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Analysis of Climate Adaptation Policies in Rio Grande do Sul

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ABSTRACT
This article analyzes urban planning policies and climate adaptation practices in Rio Grande do Sul following extreme weather events in May 2024. The increasing frequency and severity of these events demand an integrated approach to protect lives, property, and urban infrastructure. The study highlights the need for adaptive urban planning and private sector involvement in mitigating the impacts of climate disasters. The methodology includes a critical analysis of current policies, identification of shortcomings and opportunities for improvement, and presentation of successful cases in climate adaptation. Secondary data from official reports, academic articles, and government documents are used, along with case studies showcasing effective practices. The research focuses on collecting and comparatively analyzing adaptation policies from other regions and countries, offering recommendations to enhance local practices. The article emphasizes the urgency of implementing adaptive urban planning and fostering collaboration between the government, private sector, and communities to develop effective strategies. Investments in resilient infrastructure, sanitation, efficient drainage systems, and innovative technologies are crucial. Public education and awareness are vital to preparing communities for extreme weather events, as illustrated by the case study of Porto Alegre.

KEYWORDS: Urban Planning. Public Policies. Climate Adaptation. Resilience. Infrastructure.

1 INTRODUCTION

In May 2024, the state of Rio Grande do Sul was severely affected by one of the most devastating climatic events in its history. An anomalous atmospheric configuration, characterized by an intense migratory anticyclone over the South Atlantic Ocean, resulted in extreme and prolonged rainfall, causing severe flooding and landslides in various regions of the state (INPE; INMET; ANA; CENAD, 2024).

According to data from the National Center for Monitoring and Early Warning of Natural Disasters (Cemaden, 2024), the highest recorded rainfall accumulations in the state between April 22 and May 6, 2024, were in the city of Fontoura Xavier, which experienced the highest accumulated rainfall, reaching 778 mm. This was followed by Caxias do Sul, with 694 mm, and Bento Gonçalves, with 675 mm. These cities, located in different parts of the state, demonstrate that the intense rainfall was not concentrated in a single area but affected multiple regions. Additionally, Soledade recorded an accumulation of 629 mm, São Francisco de Paula registered 576 mm, and Três Coroas had 553 mm. Santa Maria, with 544 mm, Teutônia, with 511 mm, and Porto Alegre, with 368 mm, complete the list of the most affected cities. Porto Alegre, the state capital, experienced a relatively lower volume of rainfall compared to the other cities mentioned, but the impacts were still significant.

Understanding the geographical distribution of intense rainfall is crucial for Civil Defense and other disaster management agencies, as it allows for better allocation of resources and efforts to the most affected areas. Cities with the highest rainfall accumulations face elevated risks of flooding and landslides, requiring proper emergency planning to enhance rapid responses to natural disasters. Such information is of utmost importance for alerting the population and minimizing human and material losses.

The State Secretariat for the Environment and Infrastructure (SEMA, 2024a) presented a detailed analysis in its report on the impacts of extreme rainfall and flooding that occurred in Rio Grande do Sul between April 30 and May 24, 2024. On May 5, 2024, the Civil Defense of Rio Grande do Sul released a flood risk mapping for areas near the state capital, Porto Alegre. The map highlights that risk areas are primarily concentrated around the Guaíba River and Lake

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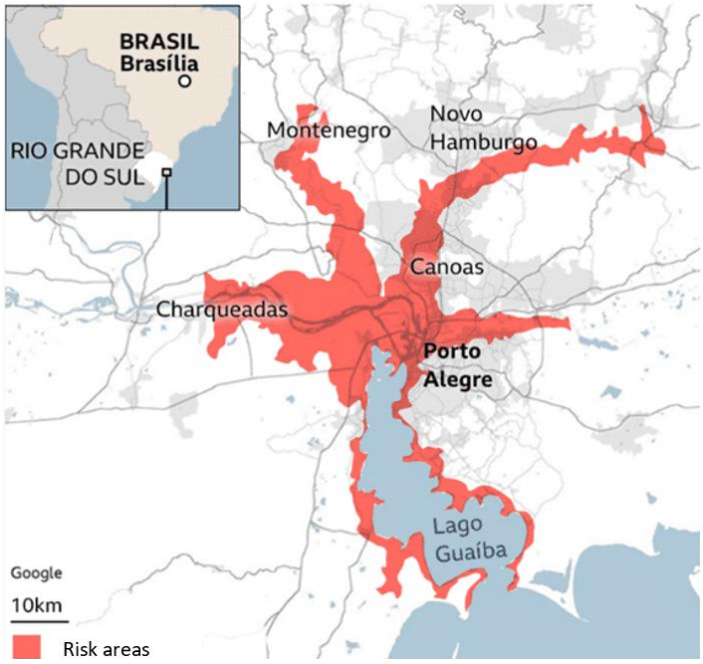
Guaíba, directly affecting municipalities such as Porto Alegre, Canoas, Novo Hamburgo, Montenegro, and Charqueadas, among others.

