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MAP OF MULTIPLE THREATS IN PARÁ: A STRATEGIC TOOL FOR ALERT AND RESILIENCE IN THE FACE OF EXTREME EVENTS IN THE AMAZON

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ABSTRACT

The Amazon faces extreme natural events annually that cause unpredictable damage to populations, ecosystems, and urban and rural infrastructure. In response to this challenge, the Fire Department of the State of Pará, through the State Coordination of Civil Defense (CEDEC/CBMPA), developed the Multiple Threat Map of the State of Pará (M²A-Pará). This document uses historical data from the Brazilian Atlas of Natural Disasters and the Integrated Disaster Information System (S²ID) to map natural threats in the seven

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Hydrographic Regions (HRs) of the state, considering historical series from 1973 to 2024. M²A-Pará offers a strategic vision for risk management, highlighting the most vulnerable regions and prioritizing preventive and mitigation actions. The analysis of multiple threats over more than a decade allows us to identify patterns and guide proactive planning, promoting the reduction of human, material, economic, and environmental losses. This instrument also reinforces the importance of integrated civil defense planning, based on historical and georeferenced data, to ensure the safety of communities. In addition, it contributes to broader discussions on climate change and disaster management, positioning Pará as a reference in the implementation of strategies based on science and technology in the Amazon.

Keywords: Climate Change. Extreme Events. Threat Management Civil Defense.

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INTRODUCTION

Threats have been present in societies since the beginning, representing the possibility of adverse events or occurrences that cause damage to people, property, and the environment. Some natural and technological disasters exemplify these serious threats. In this context, adverse, extreme, and recurrent events are considered threats, as they have the potential to cause serious damage to communities and the ecosystem.

This issue is configured as a concern of international dimension, affecting practically all countries (TELES, 2024). Recognizing the threats of a given geographic space is essential to implement corrective and preventive measures, ensuring the safety of the population in the face of the increased frequency and intensity of disasters on a global scale.

Among the main threats are floods, flash floods, heat waves, droughts, droughts and forest fires. These events, when repeated in the same area, become permanent dangers, capable of causing significant damage if not properly monitored and mitigated (SAUSEN; LACRUZ, 2025).

In the State of Pará, the Hydrographic Regions (RH) have been continuously impacted by extreme events that compromise economic, social and environmental functioning. According to Dos Santos et al. (2018), these events, which result in annual losses, have drawn the attention of the international scientific community, often treated as media spectacles. However, it is essential that they be seen as opportunities to deepen the understanding of regional vulnerabilities and promote concrete mitigation and adaptation actions (PEREIRA et al., 2016).

In this scenario, the next Conference of the Parties (COP 30), to be held in Belém, represents a strategic opportunity to integrate the global discussion on the threats that impact the HR population of Pará, especially traditional communities such as indigenous peoples, quilombolas and riverside dwellers. COP 30 can emphasize the relevance of tackling natural and technological events that, annually, cause severe damage to life and the environment (DA COSTA et al., 2024).

This article presents the Pará Threat Map (M²A-Pará) as an essential tool to identify cyclical and recurrent events, whether natural or technological. These events compromise the response capacity of local public managers and hinder the return to normality, as they occur in a cyclical manner, intensifying the challenges for crisis management and the recovery of affected territories. The theme is important because it addresses issues related

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to disaster management and environmental sustainability, especially in a strategic region such as the State of Pará, which has rich biodiversity and significant socio-environmental vulnerability.

MATERIALS AND METHODS

DATA COLLECTION

The data were obtained through the analysis of state and municipal documents, related to the period from 1973 to 2012, of the Fire Department of the State of Pará (CBMPA) and the State Coordination of Civil Defense (CEDEC), covering the Disaster Information Forms (FIDE) of the Ministry of Integration (MI) and CEDEC. For the period from 2012 to 2024, the Brazilian Atlas of Natural Disasters (ABDN) and the Integrated Disaster Information System (S²ID) were used (BRASIL, 2024; SEDEC, 2024). FIDE, ABDN and S²ID are official sources that document emergencies and calamities in Brazil, allowing the organization of historical records of extreme natural and technological events. These systems provided quantitative records of emergency and public calamity events over 51 years for each municipality, which were then stored in a database.

DATA ORGANIZATION

The National Policy for Civil Protection and Defense (PNPDEC) establishes the hydrographic basins or Hydrographic Regions (RH) as units for the analysis of disaster prevention actions. RH are defined as areas composed of adjacent river regions, which share similar natural, social and economic characteristics, and should guide the planning and management of disaster risks (PEREIRA et al., 2016; MIGUEL et al., 2017).

