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A systematic review of the projection of future scenarios with artificial intelligence through the perspective of strategic design for risk management in extreme events

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ABSTRACT

This article explores how Artificial Intelligence (AI) can contribute to the projection of future scenarios through the lens of Strategic Design, anticipating and mitigating future challenges in the context of transformations. It argues that technological advances and the accumulation of data offer valuable tools for predicting future scenarios and planning strategic interventions. Through a systematic literature review, the study seeks to investigate the integration of Strategic Design with AI and Big Data as a proactive approach to dealing with extreme events such as natural disasters, health crises and socio-environmental imbalances. The intersection between Artificial Intelligence technology and Strategic Design makes it possible to adopt more effective preventive measures, ensuring a more resilient and sustainable response to imminent challenges. The analysis reveals that while AI and Big Data provide advanced tools for analyzing and projecting future scenarios, interdisciplinary collaboration and Strategic Design are essential for translating these projections into concrete and effective actions. The study contributes to the literature by providing an in-depth understanding of how the synergy between technology, design and risk management can facilitate overcoming social and environmental challenges. However, it reiterates the importance of an informed and adaptable strategic perspective in the information age.

Keywords: artificial intelligence, future scenario projection, risk management, strategic design.

INTRODUCTION

The first decades of the 21st century reflect the impact of historical events such as the Enlightenment and the Industrial Revolution. The Enlightenment reconfigured the structures of thought, promoting the pursuit of reason, freedom and progress. At the same time, the Industrial Revolution transformed the socio-economic environment, driving mass production and consumption. These changes shaped the economic foundations and profoundly influenced the cultural, social and environmental aspects of society.

With the advance of technology, especially Artificial Intelligence (AI) and Big Data, it has become possible to predict future scenarios, anticipating challenges arising from human action and natural phenomena. However, the impacts of these transformations still pose dilemmas for contemporary society, such as the intensification of environmental disasters and

geopolitical crises. An example of this are the floods and landslides in Santa Catarina, the consequences of which highlight the vulnerability of populations to extreme weather events, aggravated by anthropogenic changes such as real estate expansion and unsustainable practices on the coast.

AI has emerged as a powerful tool in risk management, making it possible to process large volumes of data and accurately simulate future scenarios. It offers benefits such as early detection of risks, optimization of resources and improved decision-making. Combining human experience with AI's analytical capabilities makes it possible to create robust and adaptable systems capable of protecting organizations and societies from the impacts of crises and guaranteeing long-term progress.

In this context, the research proposes an interdisciplinary approach that integrates AI, Strategic Design and risk management, with a focus on creating a matrix for predicting adverse scenarios. The aim is not only to prevent disasters, but also to guide the adaptation of strategies in the present to mitigate future impacts. The proactive approach seeks to transform data into innovative solutions, ensuring a more resilient future.

Thus, the research aims to investigate the feasibility of using AI and Strategic Design as tools to anticipate crises and reformulate current strategies. The central proposal is to create a solid theoretical basis to support the modeling of future scenarios, with the aim of adjusting trajectories and guaranteeing the security and sustainable development of societies in the face of extreme events.

This study addresses both the historical and conceptual aspects of natural disasters and the importance of AI in developing future scenarios. It provides a theoretical framework for implementing measures to improve quality of life and minimize the risks associated with environmental and social changes.

1. LITERATURE REVIEW

1.1. Risk management for natural disasters: Causes and impacts

The development of modern society has brought numerous benefits, but it has also generated serious environmental and social costs, among which the increased occurrence and intensity of natural disasters stands out. These events, caused by geophysical, climatic and hydrological phenomena - such as earthquakes, volcanic eruptions, hurricanes and floods - cause serious consequences for communities, infrastructure and the environment

Among the main disasters are earthquakes, which result from the release of energy in the earth's crust and can cause large-scale destruction; erupting volcanoes that release magma and toxic gases, drastically affecting nearby regions; global warming that intensifies climatic phenomena such as hurricanes and storms, generating strong winds, intense rainfall and landslides; and hydrological phenomena such as droughts and floods, which have direct implications for food security and the dispute over water resources. In addition to human and material losses, these events cause population displacement, compromise public health and affect essential services.

The severity of these impacts varies according to the vulnerability of populations and the efficiency of risk management systems. Marginalized groups, with limited access to basic resources, face greater difficulties both during and after disasters. And the increase in the

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frequency and intensity of extreme events, driven by climate change, represents a growing challenge to social security.

