Deforestation Control at Rural Properties in Pará: a strategy using the PrevisI risk model

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1. Introduction

Pará, the state with the highest contribution to deforestation in the Brazilian Legal Amazon, accounted for 38% of total deforestation from 2021 to 2023 (Albernaz, 2023; INPE, 2023). Controlling deforestation in Pará, the second-largest Brazilian state (IBGE, 2022), is challenging due to its vast territorial extension. Moreover, deforestation control is conducted chiefly after deforestation detection, with no or minimal preventive actions. PrevisIA, a platform created to predict deforestation risk in the Amazon in the short term (i.e., within a year), can identify critical areas and prevent deforestation.

PrevisIA's risk model uses historical deforestation, topographical data, water bodies, distance to protected areas, and socioeconomic data (Sales et al., 2017). In addition, the model relies on an Artificial Intelligence (AI) algorithm that annually identifies the emergence of unofficial roads in the Amazon (Botelho et al., 2022), considered one of the most predictive variables in the PrevisIA model, with 95% of the accumulated deforestation in the Amazon has occurred within 5.5 km of them (Barber et al., 2014), and 90% of the annual fires occur within 4 km of them (Kumar et al., 2014).

Public agencies can use the PrevisIA risk maps, which identify the probability of deforestation, to guide resource allocation decisions and implement command and control actions to prevent illegal deforestation (Sales et al., 2017). When comparing actual deforestation from Prodes (INPE, 2023), the PrevisIA model predicted deforestation from 2021 through 2023 with 70-75% accuracy within 4 km (Imazon's unpublished data).

The Rural Environmental Registry (CAR) is a tool for environmental and economic control, monitoring, support the implementation of the Brazilian Forest Code, and planning (Brandão et al., 2016). The CAR system requires rural properties to submit a self-declaratory electronic document providing information on their boundaries and land cover. This data is essential for identifying and protecting forest areas, as established by the Brazilian Forest Code (MAPA, 2023). Combining the CAR data with PrevisIA can identify critical rural properties to prevent deforestation.

In this study, we assessed the PrevisIA accuracy to predict deforestation at the property level in areas registered in the CAR system in different risk levels for 2021, 2022, and 2023 in Pará. In addition, we pointed out the critical areas in which to control deforestation and proposed a strategy targeting rural properties that contribute to deforestation in this region.

2. Methods

2.1 Study area

The Pará state (Figure 1), located in the northern region of Brazil, is one of the nine states that belong to the Legal Amazon. Its territorial area is 1,245,870.7 km². Since 2006, this state has led the ranking of deforestation in the Amazon biome. Economic activities associated with deforestation, such as cattle ranching, agriculture, and logging, mainly drive this scenario. (IBGE, 2022; Albernaz, 2023; Simoes et al., 2022).

2.2 Database

We used several datasets to address the objectives of this study. First, the territorial boundary of the state of Pará (IBGE, 2022) was used to extract the annual deforestation polygons from PRODES for the years 2021 to 2023 (INPE, 2023), and the map of the Deforestation Risk Forecast in the Legal Amazon (PrevisIA) for the years 2021 to 2023 (IMAZON, 2023). Finally, we obtained the Rural Environmental Registry (CAR) database for Pará updated in 2024 (SEMAS, 2024).

2.3 Deforestation risk at the CAR level

We assessed the accuracy of PrevisIA at the CAR level through two steps. First, we combined the PrevisIA risk classes with the property boundary data for each rural property. Next, we extracted the deforestation risk for each property registered in the CAR, using the deforestation risk maps provided by PrevisIA for 2021 to 2023. As the PrevisIA data has a spatial resolution of 1 km and the risk of deforestation varies from ‘Very High’ to ‘Very Low’, we assigned the highest risk class that overlaps the property. The PrevisIA data accounted for the risk for the remaining forests in the property boundary because the cumulative deforested areas are masked.

In the second step, we combined the respective PRODES deforestation data with the deforestation risk classes assigned to the rural properties. This analysis allowed us to evaluate deforestation risk relative to the actual deforestation detected by PRODES and estimate the accuracy of PrevisIA in predicting deforestation at the rural property level.

We conducted all the spatial analyses described above using QGIS Version 3.28.15 (QGIS Association, 2024), which also provided tabulated data for further analysis of deforestation by the size of rural properties and risky classes.

