REVISTA
INTERDISCIPLINAR DE
DESENVOLVIMENTO SUSTENTÁVEL
ISSN 3086-7401

RIDES

MUNICIPAL CAPACITY FOR CLIMATE CHANGE ADAPTATION: CHALLENGES FOR BUILDING RESILIENT TERRITORIES IN BRAZIL

Municipal Capacity for Climate Change Adaptation: Challenges for Building Resilient Territories in Brazil

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How to cite: PIETROBOM, Maristela; ROESLER, Marli Renate von Borstel; ARMIN, Feiden. Municipal Capacity for Climate Change Adaptation: Challenges for Building Resilient Territories in Brazil. **Revista Interdisciplinar de Desenvolvimento Sustentável**, [S. l.], [n.d.]. DOI: 10.48075/zp27gz46. Available at: https://e-revista.unioeste.br/index.php/rides/article/view/38330. Accessed on: Aug. 29, 2026.

Abstract: Current climate change poses a challenge for municipal public management, particularly regarding the prevention of and response to extreme weather events. This study aimed to analyze the capacity of Brazilian municipalities to address climate change, considering institutional, financial, technical, and operational aspects. The research employed a mixed-methods approach (quantitative and qualitative) of a descriptive and analytical nature, based on document analysis and secondary data from the National Confederation of Municipalities (CNM), the State Court of Auditors of Paraná (TCE-PR), the Chamber of Deputies, Magazine Source FAPESP, and the Water and Sanitation Institute (IAS). The results revealed limitations in municipal preparedness, primarily related to a lack of financial resources, technical training, Civil Defense structures, monitoring capabilities, and warning systems. In the CNM survey, 68.1% of participating municipalities stated they were unprepared to deal with extreme weather events. In Paraná, 68.17% of municipalities lacked staff dedicated exclusively to Civil Defense, and 70.93% did not have their own warning systems. Therefore, the capacity to cope with climate crises depends on the integration of resources, technical expertise, planning, monitoring, and institutional structures, with the aim of reducing vulnerabilities and enhancing municipal preparedness for weather events.

Keywords: Extreme weather events; Municipal management; Adaptation; Resilience

Resumo: *As mudanças climáticas atuais têm representado um desafio para a gestão pública municipal, especialmente quanto à prevenção e resposta aos eventos climáticos extremos. Este estudo teve como objetivo analisar a capacidade dos municípios brasileiros para o enfrentamento das mudanças climáticas, considerando aspectos institucionais, financeiros, técnicos e operacionais. A pesquisa possui abordagem quanti-qualitativa, de natureza descritiva e analítica, baseada em pesquisa documental e dados secundários da Confederação Nacional de Municípios (CNM), do Tribunal de Contas do Estado do Paraná (TCE-PR), da Câmara dos Deputados, da Revista Pesquisa FAPESP e do Instituto Água e Saneamento (IAS). Os resultados apontaram limitações na preparação municipal, relacionadas principalmente à falta de recursos financeiros, capacitação técnica, estruturas de Defesa Civil, monitoramento e sistemas de alerta. Na pesquisa da CNM, 68,1% dos municípios participantes declararam não estar preparados para enfrentar eventos climáticos extremos. No Paraná, 68,17% dos municípios não possuíam servidores dedicados exclusivamente à Defesa Civil e 70,93% não dispunham de sistema próprio de alerta. Portanto, a capacidade de enfrentamento das crises climáticas depende da integração entre recursos, qualificação técnica, planejamento, monitoramento e estruturas institucionais, visando reduzir vulnerabilidades e ampliar a preparação dos municípios diante dos eventos climáticos.*

Palavras-chave: *Eventos climáticos extremos; Gestão municipal; Adaptação; Resiliência.*

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INTRODUCTION

Climate change represents one of the major challenges to sustainable development today, as its effects extend beyond the environmental realm to impact social, economic, productive, urban, rural, and infrastructure systems. Rising global average temperatures, changes in precipitation patterns, and the intensification of certain extreme events have contributed to increased risks associated with droughts, floods, storms, landslides, heatwaves, and other phenomena capable of causing human, economic, and environmental losses (IPCC, 2022; Brazil, 2024).

Municipalities with territorial planning, adequate infrastructure, monitoring and warning systems, civil defense structures, financial resources, and trained teams tend to be better positioned to anticipate, cope with, and recover from adverse events. However, a lack of these elements can increase population vulnerability and compromise the public sector's response capacity (IPCC, 2022; CNM, 2024).

