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EMANUEL FUSINATO

ASSESSING THE IMPACT OF PUBLIC POLICIES ON THE SAFE DEVELOPMENT PARADOX IN PRESIDENTE GETÚLIO MUNICIPALITY – BRAZIL

PORTO ALEGRE
2023

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Master thesis presented to the Post-Graduation Program on Water Resources and Environmental Sanitation of the Federal University of Rio Grande do Sul, as a partial requirement to obtain the master's degree.

Advisor: Prof. Masato Kobiyama
Co-Advisor: Dr. Mariana Madruga de Brito

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For every disaster victim.

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Meu sincero e singelo obrigado!

Man lives from nature, i.e. nature is his body, and he must maintain a continuing dialogue with it if he is not to die. To say man's physical and mental life is linked to nature simply means that nature is linked to itself, for man is a part of nature.

Karl Marx and Friedrich Engels – Collected Works 1987

AVALIAÇÃO DO IMPACTO DAS POLÍTICAS PUBLICAS NO PARADOXO DO DESENVOLVIMENTO SEGURO EM PRESIDENTE GETÚLIO – BRASIL

RESUMO

A redução do risco de desastres hidrológicos é um desafio complexo que requer uma abordagem abrangente que considere os sistemas sociais e hidrológicos. O paradoxo do desenvolvimento seguro (PDS) é um fenômeno socio-hidrológico que pode ocorrer quando medidas levam a uma falsa sensação de segurança e aumentam a vulnerabilidade e a exposição. Neste estudo, investigamos este fenômeno em detalhe para verificar se as políticas públicas influenciam o paradoxo do desenvolvimento seguro e a percepção de desastres hidrológicos. Para isso, realizamos (1) uma revisão sistemática da literatura científica sobre o PDS e (2) um estudo de caso para avaliar o PDS na bacia do Revólver, uma área sem grandes medidas estruturais que foi acometida por um desastre composto de fenômenos hidrológicos em cascata e a pandemia de COVID-19. Para a avaliação do PDS, foram utilizados métodos mistos, incluindo entrevistas com membros da comunidade e com stakeholders locais com funções formais utilizando a teoria da motivação para a proteção (TMP), análise documental e análise espacial. A revisão sistemática constatou que a maioria dos estudos forneceu evidências para confirmar o PDS e seu sub-fenômeno, o "efeito de dique". No entanto, os estudos quantitativos frequentemente negligenciaram dimensões críticas como vulnerabilidade, percepção de risco e a existência da falsa sensação de segurança. Avaliações mais abrangentes foram observadas em abordagens qualitativas e de métodos mistos, e englobaram aspectos como preparação, vulnerabilidade e percepção de risco. Já em relação ao estudo de caso, encontramos baixa percepção de risco e baixa percepção de capacidade para enfrentar os desastres, o que levou a um comportamento não protetivo. Ademais, a falsa sensação de segurança foi observada em um terço dos participantes, alimentada por uma alta confiança nas políticas governamentais relacionadas à redução do risco de desastres (RRD) e pela consideração de alvarás de construção como indicadores de segurança. Estes indivíduos adotaram um comportamento não protetivo devido a essa falsa sensação de segurança. Os stakeholders com papéis formais indicaram que não havia ações de RRD na área de estudo, pois era considerada segura até o desastre de 2020. As políticas locais, particularmente a flexibilização das áreas de preservação permanente e o mapeamento inadequado de riscos, facilitou o assentamento em regiões de perigo, exacerbando o PDS entre os membros da comunidade. Portanto, as políticas locais influenciaram o PDS na área de estudo, especialmente em regiões com baixa prevalência de desastres. Esta pesquisa contribui para a compreensão da complexa inter-relação entre políticas públicas e fenômenos socio-hidrológicos, e destaca a necessidade de integração de políticas para a RRD. Além disso, destaca o potencial de políticas não estruturais diretamente ou indiretamente relacionadas à RRD para produzir efeitos não intencionais na dinâmica social do risco. Para pesquisas futuras, recomendamos ampliar o escopo geográfico, investigar uma gama mais ampla de desastres e continuar a explorar o potencial efeito das políticas em áreas medidas estruturais para proteção. Também recomendamos examinar fatores que podem aumentar a percepção do risco e a preparação em áreas afetadas pela PDS, e investigar a transição de uma sensação de segurança para uma falsa sensação de segurança e identificar os fatores que influenciam.

Palavras-chave: Paradoxo do desenvolvimento seguro. Desastre hidrológico. Teoria da Motivação para a Proteção

ABSTRACT

Hydrological disaster risk reduction is a complex challenge that requires a comprehensive approach that considers both the social and hydrological systems. The safe development paradox (SDP) is a socio-hydrological phenomenon that can occur when measures lead to a false sense of safety and increase vulnerability and exposure. In this study, we investigated this phenomenon in detail to verify if public policies influence the SDP and perception of hydrological disaster risks. To this end, we performed (1) a systematic literature review of scientific literature and (2) conducted a case study to evaluate the SDP in the Revólver basin, an area with no major structural measures which experienced a compound disaster of hydrological phenomena and the COVID-19 pandemic. For the SDP evaluation, mixed methods were used, including interviews with community members and with local stakeholders with formal roles using the protection motivation theory, document analysis, and spatial analysis. The systematic review found that most studies provided evidence to confirm the SDP and its sub-phenomena, the "levee effect." However, quantitative studies often overlooked critical dimensions such as vulnerability, risk perception, and the existence of the false sense of safety. More comprehensive assessments were observed in mixed methods and qualitative approaches, which most encompassed aspects such as preparedness, vulnerability, and risk perception. In regards the case study, the Revólver basin's we found low threat and coping appraisals among community members, which led to inadequate protective responses. Additionally, a false sense of safety was present among a third of the participants, fostered by high trust in the government policies related to disaster risk reduction (DRR) and the consideration of building permits as safety indicators. These individuals adopted non-protective behaviour due to this false sense of safety. Stakeholders with formal roles indicated that DRR actions were absent in the study area, primarily because it had been deemed secure until the 2020 disaster. Local policies, particularly the relaxation of riparian regulations and inadequate risk mapping, facilitated settlement in hazardous regions, exacerbating the SDP among community members. Therefore, local policies influenced the SDP in the study area, especially in regions with rare disaster prevalence. Lastly, this research contributes to the understanding of the complex interplay between public policies and socio-hydrological phenomena, and highlights the need of policies integration for DRR. In addition, highlights the potential for non-structural policies directly or indirectly related to DRR to produce unintended effects on societal risk dynamics. For future research, we recommend expanding the geographical scope, investigating a wider range of disasters, and continuing to explore the potential effect of policies in areas without protection infrastructures. We also recommend examining factors that may increase risk perception and preparedness in areas affected by the SDP, and investigating the transition from an adequate sense of safety to a false sense of safety and identifying the influencing factors.

