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Urban resilience supported by technology in disaster management and prevention

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Resiliência urbana apoiada em tecnologia na gestão e prevenção de desastres

RESUMO

Objetivo - Investigar de que maneira a resiliência urbana pode ser fortalecida na gestão e na prevenção de desastres ambientais, com foco na aplicação do City Information Modeling (CIM) e de tecnologias.

Metodologia - Abordagem qualitativa, baseada em revisão de literatura, estudo de caso e estudo comparativo. São analisados dois desastres ocorridos no Brasil, sendo as enchentes de 2024 em Porto Alegre e o afundamento do solo em Maceió associado à mineração de sal-gema, em diálogo com experiências internacionais em Veneza e Helsinque.

Originalidade/relevância - O estudo insere-se em um campo ainda pouco explorado no Brasil ao articular tecnologias digitais, resiliência urbana e mitigação de desastres, contribuindo para o debate acadêmico sobre o uso do CIM como ferramenta estratégica na gestão de riscos urbanos.

Resultados - Os resultados indicam que o fortalecimento da resiliência urbana depende da integração entre tecnologias de modelagem da informação urbana, estruturas de governança eficientes e participação comunitária, evidenciando limitações relacionadas à escassez de investimentos e à falta de capacitação técnica.

Contribuições teóricas/metodológicas - O artigo amplia a compreensão sobre o potencial do CIM como instrumento de apoio à análise, prevenção e gestão de desastres, oferecendo subsídios para aplicação em contextos urbanos.

Contribuições sociais e ambientais - Os achados destacam o papel das tecnologias digitais na redução de impactos socioambientais, no apoio à formulação de políticas públicas e no fortalecimento de estratégias de gestão urbana.

PALAVRAS-CHAVE: Resiliência Urbana. City Information Modeling (CIM). Desastres Ambientais.

Urban resilience supported by technology in disaster management and prevention

ABSTRACT

Objective – To investigate how urban resilience can be strengthened in disaster management and prevention, focusing on the application of City Information Modeling (CIM) and digital technologies.

Methodology – Adopts a qualitative approach based on a literature review, case study, and comparative analysis. It examines two disasters in Brazil, the 2024 floods in Porto Alegre and the ground subsidence in Maceió caused by rock salt mining, alongside international experiences in Venice and Helsinki.

Originality/Relevance – The research addresses a theoretical gap in the Brazilian context by integrating digital technologies, urban resilience, and disaster mitigation, contributing to academic discussions on the strategic role of CIM in urban risk management.

Results – The findings indicate that urban resilience relies on the integration of information modeling technologies, effective governance structures, and community participation, while also revealing challenges related to limited investment and insufficient technical capacity.

Theoretical/Methodological Contributions – The article advances the understanding of CIM as a support tool for disaster analysis, prevention, and management, providing insights for its application in urban environments.

Social and Environmental Contributions – The results highlight the potential of digital technologies to reduce socio-environmental impacts, support public policy formulation, and strengthen management strategies.

KEYWORDS: Urban Resilience. City Information Modeling (CIM). Environmental Disasters.

Resiliencia urbana apoyada en tecnología en la gestión y prevención de desastres

RESUMEN

Objetivo – Investigar de qué manera la resiliencia urbana puede fortalecerse en la gestión y prevención de desastres ambientales, con énfasis en la aplicación del City Information Modeling (CIM) y de tecnologías digitales.

Metodología – La investigación adopta un enfoque cualitativo, basado en revisión de literatura, estudio de caso y análisis comparativo. Se analizan dos desastres ocurridos en Brasil, las inundaciones de 2024 en Porto Alegre y el

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hundimiento del suelo en Maceió asociado a la minería de sal gema, en diálogo con experiencias internacionales en Venecia y Helsinki.

Originalidad/Relevancia – El estudio se inserta en un campo aún poco explorado en Brasil al articular tecnologías digitales, resiliencia urbana y mitigación de desastres, contribuyendo al debate académico sobre el uso del CIM como herramienta estratégica para la gestión de riesgos urbanos.

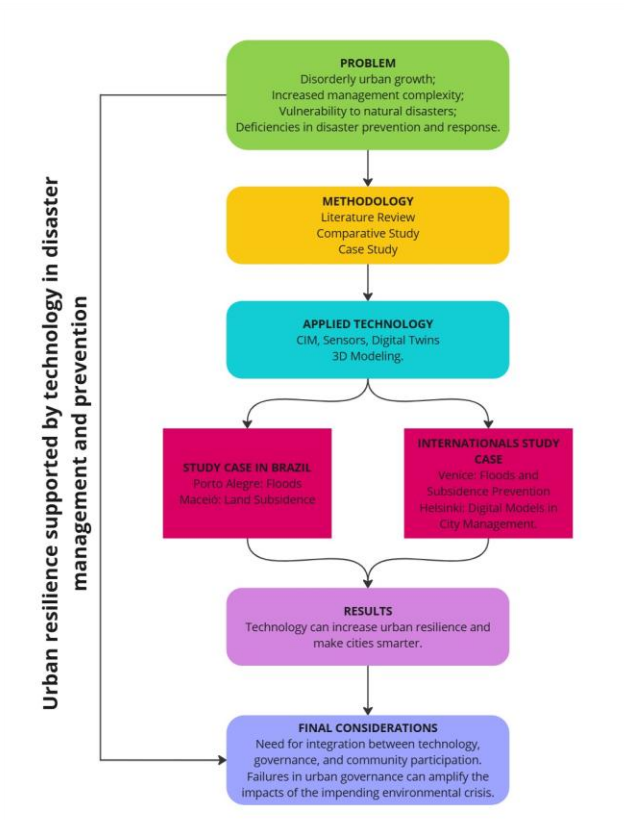
Resultados – Los resultados indican que el fortalecimiento de la resiliencia urbana depende de la integración entre tecnologías de modelado de información urbana, estructuras de gobernanza eficientes y participación comunitaria, evidenciando limitaciones relacionadas con la falta de inversión y de capacitación técnica.

Contribuciones Teóricas/Metodológicas – El artículo amplía la comprensión del potencial del CIM como instrumento de apoyo al análisis, la prevención y la gestión de desastres, aportando bases teóricas y metodológicas para su aplicación en contextos urbanos complejos.

Contribuciones Sociales y Ambientales – Los hallazgos destacan el papel de las tecnologías digitales en la reducción de impactos socioambientales, en el apoyo a la formulación de políticas públicas y en el fortalecimiento de estrategias de gestión urbana más resilientes y sostenibles.

PALABRAS CLAVE: Resiliencia Urbana. City Information Modeling (CIM). Desastres Ambientales.

