo internacional de administração fundiária (Land Administration Domain Model - LADM) no Brasil, visando harmonizar sistemas e garantir precisão cartográfica. Além disso, é essencial promover a conscientização dos produtores sobre obrigações legais e práticas de conservação ambiental. A padronização proposta pode mitigar conflitos, aprimorar a regularização ambiental e apoiar políticas públicas.

Palavras-chave: Regularização Ambiental; Cadastro Territorial; CAR.

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1. Introduction

Land registration is a georeferenced information system that records and manages data related to properties, territorial boundaries, and land use. It is essential for efficient land management, conflict prevention, and the promotion of sustainable development. According to FIG (2014), the International Federation of Surveyors, land registration systems should document information on property rights, restrictions, and attributes. Therefore, an effective land registration system must ensure high accuracy of recorded data, interoperability between systems and institutions, and the availability of information to a wide range of users.

According to Roy and Viau (2008), land registration has its origins in antiquity, with cadastral maps identified in civilizations such as Egypt, Palestine, Greece, and the Roman Empire. These maps were used to control land use, support agricultural development, and identify territorial resources. Since then, the evolution of land registration has been marked by a wide diversity of systems and practices across countries that have adopted it as an instrument for land management. However, a study evaluating cadastral systems highlighted a significant gap in the field of land administration, noting the absence of internationally accepted methodologies for assessing and comparing system performance (Steudler et al., 2004). This lack of standardization was attributed to the constant reform of these systems and the varied social perceptions of land across different regions. According to Lemmen et al. (2009), transforming the Land Administration Domain Model (LADM), then under development, into an ISO standard would be crucial for integrating all components of the Multifunctional Territorial Cadastre (CTM), emphasizing the need for an accurate and reliable spatial framework for its effective implementation.

In this context, the Land Administration Domain Model (LADM), standardized as ISO 19152, has emerged as an important international reference for territorial management. Developed by the International Organization for Standardization (ISO), in collaboration with the International Federation of Surveyors (FIG) and the UN Human Settlements Programme (UN-Habitat), this standard provides a conceptual model for representing cadastral information, encompassing rights, restrictions, and responsibilities associated with land use (ISO, 2012; LEMMEN et al., 2015).

In Brazil, several cadastral systems have been created to organize territorial, land, and environmental information, reflecting the complexity of rural property management in the country. Among the most prominent systems are the National Rural Cadastre Service (SNCR) and the Land Management System (SIGEF), both managed by the National Institute for Colonization and Agrarian Reform (INCRA). There is also the *Cadastro Fiscal de Imóveis Rurais* (CAFIR), administered by the Federal Revenue Service for tax purposes; the National Rural Property Registry (CNIR), jointly managed by INCRA and the Federal Revenue Service; and the Rural Environmental Registry (CAR), currently overseen by the Ministry of Management and Innovation in Public Services (MGI). The CAR was instituted by Law No. 12,651/2012—known as the New Forest Code—published on May 25, 2012, which also established the Environmental Regularization Program (PRA) (BRAZIL, 2012a).

Recent legislation has reinforced the growing importance of land registration in Brazil. Both the CNIR, created by Law No. 10.267/2001, and the CAR, created by Law No. 12.651/2012 and regulated by Decree No. 7.830/2012, represent significant milestones in positioning Brazil among the countries that effectively employ cadastral tools as instruments of territorial management and development. Although the CAR is more recent, it is already fully operational, whereas the CNIR remains in the early stages of implementation.

Environmental regularization essentially involves establishing actions aimed at the conservation, management, and restoration of environmental resources, especially Permanent Preservation Areas (APPs in Portuguese) and Legal Reserves (RL) within rural properties. These actions stem from the requirements of current legislation, as well as from additional practices that, although not explicitly mandated, contribute significantly to environmental quality and to improving the well-being of rural producers (RODRIGUES et al., 2009; BRAZIL, 2012a).

Within the scope of the National Environmental Information System (SINIMA), the Rural Environmental Registry (CAR) is established as a nationwide electronic registration mechanism, mandatory for all rural properties. Its primary purpose is to integrate and standardize environmental information related to rural properties and holdings, encompassing the assessment of Permanent Preservation Areas (APP), Legal Reserve areas, restricted-use zones, remnants of native vegetation, and consolidated areas. This set of information constitutes a structured database that supports activities such as environmental inspection, monitoring, strategic planning, and deforestation control (SFB, 2021).