This study follows the division proposed by Lima et al. (2021), which segments the territory of the State of Pará into the Hydrographic Regions of Portel and Marajó, highlighting the importance of this division, since Marajó Island is the largest fluvial-marine island in the world, and the Portel archipelago is formed by a complex network of rivers, streams and mangroves, with a rich and diverse biodiversity.

The division proposal considers the dismemberment of the Porte-Marajó Hydrographic Region, as defined by the State Secretariat for the Environment and Sustainability (SEMAS), allowing the consideration of the specificities of the regions of Portel and Marajó. This approach facilitates the identification of the areas of greatest vulnerability and priorities for intervention.

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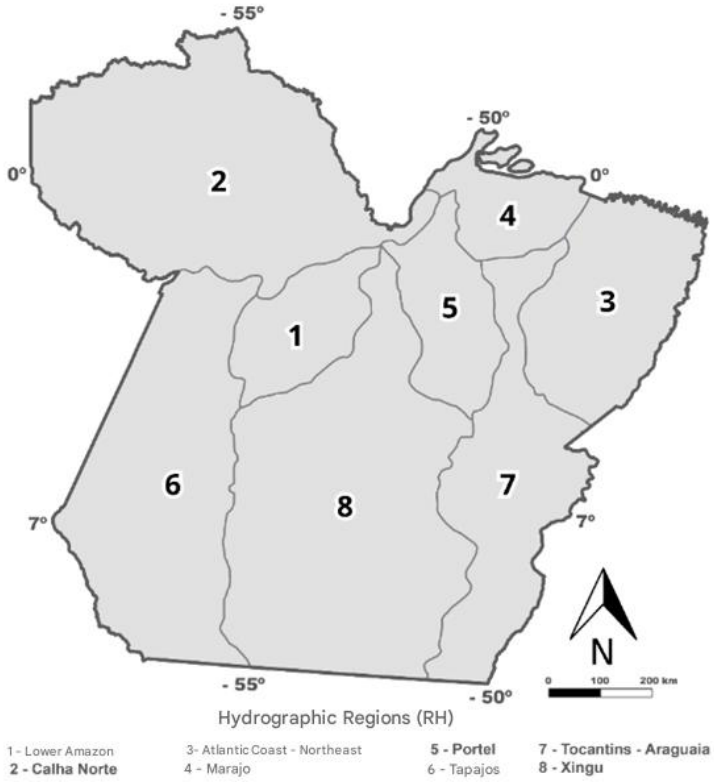
Lima's HR division (2001) should be analyzed considering several factors that influence environmental sustainability, territorial planning and regional socioeconomic development. The M²A – Pará model, based on this division, shows how the state's RH are exposed to multiple natural and technological threats, highlighting the complexity of extreme events that occur frequently, helping in disaster management in the Pará Amazon.

Figure 1 – River Basin Regions of the State of Pará (RH – Pará)



Source: Authors (2025)

A thorough analysis was carried out to detect possible inconsistencies in the data, such as duplicates, absence of information or divergent values. Excel and Python tools were used to clean the data. The municipalities and events were organized into groups, subgroups, types and subtypes, according to the Brazilian Classification and Coding of Disasters (COBRADE), in order to avoid redundancies, applying unified criteria for the categorization of events by HR-Pará.

With the standardized database, descriptive and comparative analyses of the records were performed, organized by hydrographic region. During the process of organizing the data, meetings were held with technicians from CEDEC in Pará, especially with the Community Support (DAC) and Operations Division (DivOp) divisions.

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MAPPING AND ANALYSIS OF RESULTS

The mapping of the results was carried out using the Geographic Information System (GIS) QGis, which facilitated the organization and standardization of the database. This tool allowed the visual and interpretative presentation of records of extreme events by HR-Pará, with the objective of guiding public managers and supporting decision-making. In this context, the analysis of multiple threats should help in civil defense response actions.

RESULTS AND DISCUSSION

The Tapajós (23.95%), Lower Amazon (23.34%) and Tocantins-Araguaia (19.29%) regions concentrate most of the occurrences of natural disasters, reflecting the high vulnerability of these areas. This scenario is related to the presence of large rivers, which facilitate the risk of floods, and to climatic variations, such as intense droughts and seasonal floods, observed in S2ID and recorded by the Municipal Coordinators of Protection and Civil Defense (COMPDEC). These natural factors, coupled with the scarcity of infrastructure and responsiveness, make these regions especially susceptible to the impacts of extreme events.