GRAPHICAL ABSTRACT



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1 INTRODUCTION

Amid rapid urbanization, combined with the growing consequences of climate change, numerous challenges related to urban planning have emerged in cities. In order to address this scenario, the concept of resilience has attracted increasing attention from researchers worldwide. In this context, the interconnection between urban resilience and new information technologies presents itself as an alternative to the challenges faced by Brazilian cities, representing a concrete possibility for improving the mitigation of the effects of natural disasters.

Grzegorzewski et al. (2023) emphasize that the concept of sustainability goes beyond the environmental dimension and, by incorporating social, economic, spatial, and cultural aspects consolidated both in the trajectory of sustainability in architecture and urbanism and in global urban development agendas such as the 2030 Agenda and the Sustainable Development Goals (SDGs), provides a conceptual basis for strengthening urban resilience. According to Costa and Diniz (2021), sanitary crises throughout Brazilian urban history reveal that structural fragilities and the absence of urban planning and management have increased cities' vulnerability to disease. In the current context, marked by an urban crisis associated with climate change, these limitations intensify the inability to respond to and adapt to critical situations.

For D. Serre et al. (2018), the practical use of the concept of resilience in the urban context assumes relevance by guiding reflections and the development of new tools capable of contributing to urban planning.

In order to foster discussion on this integration in Brazil, this article proposes to discuss the state of the art regarding the concept of resilience and the use of City Information Modeling (CIM) and information technologies to improve urban infrastructure, using the tragedies that occurred in Porto Alegre and Maceió as references and comparing them with the application of these technologies in Venice and Helsinki.

2 OBJECTIVES

The general objective of this study is to investigate how urban resilience can be strengthened in the management and prevention of environmental disasters, with particular emphasis on the use of CIM and other advanced technologies. The specific objectives are: to examine the concept of urban resilience within the current state of the art; to investigate the impacts of disasters and the role of urban resilience; to analyze the context of natural disasters in the cities of Porto Alegre and Maceió; and to explore the use of CIM and information technologies as tools for urban management.

3 METHODOLOGY /ANALYSIS METHOD

The methodology adopted in this study combines three complementary approaches: literature review, case study, and comparative analysis of applications.

The literature review was conducted to map the state of the art on the concept of urban resilience, to examine the disasters in Porto Alegre and Maceió, and to analyze cases of

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CIM and information technologies applied in Helsinki and Venice within the context of natural disaster mitigation. For this purpose, academic articles and technical reports were consulted, in addition to identifying existing gaps in the literature.

The case study constituted the second methodological stage. For this analysis, Porto Alegre and its floods were selected, as well as Maceió, where the so-called Braskem urban refugees have been affected by recent environmental disasters. As a counterpoint, the cases of Venice and Helsinki were examined, focusing on the use of CIM and information technologies to illustrate local mitigation practices and responses to such events.

The third methodological stage consisted of a comparative assessment of the risk-mitigation practices adopted in the aforementioned cities, with the aim of evaluating the effectiveness of the strategies implemented and identifying best practices that could be replicated in other urban contexts.

The data for the comparative analysis were obtained from secondary sources, such as published case studies, reports from international organizations, and government data. This comparison made it possible to identify similarities and differences in the approaches adopted by each city, highlighting the most successful strategies as well as those requiring further refinement.

4 URBAN RESILIENCE IN CITY MANAGEMENT IN THE CONTEXT OF “NATURAL” DISASTERS

In the context of sustainable development, the protection of urbanized territories against natural disasters resulting from the intensification of climate change is one of the fundamental points of the strategic actions promoted by the 2030 Agenda and its 17 Sustainable Development Goals (SDGs). Responses to contemporary challenges related to so-called “natural” disasters, whose increased intensity is attributed to human actions, are numerous and diverse. Social, political, and economic factors require organizational and scientific development to support these responses. When assessed at the individual level, the issue enters an equally complex field. Adaptation becomes a condition for survival; however, according to Rosoni (2020), from a biological perspective, although the meaning of adaptation is closely related to the continuity of life, being adaptable is more than merely continuing to exist.

The term most appropriate to address the current situation is therefore resilience. Yunes (2003, p. 76) notes that resilience is often associated with processes that explain the “overcoming” of crises and adversities in individuals, groups, and organizations. From the perspective of the human organism, in which physiological and psychological dimensions act together, resilience carries the meaning of transcendence, which Russ (1991, p. 282) relates to the act of overcoming.

The understanding of the concept of resilience has become increasingly discussed and relevant in preparing cities for disasters and unexpected events. According to Büyüközkan et al. (2021), this understanding is essential for urban preparedness in relation to disasters and unforeseen events, while simultaneously implying adaptation and adjustment to transformations. What was originally associated with problems caused by climate change and disaster management has expanded to encompass other aspects, focusing on the social and

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environmental perspectives of improving urban resilience. Sommese (2024) further complements this discussion:

> Urban resilience requires proactive planning through the implementation of adaptation strategies, such as the development of infrastructure and policies that address the impacts and consequences of extreme events. [...] This includes, in particular, the construction of flood-resistant infrastructure, sustainable water management systems, and the creation or enhancement of accessible public green spaces.

4.1 Urban resilience in the face of disasters

The reconstruction of areas degraded by natural disasters, often not entirely feasible, involves not only issues related to urban infrastructure (such as paving, waste collection, sewage systems, and drainage), but also the preservation of remaining structures and the construction of new ones. At the same time, given the history of the disaster, there is a demand for the provision of new housing, since private property is often directly affected by such events, which are not always unforeseen.

Balancing the need to meet social and housing demands with the conservation of the area's pre-existing environmental characteristics is a central challenge. Reconstructed housing should adhere to principles that respect nature, enhance the basic features of construction (including lighting, ventilation, and natural environments), and incorporate more economical, sustainable solutions integrated with their surroundings. Minimizing environmental impacts not only reduces energy consumption but also promotes the use of natural resources available in the environment (such as sunlight, vegetation, rainwater, and wind).

According to Grzegorzewski et al. (2023), the concept of the ecological footprint applies to this discussion when sustainability is assessed in a more objective manner, by measuring the extent to which the population appropriates the productivity of nature and the degree to which it restricts it. The calculation of the ecological footprint includes cropland, grazing land, carbon uptake land, which represents forest areas capable of sequestering CO_2 emissions, forest resources, built-up areas, and fish stocks. In other words, it encompasses uses and resources that can be measured in terms of the area required to maintain biological productivity and that are related to the affected region.

According to the United Nations Children's Fund (UNICEF), Brazilian disasters and their connections with climate change, evidence "in the intensification of socioeconomic inequality, exposing the most vulnerable segments of society to a range of adverse effects on health, food insecurity, income loss, and beyond" (UNICEF, 2022).