Figure 1 - Flood risk area mapping.



Source: Civil Defense RS, 2024. Data compiled until May 5, 2024.

The analysis covers the effects of the rainfall in various sectors, including infrastructure, water supply, primary production, and fruit farming. According to the Civil Defense of Rio Grande do Sul, more than 2 million people were affected by the floods that devastated the state (Civil Defense RS, 2024). In response to these events, the State of Rio Grande do Sul issued Decree No. 57,626 of May 21, 2024, updating the list of municipalities in a state of public calamity and emergency. In total, 456 municipalities were affected, with 78 declared in a state of public calamity and 340 in an emergency situation, covering 9,158 localities and 206,604 properties (SEMA, 2024b).

In light of this tragedy, this article critically examines urban planning policies and climate adaptation practices in Rio Grande do Sul. The relevance of this topic is justified, especially by the recurrence and worsening of extreme climate events, which demand an integrated and effective approach to urban and regional planning to protect lives, property, and urban infrastructure. The objective is to explore how adaptive urban planning and private sector participation can mitigate the impacts of climate disasters.

The methodology includes a critical analysis of existing policies, identification of shortcomings and opportunities for improvement, and the presentation of specific case studies that showcase successful practices to guide future interventions aimed at achieving urban resilience. Secondary data from official reports, academic articles, and government documents will be used, along with examples of effective climate adaptation actions from other regions and countries.

Therefore, this article explores how adaptive urban planning and private sector participation can contribute to mitigating the impacts of climate disasters, providing a

comprehensive view of the strategies needed to implement urban resilience and reduce the negative impacts of extreme weather events.

2 OVERVIEW OF THE TRAGEDY IN RIO GRANDE DO SUL

At the end of April and early May, South America experienced an atmospheric configuration marked by a robust anticyclone over the South Atlantic. This high-pressure system drove the transport of warm and humid air masses from the ocean to the continent, concentrating over the Southeast, Midwest, and parts of the Northeast regions. The intensification of the anticyclone and the blocking of cold fronts over Rio Grande do Sul, combined with moisture from the Amazon, created favorable conditions for the formation of dense clouds and heavy rainfall. The persistence of these conditions, associated with global warming and the residual effects of El Niño, intensified the occurrence of extreme weather events, such as heavy rains, strong winds, and flooding, significantly impacting the populations and economic activities of the affected regions (Rio Grande do Sul, 2024).

Climate instability began to be recorded at the end of April, when excessive rainfall volumes hit the state, continuing throughout May. These intense precipitations caused floods, landslides, and destruction across multiple regions. Several municipalities faced severe risk situations, resulting in human losses, fatalities, and material and environmental damage, including the destruction of homes, roads, and bridges. The functionality of local and regional public institutions was compromised, and many major public roads were blocked.

According to the Civil Defense of Rio Grande do Sul (2024), by May 13, 2024, 147 deaths had been confirmed. Additionally, reports indicated that 80,826 people were in shelters, 538,241 were displaced, 2,115,703 were affected, 806 were injured, and 127 were missing. The scale of the tragedy led the state government to declare a state of public calamity on May 1, covering 447 municipalities, representing 89.9% of the state's 497 municipalities (Civil Defense RS, 2024).

The most impacted areas included the main industrial hubs of Rio Grande do Sul, affecting sectors vital to the state’s economy. In this scenario, the destruction of infrastructure and the disruption of essential services have posed significant challenges to the recovery of affected regions. The economic impact is severe, with losses estimated in the millions, further worsening the situation of communities affected by the climate catastrophe (Civil Defense RS, 2024).