On the other hand, regions such as Xingu (16.59%) and Calha Norte (3.53%) have a lower proportion of events, which may be related to the lower population density and infrastructure in these areas. This can result in lower monitoring capacity and possible underreporting of disasters. The regions of the Atlantic Coast-Northeast (7.88%) and Marajó (2.05%) also have low rates, despite their vulnerability to floods and erosion, which highlights the challenges faced in the implementation and effectiveness of the warning and response systems. The map presented in Figure 2 illustrates the percentage distribution of extreme events recorded in Pará by Hydrographic Region (RH), totaling 2,296 events

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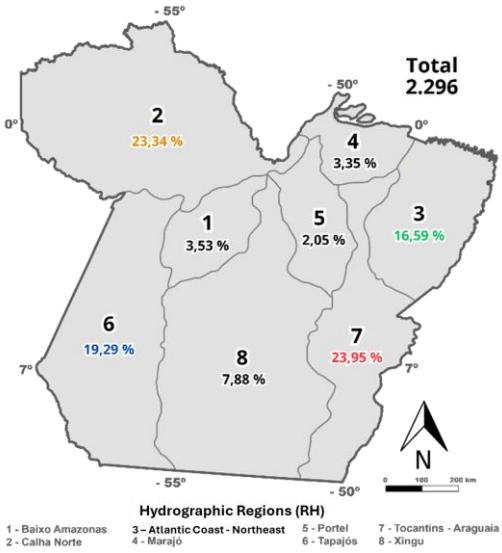
Figure 1 – Percentages of records of extreme events by HR in the State of Pará



Source: Authors (2025)

Based on the tabulation, classification and analysis of the frequencies of extreme events, disaster and emergency processes recognized by the National, State and Municipal Civil Defense of the State of Pará between 1973 and 2024, recurrent extreme events were identified in all Hydrographic Regions (RH) of Pará, characterizing these regions and their multiple threats.

Figure 3 illustrates the percentage distribution of natural and technological disasters in the Hydrographic Regions of the State of Pará (RH-Pará) over the last 51 years. Natural disasters occur much more frequently, while technological disasters account for a small portion of events. Among the natural disasters, the Tocantins-Araguaia (22.43%), Lower Amazon (21.25%) and Tapajós (18.25%) Hydrographic Regions stand out as the most affected. These numbers reflect the presence of large river systems, intense rainfall, and climatic events, such as floods and severe droughts, predominant characteristics in these regions.

On the other hand, regions such as the Atlantic Coast-Northeast (3.44%) and Marajó (1.96%) have significantly lower rates, which can be attributed to the low population density and the possible underreporting of disasters in the S²ID. As for technological disasters, the rates are low in all regions. The Hydrographic Regions of Calha Norte (2.09%) and Tocantins-Araguaia (1.52%) concentrate the highest percentages, while the regions of Marajó (0.13%) and Costa Atlântica-Nordeste (0.09%) have the lowest records. This scenario can be explained by the low industrialization in some of these areas and the

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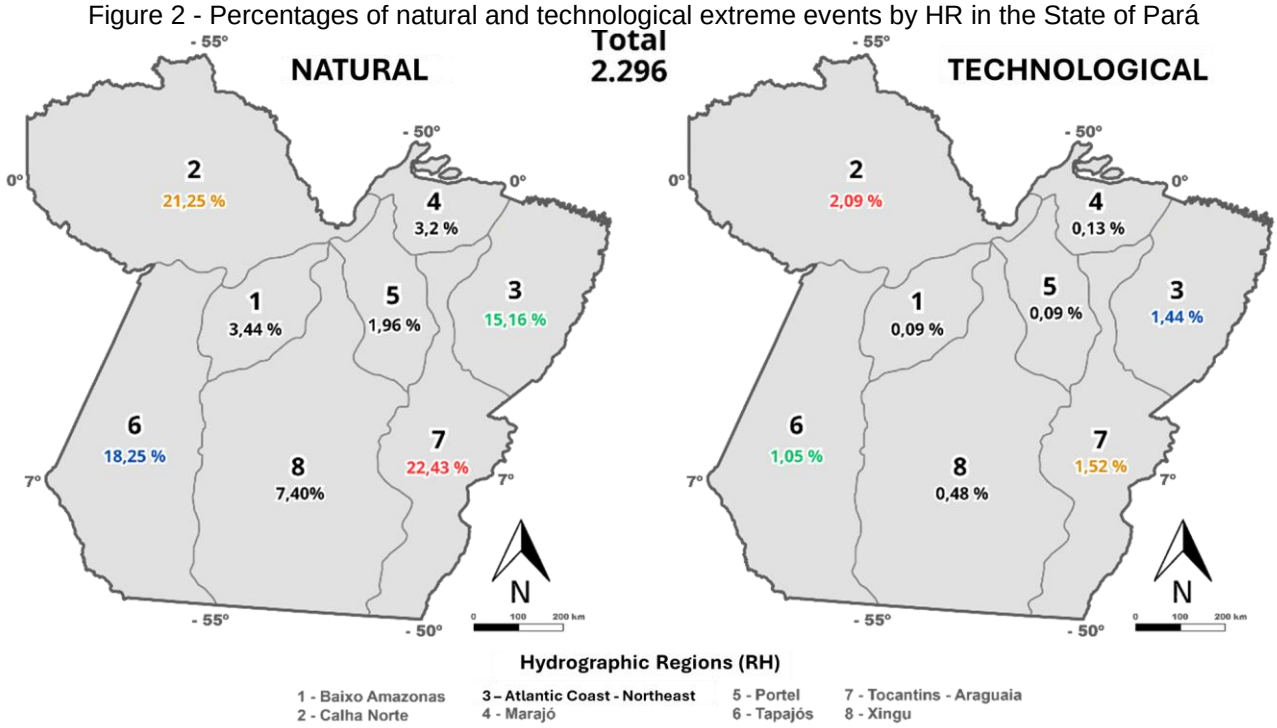
predominance of traditional economic activities, which are less susceptible to technological events.