In 1988, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) established the Intergovernmental Panel on Climate Change (IPCC), which is currently composed of 195 member countries, including Brazil (Brazil, 2022). Within this framework, the gathering of experts in fields such as urban planning, architecture, smart cities, mitigation and adaptation policies, energy security, water security and sanitation, barriers and enabling conditions for urban climate finance, insurance, livable cities, the role of normative principles in governance, as well as science, technology, and innovation for sustainable cities, has produced reports aimed at providing policymakers with regular

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scientific assessments of climate change, its implications and potential future risks, and possible adaptation and mitigation options.

Despite these transformations, the adaptive capacity of residents to new forms of access in the areas they come to inhabit can be observed. However, beyond adaptation, resilience is also evident throughout the region. Resilience, the ability of a substance to return to its original form once pressure is removed, becomes visible among residents who adjust to the new dynamics of their neighborhoods. In the context of ecology, resilience refers to the capacity of a given system to regain equilibrium after being disturbed, pointing to its ability to restore itself. From this perspective, it is possible to discern signs of overcoming and renewal already emerging in the degraded areas

4.2 Urban resilience and the social determinants of health

The social determinants of health, as defined by the World Health Organization (WHO), are fundamental aspects for building urban resilience. Social determinants of health refer to the conditions in which people are born, grow, live, work, and age, and these conditions are shaped by economic, political, and social factors that directly affect population well-being. The WHO identifies several social determinants of health, including education, employment, working conditions, housing, access to healthcare, social security, and the social and physical environment of communities. These factors play a critical role in population health, influencing the ability to cope with stress and crises, and are essential for fostering urban resilience (WHO, 2011).

The relationship between urban resilience and social determinants of health becomes particularly evident when considering that social and economic inequalities directly contribute to population vulnerability in crisis situations. In areas of high social vulnerability, precarious housing conditions, lack of access to quality healthcare services, social segregation, and inadequate infrastructure make communities more susceptible to natural disasters, epidemics, and other emergencies. The scarcity of resources and opportunities limits these communities' capacity for adaptation and recovery, increasing their dependence on external assistance and complicating their integration into recovery and sustainable development processes.

To address the necessary improvements in such areas, UN-Habitat and WHO have emphasized the Sustainable Development Goals (SDGs), including targets for upgrading informal settlements and recognizing that reducing inequality requires attention to the environmental and social conditions that keep residents in unhealthy, deficient environments and exposed to premature mortality (WHO; UN-Habitat, 2016). To this end, Social Determinants of Health (SDH) were established as factors outside of medical care that shape health outcomes, including safe housing, access to food, political and gender rights, education, and access to employment (de Snyder et al., 2011).

Urban resilience can thus be understood not only as a city's capacity to withstand disasters but also as its ability to create a more robust and adaptive social, economic, and environmental structure. For instance, universal access to quality healthcare, improved housing conditions, and the promotion of healthier and more sustainable urban environments are factors that enhance population resilience, enabling communities to respond more effectively to shocks and crises.

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5 THE TRAGEDIES AND RESILIENCE

The city of Porto Alegre, located on the banks of the Guaíba basin, and the neighborhood of Mutange, situated near the Mundaú Lagoon in Maceió, have faced significant impacts from environmental disasters in recent years. The floods in Rio Grande do Sul between late April and early May 2024 were classified by the state government as "the greatest climate catastrophe" in the state's history (Sias, 2024). In the latter case, the collapse of a rock salt mine on December 10, 2023, caused ground subsidence and the opening of a crater in the Mundaú Lagoon. These events, intensified by climate change and aggravated by failures in public management and irresponsible corporate practices, it has exposed the fragility of urban infrastructure and underscored the urgent need for effective actions to mitigate risks and promote resilience in these areas.

5.1 The floods in Porto Alegre

Throughout its history, the city of Porto Alegre has maintained a relationship with the Guaíba marked by tensions. The recurrent floods recorded in 1873, 1889, 1897, 1905, 1912, 1914, 1916, 1928, and 1936 revealed the region's vulnerability to fluvial variations within the Jacuí River delta hydrographic system (Devos, 2007). These floods, typically associated with periods of intense rainfall and elevated river flows, highlight critical hydrological patterns that challenged the city's adaptive strategies.

Figure 1 – Aerial view of flooded streets in Porto Alegre (RS), Brazil, after storms in Rio Grande do Sul

Source: Carlos FABAL/AFP, 2024. Available at: rebrand.ly/agenciaestado20240506. Accessed: Nov 12, 2024.

The 2024 flood exposed structural weaknesses in the flood-control system, generating significant economic and social losses while underscoring the urgent need for maintenance and modernization of port and sanitation infrastructure. Rio Grande do Sul experienced heavy and continuous rainfall for more than ten days beginning on April 27, 2024, which overwhelmed the local hydrographic basins of the Taquari, Caí, Pardo, Jacuí, Sinos, and Gravataí rivers. These events were intensified by the El Niño climate phenomenon, which warms the Pacific Ocean above historical averages, resulting in rainfall volumes far exceeding normal levels. The level of the Guaíba rose rapidly, surpassing the flood threshold and reaching a historic record of 5.33

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meters on May 5, 2024 (Heinzelmann, 2024). Despite the presence of the Mauá Wall, the city was inundated due to failures in other components of the flood-control system, which allowed water to breach the city.

The Municipal Government of Porto Alegre (PMPA) imposed water rationing and restricted the use of the resource in the state capital. Mayor Sebastião Melo stated that the measure was necessary due to the shutdown of a water treatment plant on the afternoon of Monday, May 6, 2024. Approximately 80% of the population was left without supply from the Municipal Department of Water and Sewage (DMAE).

The tragedy in Rio Grande do Sul resulted in 85 fatalities, according to reports from Civil Defense. Authorities also recorded 339 injured, 134 missing persons, and more than 201,000 people displaced from their homes, of whom 153,824 were temporarily housed with relatives or friends, while 47,676 sought refuge in public shelters. The floods, which affected most of the state, forced 390 municipalities to declare a state of emergency.

The absence of an "active memory" of the 1941 flood contributed to the neglect of maintenance in the city's flood-protection system. This "erasure" of memory—common in traumatic events that occur at long intervals—resulted in failures of sluice gates and pumping stations during the 2024 disaster. The "post-memory" of the 1941 flood, marked by fragmented sensations and emotions rather than comprehensive narratives, proved insufficient to sustain public and institutional awareness of the importance of prevention and maintenance in the protection system (Heinzelmann, 2024).