Thus, the CAR functions as an essential data infrastructure, supporting critical activities related to supervision, monitoring, and mitigation of deforestation processes that affect both forest formations and other types of native vegetation across the national territory (COUTO et al., 2017). However, the implementation of analyses aimed at modernizing and improving the registry in Brazil has not yet received the attention it deserves. Although the CAR has become a key

instrument in the environmental regularization process, the lack of technical standardization and the reliance on self-declared information generate overlapping areas and inconsistencies that undermine the effectiveness of environmental monitoring (SANTOS et al., 2021).

In this context, the adoption of the Land Administration Domain Model (LADM) has been identified as a potential solution for ensuring effective data integration among different systems. Although the model provides a robust framework for interoperability, its implementation depends on the quality of the underlying data. This reinforces the notion that, while the LADM facilitates integration, challenges related to the accuracy of geospatial data, the consistency of cadastral information, and the continuous updating of records remain critical (FIG, 2025).

In this context, this study aims to analyze the Rural Environmental Registry (CAR) in the Cachoeira River basin, a region of notable socio-environmental importance characterized by complex land-use and occupation dynamics. Located in southern Bahia, the basin spans from extensive livestock-grazing areas in its headwaters to cocoa agroforestry systems along the coastal zone, forming a mosaic of landscapes and production practices that reflect varying levels of conservation and pressure on natural resources. This environmental and socioeconomic heterogeneity makes the basin a representative case for assessing the effectiveness of the CAR as an instrument for environmental management and regulation.

The analysis compares CAR data with information from other cadastral systems, including the National Rural Cadastre Service (SNCR) and the Land Management System (SIGEF), both administered by INCRA, as well as the Tax Registry of Rural Properties (CAFIR), managed by the Federal Revenue Service. The study focuses on both quantitative comparisons and the specific structural characteristics of each system. Additionally, it evaluates CAR data through an assessment of the topological quality of its spatial component and an examination of declarative information on Permanent Preservation Areas (APPs) by cross-referencing hydrographic data from the National Water Agency (ANA). This evaluation is conducted in light of the principles underlying the international concept of the territorial cadastre.

2. Methodology

2.1 Study Area

The study was conducted in the Cachoeira River basin, located along the southern coast of the state of Bahia, Brazil (Fig. 1). The basin originates in the headwaters of the Colônia River, which later merges with the Salgado River to form the Cachoeira River. Altogether, it encompasses a drainage area of approximately 4,800 km², distributed across 14 municipalities.

The basin lies within the Atlantic Forest biome. Historically, it was covered by forest formations with varying degrees of deciduousness: Dense Ombrophilous (Hygrophilous) Forest in the coastal zone, Semi-Deciduous (Mesophilous) Seasonal Forest, and Deciduous Seasonal Forest in the western portion of the basin. Currently, the original vegetation cover has been substantially reduced due to intensive agricultural activity, livestock ranching, and urban expansion (NACIF, 2000; SILVA & LIMOEIRO, 2025).