Figure 2 - Percentages of natural and technological extreme events by HR in the State of Pará



Source: Authors (2025)

The total number of records presented in the image is 2,296 events, with notable variations between the hydrographic regions. River Basin 1 (Amazon Basin - Caeté) and 5 (Tocantins-Araguaia) stand out, with 536 and 550 records, respectively, reflecting their socio-environmental and economic relevance for the state. Despite the large number of events recorded, not all of them received official recognition from the competent authorities. River Basin Region 7 (Tocantins-Araguaia) stands out with 99.82% of recognized events, while River Basin 2 (Calha Norte) has only 32.32% of officially recognized events, suggesting gaps in the documentation and formal validation process.

The concentration of records in regions with higher population density and large ecosystems (such as River Basin Regions 1, 5 and 8) indicates that these areas are more vulnerable to natural and technological disasters. The variation in the number of events recorded and the discrepancy in the recognition percentages highlight the need for improvements in the collection, registration and validation of events in Pará. This is essential to improve risk management and strengthen public policies aimed at disaster prevention and mitigation.

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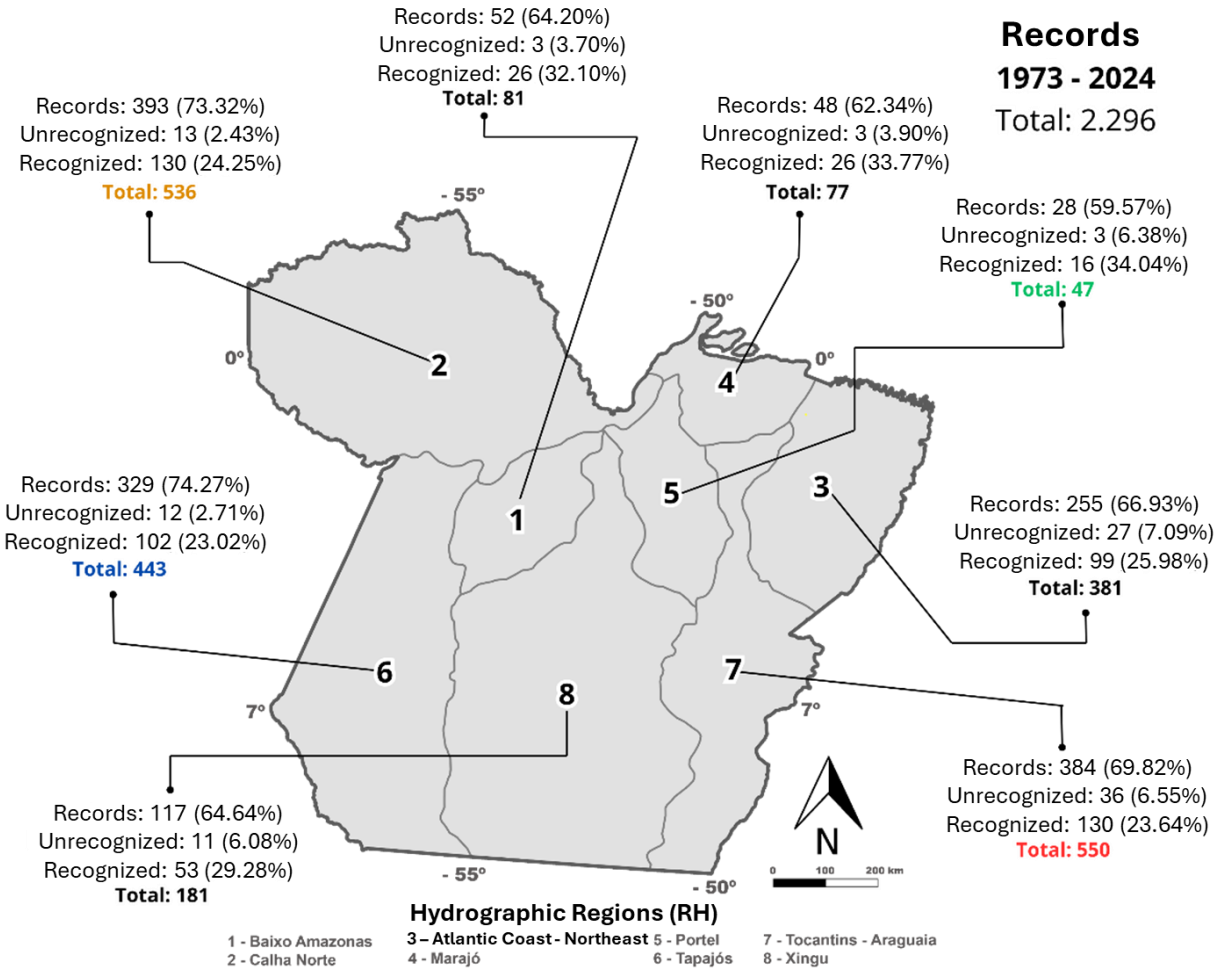
Figure 3 – Distribution of records of extreme event groups by HR in the State of Pará