Municipal management plays a fundamental role in addressing climate change, as it is at the local level that the impacts of extreme events directly affect the population, public services, infrastructure, economic activities, and natural resources. The National Civil Protection and Defense Policy, established by Law 12.608/2012, assigns municipalities responsibilities regarding disaster prevention, mitigation, preparedness, response, and recovery, including the identification and mapping of risk areas and the integration of civil protection and defense into municipal planning (Brazil, 2012).

Therefore, the capacity of municipalities to address climate change is not limited to the existence of legislation or emergency responses following disasters. It involves a set of financial, technical, institutional, and operational conditions that enable local governments to understand existing risks, plan preventive measures, monitor threats, issue alerts, mobilize resources, coordinate various institutions, and promote adaptation actions (UNDRR, 2015).

Despite the growing importance of climate adaptation, various studies indicate that Brazilian municipalities still face significant limitations in addressing the effects of climate change. Therefore, it is necessary to analyze the conditions existing within municipalities for tackling climate change in an integrated manner, considering that adaptive capacity stems from the coordination of different dimensions of public management (UNDRR, 2015; Brazil, 2024; BCB, 2025).

This study aims to analyze the capacity of Brazilian municipalities to address climate change and extreme weather events, considering institutional, financial, technical, and operational aspects related to prevention, adaptation, monitoring, response, and the building of territorial resilience, based on data from the National Confederation of Municipalities (CNM, 2024), data released by the State Court of Auditors of Paraná (TCE-PR, 2026), and information published by the Chamber of Deputies (2023), Magazine Search FAPESP (Pivetta, 2025), and the Water and Sanitation Institute (IAS, 2025)

The data and studies analyzed sought to identify the main weaknesses and challenges faced by local governments and to discuss their relationship with the capacity to build territories that are more resilient and better prepared for the impacts

of climate change.

THEORETICAL FRAMEWORK

Vulnerability, adaptation, and resilience in climate risk management

Climate change poses a major challenge to sustainable development, as its effects extend beyond the environmental realm to impact economic, social, urban, productive, and infrastructure systems. Rising global average temperatures—combined with altered precipitation patterns and the intensification of extreme events—increase the risk of droughts, floods, storms, heatwaves, and landslides, potentially resulting in human, economic, and environmental losses. These risks arise from the interplay of climate hazards, exposure, and vulnerability; consequently, the resulting impacts depend on the social, economic, territorial, and institutional conditions of each locality. Adaptive capacity therefore varies across territories and populations, influencing their exposure to and response to climate impacts (ANA, 2016; IPCC, 2022; Brazil, 2024).

Although the same weather may occur in different municipalities, it can result in distinct consequences. Heavy rainfall, for instance, may have relatively minor impacts on a territory equipped with adequate drainage systems, urban planning, water retention areas, warning systems, and a prepared population. Conversely, municipalities characterized by settlement in high-risk areas, insufficient infrastructure, low institutional capacity, and a lack of prevention mechanisms may exhibit significantly higher levels of vulnerability (CNM, 2009; Silva, 2024).

Vulnerability to climate events is the degree to which a population, territory, infrastructure, economic activity, or ecosystem is susceptible to damage from events such as floods, flash floods, droughts, landslides, heatwaves, and storms. It is linked to the characteristics of individuals, communities, infrastructure, and production systems that determine their capacity to anticipate, cope with, absorb, and recover from the effects of adverse events (Brazil, 2024; MCTI, 2025).

The existence of climate risk does not necessarily imply the occurrence of a disaster, as impacts depend on the conditions of exposure and vulnerability present in the territory. Therefore, climate change adaptation encompasses the set of measures aimed at reducing vulnerability and exposure to adverse climate effects (IPCC, 2022; BCB, 2025).

In Brazil, the law n°14.904/2024 established guidelines for the development of climate change adaptation plans, mandating that these instruments incorporate climate risks into public policies and development strategies at local, municipal, state, and regional levels. The legislation also establishes the need to identify, assess, and prioritize measures aimed at reducing the vulnerability and exposure of environmental, social, economic, and infrastructure systems (Brazil, 2024).

The law n° 14.904/2024 mandates that climate risk management be incorporated into sectoral, development, and land-use planning policies; consequently, territories must adapt to potential climate events. However, adaptation should not be understood merely as a response following the occurrence of disasters. It is a preventive, planned

strategy involving risk assessment, monitoring, land-use planning, resilient infrastructure, environmental conservation, education, communication, and population preparedness (Brazil, 2024; BCB, 2025).