Keywords: Safe-Development Paradox. Hydrological Disaster. Protection Motivation Theory.

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ABBREVIATION AND ACRONYMS LIST

APP – Permanente preservation area, from the Portuguese expression of *Área de preservação permanente.*

CAPES - Coordination for the Improvement of Higher Education Personnel – Ministry of Education of Brazil

COVID-19 – Coronavirus disease 2019

CRED - Centre for Research on the Epidemiology of Disasters

DRR – Disaster risk reduction

FEMA - Federal Emergency Management Agency - USA

IDNDR - International Decade for Natural Disaster Reduction

IPCC - Intergovernmental Panel on Climate Change

IWRM - Integrated water resources management

LE – Levee effect

MDR - Ministry of Regional Development of Brazil

NFIP - National Flood Insurance Program (USA)

NVPL - Native Vegetation Protection Law, Brazilian Federal Law nº 12651/2012

PMT - Protection Motivation Theory

QDA – Qualitative Document Analysis

ROSES – Reporting of Strategies in Systematic Evidence Syntheses standards

SC – Santa Catarina

SDG – Sustainable development Goals

SDP – Safe development paradox

SPSS – Statistical Package for the Social Sciences

UNDRO - United Nations Disaster Relief Organization

UNDRR - United Nations Office for Disaster Risk Reduction

UNGA – United Nations General Assembly

UNISDR - United Nations International Strategy for Disaster Reduction

WoS - Web of Science

SUMMARY

1 INTRODUCTION

The human occupation of natural space is a complex process that is intertwined with climate change, disasters, biodiversity decline, and habitat loss. As society's role in these adverse effects gains more attention, there has been a growing emphasis on promoting sustainable development, such as the Brundtland Report, 21 Agenda, Millennium Goals, Sustainable Development Goals (SDGs), and the Sendai Framework 2015 (UNITED NATIONS, 2015; UNDRR, 2015).

Disasters are increasingly recognized as social constructs, and the societal aspect of disasters has been receiving growing attention (CHMUTINA; VON MEDING, 2019). This has led to a paradigm shift from disaster protection to disaster risk reduction (DRR), which acknowledges that the societal aspects of disasters can be addressed to reduce future damage (WAGNER *et al.*, 2021). However, most action has been directed at addressing the physical components of risk, even in the context of climate change (BANKOFF, 2019). Thus, the fact that disaster events are socially constructed is often ignored.

Additionally, the emergence of socio-hydrology as a science and concept reinforces the necessary integrative approach over the human-water coupled systems (VANELLI; KOBIYAMA, 2021). Socio-hydrology innovates as considers societal aspects as endogenous to the water cycle and the bidirectional feedback (SIVAPALAN; SAVENIJE; BLÖSCHL, 2012). Studies conducted related to natural hazards have elucidated the potential adverse unintended consequences of risk mitigation measures, such as the safe development paradox (SDP), the levee effect (LE), and the reservoir effect (Figure 1.1).

Figure 1.1 - Description of key concepts of socio-hydrological processes

Levee effect is an observed phenomenon related to flood protection structures that produce a false safety feeling, reduces coping capacities, and increases exposure in the protected areas, thereby increasing vulnerability (TOBIN, 1995; WHITE, 1945).

Reservoir effect is a process in which an increased vulnerability is observed due to over-reliance on reservoirs for water supply and, consequently, drought damage potential increases (DI BALDASSARRE et al., 2018b).

Safe development paradox presents a comprehensive broader definition by considering structural and non-structural protection measures that induce a false sense of safety and reduces vulnerability (BURBY, 2006) **Sequence effect** refers to the consequences of drought mitigation measures on exacerbating future flood damages (DI BALDASSARRE *et al.*, 2017; JUHOLA *et al.*, 2016)

Source: Author (2023).

The SDP is a broad phenomenon that comprises both structural and non-structural mitigation measures. Therefore, builds upon previous studies on the structural measures effect on increasing exposure and vulnerability (COLLENTEUR *et al.*, 2015; DOMENEGHETTI *et al.*, 2015; FERDOUS *et al.*, 2019, 2020; GISSING *et al.*, 2018; HUTTON; TOBIN; MONTZ, 2019; TOBIN, 1995; TOSHIHARU; NARANTSETSEG, 2019; WHITE, 1945), and adds the component of non-structural measures. It was first termed by Burby (2006) in New Orleans (USA) as a contributing factor to Hurricane Katrina's damages. The combination of the flood protection system (structural) and the federal insurance scheme (non-structural) created an environment where hazardous areas were made safe for development, increasing exposure, influencing a false sense of safety in the population, and reducing coping capacity. Several studies have suggested that certain policies contribute to the SDP, such as land use policies that allow occupation of hazardous areas potentially increasing exposure (BURBY; FRENCH, 1981; GISSING *et al.*, 2018; STEVENS; SONG; BERKE, 2010) and insurance schemes that foster a sense of safety can exacerbate the SDP (CUTTER *et al.*, 2018). Conversely, risk management policies that enhance protective behaviour can mitigate the SDP (RICHERT; ERDLENBRUCH; GRELOT, 2019). Therefore, the manifestation of the SDP related to the complex interplay between policy network, structural and/or non-structural measures for DRR, and their influence and feedback on society.

In addition to SDP, Burby (2006) identified the local government paradox (LGP), which relates to the local government's lack of attention to threats posed by natural hazards when they authorize development on hazard prone areas. Additionally, local governments avoid accountability for their decisions consequences, shifting the burden to citizens or state or federal agencies. At the same time, local governments benefit from the increased tax revenue generated by development. However, it is difficult to disentangle the LGP from SDP, as they are conceptually related and the limited number of studies addressing the LGP have also addressed the SDP (BURBY, 2006; CUTTER, 2018; PARK *et al.*, 2020). In this study we did not address the LGP thoroughly as we were not able to verify potential local government shifting of the disaster burden to citizens or other levels of government.

Despite the advances in understanding the SDP, no study has yet considered the influence of policies in the absence of major collective risk relief structures and policies not intentionally related or directly aimed at DRR. Nevertheless sectorial policies from different domains can influence the social construction of the environment, thereby influencing risk dynamics (BOGO, 2020; GLAVOVIC; SAUNDERS; BECKER, 2010; LÖSCHNER; NORDBECK, 2020; SHARMA et al., 2022; SUDMEIER-RIEUX et al., 2015). For example, the preservation of wetlands and riparian zones helps prevent the occupation of vulnerable areas (DASH; PUNIA, 2019; KOBIYAMA et al., 2020), building codes can encourage the adoption of adaptation measures such as elevating residential structures (BOTZEN et al., 2019), and land-use policies can restrict construction on hazard-prone areas (RICHERT et al., 2019). To address this gap, a systematic literature review and an empirical study (case study) on the SDP were conducted, using the Protection Motivation Theory (PMT) as a framework.