Source: Authors (2025)

Another relevant factor is underreporting or the absence of sufficient data to justify the recognition of a disaster. In several hydrographic regions, particularly in the less populated ones, such as Marajó or the Atlantic Coast-Northeast, the monitoring of events is limited, which results in incomplete or inaccurate records. The absence of reliable data makes it more difficult to analyze the real impact of events and, consequently, official recognition.

In addition, the criteria for recognizing disasters must consider economic, social, and environmental damage, which may vary according to the clauses applied by the responsible agencies. This is one of the biggest challenges of COMPDECs, since the evaluation criteria often involve qualitative and quantitative analyses resulting from the impact, local conditions and the interpretation of the data presented by the affected municipalities.

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Hydrological events are the most recurrent in the Hydrographic Regions (RH) of Pará, with emphasis on floods, which add up to 587 records (25.57%), followed by flash floods (19.95%) and floods (6.36%). The areas of Calha Norte and Tapajós are especially vulnerable, due to the presence of riverside communities and the seasonality of rainfall, factors that intensify the impact. Erosion of river banks is also a significant challenge, especially in regions with greater river activity.

In the scope of meteorological and climatological risks, heavy rains appear with 269 records (11.72%), while climate estimates represent 135 events (13.08%). These threats are more frequent in the regions of Tocantins-Araguaia and the Atlantic Coast-Northeast, where the contrast between periods of drought and rain is striking. Forest fires, with 97 occurrences (4.22%), are worrying in areas pressured by deforestation, such as the Xingu and Calha Norte. In technological events, the collapses of civil works (6.44%) and urban and industrial fires (3.70%) stand out, reflecting the vulnerability of urban areas. The Tocantins-Araguaia region is especially affected, due to population growth and the intensification of economic activities, which increase the pressure on local infrastructure.

Figure 5 illustrates the distribution and proportion of extreme events in the RH of Pará, divided into six major groups: hydrological, geological, meteorological, climatological and technological. This analysis highlights the complexity of the risks in the state, demonstrating that the threats are not distributed homogeneously and are directly linked to the natural and socioeconomic characteristics of each region. These data reinforce the need for decentralized strategies adapted to the specificities of each area. Efficient management and risk mitigation depend on integrated actions that consider the particularities of each HR, promoting greater resilience for the population of Pará.