Addressing the climate crisis must be aligned with sustainable development, as adaptation measures can yield simultaneous environmental, social, and economic benefits. Adopting nature-based solutions, restoring degraded areas, preserving water resources, expanding green spaces, improving urban drainage, engaging in land-use planning, and strengthening resilient agriculture are examples of actions that can help reduce risks while simultaneously improving the population's quality of life (IPCC, 2022; ANA, 2016).

Closely linked to adaptation is the concept of resilience. At the municipal level, resilience can be understood as the capacity of a territory and its institutions to anticipate, withstand, absorb, and recover from adverse events while preserving essential functions. According to the United Nations Office for Disaster Risk Reduction (UNDRR), local governments play a pivotal role in building resilient communities, as they represent the level of governance closest to the population and hold responsibilities directly related to land-use planning and risk management (UNDRR, n.d.; MCTI, 2025).

Building municipal resilience therefore depends not only on the availability of financial resources but also on the institutional, technical, and administrative capacity of local governments. The existence of civil defense structures, trained teams, information systems, planning tools, mechanisms for social participation, and inter-institutional coordination can help transform risk information into concrete prevention and adaptation actions (Ministry of the Environment and Climate Change, 2026; Foina, Silva, & Barbosa, 2026).

Reducing vulnerability and strengthening municipal resilience depend on the coordination of scientific knowledge, spatial planning, institutional capacity, and social participation. Climate risk management must, therefore, move beyond a perspective focused exclusively on disaster response and incorporate ongoing preventive actions. such as risk identification, land-use planning, resilient infrastructure, environmental conservation, monitoring, and public preparedness (IPCC, 2022; Brazil, 2024; Ministry of the Environment and Climate Change, 2026).

Therefore, municipal planning constitutes a fundamental instrument for integrating climate adaptation and sustainable development, contributing to the reduction of socio-environmental inequalities, the minimization of losses, and the enhancement of the capacity of territories to cope with the impacts of climate change (IPCC, 2022; Brazil, 2024; MCTI, 2025).

The role of municipalities in addressing climate crises

Municipal management plays a fundamental role in addressing climate change because the impacts are concrete at the local level and directly affect local populations. It is within the municipal territory that problems such as floods, landslides, heatwaves, droughts, agricultural losses, water supply disruptions, infrastructure damage, and the impairment of public services manifest (Brazil, 2025).

The IPCC recognizes that local governments are the primary point of reference for climate adaptation, capable of acting directly and through partnerships with communities, the private sector, and various levels of government. However, response capacity is not uniform, being influenced by factors such as financial resources, technical capacity, infrastructure, institutional organization, and socioeconomic conditions (IPCC, 2022; Brazil, 2025).

In Brazil, the responsibility for addressing climate crises is underpinned by the institutional framework of the National Civil Protection and Defense Policy (PNPDEC), established by Law No. 12.608/2012. The legislation mandates that the Union, states, the Federal District, and municipalities adopt measures necessary to reduce disaster risks and stipulates that the civil protection and defense policy must encompass actions regarding prevention, mitigation, preparedness, response, and recovery (Brazil, 2012).

Legislation assigns significant responsibilities to municipalities, such as implementing the PNPDEC at the local level, coordinating actions within the National Civil Protection and Defense System, integrating civil protection and defense into municipal planning, identifying and mapping risk areas, monitoring these areas, and promoting preventive measures. Therefore, the municipality must play a preventive role in risk reduction rather than merely acting after climate-related disasters occur (Brazil, 2012; Brazil, 2025; MCTI, 2025).

The Sendai Framework for Disaster Risk Reduction 2015–2030 establishes four key priorities for managers to understand the challenges inherent in climate change and implement prevention measures: understanding disaster risk; strengthening risk governance; investing in risk reduction to enhance resilience; and improving preparedness for effective response and post-disaster recovery. Therefore, municipal planning must be proactive and solution-oriented to be effective in the face of climate events (UNDRR, 2015).

Municipal planning is a fundamental tool for translating knowledge about risks into public policies. The development of territorial assessments, risk maps, contingency plans, warning systems, emergency protocols, and adaptation plans can help anticipate impacts and reduce losses. Law No. 14.904/2024 reinforces this approach by mandating that adaptation plans identify vulnerabilities, prioritize measures, and establish monitoring and evaluation mechanisms (Brazil, 2024; Brazil, 2025).