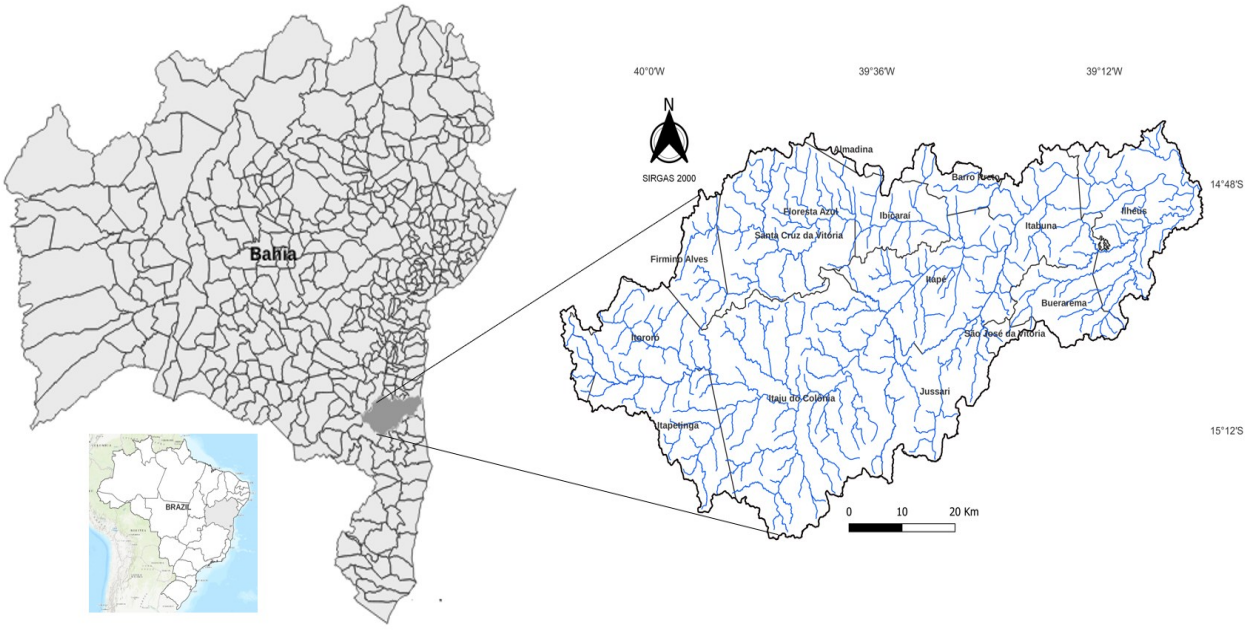


Figure 1 – Location of the Cachoeira River basin.
Source: Authors (2025).

2.2 Data Collection

Data collection was conducted through several agencies related to the subject and through the Rural Environmental Registry (CAR) for areas within the hydrographic basin, with the aim of assessing the cadastral status of rural properties and the quality of the information provided by the CAR. The free software QGIS was used to produce thematic maps and perform spatial analyses.

The first stage of the study involved the territorial delimitation of the Cachoeira River basin, using data from the Brazilian National Water Agency (ANA), obtained through the 2017 Multiscale Ottocoded Hydrographic Base (BHO)**.** Data containing the boundaries of the basin and its component sub-basins were extracted in *gpkg* format and subsequently converted to *shapefile* format using QGIS. The hydrography of the main rivers within the basin was also obtained from ANA (ANA, 2017).

The second stage consisted of obtaining CAR (Rural Environmental Registry) data, including property perimeter boundaries and the delimitation of Permanent Preservation Areas (APP). All information was extracted from the SICAR platform, and the datasets were obtained by municipality, limited to those located within the basin. During this stage, perimeter data were also collected for properties subject to georeferencing certification by INCRA, in accordance with Law 10.267/2001. These certified data will be incorporated into the National Rural Property Registry (CNIR) (INCRA, 2022; SICAR, 2022). From these platforms, information was retrieved on: (1) the number of registered properties; (2) the number of properties declaring the presence of Permanent Preservation Areas and Legal Reserves; (3) georeferenced polygon data for properties and their respective areas; and (4) polygons and areas of APPs.

Regarding the additional rural cadastral systems consulted, a formal request was submitted through the Federal Government platform Fala.BR. Information was requested from INCRA's National Rural Registry System (SNCR) and from the Brazilian Federal Revenue Service's Rural Property Registry (CAFIR) for municipalities within the Cachoeira River basin (INCRA, 2022; RFB, 2023). Data on properties certified by INCRA through the Land Management System (SIGEF) were also obtained from the agency's *Acervo Fundiário* website (https://acervofundiario.incra.gov.br/acervo/login.php).

2.3 Data Processing and Analysis

Data processing was carried out using the open-source software Quantum GIS. Initially, the dataset was clipped to the boundaries of the study area—the Cachoeira River basin. Subsequently, a cross-referencing procedure was performed between properties certified by INCRA and those registered in SICAR. To identify overlaps and inconsistencies within the information provided in SICAR, the "Topology Checker" plugin available in Quantum GIS was employed.

A comparative analysis was then conducted focusing on both legal and technical aspects. The legal assessment considered the specific legislation that established each cadastral system, while the technical evaluation examined the structure and nature of the information provided (descriptive and/or spatial), the level of detail related to land use, the methodologies for data collection and registration, the degree of georeferencing required in relation to the Brazilian Geodetic System (SGB), and the positional accuracy adopted by each rural registry consulted.

Additionally, a spatial intersection was performed between the polygons obtained from the CAR and the hydrographic network of the basin sourced from ANA. The intersection tool (Vector Overlay – Intersection) in Quantum GIS was used to execute this task, allowing the identification of all properties crossed or intercepted by watercourses and that, consequently, should have declared the presence of Permanent Preservation Areas (APPs).