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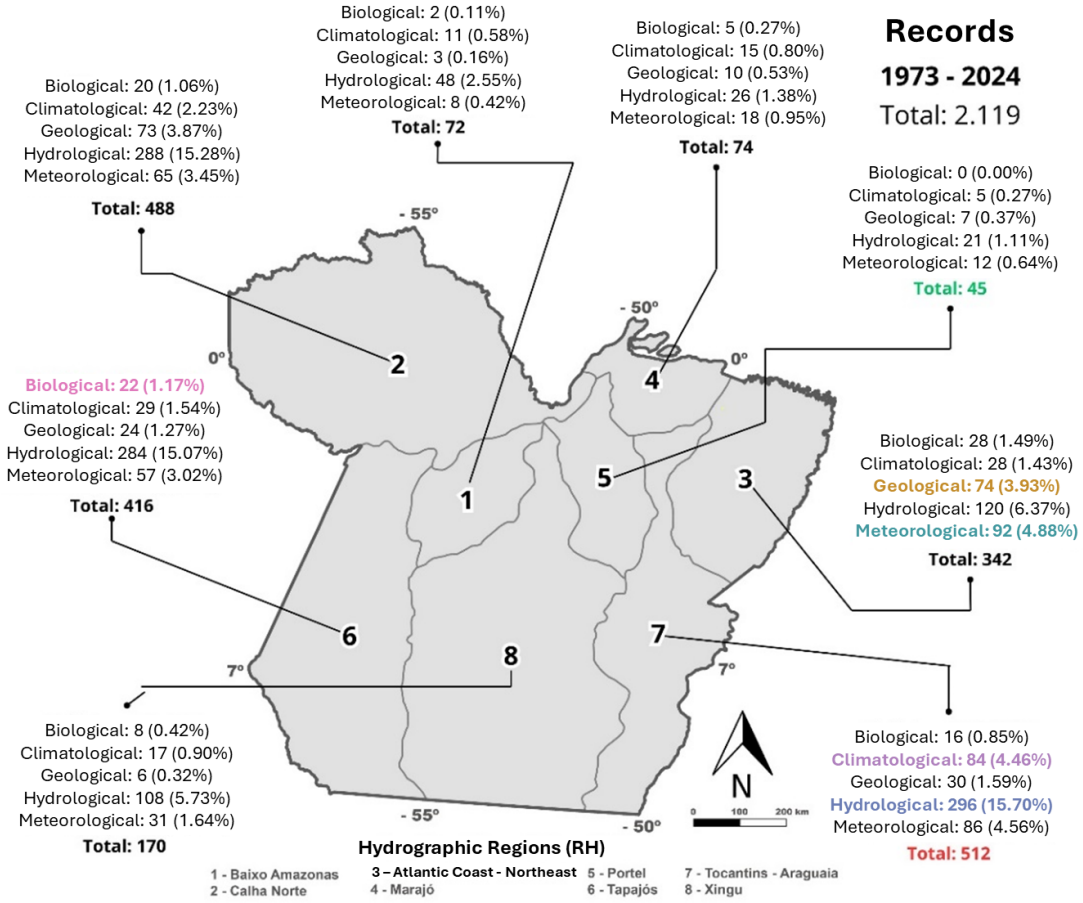
Figure 4 - Distribution of records of the Subgroups of extreme events by HR in the State of Pará



Source: Authors (2025)

Natural disasters in the Amazon have attracted the attention of the national and international scientific community, but they are often presented as mere media spectacles. This superficial approach ignores the seriousness of the threats affecting the region, which can cause significant damage to vulnerable populations and can evolve into large-scale catastrophes, increasing human, material and environmental damage.

Over more than five decades, the survey of the various threats in the Hydrographic Regions (RH) of the Pará Amazon has brought to light the need for effective monitoring of disasters. Based on extreme events previously recorded is an essential strategy for the implementation of preventive measures, which aim to reduce human, material, economic and environmental losses.

In this context, the Multiple Threat Map of the State of Pará (M²A – Pará) stands out, which offers a comprehensive view of the geographic distribution of extreme events in the eight RH of the state. With consolidated data from 51 years, the map identifies patterns of occurrence and provides valuable information for the formulation of mitigation and risk

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management strategies. The creation and use of tools such as M²A – Pará represent an important step towards understanding the dynamics of natural disasters in the region, promoting preventive actions that safeguard the most exposed communities and preserve the natural resources of the Amazon.

THE MAP OF MULTIPLE THREATS OF THE STATE OF PARÁ (M²A – Pará)

The Multiple Threat Map of Pará (M²A – Pará) highlights the complexity and severity of the threats faced by the eight Hydrographic Regions (RH) of the state over the last 51 years. Based on the Brazilian Classification and Coding of Disasters (COBRADE), M²A identifies patterns of recurrent extreme events and provides essential subsidies for risk management and decision-making.

UNDERSTANDING MULTIPLE THREAT REGIONS (RMA)

The concept of "multiple threats" reflects the overlap of natural and technological events that significantly affect the lives, the environment, and the economy of local populations. In the RH of Pará, the recurrence of hydrological, climatic, biological and technological disasters is evident. These combinations make each region unique in terms of management challenges and demands.

MULTIPLE THREAT REGIONS (RMA)

1st RMA: Lower Amazon

With only 3.75% of the events recorded, this region has significant hydrological risks, such as floods (16 events) and flash floods (29 events). Despite the low density of registrations approved as Emergency Situation (SE), the area faces increasing challenges due to changes in the rainfall regime and drought in the Tapajós and Xingu rivers, directly impacting agriculture and supply.

2nd RMA: North Channel

With 23.34% of total records, it is one of the areas most affected by hydrological disasters, including floods and erosion of river banks. The dense vegetation and isolated geography intensify the impacts, making emergency response difficult. Monitoring shows that most of the occurrences are not officially recognized as SE, highlighting the need for greater integration between municipal and state civil defenses.