An analysis of the underlying causes of the tragedy revealed a combination of climatic and human factors. The above-average rainfall, intensified by anomalous climate patterns such as the El Niño phenomenon, increased the likelihood of intense rainfall in the region. Additionally, the intensification of global climate change has contributed to the recurrence and worsening of extreme events, directly impacting the rainfall regime in Rio Grande do Sul (Nobre & Young, 2011). Among the human factors, irregular land occupation, lack of regulation and enforcement, deforestation, and unplanned urbanization have been identified as amplifiers of community vulnerability. Given the scale of the event, the insufficient and poorly maintained drainage infrastructure also failed to handle the volume of water, exacerbating flooding.

In this context, the May 2024 disaster underscores the urgent need for the implementation of public policies guided by a systemic approach, respecting the geospatial

conditions of the territory to improve urban and regional planning practices and enable the development of resilient infrastructure. This situation highlights the urgency of revising institutional and governmental policies, where collaboration between the government, private sector, and local communities is essential to develop effective adaptation and mitigation strategies, preventing similar events in the future.

Clearly, this context reinforces the need to discuss urban planning and climate adaptation, given the increasing frequency and intensity of extreme weather events and their devastating effects. The integration of climate adaptation policies into urban planning should include a set of strategic actions that have been discussed for years in academic research and institutional documents, such as the creation of green areas, efficient drainage systems, and resilient construction techniques, among others. Each of these solutions is effective, but together, they can significantly enhance urban resilience, promoting well-being and ensuring the protection of lives, properties, and urban infrastructure systems as a whole.

3 URBAN PLANNING AND CLIMATE ADAPTATION

In the context of increasing challenges resulting from climate change, the vulnerability of urban areas to natural disasters demands urgent and effective actions. In this regard, urban planning and climate adaptation strategies emerge as fundamental tools to reduce risks and promote urban resilience.

Rather than a rigid, traditional approach, adaptive urban planning is presented as a dynamic and flexible process, capable of incorporating the uncertainties and risks associated with climate change. This planning model aims to integrate adaptation measures into urban development, allowing cities to continuously adjust to changing climatic conditions. It involves the constant review of policies, the implementation of evidence-based solutions, and active community participation to ensure that adaptations align with local needs. In this sense, adaptive urban planning must incorporate flexibility to respond to unexpected climatic events through effective governance that fosters collaboration between different levels of government and sectors of society.

The Intergovernmental Panel on Climate Change (IPCC), in its 2023 report, defines climate adaptation as an approach aimed at enhancing the resilience of communities, ecosystems, and infrastructure to the adverse impacts of climate change. However, this pursuit of resilience must not occur indiscriminately. In this regard, the IPCC (2023) emphasizes the importance of...

> Prioritizing processes of equity, climate justice, social justice, inclusion, and a just transition can enable ambitious adaptation and mitigation actions and foster climate-resilient development. Adaptation outcomes are enhanced by greater support for regions and people most vulnerable to climate risks. The integration of climate adaptation into social protection programs improves resilience. Many options are available to reduce high-emission consumption, including behavioral and lifestyle changes, which offer co-benefits for societal well-being. (Painel Intergovernamental sobre Mudança do Clima, 2023, p. 48).

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Adaptation, in turn, can be classified as reactive, occurring after climate impacts, or proactive, when impacts are anticipated, and preventive measures are implemented. For adaptation to be effective, it is essential to adopt a holistic and integrated approach that considers multiple aspects, such as natural resource management, green infrastructure, and social mobilization. As a whole, adaptation solutions include the creation of urban green spaces, implementation of efficient drainage systems, and promotion of resilient construction. However, it is necessary to go beyond the technical sphere, investing in education and public awareness to ensure that communities are prepared to respond effectively to extreme weather events.

The Intergovernmental Panel on Climate Change (2023) emphasizes that climate adaptation policies should promote social inclusion and equity, ensuring that the most vulnerable communities have the capacity to face and adapt to climate change. These policies must be based on effective governance, intersectoral coordination, and adequate financing. In this sense, climate adaptation should be incorporated at all stages of urban planning, from the initial design to the implementation and maintenance of infrastructure.