3. Results and Discussion

The total number of rural properties registered in the municipalities that comprise the Cachoeira River basin varies substantially among the evaluated systems. CAFIR recorded 14,599 properties, SNCR registered 13,729, CAR accounted for 6,233, and SIGEF had 1,450 registered properties—the lowest number among the systems analyzed. Table 1 presents the diversity of information obtained from the four cadastral systems consulted for the municipalities that have part of their territory within the Cachoeira River basin.

The reduced number of properties registered in SIGEF can be explained by the legal rule established in Decree No. 4,449/2002, which requires certification only in cases of subdivision, plot division, consolidation, or in any situation involving the transfer of rural property. Certification became mandatory for properties of 25 hectares or more starting on November 21, 2023 (BRASIL, 2002). Since the data used in this study were collected in 2022—when certification was required only for properties larger than 100 hectares—the limited number of parcels registered in SIGEF is expected. This is further supported by the landholding structure observed in the other systems, which shows a predominance of properties smaller than 25 hectares: 52.73% in SNCR, 59.12% in CAFIR, and 67.32% in CAR. Therefore, it is important to emphasize that SIGEF is a continuous system that plays a critical role in the certification of rural properties; however, the requirement for certification is influenced both by property size and by the owner's interests.

Table 1 – Number of rural properties registered in the respective databases of the SNCR, CAFIR, CAR, and SIGEF systems.

Number of properties per municipality in the cadastral systems				
Municipality	SNCR	CAFIR	CAR	SIGEF
Barro Preto	349	390	166	49
Buerarema	1093	1268	366	32
Firmino Alves	360	263	211	20
Floresta Azul	590	792	369	38
Ibicaraí	860	842	429	52
Ilhéus	5644	6105	1852	193
Itabuna	894	855	641	49
Itaju do Colônia	481	429	253	118
Itapé	637	736	449	89

Itapetinga	935	897	419	253
Itororó	653	872	423	68
Jussari	556	478	236	25
Santa Cruz da Vitória	405	378	236	37
São José da Vitória	272	294	183	7

Source: Prepared by the author based on information from INCRA (2022), RFB (2023) and SFB (2022).

When comparing the main characteristics of the cadastral systems analyzed—covering managerial aspects, such as the governing institution; legal aspects, including the specific legislation regulating each system; and technical aspects, such as the composition and nature of the information—it was observed that all systems were established on legal foundations. However, only SIGEF has a constitutive character, whereas all others have a declaratory nature. Nevertheless, all systems provide information on land use within rural properties, except for SIGEF.

Regarding information accuracy, although CAR includes a graphic component, it is not required to be georeferenced to the Brazilian Geodetic System (SGB), nor is there assurance of compliance with Article 2, item IX of Decree No. 7,830/2012, which stipulates a minimum mapping scale of 1:50,000. In contrast, SIGEF requires positional accuracy for the polygons, following the guidelines of being equal to or better than 0.50 meters for vertices located on artificial boundaries, equal to or better than 3.00 meters for vertices on natural boundaries, and 7.50 meters for vertices situated on inaccessible boundaries (Table 2) (BRASIL, 2012b; INCRA, 2022b).