It is important to note that disasters do not affect all people equally. As children, the elderly and minorities are disproportionately affected, risk management policies must be inclusive and sensitive to multiple social vulnerabilities.

In this context, environmental degradation - intensified by predatory practices and rapid urbanization since the Industrial Revolution - has contributed significantly to the worsening of these disasters. Examples such as the accidents at Chornobyl (1986), Mariana (2015) and the oil spill in the Gulf of Mexico (2010) highlight the lasting effects of irresponsible actions.

With the severity of the environmental crisis, there is a need to rethink strategies and adopt more sustainable solutions. Emerging technologies, such as Artificial Intelligence (AI), play a key role in this process. By analyzing large volumes of data and identifying patterns, AI makes it possible to anticipate risks, optimize resources and support more precise and effective decisions in disaster prevention and response.

In view of this, the current scenario calls for the adoption of an integrated and proactive approach that combines sustainable planning, technological innovation and social justice. Only with coordinated actions that combine technological advances and sustainable planning will it be possible to mitigate the impacts of these natural disasters, protecting society and guaranteeing environmental protection.

1.2. Artificial Intelligence and Big Data

Investing in research aimed at developing innovative solutions to environmental and social challenges is becoming increasingly urgent in a scenario shaped by the advance of Artificial Intelligence (AI). However, it is not enough just to apply technologies alone, but to consider the social, political and economic dimensions involved in the whole context of these problems. According to Bostrom (2014), AI can transform various aspects of society, bringing benefits such as increasing productivity, automating tasks and creating innovative solutions to global challenges. AI, when used critically and strategically, proves to be a powerful tool for managing risks associated with both natural imbalances and human actions.

According to Russell and Norvig (2013), AI processes data and simulates human intelligence, being able to learn, reason, solve problems and make decisions autonomously. This capability becomes especially relevant when applied to anticipating risk scenarios, especially through generative AI, which can create new content and simulate possible outcomes based on real data. Authors such as Johnson and Jones (2016) and Chen et al. (2018) highlight the importance of this technology for anticipating complex scenarios and promoting more preventive risk management.

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In this context, the use of AI in risk management is driven by Big Data, a vast repository of data in great volume, speed and variety (Mayer-Schönberger & Cukier, 2014). Big Data allows AI to analyze large volumes of information and extract patterns to predict future events. This makes it easier to identify patterns and trends, enabling more accurate predictions of future events, such as natural disasters. This predictive capacity is fundamental for formulating effective risk management strategies in the present, allowing managers and authorities to act proactively.

The convergence of AI and Big Data also makes it possible to continuously analyze environmental and social conditions in real time, which makes it easier to quickly adapt risk

management strategies to new circumstances. In this way, this technological integration represents an essential tool for promoting collective security in the face of natural and environmental threats.

The combination of AI and Big Data means that Strategic Design can further enhance the results of this approach. The prospect of this integration promotes innovation, resilience and the transformation of paradigms, offering possible more concrete ways of dealing with the environmental crisis. Interdisciplinary analysis of natural disasters, combined with AI and Strategic Design, is essential for predicting future scenarios and mitigating adverse impacts on society and the environment.

1.3. Strategic design: Concepts and approaches

Strategic Design is emerging as a practical area that integrates elements of Artificial Intelligence (AI) and Big Data, applying them in a structured way to projects and research. Its main mission is to improve society's future scenario, acting as a bridge between AI's analytical capacity and Big Data's vast amounts of data. Through collaborative and user-oriented approaches, Strategic Design aims to anticipate future scenarios and develop innovative and sustainable solutions.

The concept of Strategic Design emerged in the 1950s, initially associated with solving business problems. In the 1980s, it gained academic recognition as a tool for innovation and competitiveness and was consolidated in the 1990s with an increase in publications on the subject. Today, its relevance is growing in a world of continuous change, where creativity and innovation are pillars for success.

Strategic Design acts as a bridge between business strategy and the customer experience and is fundamental to processes of co-creation and collaboration. Zurlo (1999) argues that management strategies should be structured on the basis of society's needs, avoiding extremist or unilateral logic. This perspective allows, for example, the creation of more efficient and humanized public services, using Big Data and AI tools to analyse future social projections. Stuart (2009) defends the importance of design in building a more sustainable future and solving social problems.