In the port area of Porto Alegre, "ships stopped arriving, which disrupted the supply of fertilizers for agriculture, the provision of gas for Porto Alegre, and the export of chemical products from Braskem, as well as bulks solids and liquids from local industries, all of which came to a halt. The company restored its private terminal and dredged access channels to its terminal using its own resources" (Simões, 2024).

5.2 The Braskem's case in Maceió

The Braskem, a company that emerged from the Odebrecht Organization and is currently controlled by Novonor (Braskem, 2025), operates in Maceió, where ground subsidence above underground rock salt mines have been expanding, forcing the evacuation of areas in the capital of Alagoas. Braskem is responsible for the exploitation of these mines. "Since rock salt mining conducted by Braskem was identified as the main cause of ground subsidence in Maceió, an extensive effort has been undertaken to close and stabilize 35 mines in the Mutange and Bebedouro regions" (Braskem, 2025).

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Figure 2 – Formerly inhabited area now degraded by soil displacement

Source: Schmidt, 2024.

In addition to the Mutange neighborhood, the districts of Bebedouro, Bom Parto, Farol, Gruta de Lourdes, Pinheiro, Ponta Grossa, and Vergel do Lago have become veritable ghost towns. The evacuation of areas affected by ground subsidence has transformed entire districts, generating economic, environmental, and social impacts, while directly affecting urban mobility that once passed through these areas.

Civil Defense determined that the subsidence process occurred in five neighborhoods. Figure 2 illustrates the necessary abandonment of dwellings and the emptying of entire communities. As residents left, they took with them not only their belongings but also construction materials that could be reused: doors, windows, gates, sanitary fixtures, roofing, and floorboards, whenever possible.

According to Rodrigues (2023), the Alagoas Environmental Institute (IMA-AL) fined Braskem more than R$ 72 million for withholding information, causing environmental damage, and for the risk of collapse of Mine 18—this being the twentieth fine imposed on the company. "The evacuation of the risk area was carried out proactively, with the relocation of approximately 40,000 people over four years. To date, 94% of compensation claims have been paid" (Braskem, 2025). However, the company's announced reparation extends further, involving the task of ensuring the preservation of the historical heritage of the vacated areas, requalifying the newly available spaces for community use, and contributing to the adaptation and improvement of urban mobility while mitigating the environmental impacts caused by subsidence.

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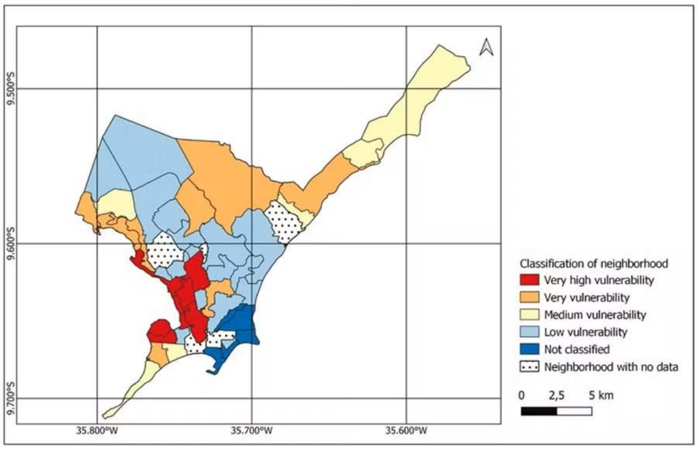
Figure 3 – Maceió neighborhoods at risk of ground subsidence



Source: Lenino *et al*. *apud* G1 Alagoas, 2024.

The academic community had already been studying the area, as exemplified by geologist Marcos Harting from the Federal University of Espírito Santo (UFES), who reported a ground subsidence of one meter between 2016 and 2020, noting that the closer to the mines, the greater the subsidence (Schmidt, 2024). According to Vassileva et al. (2021, p. 1), land subsidence caused by natural or anthropogenic processes affects large urban areas worldwide, and the formation of sinkholes and infrastructure fractures has intensified in Maceió since early 2018.

In their research, Fontana et al. (2023) apply to the Maceió case a model composed of three main stages: problem definition, risk management, and decision analysis. For this purpose, the Picture Fuzzy-Delphi method was employed to collect data and elucidate expert judgments. Harting's studies hypothesize that the reactivation of fractures constitutes an important mechanism leading to the formation and propagation of numerous surface cracks. This investigation provides a better understanding of settlement dynamics in salt mines and their dissolution fields (Schmidt, 2024).

Among the outcomes produced by researchers from four universities—the Federal University of Alagoas (UFAL), the Federal University of Pernambuco (UFPE), the Federal University of Piauí (UFPI), and the University of Brasília (UnB)—the map below presents a vulnerability analysis. According to G1 Alagoas (2024), the study classifies neighborhoods into four vulnerability levels: most vulnerable, vulnerable, moderately vulnerable, and low vulnerability, also indicating how additional neighborhoods may be environmentally, economically, and socially affected. Approximately 14,000 properties have already been impacted.

The study by Lenivo et al., cited in G1 Alagoas (2024), was based on a multicriteria Geographic Information System (GIS) analysis, an approach that combines geospatial information systems with multicriteria decision-support methods. This GIS-based platform enables spatial visualization and comprehension of the ongoing problems, serving as a facilitator for local analysis and decision-making. As observed, the area demonstrates both socioeconomic and environmental vulnerability. In addition to the neighborhoods directly affected by mining, other regions are either impacted or at risk of being affected, largely due to the migration of

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approximately 60,000 residents who were forced to abandon their homes and relocate to other regions.

6 CIM IN URBAN RESILIENCE AND INTERNATIONAL EXPERIENCES IN CITY MANAGEMENT

City Information Modeling (CIM) is an advanced digital methodology aimed at creating detailed and dynamic models of urban environments. This concept integrates data from multiple sources—such as georeferenced information, infrastructure systems, transportation networks, land use, and environmental variables—providing a comprehensive and systematic view of cities. Such an approach is essential for effective urban planning and management in contemporary contexts (Lu et al., 2020). CIM represents an evolution of Building Information Modeling (BIM), which focuses on the scale of individual buildings, by extending this perspective to the urban context.

Figure 4 – CIM infrastructure model of a location in Paris

Source: Arcadis ESG, 2019. Available at: https://www.arcadis.com/. Accessed: Jan 12, 2025.