However, municipalities with smaller populations face unique challenges when implementing comprehensive disaster risk reduction (DRR) measures due to limited human and financial resources (RIBEIRO *et al.*, 2022). In this sense, our selected study area consisted of the Revólver basin in Presidente Getúlio, Santa Catarina state, southern Brazil. The basin is situated in a small municipality with no major structural measures and is prone to frequent and rare hydrological disasters. Frequent disasters are observed in the basin outlet due to the main fluvial floods (Krauel and Índios rivers), while rare hydrological phenomena were related to the Revólver River, such as the December 2020 disaster event. This event significantly impacted Presidente Getúlio municipality, along with Ibirama and Rio do Sul municipalities, with the Revólver basin being the most severely affected area encompassing 18 fatalities (86% of the total) (MICHEL *et al.*, 2021; VIEIRA, C., 2022). Additionally, the Revolver neighbourhood was deemed as risk-free area of the basin through multiple risk mapping and territorial planning instruments. For instance, the Revolver neighbourhood was designated as prone to residential occupation in the 1988 Municipal Master Plan as it was described as flood-free, however, based on no risk assessment instruments (PRESIDENTE GETÚLIO, 1988). This case study differs from most SDP assessments, as we considered non intentional mitigation measures that induces exposure or vulnerability and the false sense of safety, thereby expanding the conceptualization of SDP. We highlight that it still fits as an archetype of fixes that backfire, as we considered that fixes can backfire on multiple directions, such as territorial planning fixes may backfire on increased disaster exposure and vulnerability.

This study aims to further advance the integration and intersectoral policy approach for DRR, while considering the potential adverse effects associated with policies (SDP). Additionally, it is hypothesized that the actual public policies are inadequate in fostering the necessary risk perception and protective behaviour, thereby leading to the expanded Safe Development Paradox in the study area.

1.1 RISK FRAMEWORK

Initially, we examined the evolution of risk-related concepts to assess the advancement of studies in this field. The 1950s marked an essential decade due to the escalating losses caused by disasters, which were perceived as uncontrollable events that disrupted vital societal functions (ALCÁNTARA-AYALA, 2002). Due to the individual or societal perception that nothing or little could be done to avoid the calamity (SOUZA, K. R. G.; LOURENÇO, 2015). Consequently, disasters were considered the result of natural random phenomena (PEDUZZI, 2019), leading to a focus on structural protection, such as flood protection structures (WAGNER *et al.*, 2021).

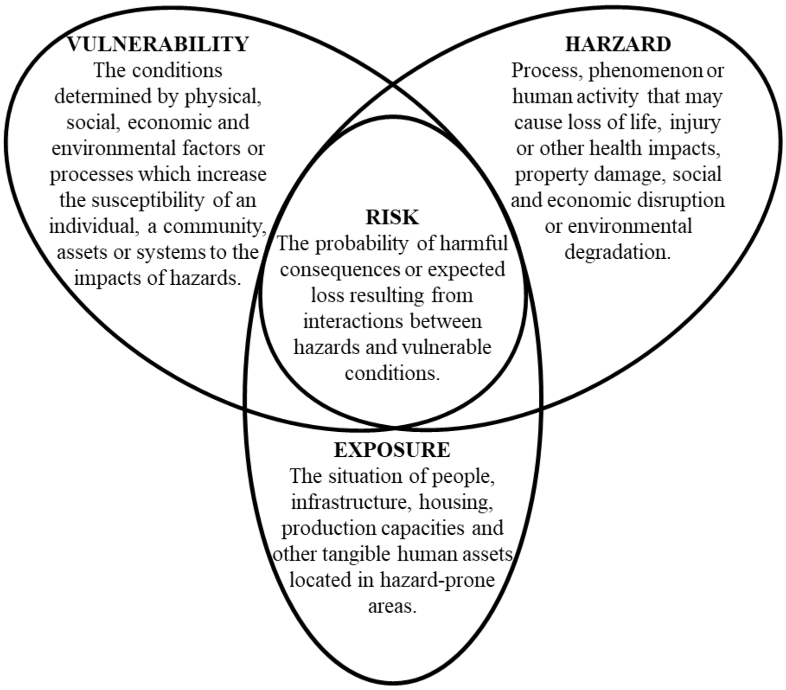
While studies in the 1940s already advocated for considering social aspects in the understanding of disasters (WHITE, 1945), it was only in the 1970s that the importance of the interaction between phenomena and human groups referred to as vulnerability, was recognised (VILLAGRÁN DE LEÓN, 2006). This was a pivotal shift in the understanding of disasters, no longer viewed as solely natural or random events (PEDUZZI, 2019).

However, various disciplines and communities worldwide were actively studying disasters and risks, resulting in different definitions and confusion over the concepts (PEDUZZI, 2019). To resolve this, the United Nations Disaster Relief Organization (UNDRO) created a unified concept of risk as “meaning the expected number of lives lost, persons injured, damage to property and disruption of economic activity due to a particular natural phenomenon, and consequently the product of specific risk and elements at risk” (UNDRO, 1979, p. 5).

Recognizing disaster as a topic with global importance, the United Nations General Assembly designated the 1990s as the International Decade for Natural Disaster Reduction (IDNDR), which resulted in the new publications and the update of related terms by the “Internationally Agreed Glossary of Basic Terms Related to Disaster Management” (UNGA, 1989). At the end of the decade, the IDNDR was succeeded by the United Nations International Strategy for Disaster Reduction (UNISDR) to ensure the implementation of the strategies developed during that period (UNGA, 1999).

Therefore, according to UNDRR (2022, p. 2), disaster is defined as a "Serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts". In addition, disasters are the materialization of risk, which results from the combination of hazard, vulnerability and exposure factors (Figure 1.2).

Figure 1.2 – Conceptual scheme of the relationship between risk, hazard, vulnerability and exposure.



Source: Adapted from UNDRR (2022).

In addition, disasters are also influenced by society's coping capacity and adaptive capacity. Coping capacity refers to the ability to manage events through short-term strategies and resources, such as emergency supplies and action plans (MONTE *et al.*, 2021; UNGA, 2016). On the other hand, adaptive capacity refers to the ability to modify structures and behaviours to decrease risks (MONTE *et al.*, 2021). It involves actions taken before disasters and can lead to increased coping capacity, such as implementing early warning systems and conducting evacuation simulations. Building adaptive capacity enables societies to achieve adaptation, involving the adjustment of responses to climate-related stimuli or hazards to minimize damage and vulnerability (MONTE *et al.*, 2021; UNISDR, 2009). Examples of adaptation measures include the implementation of sustainable drainage systems and elevating residences above flood levels.

Therefore, disasters and DRR are influenced by societal and individual dynamics. For instance, the intensity and frequency of disaster experience can shape individual risk perception and motivate people to demand government action to develop mitigation measures, such as levees, dams, or early warning systems. The adoption of a mitigation measures can change the environment and disaster frequency, thus influencing individual risk perception, and individual and community behaviour changes (Figure 1.3).