Another important aspect to consider when addressing weather-related events is cooperation among municipalities. Many environmental risks transcend municipal administrative boundaries, particularly those related to watersheds, transportation systems, water supply, solid waste, and meteorological events. Therefore, inter-municipal cooperation and regional arrangements can enhance the response capacity of municipalities with limited resources (Brazil, 2024; UNDRR, n.d.; MCTI, 2025).

Addressing the climate crisis at the municipal level requires a long-term perspective grounded in prevention, vulnerability reduction, and the strengthening of institutional capacity. Municipalities should not focus merely on disaster response; local governments need to develop permanent mechanisms for risk identification and management, integrating public policies, scientific knowledge, social participation, and cooperation across different levels of government (UNDRR, 2015; IPCC, 2022).

Mobilizingity of municipalities to understand their risks, plan preventive actions, mobilize resources, coordinate institutions, and engage society is fundamental to building more resilient territories in the face of intensifying extreme weather events. Consequently, this shift entails incorporating climate risk into municipal planning, public investments, infrastructure policies, land-use planning, and social policies (Brazil, 2012; Institute of Climate Studies, n.d.).

Therefore, municipal action becomes strategic not only for minimizing the impacts of extreme weather events but also for fostering territories that are safer, more resilient, and better prepared for the challenges arising from climate change.

METHODOLOGY

This study is characterized as documentary research of a descriptive and analytical nature, based on the analysis of institutional and technical-scientific documents as well as secondary data regarding the capacity of Brazilian municipalities to address climate change and extreme weather events. The choice of documentary research is justified by the opportunity to gather and analyze information produced by various public and research institutions, enabling the identification of evidence concerning the institutional, financial, technical, and operational conditions of local governments in the face of climate risks.

The document review was conducted using institutional and technical-scientific sources selected for their relevance and direct connection to municipal capacity regarding the prevention of, preparation for, adaptation to, monitoring of, and response to extreme weather events. Key documents included the study climate emergency, prepared by the National Confederation of Municipalities (CNM, 2024); information from the State Court of Auditors of Paraná (TCE-PR, 2026); data and documents made available by the Chamber of Deputies (2023); studies published by Magazine Source FAPESP, specifically Pivetta (2025), and information from the Institute for Water and Sanitation (IAS, 2025).

The selection of documents used the following inclusion criteria: (a) presenting information related to the capacity of Brazilian municipalities to prevent, prepare for, adapt to, or respond to climate risks and events; (b) containing data or evidence regarding the institutional, financial, technical, or operational conditions of local governments; (c) having identifiable authorship or institutional origin; and (d) presenting information described in sufficient detail to allow for its interpretation and connection to the study's objectives. Documents were excluded if they lacked a direct relationship with municipal capacity for addressing climate change or did not provide information relevant to the dimensions analyzed.

The period covered by the document analysis spanned the years 2023 to 2026, as the selected sources correspond to various surveys and publications produced during that timeframe. It should be noted, however, that the publication dates of the documents do not necessarily correspond to the periods during which the data presented within them were collected. Consequently, the results were interpreted with due regard for the temporal, methodological, and sampling specificities of each source,

avoiding direct comparisons between percentages derived from different surveys.

The documents were analyzed using a thematic document analysis approach, employing four dimensions of municipal capacity to address climate change as analytical categories: financial, technical, institutional, and operational. These dimensions were defined based on recurring elements related to public management capacity identified in the literature and the examined documents. The financial dimension refers to resource availability and access to financing mechanisms for prevention, adaptation, and response actions. The technical dimension relates to the availability of training, specialized knowledge, and teams capable of managing climate risks. The institutional dimension encompasses the existence of plans, administrative structures, legal instruments, and public management organizational mechanisms related to risk reduction and climate adaptation. Finally, the operational dimension covers the conditions in place for monitoring, issuing alerts, emergency preparedness, and executing response and contingency actions.

These dimensions were operationalized by identifying, within the selected documents, information and evidence corresponding to the indicators presented in Table 1. Thus, the indicators were not treated as variables within a single statistical dataset, but rather as reference elements for organizing and interpreting findings from various sources. This classification made it possible to systematize heterogeneous information and determine which aspects of municipal capacity were most frequently associated with difficulties in addressing climate risks. The data were analyzed in relation to the factors described in Table 1.