Strategic Design is a multifaceted discipline that encompasses various methodologies to guide innovation and problem-solving in different contexts. Its holistic and future-oriented nature goes beyond the development of products or services, addressing broader issues of sustainability, innovation and adaptation. Future orientation seeks to create sustainable competitive advantages and promote resilience in an ever-changing world.

A fundamental aspect of Strategic Design is recognizing the interconnectedness between different systems and actors. This approach, often carried out in collaboration with various stakeholders - including clients, users, technical experts and local communities - aims to ensure that the solutions developed are relevant, viable and socially responsible. In this context, complex networks play a crucial role in Strategic Design, providing a framework for understanding and analysing the interconnections between system elements. By mapping and visualizing these networks, strategic designers can identify emerging patterns, strategic intervention points and opportunities for innovation.

The Strategic Design approach has expanded beyond traditional business and innovation contexts and is increasingly being applied in areas such as sustainability, health, education and

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social development. For example, it is being used to develop innovative solutions to environmental challenges, such as climate change and resource scarcity, and to develop public policies, community health programs and social inclusion strategies.

Despite significant advances in the theory and practice of Strategic Design, there are still challenges to be faced. One of these is more effective integration with other areas of knowledge, such as science, technology, engineering and mathematics (STEM). This requires closer collaboration between designers, scientists, engineers and decision-makers to tackle the complex and interconnected challenges of the 21st century.

A common tool in Strategic Design is the use of scenarios, which are exploratory narratives of possible futures. These scenarios are built on an in-depth understanding of the trends, drivers and uncertainties that shape an organization's environment. In developing them, strategic designers seek to identify emerging opportunities, potential threats and areas for strategic intervention, enabling organizations to adapt and respond effectively to different futures (Schwalbe, 2016).

1.4. Projecting future scenarios

Future scenario projection is a strategic approach widely used to anticipate and explore different possibilities and development paths in a specific environment (Chiapinotto, 2020). This practice involves creating narratives or detailed descriptions of alternative futures based on a thorough understanding of the relevant trends, uncertainties and drivers of change (Horlle, 2022).

By making it possible to visualize multiple possible paths, scenario projection stands out as an essential tool for understanding the risks and opportunities linked to current decisions. Through it, organizations and communities can prepare more effectively to deal with future transformations (Franzato, 2023). Projecting future scenarios can be carried out in various ways, including quantitative data analysis, computer modeling and participatory stakeholder engagement methods (Coutinho & Penha, 2017). Regardless of the technique chosen, it is essential that scenarios are based on rigorous research, involving consultations with experts, data review and the holding of collaborative workshops (Gonçalves, 2014; Silva, 2021).

One of the main merits of Strategic Design is precisely that it challenges consolidated assumptions and broadens the horizon of analysis, encouraging planners and decision-makers to consider innovative alternatives (Pastori, 2010). By developing alternative scenarios, planners and decision-makers are encouraged to consider a wider range of possibilities and explore new ideas and strategies (Argenti, 2019). This process helps to avoid so-called "groupthink" and fosters creativity and innovation in the formulation of strategies and public policies (Schwalbe, 2016).

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The intersection between technologies and Strategic Design contributes to the formulation of more informed and adaptable strategic decisions. By considering a wide range of possibilities and their implications, managers and communities increase their ability to respond to uncertain contexts (Prata, 2022). In a world marked by rapid transformations and growing complexity, projecting future scenarios has therefore become an indispensable tool for strengthening collective resilience (Sato & Mazzilli, 2023).

Projecting scenarios, in turn, are crucial for the field of natural disaster management, where unpredictability is a constant (Lima Filho, 2012). Anticipating scenarios of extreme events -

such as earthquakes, hurricanes, floods or droughts - allows communities to identify vulnerabilities, strengthen critical infrastructure and draw up robust action plans (Silva et al., 2021; Horlle, 2022). In addition, the scenario visualization exercise contributes significantly to raising awareness and mobilizing the population around preventive measures, such as early warning systems, evacuation strategies and mitigation actions (Gonçalves, 2014; Prata, 2022; Schwalbe, 2016).