Figure 1.3 – The individual and societal interplay with hydrological hazards.

Source: Mondino (2021)

Hence, disasters are social constructs shaped by historical development, policies, individual and collective action, and the interplay with the physical environment. Additionally, disasters serve as catalysts for underlying social processes (MASSAZZA; BREWIN; JOFFE, 2019). In this perspective, the UNISDR removed the term "natural disaster" from its communications, encouraging the "denaturalization" of disasters (VALENCIO, 2010 MARCHEZINI, 2014, MATTEDI, 2017,CHMUTINA; VON MEDING, 2019). This approach empowers society by emphasizing its responsibility and capacity to both generate and mitigate disaster events (PELLING *et al.*, 2004).

1.2 SOCIO HYDROLOGY: AN APPROACH FOR DISASTER RISK REDUCTION

Society presents an intimate relationship with water, from food production to religious significance. Throughout history, early civilizations thrived alongside major rivers (Nile, Tigris-Euphrates, Yellow, and Hindus) implementing rudimentary water management techniques. Still, modern society faces challenges in managing water due to technological advancements, climate change, and evolving human-water dynamics. To address these challenges, diverse strategies have been employed, including sustainable urban water management (BROWN; KEATH; WONG, 2009; WONG; BROWN, 2009) and the technical and political transformation of the environment (SWYNGEDOUW, 2007). These and more approaches, contribute to the creation of new spatial configurations, where society and individuals adapt and provide feedback into the water system, indicating a coupled evolution of the human-water systems.

The study of coupled human-water systems dynamics and possible trajectories of its co-evolution is the scope of socio-hydrology science (SIVAPALAN; SAVENIJE; BLÖSCHL, 2012). While Sivapalan, Savenije and Blöschl (2012) study popularized the term socio-hydrology, Herrera-Franco *et al.* (2021) highlight that Falkenmark (1977) previously investigated the intimate connection between humans and water, referring to it as hydrosociology.

This new science or concept relates to the fields of water resources systems, integrated water resources management, and socio-ecological systems (DI BALDASSARRE *et al.*, 2019). It innovates by considering human and societal factors as endogenous to the water cycle, rather than external non-interacting variables. In addition, socio-hydrology focuses on an exploratory and explanatory approach, assessing and predicting acknowledged phenomena and comprehending emerging patterns related to the coupled human-water systems (SIVAPALAN; SAVENIJE; BLÖSCHL, 2012).

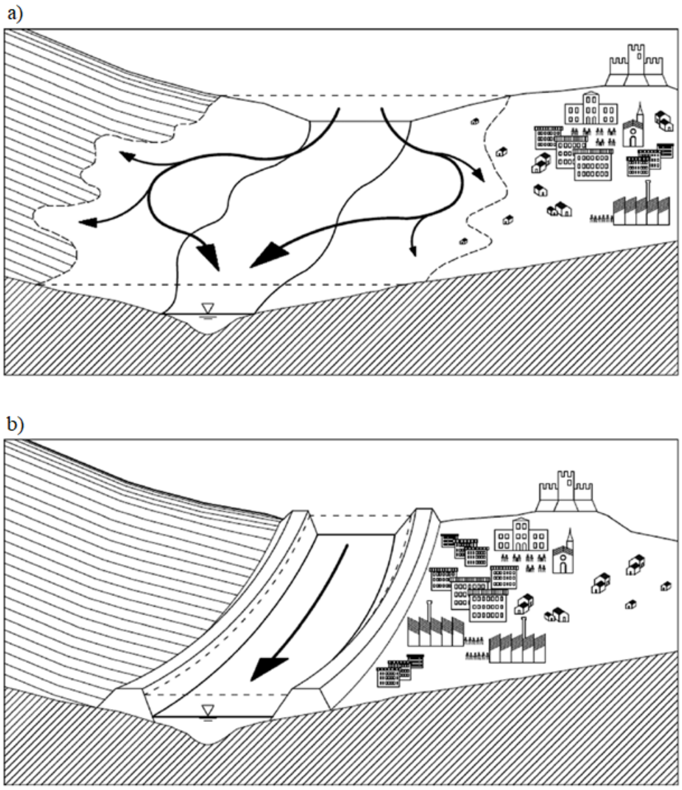
The socio-hydrology framework offers valuable insights for disaster risk reduction by considering the bidirectional feedback of human-water systems. This interdisciplinary and integrative approach of social and natural sciences and water and risk management disciplines (VANELLI; KOBIYAMA, 2021) has been used to study socio-natural disasters, such as floods (COLLENTEUR *et al.*, 2015; DI BALDASSARRE *et al.*, 2013b; FOX-ROGERS *et al.*, 2016; GISSING *et al.*, 2018) and droughts (MAZZOLENI *et al.*, 2021; VAN LOON *et al.*, 2022). These studies have revealed patterns and dynamics that allow us to identify various phenomena, such as the adaptation effect and the safe development paradox.

The adaptation effect refers to the societal and human adaptation to disasters, either through spontaneous or deliberate processes. Past experiences with frequent, short-term, and moderate disasters contribute to building up memory, reducing vulnerability to subsequent disasters, which is a desirable effect. However, the adaptation to one hazard typology can increase the potential loss to another, such as the sequence effect. For instance, reservoir dams designed to mitigate drought-related damages might exacerbate flood damages (DI BALDASSARRE *et al.*, 2019; MAZZOLENI *et al.*, 2021).

In opposition to the adaptation effect, the safe development paradox (Figure 1.4) occurs when structural or non-structural mitigation measures increase vulnerability and exposure (DI BALDASSARRE *et al.*, 2015). Burby (2006) first cited this phenomenon on the research on the historical decisions that made New Orleans vulnerable to Hurricane Katrina. The author observed that flood protection systems, such as levees, and policies with lenient requirements for building codes and insurance schemes, attempted to make hazardous areas safer for development. The research on the SDP builds on the LE and related research by White (1945) and Tobin (1995) which addressed only the effects of structural measures. The SDP innovates by including the non-structural measures to affect human-water coupled systems (BURBY, 2006; MALECHA; WOODRUFF; BERKE, 2021; STEVENS; SONG; BERKE, 2010).

Figure 1.4 – Examples of society under adaptation effect (a) and levee effect (b)

a)



b)

Source: Di Baldassarre *et al.* (2015)

The interdisciplinary and transdisciplinary nature of socio-hydrology is an innovative approach for understanding the dynamics of disasters comprehensively. It also informs policy design to effectively address adverse scenarios and promote disaster risk reduction, especially considering the shifting paradigm from flood protection to risk management paradigm.

1.3 OBJECTIVES

1.3.1 GENERAL OBJECTIVE

The general objective of this master thesis is to verify if diverse sectoral public policies are influencing the safe development paradox and the perception of hydrological risks in the Revolver Basin – Presidente Getúlio – Brazil.