Table 1: Dimensions analyzed for the study

Dimension	Indicators Analyzed	Source
Financial	Prevention resources; access to financing	CNM
Technical	Training; Specialized teams	CNM/TCE-PR
Institutional	Plans; Civil Defense Structures; Legal Instruments	TCE-PR/FAPESP/IAS
Operational	Monitoring; Warning Systems; Contingency	CNM/TCE-PR

Source: The authors, 2026

The thematic analysis was conducted in three stages. In the first, the information regarding municipal capacity to address climate risks was read and identified. In the second, the findings were classified according to the four analytical dimensions established in Table 1. In the third, a comparative interpretation of the results was carried out, seeking to identify convergences, differences, and gaps among the sources examined. This procedure made it possible to link the quantitative data presented in the documents to the institutional and administrative aspects represented in the surveys, without if the various studies constituted a single empirical base.

The percentages and other quantitative data from the various sources were not summed, aggregated, or subjected to joint statistical procedures, given that the surveys involved different data collection periods, populations, sample sizes, indicators, and methodologies. Consequently, no statistical triangulation of the data was performed.

The comparison undertaken was analytical and thematic in nature, using results from the different sources as complementary evidence to examine the four dimensions of municipal capacity. Thus, the recurrence of specific findings across distinct sources served as an element of interpretation, without implying statistical equivalence among the surveys.

The interpretation of the results was guided by the understanding that a municipality's capacity to address climate change is not limited to emergency disaster response but encompasses ongoing conditions regarding planning, financing, institutional organization, technical expertise, monitoring, and preparedness. Based on four analytical dimensions, the study sought to identify the key factors that facilitate or constrain the ability of Brazilian municipalities to integrate climate risks into public planning and to develop strategies for adaptation and the building of territorial resilience.

During the development of this study, Artificial Intelligence (AI) tools were used to assist with text revision, helping to improve the clarity, cohesion, and organization of the writing, as well as to identify and reduce the repetition of terms and expressions. AI was also employed to support the selection, organization, and formatting of bibliographic references; however, the information, sources, and references were subsequently verified and validated by the authors, who remained responsible for the analysis, interpretation, and final content of the work.

RESULTS AND DISCUSSION

Based on document analysis and existing literature, significant weaknesses were observed in how Brazil addresses climate change. However, these weaknesses should not be understood solely in terms of a lack of adaptation plans or a perception that officials are unprepared. The data indicate that a municipality's capacity to address the issue does not depend solely on local management; rather, it simultaneously involves the availability of financial resources, technical expertise, administrative structures, planning tools, monitoring and early warning systems, and the capacity for institutional coordination.

In recent years, there has been a significant increase in the frequency and intensity of events such as droughts, floods, inundations, landslides, and heatwaves. A study by the National Confederation of Municipalities (CNM), conducted between December 2023 and January 2024, highlights precisely this trend. The survey, sent by the CNM to all 5.568 Brazilian municipalities, received responses from 3.590, representing 64.5% of the sample. Among the participating municipalities, 89.3% were small-sized.

One of the most significant findings concerns how municipal managers themselves perceive their capacity to cope with extreme weather events. Among the 3,590 responding municipalities, 68.1% stated they were unprepared to deal with the increasing frequency of droughts, floods, or other natural disasters, while only 22.6% considered themselves prepared. Another 6.0% reported being unaware of forecasts regarding extreme events that could affect their territories. These data reveal a

structural weakness in local public management, demonstrating a gap between the growing awareness of the climate emergency and the actual capacity to translate that awareness into planning, public policies, and preventive investments.

The findings analyzed in the CNM study are reinforced by a survey released by the Ministry of the Environment at the Chamber of Deputies, which showed that 66% of Brazilian municipalities were unprepared to face climate change (Chamber of Deputies, 2023). Although the two percentages should not be compared as results of the same survey, their proximity reinforces the existence of a national trend of low municipal preparedness.

These data reveal a structural weakness in local public management, particularly when viewed through the lens of adaptation concept that encompasses not only the availability of material resources but also access to knowledge, institutions, technical expertise, planning, and governance mechanisms capable of anticipating and responding to climate risks. The IPCC (2022) highlights that the adaptive capacity of municipalities is a fundamental dimension of vulnerability reduction, conditioned by the institutional, economic, social, and environmental characteristics of the territories.