However, it is necessary to recognize the limits of this process. The very nature of projection implies dealing with uncertainties: the scenarios drawn up will not always be able to capture the full complexity and dynamics of natural and social systems (Coutinho & Penha, 2017). As they are based on assumptions and estimates, models can become inaccurate over time (Arikan, 2007). It is therefore essential to adopt a transparent stance in the face of these limitations and ensure that the plans derived from them are flexible and adaptable (Franzato, 2023).

In this context, the combination of scenario projection, Strategic Design, Artificial Intelligence and Big Data represents a unique opportunity for dealing with extreme risks. Combining these approaches enables more comprehensive, collaborative and action-oriented analysis. Through co-creation and the incorporation of generative technologies, it becomes possible to develop innovative solutions that contribute to building a safer, more resilient and sustainable future for all.

2. METHODOLOGY

This research adopted the systematic review methodology, characterized by a rigorous and systematic process of searching, analysing and synthesizing scientific literature. This methodology made it possible to carry out an in-depth investigation of a specific topic, bringing together and critically evaluating the available scientific production. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol was used to develop the systematic review.

The process of selecting and excluding articles was documented in an adapted flowchart as shown in Figure 1.

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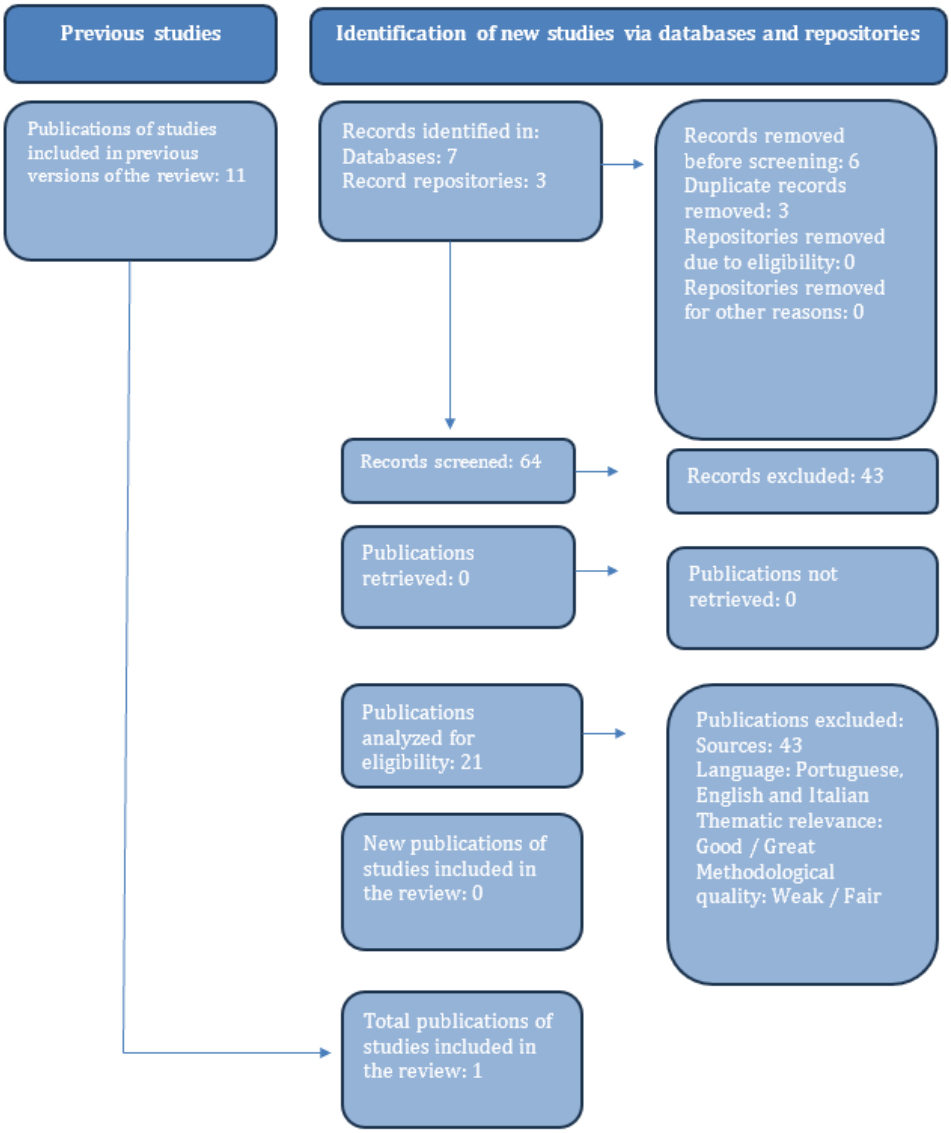

Figure 1. PRISMA flowchart

The search strategy used terms defined on the basis of previous mapping of the literature, such as: Natural Disasters, Scenario Projection, metaproject, Digital Transformation, Big Data and Artificial Intelligence. These different terms were combined using Boolean operators (AND, OR, NOT).