1.3.2 SPECIFIC OBJECTIVES

1. To conduct a comprehensive review of existing methods and variables employed in the study of the SDP and its sub-phenomenon, the LE, in the context of hydrological disasters;
2. To critically assess whether or not the studies that address these phenomena provide evidence supporting their existence in the respective study areas and identify the types of hydrological hazards that are analysed (e.g. flash floods, debris flow, and wet mass movement);
3. To verify if non-structural measures alone, such as public policies, influence the safe development paradox and the perception of risk of hydrological disasters in the absence of major structural measures;
4. To examine the impact of public policies on the population's perception of the risk of hydrological disasters such as flash floods, debris flow, and landslides.

1.4 STRUCTURE OF THE THESIS

The master thesis is organized into four chapters, as depicted in Figure 1.5. In Chapter 1, it is provided a general outline of the theme and the aims of the research. Chapter 2 constitutes the first article, presenting a systematic review of the SDP. This chapter involves a comprehensive literature review on the SDP concerning hydrological disasters, as well as a synthesis of evidence and methods related to the phenomenon. Chapter 3 comprises the second article, which is a case study investigating the SDP in the Revólver basin located in southern Brazil. Lastly, in Chapter 4, the thesis presents conclusions drawn from the research and offers recommendations for future studies and the management of municipalities. Additionally, the appendix includes extra material and detailed information on interview procedures used throughout the research.

Figure 1.5 – Overview of the master thesis chapters.

CHAPTER	FUNCTION
Chapter 1 - introduction	Overview of the research problem, hypothesis and goals of the study.
Chapter 2 - Article 1: Unintended consequences of disaster mitigation: a systematic review of the safe development paradox	Literature review of the safe development paradox in terms of hydrological disasters, and synthesis of evidence and methods related to the phenomena. Related to the Specific Objectives 1 and 2.
Chapter 3 - Article 2: Socio-hydrological assessment of the safe development paradox in Revólver basin, southern Brazil	Assessment of safe development paradox in a study area. Related to the Specific Objectives 3 and 4.
Chapter 4 - Conclusion and recommendations	Summary of findings, final reflection, and recommendation for future studies and municipalities managers.

Source: Author (2023).

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2 UNINTENDED CONSEQUENCES OF DISASTER RISK MITIGATION: A SYSTEMATIC REVIEW OF THE SAFE DEVELOPMENT PARADOX

Abstract
Hydrological disasters are among the most damaging worldwide. Historically, efforts to mitigate these risks have often ignored complex interactions between human-water systems. This oversight has led to various socio-hydrological phenomena, including paradoxical dynamics or unintended consequences. One of such phenomenon is the "safe development paradox" (SDP), where efforts to reduce risk increase vulnerability in the long run. Despite theoretical advances, the empirical investigation of these phenomena remains highly fragmented. In this study, we systematically reviewed 79 studies from 2001 to 2021 to summarize research in the field. Our analysis revealed that most studies provided evidence to confirm the SDP and its sub-phenomena, the "levee effect" (LE). A wide range of methods has been used, especially quantitative ones (e.g. spatial analysis), followed by qualitative and mixed-methods. Studies often focus on the exposure of communities to hydrological risks and do not fully capture other critical dimensions, such as vulnerability and the psychological effects of feeling safe. A more holistic assessment should thus include aspects such as preparedness, vulnerability, and risk perception. For future research, we indicate (1) expanding the studies' geographical scope to include countries in Latin America, Africa and Asia, (2) investigating a wider range of hydrological disasters and (3) exploring scenarios without flood protection infrastructures to identify the potential adverse effects of the non-structural measures alone. This would help to better understand the diversity of scenarios in which the SDP can occur and provide policymakers with the information they need to avoid its adverse effects.

Keywords: Safe development paradox; Levee effect; False sense of safety; Hydrological disasters; Socio-hydrology.

2.1 INTRODUCTION

Hydrological disasters, such as floods and landslides, are among the most damaging worldwide. In 2021, these disasters inflicted losses higher than US$ 74 billion resulting in over 4 thousand deaths (CRED, 2022). These numbers are expected to increase in the future due to climate change (IPCC, 2022; MCDERMOTT, 2022), posing even greater challenges for risk management.

Historically, hydrological disasters have been managed based on a technocratic approach. In each hydrological crisis, society commonly implements actions to benefit development. With this, the hydrological regime is altered and reorganized, influencing new societal responses. However, since human-water systems co-evolve and influence each other (SIVAPALAN; SAVENIJE; BLÖSCHL, 2012), the neglection of societal variables in risk management can lead to unintended outcomes (DI BALDASSARRE *et al.*, 2019; SIVAPALAN; SAVENIJE; BLÖSCHL, 2012). For instance, temporary water abstraction licenses may exacerbate underlying water scarcity as they can be difficult to reverse when a drought ends (DI BALDASSARRE *et al.*, 2018b). Levees and dams can encourage the occupation of flood-prone areas and increase the number of people and assets exposed to residual risk[1], resulting in more severe damages (DI BALDASSARRE *et al.*, 2013a). Poorly developed land-use policies can also induce the occupation of hazardous areas (BURBY, 2006).

These unintended outcomes are termed *socio-hydrological phenomena or paradoxes* and include, among others, the *levee effect (LE)* and the *safe development paradox (SDP)*, which are the focus of this paper. The SDP occurs when measures create a false sense of safety, decreasing individuals' protective behaviour. A specific sub-phenomenon of SDP is the LE (DI BALDASSARRE *et al.*, 2019), which indicates that structural measures can influence people`s preparedness due to the protection provided by infrastructure and disaster memory decay as small floods become less frequent. If decision-makers do not consider these phenomena when designing disaster risk reduction (DRR) policies, they may foster the risk of socio-natural disasters rather than reduce them. Therefore, policymakers should recognize and plan for the potential occurrence of these phenomena.

In the past decade, hydrologists have examined these phenomena to better understand the human-water complex interactions and avoid adverse effects (DI BALDASSARRE *et al.*, 2018a). However, the research in this field is still fragmented. The first attempt to organize the knowledge on the SDP was made by Breen, Kebede and König (2022) in a critical review which presented the state-of-the-art of the SDP in the context of flood events. The authors observed the lack of consistency in the phenomenon terminology, geographical bias in the research distribution, and focus on fluvial flooding. As such, despite the progress in the theoretical understanding of the socio-hydrological phenomena, some gaps remain unaddressed. First, the empirical evidence that corroborated or refute the phenomena are still not clear, in other words, what was the evidence that refuted or corroborated the phenomena in a study area. Second, there is no synthesis of the methods and variables used to investigate these phenomena. Such a synthesis could enable comparison among studies and contribute to solving the lack of fundamental knowledge on the social, technical and hydrological conditions that trigger unintended consequences (DI BALDASSARRE *et al.*, 2018a).