While BIM addresses the building life cycle, CIM expands this perspective to encompass streets, sanitation networks, green areas, as well as socioeconomic and environmental aspects. To achieve this, CIM integrates with GIS, which provide a broader and more detailed view of the territory, facilitating spatial analysis and decision-making (Lopes, 2019). The combination of CIM, BIM, and GIS creates a comprehensive system for urban management, in which BIM contributes the integration of geometric data with performance analysis and building maintenance, while GIS supports land-use change assessments, traffic analysis, and territorial monitoring. This integration results in an urban digital twin, a detailed virtual representation of a city, that can be employed in urban planning, infrastructure management, and the optimization of operational processes.

CIM stands out for its multiple applications in the urban context, serving as a database for governments in processes such as permit approval, supervision of BIM files, and the planning of new urban projects (Xia, 2022). Furthermore, CIM enables the collection of accurate data that supports innovation and the transformation of cities, fostering continuous improvements in resource use and quality of life (Lu, 2020).

Another significant application of CIM is the conservation of historic heritage. Heritage Building Information Modeling (HBIM) allows for the creation of detailed representations that facilitate revitalization and preservation processes, ensuring the long-term protection of cultural

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and architectural assets. When combined with CIM, HBIM enables integrated management of the cultural landscape by consolidating architectural and urban data into a single repository (Lu, 2020). The integration of CIM with other technologies, such as remote sensing, the Internet of Things (IoT), and big data, further enhances its monitoring and analytical capabilities, providing real-time data on urban conditions and enabling the efficient management of resources.

The applications of CIM encompass diverse domains, ranging from emergency management (e.g., evacuation route planning) and urban planning (e.g., the development of new districts) to infrastructure management, optimizing transportation and sanitation networks (Rosa et al., 2023). The tool also emerges as a valuable ally in risk forecasting and natural disaster mitigation, such as floods and earthquakes (Lu, 2020).

In terms of risk and disaster simulation, CIM enables multi-hazard simulations—including earthquakes, fires, and wind events, for both individual buildings and broader urban areas. When integrated into CIM, modeling allows for precise simulations of these events, taking into account building characteristics and ground motion in the case of earthquakes. Fire simulations, based on physics-based models, consider factors such as climatic conditions and construction fire resistance. For wind simulations, computational fluid dynamics (CFD) models are employed to replicate air behavior under different conditions, thereby visualizing risk scenarios and predicting social and economic impacts, including potential loss of life and material damage. These capabilities optimize the planning of preventive and rapid-response measures (Xia, 2022).

Despite its advantages, CIM faces limitations such as dependence on data quality, challenges in system interoperability, and high implementation costs, particularly in complex cities or in economically peripheral countries (Xia, 2022). Moreover, simulations do not always fully capture real-world dynamics (Rosa et al., 2023), requiring caution in the interpretation of results.

6.1 International Experiences with CIM and Technologies in Urban Management

International experiences highlight the relevance of technological innovation in urban care and management. Venice, an emblematic example, adopts technologies such as CIM, GIS, BIM, digital mapping, and digital twins, in an integrated manner to address unique challenges, including climate change, land subsidence, and the management of the MOSE project (Galeazzo, 2023). Despite these advancements, the integrated use of these technologies is still relatively recent and constantly evolving, aiming to improve the effectiveness and applicability of solutions.

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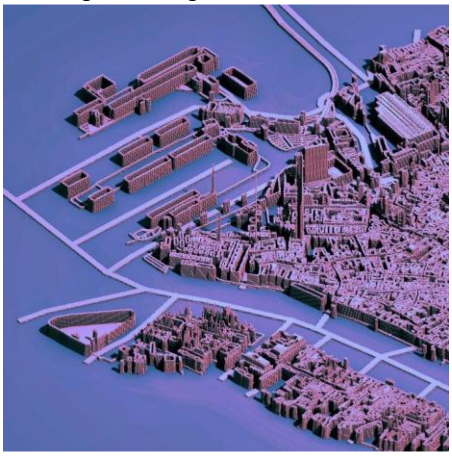
Figure 5 – Digital Twin of Veneza



Source: Extract Project, 2025.

The digital twin (DT) plays a central role in this approach, functioning as a virtual representation of the city that integrates data from multiple sources to monitor, predict, and manage complex systems (Villani, 2025). In Venice, the use of the DT is essential to address the fragility of cultural heritage and the complexity of the infrastructure. The tool enables scenario simulations, traffic analysis, energy consumption monitoring, and environmental risk assessment. Data collected from IoT sensors, satellite imagery, and historical records provide a comprehensive view and facilitate rapid responses to emergencies and unforeseen events. At the core of this DT is a Python script developed to convert geographic and structural data from OpenStreetMap (OSM) into a semantically enriched format. This format optimizes real-time integration with Venice's dynamic digital model. The script extracts essential information about urban infrastructure, such as roads and buildings, and converts it into a Resource Description Framework (RDF), facilitating semantic processing and data interoperability (Extract Project, 2025).

The use of BIM is another key component for the preservation and maintenance of heritage in Venice. Detailed three-dimensional models of buildings and infrastructure incorporate information about materials, systems, and physical characteristics (Villani, 2025). These models, exported in IFC format, promote collaboration among project teams and are integrated into the DT for analysis and visualization.

Furthermore, GIS enables the mapping and analysis of geographic data, generating interactive maps that support urban planning and cultural heritage protection (Galeazzo, 2023). Digital mapping techniques, such as photogrammetric and laser surveys, complement the set of technological tools, providing precise measurements of structures, including those that are submerged or damaged (Galeazzo, 2023).

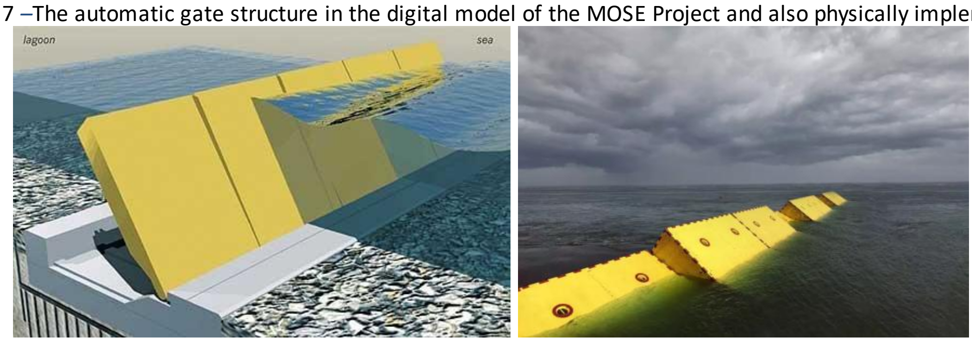
Figure 6 – Flood in Veneza

Source: Habitability, 2024. Available at: https://habitability.com.br/projeto-mose/. Accessed: Jan 15,2025.