Thinking of urban planning as a shield against climate change, it is necessary to understand that it goes beyond the construction of infrastructure, involving a series of integrated actions aimed at promoting sustainable land use, preserving green areas, building resilient infrastructure, and implementing efficient drainage systems.

Sustainable land use, for example, requires strict zoning regulations to prevent occupation in risk areas and promote urban densification in safer locations. At the same time, the preservation and expansion of green areas play a crucial role in microclimate regulation, water infiltration, and soil protection, contributing to mitigating the effects of climate change.

The construction of resilient infrastructure, such as buildings and engineering systems capable of withstanding extreme events, is another fundamental aspect. By investing in innovative technologies and materials, cities can significantly reduce damage caused by natural disasters and ensure the continuity of essential services.

The implementation of efficient drainage systems is essential to prevent flooding and reduce soil erosion risks. By investing in nature-based solutions, such as rain gardens and retention areas, cities can improve water quality and create more pleasant public spaces.

Beyond these measures, the development of contingency plans and disaster simulations are indispensable tools to ensure that cities are prepared to respond effectively to extreme events. By investing in early warning systems and environmental education programs, cities can increase public awareness and strengthen crisis response capacity.

According to Braga (2012),

> Urban policy strategies aimed at climate change adaptation seek to increase the resilience of urban spaces and reduce vulnerability to the effects of climate change. These strategies involve measures directly targeting at-risk populations, as well as broader preventive actions. Urban environmental risks associated with climate change are primarily linked to increased rainfall and rising temperatures, which tend to heighten the risks of flooding, landslides, and the greater incidence of tropical diseases. (p. 7).

Climate urgency demands immediate action through the implementation of public policies aimed at adaptation and resilience. Measures such as green infrastructure and early

warning systems are essential to mitigate the impacts of climate change. Equally important, coordination among different levels of government and active participation of civil society are crucial to the success of these initiatives. By following these guidelines, cities can better prepare for future challenges, ensuring sustainable and equitable urban development.

In alignment with this approach, Recife approved the Recife Climate Action Plan, which discusses comprehensive measures for tackling climate change. This plan includes 21 structural and non-structural actions necessary for adaptation and addressing climate impacts. Key actions highlighted are the improvement of basic sanitation to reduce water pollution, the development of resilience strategies to cope with rising sea levels and meteorological drought, and the creation of technical instruments for climate mitigation and adaptation. The integration of such measures demonstrates a commitment to sustainability and the protection of the most vulnerable populations.

Additionally, the city has implemented the Cities Footprint Project, which assesses carbon and water footprints, utilizing these results to promote actions aimed at reducing greenhouse gas emissions (GHG) and improving water management (Wernke et al., 2022). In terms of governance, Recife has established structures such as the Multidisciplinary Technical Group of Managers (Geclima) and the Municipal Committee on Climate Change (Comclima). These structures aim to enhance climate resilience in areas susceptible to risks through improved governance, integrated planning, and proactive management.

Furthermore, alignment among federal, state, and municipal legislation, such as Brazil's National Policy on Climate Change (Law nº 12.187/2009) and the State Policy on Climate Change of Pernambuco (Law nº 14.090/2010), provides a comprehensive framework of strategic measures. These include the goal of achieving carbon neutrality by 2050, as outlined in Recife's strategic plan (Recife500), and promoting integrated, sustainable management of water and climate resources through local urban regulations (Wernke et al., 2022).

On this matter, the Intergovernmental Panel on Climate Change (IPCC, 2023) underscores the significance of integrated urban systems incorporating physical infrastructure, effective governance, and community participation. Such systems enable cities to respond efficiently to climate emergencies, emphasizing the necessity of comprehensive strategies that involve governments, businesses, and local communities to address climate challenges effectively.

In summary, adaptive urban planning and climate adaptation are essential for enhancing urban resilience against climate change. Due to their integrated nature, they serve as powerful tools to standardize efficient land use and occupation, thus preventing diverse socio-environmental vulnerabilities and risks. Implementing effective adaptation measures, including green infrastructure and resilient constructions, along with robust community engagement, can help cities significantly mitigate negative climate impacts, ensuring sustainable and equitable urban development.