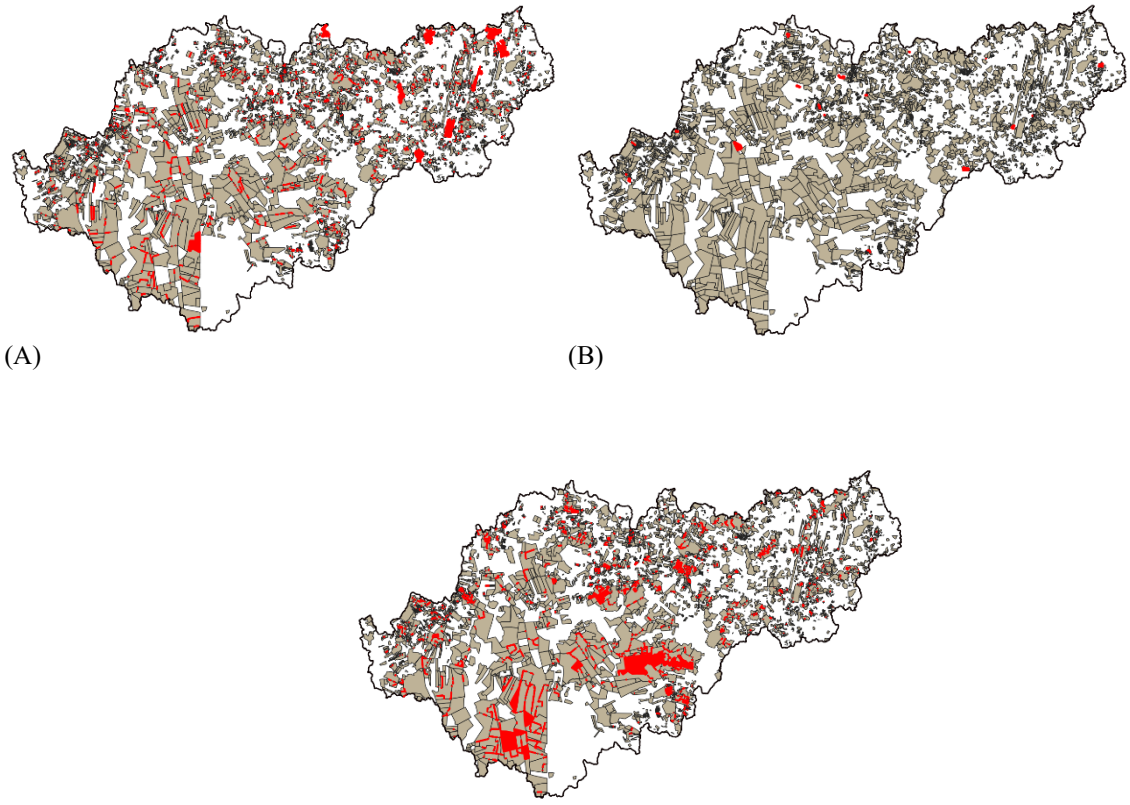
Table 2 – Comparison between cadastral systems SNCR, CAFIR, CAR and SIGEF.

Comparison between cadastral systems SNCR, CAFIR, CAR and SIGEF characteristics	SNCR	CAFIR	CAR	SIGEF
Governing Authority	Administered by Incra	Administered by the Federal Revenue Service	Administered by the Brazilian Forest Service and Environmental Agencies	Administered by Incra
Legal creation	Established by Law No. 5,868/1972	Established by Law No. 9,393/1996	Established by Law No. 12,651/2012	Established by Law No. 10,267/2001
Composition	Strong literal component	Strong literal component	Strong literal and graphic component	Strong graphic component
Legal status of properties	Includes properties with ownership, lawful possession, and possession by simple occupation	Includes properties with ownership, lawful possession, and possession by simple occupation	Includes properties with ownership, lawful possession, and possession by simple occupation	Includes properties with ownership and lawful possession
Cadastral unit	Rural property	Rural property	Rural properties and possessions	Parcel
Declaratory nature	Declaratory nature	Declaratory nature	Declaratory nature	Constitutive nature
Information on property use	Has	Has	Has information on legally protected areas	Does not have
Methodology	Literal declaration	Literal declaration	Declaration via application with definition of	Standardized georeferenced survey, carried out

			polygons of areas of interest in GIS environment by interested parties (individual or legal entity)	by an accredited professional with technical responsibility
Georeferencing to the Brazilian Geodetic System (SGB)	Not required	Not required	Not required	Required
Positional accuracy	Not applicable	Not applicable	Minimum scale of 1:50,000 (art. 2, item IX – Decree 7830/2012)	Defined in relation to the vertex situation: - Artificial boundaries <= 0.50 m; - Natural boundaries <= 3.00 m; - Inaccessible boundaries <= 7.50 m

Source: Authors (2025).

Based on information from SICAR, 4503 properties registered in CAR were located totally or partially within the basin's boundaries. 2004 overlaps between registered properties were identified (Fig. 2(A)), 25 duplicate property polygons (Fig. 2(B)), and 2400 gap errors between property boundaries (Fig. 2(C)).



(A) (B)

(C)

Figure 2 – Topological analysis of properties in CAR: The identified errors appear selected in red in the figures. (A) overlapping polygons; (B) duplication of polygons; (C) gaps between polygons.
Source: Authors (2025).