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3rd RMA: Atlantic Coast – Northeast

The proximity of the coastline exacerbates the threats of coastal erosion and flooding. This RMA also faces technological challenges, such as civil works collapses and industrial accidents. The 3rd RMA stands out for its diversity of disasters, from urban fires to dam failures, which requires multifaceted mitigation strategies.

4th RMA: Marajó Archipelago

With only 3.40% of occurrences, hydrological risks, such as floods and droughts, are predominant. Extreme events, such as storms and epidemics, affect local infrastructure and food security, exacerbating the region's vulnerability.

5th RMA: Portel

Registering only 2.09% of the threats, this region mainly faces hydrological problems. Financial losses, especially in agriculture, exceed two million reais, highlighting the economic impact of the storms.

6th RMA: Tapajós

With 19.38% of the records, this region is marked by hydrological events, including 153 floods. Deforestation and disorderly occupation intensify disasters, while prolonged droughts affect river transport and water security.

7th RMA: Tocantins/Araguaia

The most vulnerable, with 23.95% of occurrences, this region faces climate challenges, such as droughts and forest fires. Frequent storms also cause damage to critical infrastructure, such as dams and bridges, increasing the need for strict enforcement and preventive actions.

8th RMA: Xingu

With 7.88% of the records, floods and flash floods dominate the threats. The impact on agriculture and fisheries has significant implications for the local economy, with losses exceeding R$ 60 million.

Recurrent droughts and the intensification of extreme events in RHs have harmed sectors such as agriculture and fishing, in addition to limiting access to drinking water. The

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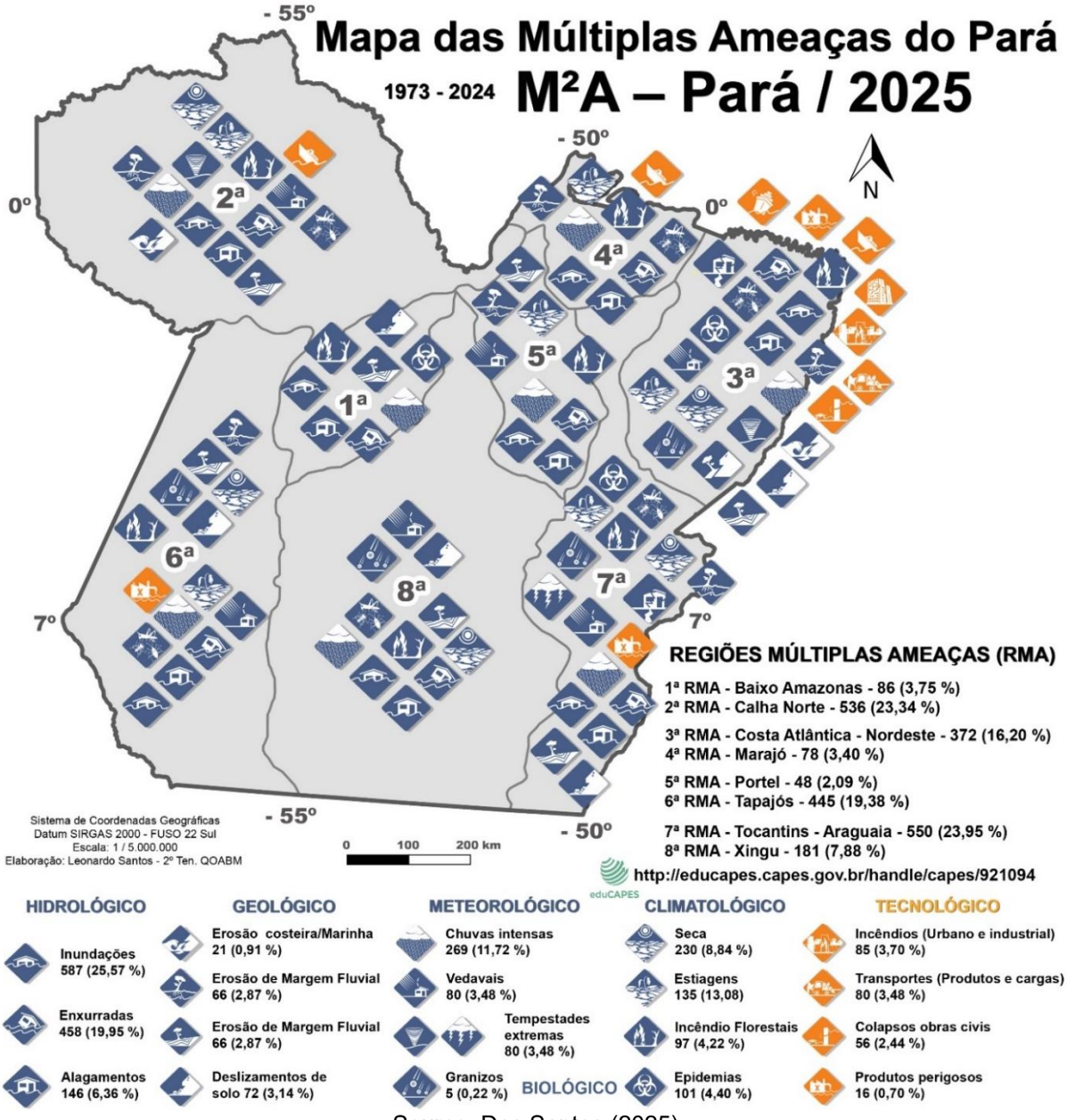
State Civil Defense estimates that, in 2024, more than 48,900 people were directly affected by the drought in three RMAs, evidencing the severity of the water and food crisis.