3. Results and discussion

During the years 2021 to 2023, a total of 12,672 km² of deforestation occurred in the state of Pará (INPE, 2023), 78% of which occurred in areas registered in the state's Rural Environmental Registry (CAR) (Table 1).

This study assessed deforestation risk in more than 321 thousand properties registered in the state's system. On average, 11% of these properties received 'Very High' and 'High' risk classifications. Despite representing the classes with the lowest number of CARs, on average, 76% of deforestation happened in these two risk classes. When we add up the 'moderate' risk properties, deforestation reaches 94%, on average (Figure 2).

We also found that 68% (on average) of the rural properties had a 'Low' or 'Very Low' deforestation risk. However, these areas accounted for only 6% of the detected deforestation. We detected no deforestation in CARs classified as 'no risk' (Table 1). The results highlight the high level of predictability of PrevisIA for deforestation at the CAR level. Therefore, 'Very High' and 'High deforestation risk classes can be prioritized to prevent deforestation in Pará.

We also observed some spatial variation of the deforestation risk areas over the three years at the CAR level. Deforestation-risky areas (i.e., 'Very High' and 'High) concentrated in six clusters of rural properties in the center and western of Pará, over 2021, 2022, and 2023 (Figure 1). This spatial location of critical deforestation in Pará suggests continuing the activities that stimulate deforestation in these regions, making them targets for preventing and controlling deforestation.

Table 1: The number of Rural Properties registered in the CAR by Risk Class and deforestation detected by PRODES in their respective areas.

Risk Class	2021		2022		2023		Total PRODES (km²)
	No. of CARs	PRODES (km²)	No. of CARs	PRODES (km²)	No. of CARs	PRODES (km²)	
Very high	497	712,2	7482	1907,3	1032	657,1	3.276,6
High	30940	2145,9	42555	984,5	25062	1061,3	4.191,6
Medium	65707	797,4	69761	509,7	65245	463,1	1.770,3
Low	84549	258,2	86410	180,8	90160	124,9	563,9
Very low	100176	55,2	81433	11,0	87597	14,8	81,0
No Risk	39140	-	33368	-	51913	-	-
Total	321.009	3.969,0	321.009	3.593,3	321.009	2.321,2	9.883,4

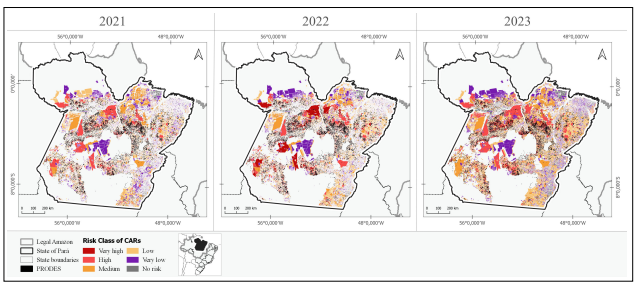

Figure 1: Properties registered in the CAR, categorized by risk classes according to the PrevisIA map, with the deforested area detected by PRODES in the same year.

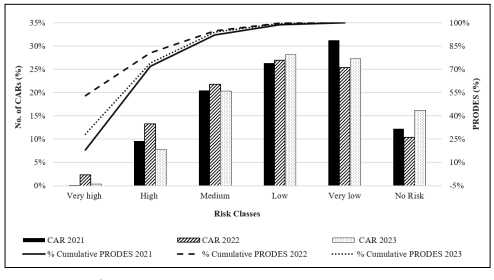

Figure 2: Percentage of Rural Environmental Registrations (CAR) by risk class and respective deforestation detected on properties.

4. Conclusion

The study demonstrates the effectiveness of integrating the PrevisIA Risk Map with the CAR in predicting rural properties that will likely clear their forests within a year. Properties classified with "High" and "Very High" risk levels responded to 11% of the rural properties responsible for 76% of deforestation, on average. These results show that allocating resources to prevent deforestation in critical, risky areas is possible. Therefore, the Pará can shift from a command-and-control action to directing enforcement and conservation efforts towards avoiding deforestation and potentially generating carbon credits. This approach has the potential to substantially reduce the high cost and resources dedicated to combating deforestation on the ground after deforestation happens, saving forests, and mitigating environmental impacts.

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