A total of 4,484 registered rural properties were surveyed in the basin after removing duplicates, correcting overlaps, and consolidating parcels for the year 2022. Following an intersection analysis with ANA's hydrography layer, 1,613 properties were identified in which the intersection or overlap of their polygons with the hydrographic layer indicates the potential presence of riparian Permanent Preservation Areas (APPs), as illustrated in Figure 3.

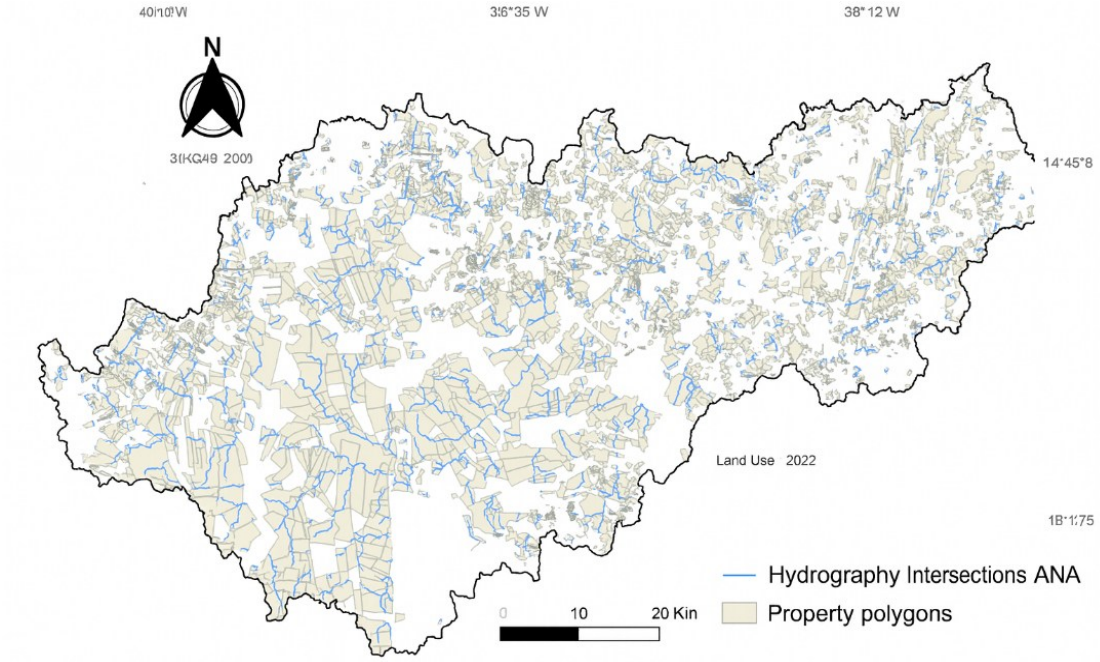


Figure 3 – Intersection of ANA Hydrography and properties registered in CAR.
Source: Prepared by the author based on information from ANA (2022) and SFB (2022).

When comparing the properties registered in SICAR that declared APPs and Legal Reserves (RLs), it was found that only 65.5% of the submitted declarations indicated the presence of riparian APPs (Table 3). With respect to Legal Reserves, 84.3% of the registered properties declared having a Legal Reserve, at least in its proposed form.

Table 3 – Number of properties registered in SICAR that declared APP and RL

Characterization	Properties declaring APP	Properties declaring RL
River APP up to 10 m	948	
River APP from 10 to 50 m	95	
River APP from 50 to 200 m	14	
Proposed RL		3781
Registered RL		5
Approved RL not registered		6
Total declarations	1057	3792

Source: Prepared by the author based on information from SICAR (2022).

The results obtained from the comparative analyses among the different cadastral systems (SNCR, CAFIR, CAR, and SIGEF) highlight the lack of integration and the diversity of information regarding rural properties located within the basin, which creates uncertainty in decision-making related to land management. First, it is important to note that Brazilian legislation has established several rural cadastral systems over the years, each with its own specific characteristics and purposes.

The different cadastral systems evaluated (SNCR, CAFIR, CAR, and SIGEF) present differences in terms of governing authority, database structure, legal aspects of properties, cadastral units, nature, and methodology, which complicates the effective integration of these systems. Some studies argue for the need for more effective integration among cadastral systems. They claim that integration leads to greater efficiency in land management, facilitates decision-making, and is crucial for the effectiveness of public policies related to environmental monitoring (YILMAZ & ALKAN, 2022; FONTES, 2022).