4 THE ROLE OF THE PRIVATE SECTOR

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Climate adaptation requires a collaborative approach, and the private sector plays a crucial role, particularly in the implementation of resilient infrastructure and the promotion of innovative technologies that minimize the negative impacts of climate emergencies. Public-private collaboration in this context is not only desirable but essential for developing effective and sustainable solutions.

Public-private partnerships are fundamental for implementing resilient infrastructure and developing climate adaptation strategies, as they allow for the combination of resources and expertise from both sectors to create enhanced and innovative solutions. Collaboration between the government and the private sector can accelerate the construction of resilient infrastructure, such as urban drainage systems, dams, and green spaces, which are essential for reducing the risks of floods and other climate-related disasters.

Furthermore, public-private collaboration can facilitate risk-sharing and mobilize financial resources required for large-scale climate adaptation projects. The Intergovernmental Panel on Climate Change (IPCC, 2023) highlights that public-private partnerships are essential for implementing large-scale projects, such as resilient transportation networks and sustainable energy systems, which demand significant investments and effective coordination between sectors.

The private sector has demonstrated leadership in implementing projects and investments in adaptive technologies and infrastructure. Companies in various industries are investing in solutions that not only mitigate climate risks but also capitalize on economic opportunities arising from the transition to a greener economy.

Additionally, climate adaptation can be economically advantageous for the private sector in several ways. First, investing in resilient infrastructure can reduce costs associated with damage and disruptions caused by climate disasters. Second, according to Nobre and Young (2011), companies that adopt sustainable practices and invest in green technologies can benefit from tax incentives and favorable regulations, as well as enhance their reputation and appeal to sustainability-conscious consumers and investors.

Moreover, the transition to a green economy can create new business opportunities and markets. For instance, the renewable energy sector is experiencing rapid growth, offering significant investment and innovation opportunities. Companies that lead in climate adaptation and sustainability are positioned to gain a competitive advantage in the global market, attracting investments and business partnerships.

Climate adaptation can also generate indirect economic benefits, such as the creation of green jobs and the development of new industries. Investing in sustainable technologies and resilient infrastructure can stimulate innovation and competitiveness, fostering long-term sustainable economic growth.

In this sense, it is essential to emphasize that collaboration between the private sector and the government is crucial to addressing climate challenges, and investment in climate adaptation offers significant economic benefits for businesses. Thus, the private sector plays a key role in adopting innovative technologies and building resilient infrastructure, contributing to the creation of a more sustainable and climate-prepared society.

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5 PUBLIC POLICIES IN RIO GRANDE DO SUL

Understanding the public policies implemented in Rio Grande do Sul is essential for assessing the existing measures related to climate risk management. This critical analysis aims to identify shortcomings and opportunities for improvement, as well as examine specific case studies to extract important lessons for the development of effective public policies. In this context, Porto Alegre, the capital of Rio Grande do Sul, stands as a notable case for analyzing climate adaptation policies in the state due to its particular vulnerabilities.

Rio Grande do Sul has a series of state and municipal policies focused on climate risk management and climate change adaptation. Among the most relevant policies are the State Water Resources Plan (PERH), which aims to ensure the sustainable management of water resources, and the Contingency Plan for Natural Disasters, which sets guidelines for responding to climate emergencies (SEMA, 2024).

At the municipal level, cities such as Porto Alegre have adopted specific policies, including the Municipal Risk Reduction Plan (PMRR) (PMPA, 2022), which identifies vulnerable areas and defines actions to mitigate the impacts of natural disasters. The PMRR includes measures such as the construction of drainage infrastructure, the establishment of early warning systems, and public awareness campaigns (PMPA, 2022).

Despite the existing public policies, there are numerous shortcomings that need to be addressed to improve climate risk management in Rio Grande do Sul. One of the main issues is the lack of integration and coordination between different government levels and societal sectors. State and municipal policies are often misaligned, leading to fragmented and isolated actions, which ultimately prove ineffective. Cortese (2013) highlights that the absence of an integrated and coordinated approach hampers the implementation of effective adaptation and mitigation measures.