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[1] Risk relief structural measures are designed for a certain level of protection, related to the probability of a disaster. Therefore, the residual risk consists on the event with probability that exceeds the structural protection level. In addition, all the structures present possibility of rupture and malfunction.

This study addresses these gaps through a systematic review of scientific literature. Our goals were to (1) identify the methods and variables used to investigate the SDP and its sub-phenomena, the LE; (2) determine whether or not the studies that address these phenomena provide evidence for their existence in the respective study areas; and (3) identify the types of hydrological hazard that are analysed (e.g. flash floods, debris flow, and wet mass movement). By addressing these goals, this study offers a comprehensive examination of the methods and findings of previous research in this field and identifies topics where further research is required to assess the adverse outcomes of policies. With this, the ultimate goal of this article is to provide a foundation for researchers in the field and provide insights for novel methodological approaches.

2.2 AN OVERVIEW OF SOCIO-HYDROLOGICAL PHENOMENA

A wide range of socio-hydrological phenomena has been observed by researchers investigating the complex and interconnected nature of water and society (Table 2.1). Of these, this study focuses on the SDP and its sub-phenomena LE, as they are adverse effects associated with hydrological disasters. In addition, they are opposed to the adaptation effect, which is mostly positive, if not desirable. It should be highlighted that the list in Table 2.1 does not strive to be exhaustive, and other phenomena do exist. Also, the typology used is, to some extent, subjective and should be used only as an indication.

Table 2.1 - Overview of key socio-hydrological phenomena.

General Phenomenon	**Related sub-phenomenon**
Adaptation effect Frequent moderate disasters increase coping capacities, thereby reducing social vulnerability (DI BALDASSARRE *et al.*, 2015).	**Sequence effect or maladaptation** The measures we take to cope with drought can make us more vulnerable to flooding, and vice versa (DI BALDASSARRE *et al.*, 2017; JUHOLA *et al.*, 2016).
	Limits to adaptation Societal, environmental and cultural factors (e.g. depletion of resources) can limit the adaptation capacity of a society (ADGER *et al.*, 2009; DOW *et al.*, 2013).
Aggregation effect Decisions made at the individual level by individuals or subgroups within a community do not align with outcomes at the aggregate level, resulting in negative impacts on the overall community or society (PARIJS; BOUDON; ELSTER, 1982).	**Collective action** Individuals are joined for a common goal, but self-interest may undermine their success (ABDULLAEV *et al.*, 2010).
	Water injustice Water resources are unequally distributed, and some groups have more access to water at the cost of others (TADEU; SINISGALLI, 2019).
Institutional complexity	**Robustness-fragility trade-of**

General Phenomenon	Related sub-phenomenon
Water management is subject to dynamic and often unpredictable changes and interactions between various institutions and actors, where negotiations are based on water resources, individual behaviour, and changes in governance arrangements (CLEAVER; DE KONING, 2015).	Efforts to increase robustness often result in the transference of vulnerabilities to other areas rather than eliminating them. This encourages a false sense of safety, as newly created weaknesses are usually concealed and only become apparent due to a crisis (ASSOC, 2015).
Pendulum swing Water management policies and people's collective preference for water resource allocation tend to oscillate between extremes over time, leading to a lack of consistency and continuity in water management policies and practices (KANDASAMY *et al.*, 2014).	**Peak water paradox** Once the water peak is reached, sustaining the level of water extraction may lead to groundwater exhaustion or a decrease in the quality of the ecosystem for renewable water sources (GLEICK; PALANIAPPAN, 2010).
	Environmental Kuznets curve In the early stages of economic growth, there is a tendency for environmental degradation; however, once a particular threshold of income per capita is reached, environmental quality tends to be improved (STERN, 2004).
Rebound-effect or Jevons' paradox The increase in efficiency of a resource such as water, tends to increase its consumption rather than decrease it (BERBEL *et al.*, 2015).	**Irrigation efficiency paradox** The augmentation of irrigation efficacy will not necessarily result in a rise in the abundance of water within the watershed. (GRAFTON *et al.*, 2018)
	Scale paradox The reduction of water loss in irrigation can decrease water availability downstream (SCOTT *et al.*, 2014).
Supply-demand cycle The increase in supply generates growth, which in turn increases demand (KALLIS, 2010).	**Fixes that backfire** A solution may seem helpful in the short term, but it will create long-term issues that may require additional repairs (GOHARI *et al.*, 2013; KIDWAI; SARAPH, 2016).
Safe-development paradox or safety dilemma Protection measures, whether structural or non-structural, leads to increased exposure and can give people a false sense of security, reducing coping capacities, and thereby increasing social vulnerability (BURBY, 2006; DE MARCHI; SCOLOBIG, 2012; KATES et al., 2006).	**Levee effect or levee paradox, dike effect, dike Paradox** Structural protection measures create a false sense of safety, increasing vulnerability (TOBIN, 1995; WHITE, 1945).
	Reservoir effect Reservoirs reduce people's and communities' motivation to take adaptive measures, leading to greater negative consequences when drought strikes (DI BALDASSARRE *et al.*, 2018b).

Source: Adapted from Di Baldassarre et al. (2019)

White (1945) introduced LE, arguing that structural measures designed to reduce risk can lead to increased damages in the future. Tobin (1995) corroborated White's (1945) findings and added that structural measures create a false sense of safety, influencing people to occupy risk areas without being adequately prepared for potential hazards. Therefore, the LE can be defined as an unintended outcome of a risk relief structure wherein the false sense of safety reduces coping capacities, thereby increasing vulnerability, and increasing exposure of individuals and communities to residual risk, due to increasing occupation of the protected areas (DI BALDASSARRE *et al.*, 2015).

Burby (2006) identified the SDP as government policies intended to enhance safety in hazardous areas but inadvertently increased the susceptibility to disasters. In other words, the

SDP consists of structural and/or non-structural measures that induce a false sense of safety, increasing vulnerability and exposure to hazards. Di Baldassarre *et al.* (2019) further classified the SDP as a general phenomenon, comprising the LE as a sub-phenomenon. While the LE focuses on the impact of structural risk reduction measures, the SDP focuses on structural and/or non-structural measures. The SDP, thus, also includes the regulatory and social context in which structural interventions take place.

2.3 METHODS

To ensure transparency, replicability and to provide a comprehensive search, a systematic review was performed following the Reporting of Strategies in Systematic Evidence Syntheses standards - ROSES proposed by Haddaway et al. (2018). The search was performed on 14/05/2022 and considered English publications until 31st December 2021, included in the Web of Science (WoS) and Scopus databases. The terms searched (Table 2.2) were selected based on related terms observed in Ferdous *et al.* (2020), Gissing *et al.* (2018) and Haer *et al.* (2020). The search was performed based on the title, abstract and author and index keywords.