Figure 6 shows the M²A – Pará reveals not only the diversity, but also the complexity of the threats that affect the state's River Basin Regions. The analysis of historical data highlights the urgent need for coordinated and integrated actions, which take into account the specificities of each RMA. Investing in continuous monitoring, strengthening civil defenses, and educating local communities is essential to mitigate the impacts of multiple threats and ensure the resilience of Pará populations in the face of future disasters.

Figure 5 - Multiple Threat Map of the State of Pará (M²A-Pará / 2025)



Source: Dos Santos (2025)

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During the period analyzed, no official records of states of public calamity were identified in Pará. This absence may be directly related to the difficulty in meeting the criteria required by Brazilian legislation for the characterization of such a state. The current regulation establishes that it is necessary to prove significant impacts on the lives of the population, such as the destruction of essential infrastructure or the inability of the municipality to respond to the event with its own resources. However, this proof is not always consistently demonstrated.

One of the main obstacles to the registration of public calamity is the lack of qualified technical teams and adequate infrastructure in many municipalities. The use of the Integrated Disaster Information System (S²ID), for example, requires the insertion of detailed information about the events, such as the characterization of the disaster, the impacts on the population and infrastructure, and the extent of the damage, including technical reports, photographs, and georeferenced maps. These requirements make the process complex and often unfeasible for locations that lack adequate human and technological resources. As a result, more than 1,600 records analyzed (69.95%) presented incomplete or non-existent data, making it difficult to formally recognize states of public calamity or emergency situations.

The absence of official records not only reflects technical weaknesses, but also directly impacts disaster management in the state. Without the formalization of calamities, municipalities no longer access essential federal resources for response and reconstruction actions, which compromises local resilience. In addition, the lack of detailed data limits the planning and implementation of effective public policies, aggravating the vulnerability of affected populations.

To overcome these barriers, it is essential to invest in the technical training of municipal teams, prioritizing training in the operation of the S²ID and in the preparation of required technical documents. It is also necessary to strengthen local infrastructure by providing equipment such as drones and georeferencing software to optimize data collection and analysis. Finally, the creation and strengthening of municipal civil defense centers, with technical and financial support from the state and federal governments, are essential measures to improve disaster response and minimize impacts on the population.

The absence of records of public calamity in Pará does not mean that severe events did not occur, but it highlights significant gaps in the formalization and recognition process.

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Addressing these challenges is baseline so that affected communities receive the necessary support and are better prepared to face future emergencies.

CONCLUSION

Pressure on natural resources, combined with global climate change, has intensified the impacts of disasters on River Basin Regions (HRs). In this context, the Multiple Threat Map of Pará (M²A-Pará) emerges as a tool for risk and disaster management in the state, offering an integrated and detailed view of cyclical threats in RHs. This approach is aligned with Law No. 12,608/2012 and the National Policy for Civil Protection and Defense, which recognize watersheds as strategic units for disaster analysis and mitigation.

Through M²A-Pará, public managers and municipal civil defense coordinators can plan preventive actions, prepare contingency plans, and strengthen the resilience of vulnerable communities, especially in a scenario of intensifying climate change impacts. The map also stands out as a technical and political instrument that contributes to global discussions, such as those foreseen at COP 30, by highlighting the relationship between extreme weather events, socio-environmental inequalities, and the need for adaptation and mitigation strategies in the Amazon.

Finally, M²A-Pará demonstrates how the use of georeferenced technologies and spatial analysis can transform historical data into practical tools to save lives, prevent losses, and ensure the preservation of natural resources. In addition to its usefulness in local management, the map positions Pará as an example of integrated risk management, capable of dialoguing with global climate challenges, promoting security, sustainability, and a vision of the future for the Amazon.

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