Another significant shortcoming is the lack of financial and technical resources to effectively implement the strategies outlined in each public policy. Many municipalities lack the technical and institutional capacity, as well as adequate funding, to execute the adaptation and risk management measures outlined in their plans. In addition, Nobre and Young (2011) point out that insufficient investment in resilient infrastructure and climate monitoring technologies severely limits the capacity to respond to disasters.

The collection and analysis of climate data are fundamental steps in the policy assessment process. However, the lack of reliable data prevents the formulation of evidence-based policies. Accurate and updated climate data are crucial for identifying risk areas, predicting extreme climate events, and planning effective adaptation actions. In this regard, improving the management of vulnerable areas and risks, as well as integrating climate monitoring and forecasting systems, is essential to enhance decision-making precision and effectiveness.

The severity and complexity of the climate disaster in Rio Grande do Sul highlight the urgent need to address these shortcomings. To overcome these challenges, it is crucial to promote integration and cooperation among different government levels, as well as between the public and private sectors. The creation of intersectoral committees and the promotion of public-private partnerships (PPPs) could enhance coordination and efficiency in climate adaptation actions.

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All implemented measures must converge towards resilient infrastructure development and the adoption of climate monitoring and forecasting technologies, which are essential for strengthening disaster response capacity (Intergovernmental Panel on Climate Change, 2023).

The severe floods in January 2024, which caused significant infrastructure damage and substantial economic losses, served as a critical case study highlighting both policy failures and opportunities for improvement in climate risk management. Reports indicate that the floods in Porto Alegre were exacerbated by a combination of climatic and human factors. The intense rainfall exceeded the capacity of the city's drainage systems, which were poorly maintained and insufficient to handle the water volume (PMPA, 2022). Furthermore, unregulated land occupation and the lack of green space maintenance increased surface runoff, contributing to the severity of the flooding (Braga, 2012).

A critical analysis reveals that one of the major policy failures was the lack of maintenance and modernization of existing drainage infrastructure. Many areas of Porto Alegre still rely on outdated drainage systems that are incapable of handling the increasing intensity and frequency of rainfall due to climate change. Additionally, unregulated urban expansion and construction in high-risk areas, such as hillsides and riverbanks, have further exacerbated the city's vulnerability to floods and landslides.

Despite these failures, the city's inadequate disaster response also provided valuable lessons and opportunities for improvement. In response to the calamity, Porto Alegre implemented a series of emergency measures, including the creation of temporary shelters and the distribution of supplies to affected areas. However, the event made it clear that a more effective and preventive urban planning approach is imperative to prevent future tragedies.

To improve Porto Alegre's resilience, it is essential to substantially increase investments in infrastructure, specifically by investing in modern drainage infrastructure and early warning systems. In addition to these aspects, the city must implement housing policies adapted to the needs of low-income populations, strengthen land-use regulation enforcement, and promote the revitalization of vulnerable areas. The implementation of green roofs and vegetated walls can help mitigate the urban heat island effect while also improving soil absorption capacity (Rio Grande do Sul, 2024). Porto Alegre's experience demonstrates the importance of integrated policies based on scientific data for effective climate adaptation.

The city can also benefit from education and public awareness programs that inform the population about climate risks and preventive measures that can be adopted. Community participation is necessary and relevant to ensure that adaptation policies are effective and sustainable in the long term.

6 RECOMMENDATIONS FOR THE FUTURE

Given the severity of the impacts caused by the climate event, in order to address the challenges of climate change and minimize the impacts of natural disasters, Rio Grande do Sul needs to implement a rigorous urban planning process that promotes the implementation of adequate housing policies adapted to local specificities, incorporates effective adaptation strategies, fosters community engagement, and invests in education and awareness programs.

Other measures will also be necessary, such as investing in green and blue infrastructure, including large green areas, parks, green roofs, and water retention basins, considering their functions in mitigating flood impacts and improving the resilience of urban areas. These solutions reduce surface runoff, improve air quality, and enhance thermal comfort in cities. Equally important will be the modernization and expansion of urban drainage systems to cope with intense and frequent rainfall. The implementation of sustainable drainage systems can increase the capacity for water absorption and retention, reducing the risk of flooding. The requalification of vulnerable areas, such as slopes and riverbanks, through environmental and landscape engineering projects, can significantly reduce the risks of landslides and floods (Soz; Krypin-Watson; Stanton-Geddes, 2016). The preservation and restoration of green areas are essential to increase the soil's water infiltration capacity.