The integration of tools such as HGIS, through the VeNiss project, allows for the mapping and analysis of Venice's historical evolution in urban, social, and cultural aspects, highlighting the relationship between the city and its aquatic landscape. This analysis contributes to the understanding of the historical context and to the formulation of preservation and development strategies.

Venice also faces the impacts of climate change, such as sea-level rise and extreme weather events (Villani, 2025). The DT plays a role in monitoring and forecasting these phenomena, supporting risk mitigation. Satellite data, such as those from the Copernicus program, indicate an average southwestward displacement of 2 mm per year, highlighting the need for continuous monitoring. Furthermore, the DT also assesses environmental risks and monitors vulnerable areas, such as those prone to fires and floods.

Figure 7 –The automatic gate structure in the digital model of the MOSE Project and also physically implemented



Source: Villani, 2025; Habitability, 2024. Available at: https://habitability.com.br/projeto-mose/. Accessed: Jan 15, 2025.

The MOSE project, a system of mobile barriers designed to protect Venice from flooding, is optimized with the support of the DT. The tool analyzes real-time data to predict the need for barrier activation, minimizing the impacts of floods. The frequent use of the system, as observed in 2023, highlights the pressure faced by the infrastructure (Maggi, 2024).

Despite the progress achieved, the integrated application of these technologies in Venice is still recent and presents challenges in establishing a fully functional model. Data and system integration, enabled by the DT, forms the foundation for efficient and sustainable urban

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management. By combining information from IoT sensors, satellite imagery, and historical records, Venice builds a holistic approach to address its challenges. This model aims to transform the city into a more resilient, sustainable, and technologically advanced environment, ensuring the preservation of its cultural heritage and improving the quality of life for its inhabitants (Villani, 2025).

Another noteworthy international experience is the Helsinki 3D+ project, an example of CIM in Helsinki, Finland. With a budget of 1 million euros, the project was initiated by the city to create two 3D models of the urban area using innovative data capture technologies (Xu et al., 2021). Among the main objectives are: promoting the development of smart cities, fostering new commercial ventures, collaborating with universities in joint programs, and supporting urban planning decisions, addressing issues such as the impact of new developments on the sunlight received by neighboring buildings (Geoweek, 2021).

To create the models, Helsinki used a combination of advanced 3D capture methods. This included aerial LiDAR for terrain and surface data collection, processed with Bentley's Pointools and Terrasolid software, as well as 50,000 oblique images captured with a Microsoft Osprey camera, processed using Bentley ContextCapture on a network of 10 computers (Xu et al., 2021). The project also utilized over 600 ground control points to ensure data accuracy, resulting in a pixel accuracy of 10 cm and an overall model accuracy of 20 cm +/- 10 cm (Geoweek, 2021).

Figure 8 – Energetic Model of Helsinki

Source: City of Helsinki. Available at: https://www.hel.fi/. Accessed: Jan 20, 2025.

In addition to the detailed mesh model, Helsinki created an intelligent CityGML model, aiming to explore different potential uses of the raw data, as the city was initially uncertain about its applications. Both models were made freely available to citizens and private companies, while also supporting various pilot programs in collaboration with universities (Geoweek News, 2021).

Helsinki's CIM models include: a high-quality visual mesh model, ideal for visualization in browsers and mobile devices, and a semantic model based on CityGML, which allows for various analyses, such as energy consumption, greenhouse gas emissions, and environmental impacts from traffic (Xu et al., 2021).

The city stands out for its open approach, enabling active citizen participation in data collection and usage for multiple applications, including: use in games such as Minecraft

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Helsinki, 3D virtual parks, systems for maintenance process modeling, tools for urban analyses (urban space quality indicators, CO2/GHG/emission analysis, and solar potential), citizen interaction platforms for urban planning, and energy analysis methods in partnership with the Technical University of Munich to achieve energy targets (Geoweek News, 2021). These models are essential for understanding and mitigating the effects of climate change in cities. Helsinki, for instance, aims to become carbon-neutral by 2050, and the CIM supports energy analysis to achieve these goals.

7 SYNERGY BETWEEN CIM AND URBAN RESILIENCE (ANALYSIS OF EXISTING CASES AND FUTURE POTENTIALS)

The implementation of urban solutions inspired by the experiences of Venice and Helsinki in Porto Alegre and Maceió could bring significant advances in urban management, particularly in addressing challenges such as flooding, ground subsidence, and infrastructure deterioration. The adoption of integrated technologies and planning strategies can create urban environments with reduced exposure to risks, promote smarter management, and strengthen urban resilience.

In Porto Alegre, the creation of a Digital Twin (DT) could transform the monitoring of the Guaíba and Jacuí river levels, enabling more accurate flood forecasting and optimizing the performance of drainage systems. The integration of IoT sensors, satellite imagery, and historical data would allow for early anticipation of extreme weather events and guide preventive actions in critical areas, such as the islands and the Fourth District.

In Maceió, a DT could play a fundamental role in monitoring ground subsidence, a phenomenon affecting neighborhoods such as Pinheiro and Mutange. The combination of GIS data, IoT sensors, and satellite imagery would enable the early identification of risk zones, allowing mitigation actions and ensuring the safe relocation of residents before structural collapses occur. This approach would also allow the simulation of different future scenarios, supporting the development of adaptation strategies and the rehabilitation of areas affected by subsidence.

HBIM in Porto Alegre would enable the three-dimensional modeling of historical buildings prone to recurring flood damage, such as those in the Historic Center. This modeling would allow for an assessment of structural integrity, supporting planned interventions that preserve heritage value without compromising functionality and safety, in an integrated urban landscape approach. In Maceió, BIM could be used to evaluate the stability of buildings located in areas prone to subsidence, enabling preventive measures and the safe relocation of the exposed population.

The use of GIS and advanced digital mapping techniques can represent a significant leap in territorial management and urban planning in both cities. In Porto Alegre, GIS could map flood-prone areas with precision, facilitating the identification of critical points and guiding the implementation of solutions, such as expanding drainage systems and creating buffer zones. In Maceió, digital mapping would provide a deeper understanding of areas at risk of subsidence, supplying technical support for urban rehabilitation strategies that promote orderly and safe occupation of affected regions. Integrating these maps into interactive three-dimensional

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models would offer a clearer visualization of urban dynamics, assisting decision-makers in planning more effective interventions.

Data interoperability, as observed in Venice, would be valuable for modernizing urban management in both cities. The use of scripts to convert and integrate geographic and structural data into standardized, semantically enriched formats would enable more detailed analyses and informed decision-making. In Maceió, standardizing and integrating subsidence data would allow for more precise planning of necessary interventions, optimizing resources and response times for emergency actions. In Porto Alegre, this approach could improve the operation of drainage systems, enabling continuous monitoring of the city's hydrological and structural conditions.