Table 2.2 - Search string for each database

WoS search string: TS= (((“SAFE DEVELOPMENT PARADOX” OR “SAFE-DEVELOPMENT PARADOX”) OR “LEVEE* EFFECT” OR “LEVEE* PARADOX” OR “DIKE* EFFECT” OR “DIKE* PARADOX” OR “SAFETY DILEMMA” OR “FALSE SENSE OF SECURITY” OR “FALSE FEELING OF SECURITY” OR “FALSE SAFETY FEELING” OR “FALSE SENSE OF SAFETY” OR “FALSE PROTECTION” OR “FALSE SENSE OF PROTECTION”) AND (“FLOOD*” OR “LANDSLIDE*” OR “DEBRIS FLOW” OR “MASS MOVEMENT” OR “MASS WASTING”)) AND PY=(1900-2021) Scopus search string: TITLE-ABS-KEY (((“SAFE DEVELOPMENT PARADOX” OR “SAFE-DEVELOPMENT PARADOX”) OR “LEVEE* EFFECT” OR “LEVEE* PARADOX” OR “DIKE* EFFECT” OR “DIKE* PARADOX” OR “SAFETY DILEMMA” OR “FALSE SENSE OF SECURITY” OR “FALSE FEELING OF SECURITY” OR “FALSE SAFETY FEELING” OR “FALSE SENSE OF SAFETY” OR “FALSE PROTECTION” OR “FALSE SENSE OF PROTECTION”) AND (“FLOOD*” OR “LANDSLIDE*” OR “DEBRIS FLOW” OR “MASS MOVEMENT” OR “MASS WASTING”)) AND PUBYEAR BEF 2022

Source: Authors (2023).

The search resulted in 135 studies. After merging the results and removing the duplicates, the remaining (n = 79) were screened first at the title and abstract level, and then on the entire text. The following criteria were used for selecting relevant articles: (1) the study consists of a case study; (2) it addresses the general phenomena SDP or the sub-phenomena LE; (3) it does not consist of a review, editorial, or opinion article; (4) it is available in English or Portuguese language; (5) it does not focus solely on hydraulic aspects of levees or dikes; (6)

it analyses a hydrological disaster accordingly to CRED classification (BELOW; WIRTZ; GUHA-SAPIR, 2009). Full-text analysis was performed on the retrieved results (n = 23). To answer the research questions, the selected articles (n = 23) were categorized according to Table 2.3. A summary of the review process is presented in Figure 2.1.

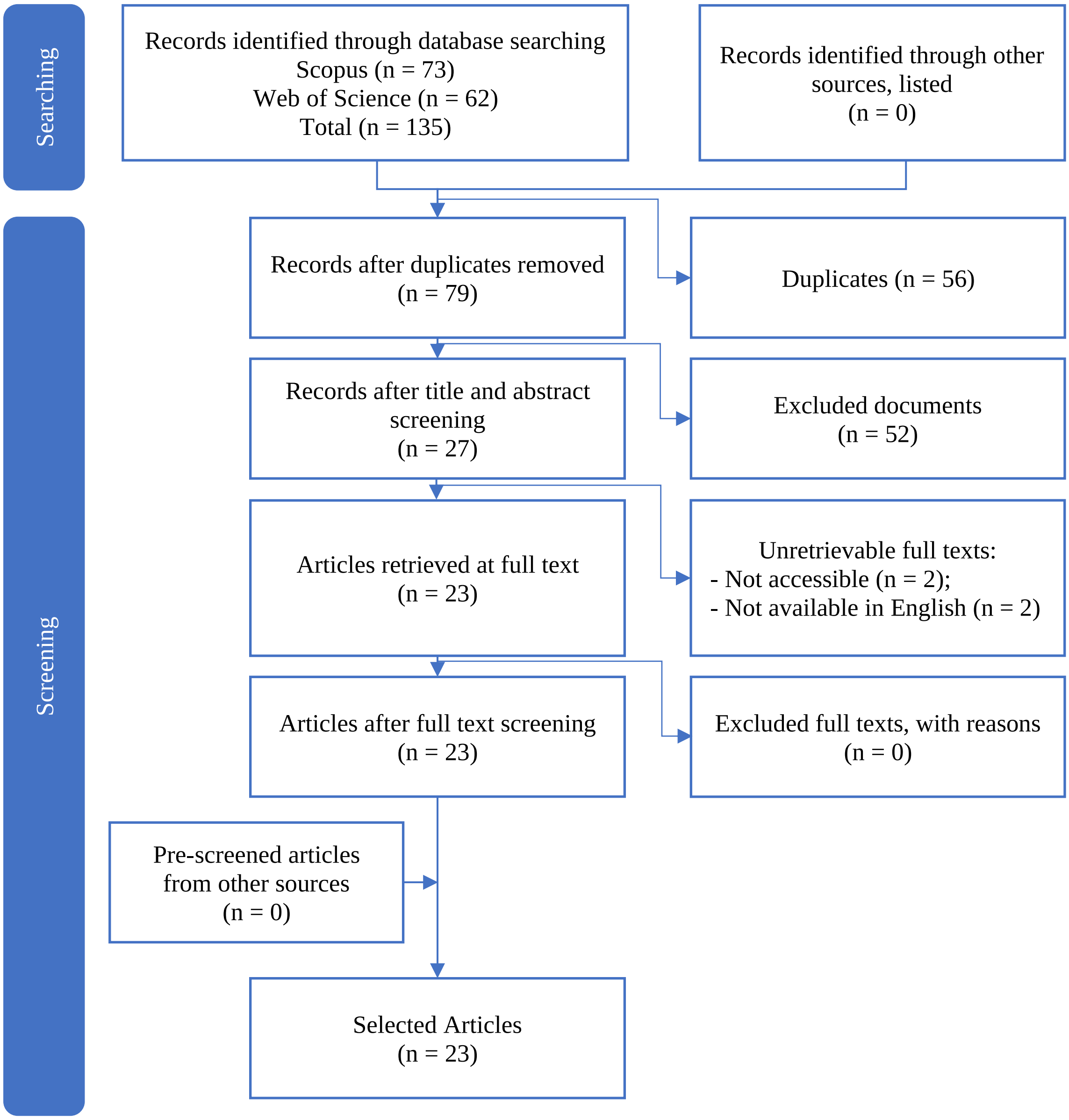
During the interpretation of the results, it is important to acknowledge the inconsistent terminology regarding LE and SDP, also noted by Breen, Kebede and König (2022). This might have resulted in unassessed studies, due to the use of varying terms used to refer to the phenomena, or assessment of the phenomena without explicitly mentioning related terms.

Table 2.3 – Categories of the reviewed articles.