The overlapping information and errors identified in the CAR are concerning. The analyzed data reveal the existence of properties registered in duplicate, overlapping areas, and gaps between property boundaries. These issues may lead to

serious complications in land management and in the enforcement of environmental laws. Santos et al. (2021) highlight the need to review the criteria for data collection and validation to ensure greater reliability of the system. Effective environmental regularization requires accurate and consistent information, and the problems identified in the CAR pose a risk to this process.

The analysis of the declarations of Permanent Preservation Areas (APPs) and Legal Reserves (RLs) also reveals challenges in environmental regularization. The discrepancy between the declarations of riparian APPs (1,057 properties) and the actual presence of these areas (1,613 properties) exemplifies this issue. This suggests the need for stricter control and more effective enforcement to ensure compliance with environmental legislation. The absence of adequate oversight and control is a common barrier to the implementation of environmental policies.

Despite the inconsistencies identified in relation to APPs, the high percentage of properties that declared having a Legal Reserve, at least in its proposed form, is a positive indication, as it reflects an awareness among rural landowners regarding the importance of environmental conservation. However, it is essential to ensure that these declarations are accompanied by effective conservation actions and sustainable management of RL areas. Pacheco et al. (2021) suggest that the effectiveness of environmental protection policies depends on the implementation of concrete actions that guarantee the conservation of Legal Reserves.

3.1 Proposed Guidelines for the Validation and Verification of CAR Data

In this context, a set of guidelines is proposed to establish requirements for the verification—and potentially the validation—of CAR data, as illustrated in Figure 4. The validation of data within the Rural Environmental Registry (CAR) is essential to ensure the integrity and usefulness of the information for environmental and territorial management. In addition to using data from the National Water Agency (ANA) to identify APPs along river margins, it is also crucial to expand the analyses to include other categories of APPs, such as areas surrounding springs, reservoirs, and other Permanent Preservation Areas as established by current legislation (BRAZIL, 2012a).

Advanced geoprocessing tools and spatial analyses can be employed to cross-reference cadastral information with environmental datasets, providing a more comprehensive approach to the identification and management of protected areas.

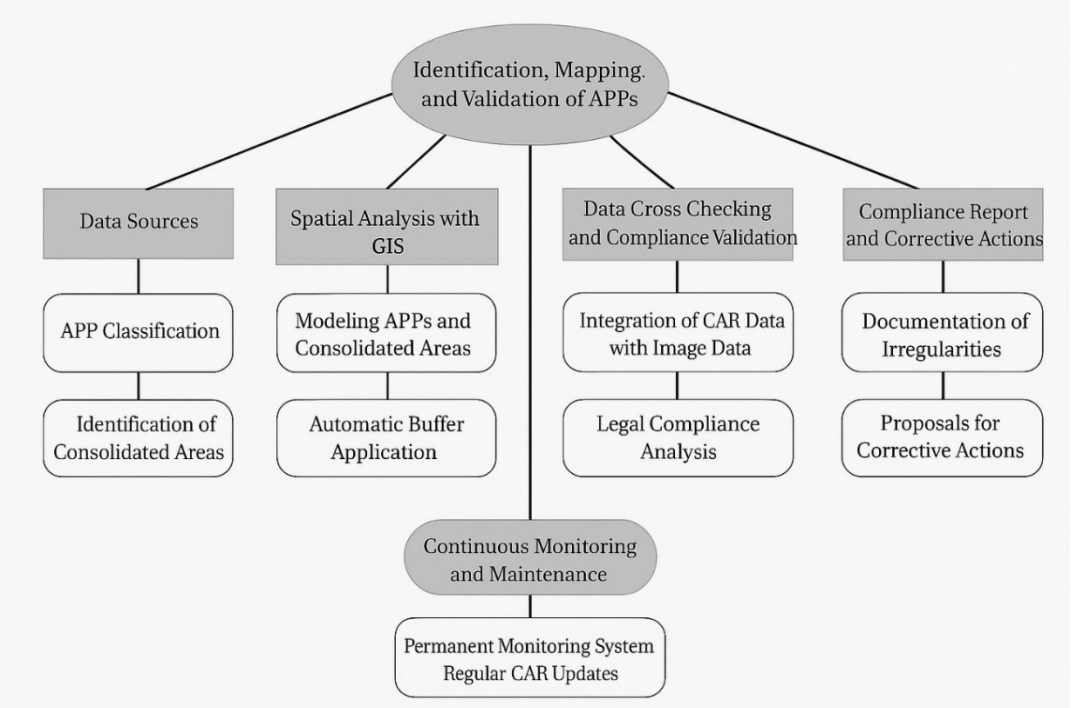


Figure 4 – Suggested roadmap for establishing CAR verification and validation requirements. Source: Authors (2025).