Helsinki's experience with three-dimensional urban models also provides valuable insights for urban management in Porto Alegre and Maceió. In Porto Alegre, creating detailed 3D models would assist in simulating the impact of new drainage infrastructure and in evaluating the effectiveness of climate adaptation measures. In Maceió, the use of CityGML could facilitate the analysis of structural vulnerabilities and support the planning of interventions in risk areas, ensuring that adopted solutions are technically and environmentally viable. Moreover, Helsinki leverages CIM to improve residents' quality of life, focusing on public health, housing, and safety. This approach could be adapted to Porto Alegre and Maceió, where urban data modeling would identify areas lacking basic infrastructure, such as sanitation, street lighting, and transportation, guiding public policies that promote social equity in areas with specific needs, including housing improvements, access to healthcare, and public safety in citizens' daily lives.

Encouraging citizen participation and the use of open data, as practiced in Helsinki, could also be incorporated into the urban planning strategies of Porto Alegre and Maceió. Providing data on urban risks and interactive three-dimensional models would foster active public engagement in identifying problems and formulating solutions, enhancing transparency and the effectiveness of interventions.

8 FINAL CONSIDERATIONS

In light of the growing challenges imposed by climate change and the intensification of urban disasters, urban resilience emerges as a central concept for the intelligent and sustainable management of cities. The analysis of the cases of Porto Alegre and Maceió illustrates that environmental disasters cannot be regarded as isolated events, but rather as complex phenomena that demand structured responses integrated with urban planning and supported by active social participation.

The international experience, as highlighted in comparative studies of models adopted in cities such as Venice and Helsinki, reinforce the relevance of incorporating technologies such as CIM, BIM, and GIS. These tools play a strategic role in risk prevention and mitigation, contributing to more efficient adaptation and recovery processes in urban contexts. The integration of digital methodologies and tools into territorial management not only enhances the capacity for disaster response but also strengthens the adaptive dimension of mitigation policies, thereby fostering more inclusive and resilient cities in the face of twenty-first century challenges.

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The adaptation of these approaches to the Brazilian context, while respecting national and local specificities, holds the potential to generate significant benefits, including the reduction of socioeconomic impacts, the promotion of greater equity in the distribution of infrastructure and essential services, and the development of cities better prepared to confront adverse scenarios. Nevertheless, such advances depend on overcoming persistent barriers, notably the insufficient investment in technological innovation, the lack of technical training, and the urgent need for more integrated and transparent governance mechanisms.

However, to consolidate this transformation, a paradigm shift is required, one in which urban resilience is understood as an ongoing process that integrates technological innovation, effective governance, and community engagement. Equally important is the need to confront climate denialism, particularly in the political sphere, and to address corporate interests that prioritize profit over sustainability, often reducing compensation measures to a purportedly sufficient response to damages arising from negligence or mismanagement.

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10 REFERENCES

BRASIL. **Painel Intergovernamental sobre Mudança do Clima – IPCC**, Min. Ciência, Tecnologias e Inovações, 2022**.** Disponível em: https://www.gov.br/mcti/pt-br/. Acesso em: 20 jan. 2025.

BRASKEM. **A Braskem,** 2025. Disponível em: https://www.braskem.com.br/. Acesso em 21 jan. 2025.

BÜYÜKÖZKAN, G. *et al*. A review of urban resilience literature. **Sustainable Cities and Society**, v. 77, p. 103579, 2022. Disponível em: https://doi.org/10.1016/j.scs.2021.103579. Acesso em: 18 jan. 2025.

D. SERRE *et al.* Assessing and mapping urban resilience to floods with respect to cascading effects through critical infrastructure networks. Int. J. Disas. **Risk Reduct**, 2018.

DE SNYDER, V. Nelly Salgado *et al*. Social conditions and urban health inequities: realities, challenges and opportunities to transform the urban landscape through research and action. Journal of Urban Health, v. 88, p. 1183-1193, 2011.

DEVOS, R. **A "questão ambiental" sob a ótica da antropologia dos grupos urbanos, nas ilhas do Parque Estadual Delta do Jacuí, Bairro Arquipélago, Porto Alegre, RS**. Tese (Doutorado em Antropologia Social), Universidade Federal do Rio Grande do Sul, Porto Alegre, 2007.

GALEAZZO, Ludovica *et al*. A geospatial and time-based reconstruction of the Venetian Lagoon in a 3D web semantic infrastructure. **CEUR Workshop Proceedings**, 2023. Disponível em: http://ceur-ws.org. Acesso em: 24 jan. 2025.

EXTRACT PROJECT. **Urban Safety and Efficiency**: A Digital Twin of Venice, 2025. Disponível em: https://extract-project.eu/urban-safety-and-efficiency-a-digital-twin-of-venice/. Acesso em: 12 jan. 2025.

FONTANA, M. E. *et al*. Risk analysis os transport requalification projects in the mobility problem caused by a mining disaster. **Logistics**. 2023, v 7, n. 3. 04 set. 2023.

G1 Alagoas. **Estudo aponta bairros de Maceió que podem ser atingidos por afundamento do solo causado pela Braskem**. G1 Alagoas, 24 jan. 2025. Disponível em: https://g1.globo.com/al/alagoas/. Acesso em: 24 jan. 2025.

COSTA, Mariana M.; DINIZ, Luciana N. Epidemics X Popular Housing in Rio de Janeiro: Analysis through the SWOT Matrix. **Periódico Eletrônico Fórum Ambiental da Alta Paulista**, v. 17, n. 6, 2021. Disponível em: https://publicacoes.amigosdanatureza.org.br/index.php/forum_ambiental/article/view/3068. Acesso em: 10 jan. 2026.

GRZEGORZEWSKI, Flávia C et al. Sustentabilidade: conceitos e aplicação na Arquitetura. **Periódico Eletrônico Fórum Ambiental da Alta Paulista**, v. 19, n. 5, 2023. Disponível em: https://publicacoes.amigosdanatureza.org.br/index.php/forum_ambiental/article/view/4723. Acesso em: 10 jan. 2026.

GEOWEEK NEWS. **City model of the future**: Helsinki 3D+, 22 fev. 2017. Disponível em: https://www.geoweeknews.com/. Acesso em: 24 jan. 2025.

HEINZELMANN, L. O Muro da Mauá e a memória das enchentes. **Jornal da Universidade**, Porto Alegre, 29 mai. 2024.