Developing and implementing early warning systems for natural disasters can save lives and reduce material damage. These systems should include climate monitoring sensors, effective communication platforms, and well-structured evacuation plans. The integration of these measures into urban planning is essential to ensure that cities are prepared to respond to extreme climate events.

According to Soz, Krypin-Watson, and Stanton-Geddes (2016), active involvement of the local community is fundamental to the success of climate adaptation measures. Community participation ensures that adaptation strategies are suitable for local needs and that residents are prepared to respond to extreme climate events. Including the community in the urban planning process and decision-making regarding climate adaptation projects is vital. Conducting public consultations and participatory workshops can help identify the population's needs and priorities. Promoting volunteer programs that encourage people to participate in disaster prevention and response actions, such as tree-planting campaigns, river cleanups, and drainage infrastructure maintenance, strengthens the sense of community responsibility (PMPA, 2022).

Establishing community support networks to strengthen local resilience is equally important. These networks may include neighborhood groups, non-governmental organizations (NGOs), and local institutions working together to implement adaptation measures and provide support during emergencies. Thus, active community participation in all phases of planning and implementing adaptation strategies is crucial for the long-term success of these initiatives (Soz; Krypin-Watson; Stanton-Geddes, 2016).

In this context, a range of initiatives can be adopted. Among them, educational programs deserve special attention, as they should focus on informing the population about climate risks and preventive measures that can be taken. Developing awareness campaigns that inform the public about the risks associated with climate change and the actions that can be taken to mitigate these risks is essential. These campaigns can use various media, such as radio, television, the internet, and social networks. Integrating environmental education into school curricula to teach children and young people about the importance of sustainability and climate adaptation practices is an effective strategy. Practical activities, such as visits to preservation areas and climate science projects, can increase student engagement.

Organizing workshops and training sessions for the population on how to prepare for and respond to natural disasters is another important measure. These events may include evacuation drills, first aid training, and household protection measures against floods and

landslides. Establishing partnerships with non-governmental organizations and higher education institutions to develop and implement education and awareness programs can bring technical expertise and additional resources to climate adaptation efforts (Nobre and Young, 2011).

Implementing this set of recommendations can significantly increase Rio Grande do Sul's resilience to climate change, protect the population, and reduce the impacts of natural disasters. The combination of effective adaptation strategies, community engagement, and public education is essential for building a sustainable and safe future for all.

7 CONCLUSION

The critical analysis of the climate tragedies that occurred in Rio Grande do Sul in May 2024 highlights the urgent need to review and enhance urban planning and climate adaptation policies. The devastating events, marked by severe floods and landslides, not only underscored the vulnerability of urban areas but also exposed significant shortcomings related to incipient urban planning and management processes, which are inadequate in addressing necessary infrastructure adaptations and climate risk management. The combination of climatic factors, such as the El Niño phenomenon and global climate change, with human factors, such as irregular land occupation and deficient infrastructure, exacerbated the impacts of intense rainfall.

Studies have demonstrated the importance of adopting adaptive urban planning to mitigate the effects of future climate disasters. This approach must integrate climate change adaptation measures in a continuous and flexible manner. Collaboration between the government, private sector, and local communities will be vital in developing and implementing effective adaptation and mitigation strategies. Investments in social housing policies, green and blue infrastructure, modern and efficient drainage systems, and innovative technologies are essential to increase the resilience of cities.

Moreover, education and public awareness play a crucial role in preparing communities to respond to extreme climate events. Environmental education programs, awareness campaigns, and active community participation in urban planning are essential measures to ensure that adaptation policies are effective and sustainable in the long term.

Porto Alegre, as a case study, illustrates the importance of integrated, scientifically based policies in addressing climate change challenges. The experience gained from the recent impacts on the city demonstrated that efficient planning, combined with resilient infrastructure and effective governance, can significantly reduce climate disaster risks and impacts.

In summary, to protect lives, properties, and local economies, it will be imperative for Rio Grande do Sul to adopt an integrated and proactive approach to urban planning and climate adaptation. Implementing the recommendations presented in this article could significantly enhance the state's resilience to climate change, fostering a safer and more sustainable future for all its inhabitants.

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