The proposed flowchart for the verification and potential validation of CAR data begins with "Identification and Mapping of APPs," using multitemporal satellite imagery to assess conditions in rural properties that had preexisting anthropogenic occupation prior to July 22, 2008, as established by Law No. 12,651/12 regarding consolidated rural areas. This process includes the classification of APPs using image-processing algorithms to distinguish native vegetation, agricultural areas, urbanized zones, and other land uses. Subsequently, consolidated areas are identified using historical imagery, allowing verification of current compliance.

The next stage is the "GIS-Based Spatial Analysis," where digital terrain models (DTMs) are generated to analyze slope and elevation—parameters essential for delineating APPs in hill, mountain, and hillside regions, as well as for identifying water bodies and springs. Automated buffers are applied around water bodies in accordance with legislation, and change detection techniques validate the consolidated areas, ensuring there have been no significant alterations. Finally, the phase titled "Data Cross-Referencing and Compliance Validation" integrates CAR data with imagery and GIS analyses to verify the accuracy of APP and consolidated-area declarations, ensuring legal compliance and proposing corrective actions, culminating in a "Compliance Report and Corrective Measures".

The use of multitemporal satellite imagery and advanced image-processing techniques is essential for the environmental monitoring of Permanent Preservation Areas (APPs). Tilahun et al. (2023) highlight how image-processing techniques—such as image classification and pattern analysis—can be used to extract meaningful information for environmental monitoring. Such technologies, along with digital terrain modeling performed through Geographic Information Systems (GIS), are fundamental not only for documenting the prior condition of areas but also for verifying current compliance or noncompliance with environmental regulations (TAYLOR & LINDENMAYER, 2022).

On the other hand, integrating data from the Rural Environmental Registry (CAR) with information obtained through satellite imagery and GIS analyses enables cross-checking that can verify the accuracy of declared Permanent Preservation Areas (APP) and the status of consolidated areas. This integration is essential for assessing legal compliance and for preparing detailed reports on identified non-compliances, proposing the necessary corrective actions, such as APP restoration and the reestablishment of native vegetation. Studies reinforce the importance of using drones and remote sensing for continuous environmental monitoring (ANCIN-MURGUZUR et al., 2019). Together with regular updates to the CAR, these tools ensure that the registry accurately reflects the reality of land use and vegetation cover.

4. Final Considerations

The results of this study underscore the need for improvements in rural land registration systems and in the environmental regularization of rural properties within the Cachoeira River basin. The lack of integration among systems, the presence of errors and overlaps in the CAR, and discrepancies in APP and RL declarations represent challenges that must be addressed. Thus, the urgent implementation of the Land Administration Domain Model (LADM) within the Brazilian land cadastre framework is necessary to support a land information management system that encompasses the full spectrum of formal, informal, and customary rights.

The implementation of LADM in the land cadastre provides a standardized foundation that facilitates interoperability among different cadastres and geographic information systems an essential aspect for integrating data from diverse governmental and non-governmental sources. Through an innovative approach, LADM proposes a strategy involving the categorization of land rights, data collection, and data conversion, aiming for integrated management of multiple types of information within a single environment. In this regard, the cartographic basis for integrating different data types and systems should follow the legal and technical specifications of SIGEF, requiring georeferencing to the Brazilian Geodetic System (SGB) with defined positional accuracy.

The proposed workflow for verification and validation of the CAR demonstrates a strategic approach for overcoming current challenges related to data inconsistencies and overlaps. The integration of geospatial technologies—such as multitemporal satellite imagery, digital terrain models, and geographic information systems—enables robust analysis of APPs, RLs, and consolidated areas, ensuring alignment with current legislation. Implementing this workflow, combined with regular CAR updates, ensures that the registry accurately reflects the environmental reality of rural properties, contributing to effective public policies and environmental conservation.

Furthermore, it is essential to promote environmental awareness and effective conservation practices among rural landowners. More efficient and integrated environmental regularization, along with collaborative efforts among federal and municipal agencies, is crucial for fostering sustainable development and conserving natural resources in the Cachoeira River basin.

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