The search was carried out between the years 1999 and 2024. This period was established to ensure the contemporaneity of the results and the relevance of the studies to the current context, avoiding including outdated sources.

The search was based on seven databases:

1. Scielo: Platform that brings together scientific journals from countries in Latin America, the Caribbean and Iberia;
2. BTDB: Database of the Brazilian Digital Library of Theses and Dissertations;
3. ABRASPE: Database of the Brazilian Association of Administration Researchers;
4. UFSC Repository: Institutional repository of the Federal University of Santa Catarina;
5. BRAPCI: Information Science Database;

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6. SCOPUS: Database of abstracts and citations of peer-reviewed literature, offering access to high-quality scientific information in various areas of knowledge;
7. Google Scholar: Academic literature search engine that indexes a wide variety of sources and formats, including articles, theses, books and academic documents, facilitating access to quality scientific information.

Table 1. Search strategy and databases used

Item	Description
Key words	"Natural Disasters", "Scenario Projection", "metaproject", "Digital Transformation", "Big Data", "Artificial Intelligence"
Boolean operators	AND, OR, NOT
Search period	From 1999 to 2024
Databases	SciELO, BTDB, Abraspe, UFSC Repository, BRAPCI, SCOPUS, Google Scholar

The inclusion criteria considered articles with a well-defined methodology, published in scientific journals or institutional repositories, in Portuguese, English, or Italian, and aligned with the central research theme. Sixty-four studies were initially identified, of which 42 were excluded after screening by title and abstract. Twenty-two articles remained for full reading, of which 22 met the established criteria and comprised the corpus of analysis.

Table 2. Study selection stages

Stage	Quantity
Records identified	64
Duplicates removed	42
Records after removal of duplicates	0
Deleted after reading title/summary	0
Evaluated in full text	22
Excluded after full reading	0
Included in final review	0

The selection of studies followed a rigorous process. Initially, the titles and abstracts were evaluated according to the inclusion criteria. Next, the full texts of the articles considered relevant were examined to ensure that they met the established requirements.

Table 3. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion Criteria
Type of publication	Scientific articles, dissertations, theses and conference papers	Technical reports, opinion pieces, blogs
Source	Recognized scientific journals or institutional repositories	Publications without peer review or academic affiliation
Language	Portuguese or English	Other languages
Thematic relevance	Related to the intersection between natural disasters, AI, strategic design, metaprojects and scenarios	Themes out of scope or too generic
Methodological quality	Methodology described and results clearly presented	Lack of methodology, insufficient description of data

The criteria used to select the studies were publication in a duly recognized scientific journal or in an institutional repository, appropriateness to the research topic, a rigorous and valid methodological approach and the indication of relevant and reliable results.

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3. RESULTS

The systematic review provided important insights into how the integration of Strategic Design, Scenario Projection, and Generative Artificial Intelligence can contribute to the development of sustainable strategies focused on resilience in the face of natural disasters, as shown in Figure 2.