LOPES, Tiago Rocha. Modelagem de Informação da Cidade (CIM) e suas potencialidades para gestão da manutenção urbana de Curitiba. **Revista arq.urb**. N.25, São Paulo, 2019. Disponível em: https://www.revistaarqurb.com.br/arqurb/article/view/18. Acesso em: 15 jan. 2025.

LU, Xinzheng *et al.* CIM-powered multi-hazard simulation framework covering both individual buildings and urban areas. **Sustainability**, p. 5059, 2020. Disponível em: https://doi.org/10.3390/su12125059. Acesso em: 25 jan. 2025.

MAGGI, Bruno. Living and adapting to climate change in coastal areas. A case study on citizens' perception of an infrastructure: the MOSE in Venice. **The Egyptian Journal of Environmental Change**, v.16, 2020.

OMS – ORGANIZAÇÃO MUNDIAL DA SAÚDE. **Diminuindo diferenças**: a prática das políticas sobre determinantes sociais da saúde. Rio de Janeiro, 2011. Disponível em: http://cmdss2011.org/. Acesso em: 19 jan. 2025.

OMS – ORGANIZAÇÃO MUNDIAL DA SAÚDE; ONU-HABITAT. **Global report on urban health: Equitable, healthier cities for sustainable development**, 2016. http://www.who.int/. Acesso em: 19 jan. 2025.

RODRIGUES, Alex. **Afundamento do solo de mina em Maceió já passa de 2 m de profundidade**. Agência Brasil, Brasília, 08 dez 2023. Disponível em: https://agenciabrasil.ebc.com.br/geral/no ticia/2023-12/afundamento-do-solo-de-mina-em-maceio-ja-passa-de-2-m-de-profundidade. Acesso em: 24 jan 2025.

ROSA. S. C. *et al*. Estado da arte da integração GIS x BIM no contexto das cidades inteligentes Análise do ecossistema de inovação de startups da construção civil cearense. In: SIMPÓSIO BRASILEIRO DE GESTÃO E ECONOMIA DA CONSTRUÇÃO, 13., 2023, Aracaju. **Anais** [...]. Porto Alegre: ANTAC, 2023.

ROSONI, Marcus. **Aumentando a sua capacidade de adaptação**, 2020. Disponível em: https://ofuturodascoisas.com. Acesso em 13 jan. 2025.

RUSS, Jaqueline. Dicionário de Filosofia. São Paulo: Editora Scipione, 1991.

SCHMIDT, Sarah. Solos de Maceió afundam há 20 anos. Revista Geociências – Pesquisa FAPESP, n. 335, jun. 2024. Disponível em: https://revistapesquisa.fapesp.br/solos-de-maceio-afundam-ha-20-anos/. Acesso em 24 jan. 2025.

SIAS, Estael. **Meteorologista estael sias e a chuva**: "a hora mais dramática". Metsul, 02 mai 2024. Disponível em: https://metsul.com/meteorologista-estael-sias-e-a-chuva-a-hora-mais-dramatica/. Acesso em 22 jan 2025.

SIMÕES, José Bedran. A enchente e o porto de Porto Alegre. Entrevista concedida aos autores. Porto Alegre, 2024.

SOMMESE, Francesco. Nature-Based Solutions to Enhance Urban Resilience in the Climate Change and Post-Pandemic Era: A Taxonomy for the Built Environment. **Buildings**, p. 2190, 2024.

UNICEF - FUNDO DAS NAÇÕES UNIDAS PARA A INFÂNCIA. **Os desastres brasileiros e suas relações com as mudanças climáticas**, 2022. Disponível em: https://www.unicef.org/brazil/blog/os-desastres-brasileiros-e-suas-relacoes-com-mudancas-climaticas. Acesso em: 20 jan. 2025.

ISSN 2966-2931 - v. 22, n. 1, 2026

VASSILEVA, M. *et al.* A decade-long silent ground subsidence hazard culminating in a metropolitan disaster in Maceió, Brazil. **Scientific Reports**, p. 7704, 2021. Disponível em: https://doi.org/10.1038/s41598-021-87033-0. Acesso em: 08 abr 2024.

VILLANI, L. *et al*. Digital Twin Framework to Improve Urban Sustainability and Resiliency: The Case Study of Venice. **Land**, p. 83, 2025. Disponível em: https://doi.org/10.3390/land14010083. Acesso em: 16 jan. 2025.

WWF - WORLD WILDLIFE FUNDATION. Pegada brasileira, 2024. Disponível em: https://www.wwf.org.br/natureza_brasileira/ especiais/pegada_ecologica/pegada_brasileira. Acesso em: 19 mar. 2024.

XIA, Haishan *et al*. Study on city digital twin technologies for sustainable smart city design: A review and bibliometric analysis of geographic information system and building information modeling integration. **Sustainable Cities and Society**, p. 104009, set. 2022. Disponível em: https://doi.org/10.1016/j.scs.2022.104009. Acesso em: 18 jan. 2025.

XU, Zhen *et al*. City information modeling: state of the art. **Applied Sciences**, v. 11, n. 19, p. 9333, 2021. Disponível em: https://doi.org/10.3390/app11199333. Acesso em: 24 jan. 2025.

YUNES, Maria A. Psicologia positiva e resiliência: o foco no indivíduo e na família. **Psicologia em Estudo**, v. 8, p. 75-84, 2003.

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DECLARATIONS

Authors' Contributions

- **Luciana Nemer**: Responsible for the study design and overall supervision of the article's development. Critically revised the manuscript, enhancing its clarity and coherence, coordinated the overall research activities, and ensured the integrity and quality of the work throughout the process. Co-responsible for the theoretical sections that supported the article's discussion.
- **Mariana de Melo Costa:** Contributed to the critical revision of the article, wrote the introduction, and co-authored the theoretical sections. Also co-responsible for the revision and final adjustments of the text in accordance with the journal's editorial guidelines, ensuring the overall quality of the work.
- **Felipe Gustavo Silva**: Responsible for the comparative case study and for analyzing the cases to interpret the results obtained during the research. Co-responsible for the revision and final editing of the manuscript, adjusting the text according to the journal's editorial guidelines and ensuring the final quality of the work.

DECLARATION OF CONFLICTS OF INTEREST

We, **Luciana Nemer, Mariana de Melo Costa, and Felipe Gustavo Silva**, hereby declare that the article entitled "**Urban resilience supported by technology in disaster management and prevention**":

1. Has no financial relationships that could influence the results or interpretation of the work. No institution or funding agency was involved in the development of this study.
2. Has no professional relationships that could impact the analysis, interpretation, or presentation of the results. No professional relationship relevant to the content of this manuscript was established.
3. Has no personal conflicts of interest related to the content of the manuscript. No personal conflict related to the content was identified.