Based on the studies analyzed, a lack of capacity among municipalities to adapt to climate events was observed, as highlighted by the Urban Adaptation Index (UAI) developed using 25 indicators covering the country's 5.569 municipalities as of 2021. According to a survey released by Pivetta (2025), fewer than 13% of municipalities demonstrated good institutional capacity and a reasonable set of legal instruments for climate change adaptation. Only 1.4% achieved a UAI score above 0.81, while 11.4% showed performance ranging from fair to good. In contrast, 4.893 municipalities with fewer than 50.000 inhabitants recorded indices between 0.33 and 0.44, a range classified as poor performance.

The difference observed regarding population size is a factor to be considered. Smaller municipalities tend to exhibit lower institutional capacity, less data availability, and fewer planning instruments, which can limit their ability to anticipate and manage risks. The survey shows that the 49 most populous municipalities, those with over 500.000 inhabitants, had an average UAI of 0.74, whereas the 4,893 municipalities with fewer than 50.000 inhabitants fell within the 0.33 to 0.44 range.

Institutional shortcomings become even more evident when specific climate risk management tools are considered. According to a study released by FAPESP (2025), only 4.9% of municipalities achieved a score above 0.6 on the specific climate risk management index, while 65% recorded a score below 0.2. Merely 13% of municipalities reported having Municipal Risk Reduction Plans, and 5.5% possessed geotechnical maps. These data indicate that the formal existence of administrative structures or legal instruments remains limited across the country, hindering the systematic incorporation of climate risk into urban and territorial planning.

The lack of adaptation tools is also highlighted by the Water and Sanitation Institute (IAS) (2025). A survey presented by the institution indicates that more than 85% of Brazilian municipalities lack the institutional capacity and adequate legal instruments to address climate change. The study utilized indicators related to housing, urban mobility, local food production, environmental management, and climate risk management. Furthermore, data from Adapta Brazil indicate that 3.668 municipalities

fall into the "Very Low" and "Low" adaptive capacity categories, while only 13.1% are classified at "High" or "Very High" levels.

The CNM data show that financial constraints are a major obstacle to strengthening municipal capacity in the face of climate-related crises. Among the 2,443 officials who stated that their municipalities were unprepared to deal with extreme weather events, 94.1% cited the need for financial resources as a reason for this lack of preparedness, while 74.5% pointed to the need for technical training (CNM, 2024).

This financial dimension is particularly important when considering that prevention requires continuous investment in infrastructure, monitoring, warning systems, capacity building, land-use planning, and the maintenance of protective structures. The CNM study (2024) found that 68.9% of the participating municipalities had not received financial resources earmarked for measures to prevent extreme weather events. Only 13.2% reported receiving federal funds, and 6.8% reported receiving state funds. In Paraná, the percentage of municipalities stating they had not received funds for this purpose was 68.9%, according to the same survey.

In Paraná, data from the State Court of Auditors of Paraná (TCE-PR, 2026) indicate the existence of institutional weaknesses at the state level. In 2026, the TCE-PR reported that 68.17% of Paraná's 399 municipalities lacked staff dedicated exclusively to Civil Defense activities, and 60.9% lacked specific physical infrastructure for this service. Furthermore, 70.93% did not have their own risk-alert system capable of reaching the entire population. The survey also identified that, in 2025, 55.14% of municipal governments had not evaluated the effectiveness of their Civil Protection and Defense Contingency Plan for that fiscal year (TCE, 2026).

The results for the state of Paraná are particularly significant because they demonstrate that municipal vulnerability is not limited to the absence of climate adaptation plans but extends to the very operational structure required to turn planning into action. A lack of specialized personnel, equipment, vehicles, communication channels, and warning systems limits the capacity for anticipation and response. This vulnerability is especially critical given the 574 disasters recorded in 2025, which affected 246 municipalities, representing more than half of the state's municipalities, impacting 292.237 people and causing 27 deaths (TCE, 2026).

Monitoring capacity presents another challenge. In the 2024 CNM national survey, 43.7% of municipalities reported having no department, position, or individual responsible for the daily, real-time monitoring of risk areas, whereas only 38.7% stated they had such a structure in place. The lack of continuous monitoring reduces the likelihood of early threat detection and compromises the issuance of alerts, the mobilization of response teams, and population preparedness. Thus, the identified institutional shortfall is not merely an administrative limitation; it can translate directly into greater population exposure and increased social, economic, and environmental damage (CNM, 2024).