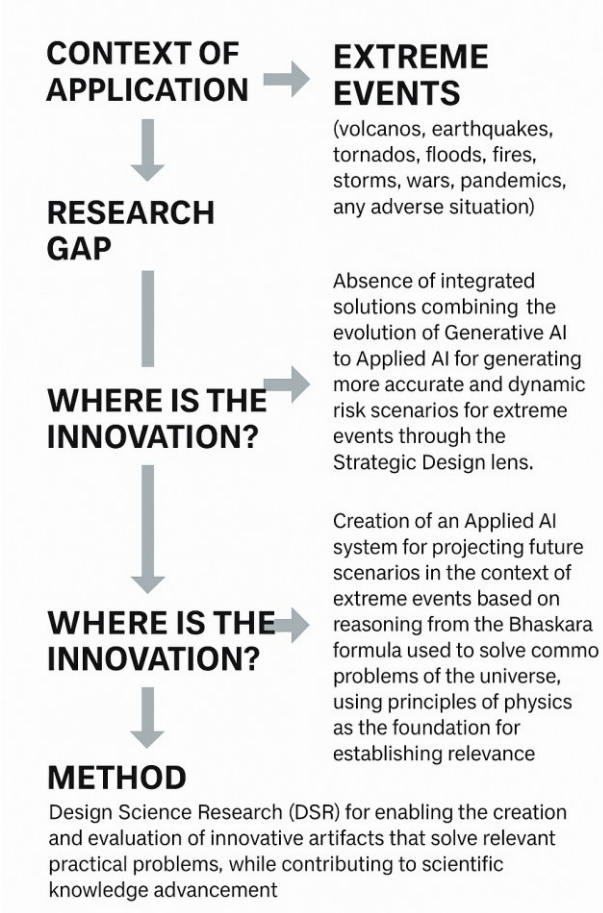

Figure 2. Reasoning that connects all the topics covered in the Introduction

The origins and developments of Strategic Design were discussed with an emphasis on the interconnection between human capacities and technological ecosystems. This approach offers a basis for strategies, highlighting the need for collaboration between technological and organizational elements. The research revealed the concepts, approaches and applications of Strategic Design, with emphasis on its contribution to identifying needs and developing solutions for complex contexts such as natural disasters. Applied to disaster management, Strategic Design makes it possible to identify needs, define objectives and develop solutions to complex problems (Coutinho & Penha, 2017).

This approach emphasizes the active participation of different stakeholders, ensuring that the proposed solutions are aligned with the real needs of the affected communities (Argenti, 2019). Strategic Design promotes innovation and adaptation in response to emerging challenges. Through techniques such as design and rapid prototyping, organizations can develop solutions to deal with the impacts of natural disasters (Freire, 2014). More than designing products and services, Strategic Design works to formulate organizational and systemic policies and guidelines (Horlle, 2022).

Its orientation towards sustainability, equity and diversity makes it possible to build fairer, culturally sensitive and effective solutions, strengthening community resilience (Gonçalves, 2014; Franzato, 2023).

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In conjunction with Strategic Design, Scenario Projection stands out as an essential tool for foreseeing risks and planning effective responses. By drawing up narratives about possible futures, this practice helps to identify vulnerabilities and opportunities, supporting decision-making in contexts of uncertainty (Chiapinotto, 2020; Horlle, 2022). Using everything from quantitative modeling to participatory processes, the projected scenarios support the planning of prevention and mitigation actions (Gonçalves, 2014; Silva, 2021).

This approach also plays an important role in social mobilization, by making communities aware of potential risks and encouraging proactive measures (Prata, 2022; Schwalbe, 2016). Despite the uncertainties inherent in the projection, the flexibility of the scenarios allows for constant reassessment and adaptation of the strategies developed (Arikan, 2007; Franzato, 2023). By adopting user-centered approaches that are sensitive to the cultural context, Strategic Design contributes to socially just and economically viable solutions (Franzato, 2023).

Analysis of natural disasters has revealed their multifactorial nature, resulting from the interaction between geophysical, climatic, hydrological and socioeconomic factors. Events such as earthquakes, hurricanes, floods and droughts, often intensified by climate change, have severe impacts on vulnerable populations (Gonçalves, 2014; Horlle, 2022). Projecting scenarios is fundamental to identifying areas of vulnerability and critical points for intervention, allowing communities and institutions to be prepared to face the challenges of natural disasters (Schwalbe, 2016).

The literature highlights the importance of understanding the processes underlying these events. The interaction between geophysical, climatic, hydrological and human factors plays a role in the occurrence and intensity of natural disasters (Günther & Triska, 2013). This methodology identifies trends, patterns and areas of vulnerability, helping to prioritize adaptation and mitigation measures. The vulnerability of communities to natural disasters is linked to socioeconomic, political and cultural factors (Prata, 2022). Lack of urban planning, occupation of risk areas, poverty, social inequality and lack of access to basic resources and services can increase people's exposure to disasters and aggravate their impacts (Horlle, 2022). By visually presenting possible future scenarios, this approach can raise awareness of the risks associated with natural disasters and motivate action to mitigate these risks.

In this scenario, the adoption of preventive and adaptation measures to reduce risks and increase resilience to natural disasters stands out. This includes developing risk management policies and plans, implementing early warning systems, strengthening critical infrastructure, promoting public education and awareness, and incorporating risk considerations into urban development and planning processes (Silva, 2021). By adopting a proactive and integrated approach, communities can be prepared to face the challenges presented by natural disasters and promote the safety and well-being of their members.

In light of these factors, the role of emerging technologies, such as Artificial Intelligence (AI) and Big Data, has emerged in expanding the capacity to analyze, predict and respond to extreme events. Generative AI, by simulating complex scenarios based on large volumes of data, makes it possible to anticipate risks, optimize resources and support strategic decisions (Bostrom, 2014; Russell & Norvig, 2013). Its integration with Strategic Design and the Projection of Scenarios strengthens more precise, adaptive and community-centered approaches. The authors highlight the ability of generative AI, by simulating human cognitive processes, to predict complex scenarios and support more preventive risk management.

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This convergence is fundamental to promoting community safety in the face of natural threats, enabling more effective and sustainable responses. These technologies can help formulate preventive strategies in the present, with the aim of protecting society from harm and promoting social resilience in the face of emerging challenges. The systematic review indicates that combining these disciplines offers an opportunity to develop strategies for preventing, preparing for and responding to natural disasters (Coutinho & Penha, 2017).

One of the advantages of this integration is the ability to use the systemic approach of Strategic Design to devise solutions to the challenges presented by natural disasters (Argenti, 2019). By incorporating Scenario Projection into the planning and design phase with the contribution of Artificial Intelligence to generate speed, accuracy, scalability and efficiency, organizations can explore possible futures and their possible impacts, enabling informed and adaptive decision-making (Chiapinotto, 2020).

The joint vision of using scenarios and Strategic Design with the contribution of Artificial Intelligence can help overcome the limitations of traditional disaster management approaches, which are reactive and based on standardized solutions (Horlle, 2022). By adopting a technological and participatory approach, organizations can involve stakeholders in decision-making, ensuring that solutions meet the needs of disaster-affected communities quickly and accurately.

Another contribution that Artificial Intelligence can make is to promote resilience and adaptation to the uncertainty and complexity of natural and social systems (Prata, 2022). By developing flexible and adaptable solutions that consider different future scenarios, organizations can be prepared to deal with the challenges of natural disasters and respond to environmental and socio-economic changes.

Finally, the results of the systematic review highlight the complexity and interdependence of the proposed themes, underscoring the need for an integrated and flexible approach to respond to contemporary challenges and strengthen the resilience of social and environmental ecosystems. The combination of technical knowledge, strategic planning and technological innovation is essential for strengthening social and environmental resilience in the face of the challenges posed by natural disasters and global transformations.

4. CONCLUSIONS

Analysis of the scientific literature has revealed that the intersection between Artificial Intelligence, Big Data and Risk Management offers new perspectives for anticipating crises and formulating preventive strategies. The integration of these technological tools, combined with the application of Future Scenario Projection under the lens of Strategic Design, is emerging as a promising approach to dealing with contemporary challenges such as environmental and social crises.

The analysis identified significant opportunities for developing innovative solutions. For example, the creation of generative Artificial Intelligence software capable of projecting future scenarios and guiding actions in the present demonstrates the potential of these technologies to mitigate the impacts of adversity and promote social security.

This study highlights the importance of interdisciplinary collaboration and the responsible use of technology to tackle the complex challenges of the 21st century. The interconnection

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between Artificial Intelligence, Big Data and Risk Management strengthens the ability to deal with current challenges and prepares organizations for a dynamic and uncertain future.

The systematic review emphasizes the importance of methodological quality to ensure the reliability of the conclusions. In the context of natural disasters, strategies designed for the future must encompass risk assessment, anticipatory planning, resilient infrastructure, education, innovative technologies, inter-institutional collaboration, financial policies and sustainability.

By learning from the past, preparing for the present and anticipating the future, communities and organizations can build a safer and more sustainable path to overcome the challenges presented by natural disasters. The systematic review methodology proved to be suitable for achieving the research objectives, allowing an in-depth investigation of the subject and the construction of solid and reliable knowledge. The critical analysis of the scientific literature made it possible to identify opportunities based on the association between different technological mechanisms in a complex social context. Therefore, understanding the different perspectives on the subject and its possible tools suggests the formulation of new hypotheses and the generation of future research.

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