The weather-related alert system is another limiting factor for municipalities; according to the CNM (2024), 57.2% lacked mobile or fixed disaster alert systems. Although 33.7% utilized digital channels, such as SMS, social media, or apps, the absence of structured systems remains widespread. The study also highlights an inequality linked to municipal size: 44% of small municipalities reported having no alert

system, compared to 24% of medium-sized and 14% of large municipalities. This disparity underscores the importance of state and federal cooperation policies, particularly given that smaller municipalities often lack the financial and technical capacity to independently establish complex monitoring and alert systems.

Another important aspect concerns the training of public officials. Research by the CNM (2024) showed that only 46.6% of municipalities had participated in technical training activities related to the causes and consequences of climate change, while 46.4% reported not having done so. Among small municipalities, the proportion that had not participated in such training reached approximately 49%, whereas it was 29% for medium-sized municipalities and only 5% for large ones. These results reinforce the idea that institutional capacity to address climate change depends not only on financial resources but also on the availability of qualified personnel.

A joint analysis of this data reveals a relationship among three fundamental dimensions for municipalities facing climate events: financial resources, technical capacity, and institutional structure. A deficiency in any one of these areas can compromise the others. A lack of funding hinders the hiring and training of teams, the implementation of monitoring and early-warning systems, and the development of planning instruments. Conversely, limited technical capacity can restrict access to resources and impede the preparation of projects and plans capable of meeting the requirements of funding mechanisms.

Therefore, the results demonstrated that the adaptive capacity of municipalities must be understood as an integrated institutional capacity, comprising the coordination of financial resources, technical knowledge, planning instruments, administrative structures, information systems, monitoring, early warning, governance, and inter-municipal cooperation. The limited availability of these elements helps explain the high levels of vulnerability identified in various national studies.

Municipal resilience in the face of climate events depends on shifting from management focused predominantly on emergency response to a permanent policy of identification, monitoring, prevention, adaptation, and reduction of climate risks. Adaptation ceases to be merely a response to the effects of climate change and becomes a structural dimension of planning and sustainable territorial development.

It is worth highlighting certain limitations of the present study. The first concerns the methodological heterogeneity of the sources used, given that the survey analyzed feature differing objectives, indicators, data collection procedures, study populations, and analysis criteria, thereby precluding direct statistical comparisons of their results. Furthermore, the study relied exclusively on secondary data and institutional documents, without involving primary data collection from managers, technical teams, or other stakeholders involved in the municipal management of climate risks. Added to this is the variation in timeframes across the analyzed studies, reflecting distinct contexts and periods regarding the assessment of municipal capacity.

Therefore, the results were interpreted as an analytical synthesis of evidence from various sources, guided by the four established dimensions (financial, technical, institutional, and operational), rather than as a single or homogeneous measure of Brazilian municipalities' capacity to address climate change. Despite these limitations, the convergence of findings across different surveys helps highlight recurring

weaknesses and provides relevant insights for understanding the challenges local governments face in building climate resilience.

CONCLUSION

Based on the analyzed data, it was observed that Brazilian municipalities face significant limitations in addressing climate change and extreme weather events. The results highlighted weaknesses regarding the availability of financial resources, technical expertise, Civil Defense structures, planning instruments, and monitoring and warning systems—factors that affect the capacity of local governments for prevention, adaptation, and response.

The data analyzed also indicated that these limitations are more pronounced in smaller municipalities, which often have fewer resources and less technical infrastructure to develop climate risk adaptation and management initiatives. In Paraná, the information analyzed reinforces this scenario, revealing deficiencies regarding Civil Defense infrastructure, a lack of specialized personnel, warning systems, and the assessment of contingency plans.

Addressing climate change requires ongoing planning, prevention, and adaptation actions aligned with municipal, state, and federal public policies. Therefore, preparing municipalities for the impacts of climate change is a continuous process that must move beyond a focus on disaster response to incorporate prevention and adaptation into public planning. Strengthening these capabilities can help reduce vulnerabilities, minimize losses, and enhance the capacity of territories to face extreme weather events in a more prepared and resilient manner.

ACKNOWLEDGMENTS

We acknowledge the financial support from the Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES) – Funding Code 001, and from the Araucária Foundation for the scholarship awarded to the authors of this work.

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Submitted on: 21/08/2026
Accepted on: 29/08/2026
Published on: 29/08/2026
Translated on: 30/08/2026