Categories	**Options**
Country of the study	descriptive answer
Methodological approach	(a) empirical and/or (b) conceptual
Methods applied	descriptive answer
Research design	(a) qualitative, (b) quantitative or (c) mixed methods
Data type	(a) primary data and/or (b) secondary data
Spatial scale (FISCHER *et al.* 2021)	(a) continental, (b) national, (c) state/province, (d) county, (e) city, (f) neighbourhood, (g) social network, and (h) waterbody network
Socio-hydrological phenomena assessed	(a) safe-development paradox or safety dilemma and/or (b) LE or levee paradox, dike effect or dike paradox
Social theory(ies) applied in the study	descriptive answer
Hydrological disaster event typology (BELOW; WIRTZ; GUHA-SAPIR, 2009)	(a) general (river) flood, (b) flash flood, (c) storm surge/coastal flood, (d) rockfall, (e) landslide, (f) debris flow, (g) avalanche, (h) snow avalanche, (i) debris avalanche, (j) subsidence, (k) sudden subsidence, (l) long-lasting subsidence and/or (m) other
Measures considered	(a) structural and/or (b) non-structural
Observation if structural or non-structural measures reduced disaster frequency	(a) yes, (b) no or (c) unclear
Proof or refutation of the SDP or related phenomena in the respective study area	(a) confirmed the phenomenon or (b) refuted the phenomenon
Policies assessed by the studies	(a) risk management, (b) risk insurance or compensation, (c) building codes, (d) land use, (e) environmental management, and/or (f) transportation

Source: Authors (2023).

Figure 2.1 - Systematic review procedure following the ROSES guidelines (n = number of articles)



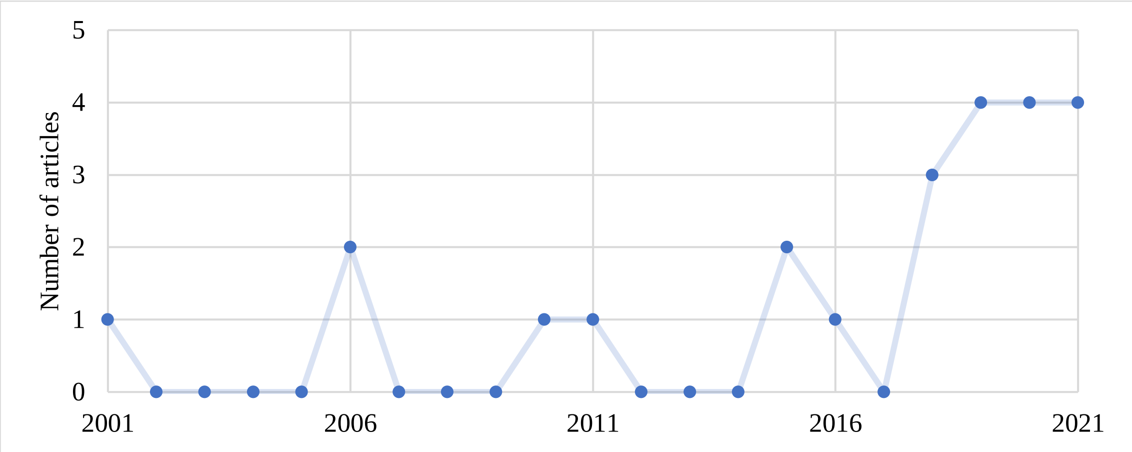
Source: Author (2023).

2.4 RESULTS

2.4.1 Overview of the reviewed articles

The selected studies on SDP and LE were unevenly published from 2001 to 2021 (Figure 2.2), with most studies published from 2018 to 2021 (n = 15). The assessed hydrological hazard typology was also uneven, with most studies on floods (n = 19) followed by flash floods (n = 3) (Figure 2.3), corroborating Breen, Kebede and König (2022). Four studies addressed multihazards, including flood and flash flood events related to hurricanes (n = 3) (BURBY, 2006; FOX-ROGERS *et al.*, 2016; MALECHA; WOODRUFF; BERKE, 2021), and one study focused on the sequence event of drought-to-flood (MAZZOLENI *et al.*, 2021). One publication addressed riverbank erosion (FERDOUS *et al.*, 2019) and none investigated wet mass movements (e.g. debris flows and landslides).

Figure 2.2 - Temporal distribution of the reviewed studies.

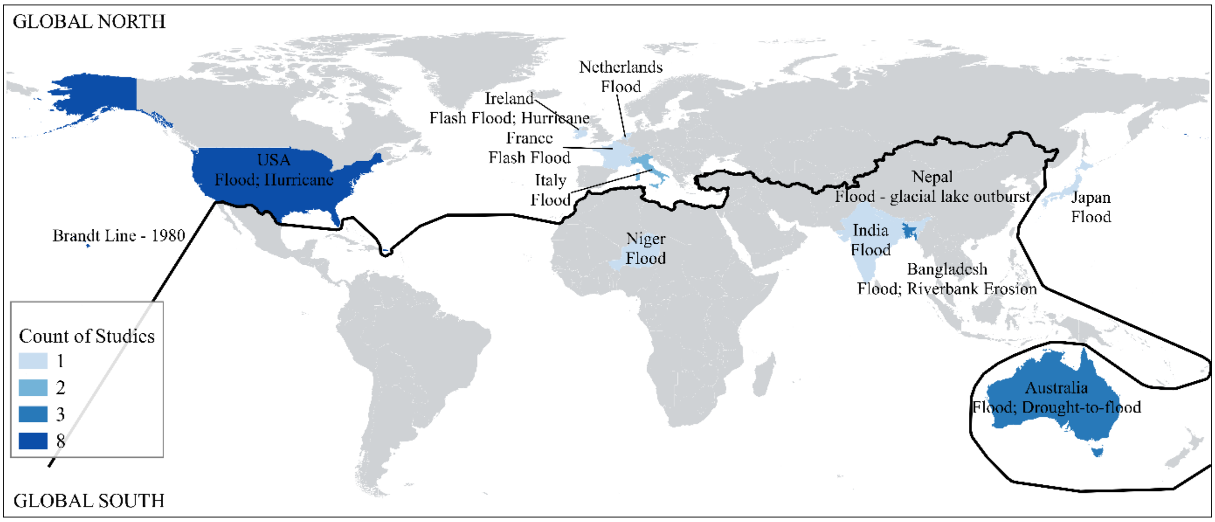


Source: Authors (2023).

Regarding the spatial distribution, the studies were conducted in 11 different countries (Figure 2.3), including a study using synthetic data in Italy (DOMENEGHETTI *et al.*, 2015) and one in the European Union (HAER *et al.*, 2020). The USA presented the highest number of publications (n = 8), followed by Bangladesh (n = 3). Previous reviews have also highlighted a similar pattern, illustrating a significant disparity between the number of studies conducted in the Global North[2] (n = 18) and the Global South (n = 6). The review by Breen, Kebede and König (2022) observed USA, Italy, and Bangladesh as the countries with the most publications on the SDP. Similarly, the reviews on socio-hydrology by Fischer *et al.* (2021) and Vanelli *et al.* (2021) identified the USA, China and Australia; and Italy and Bangladesh, respectively.

[2] Division of global north and south based on Brandt (1980).

Figure 2.3 - Country of study and disaster events typology

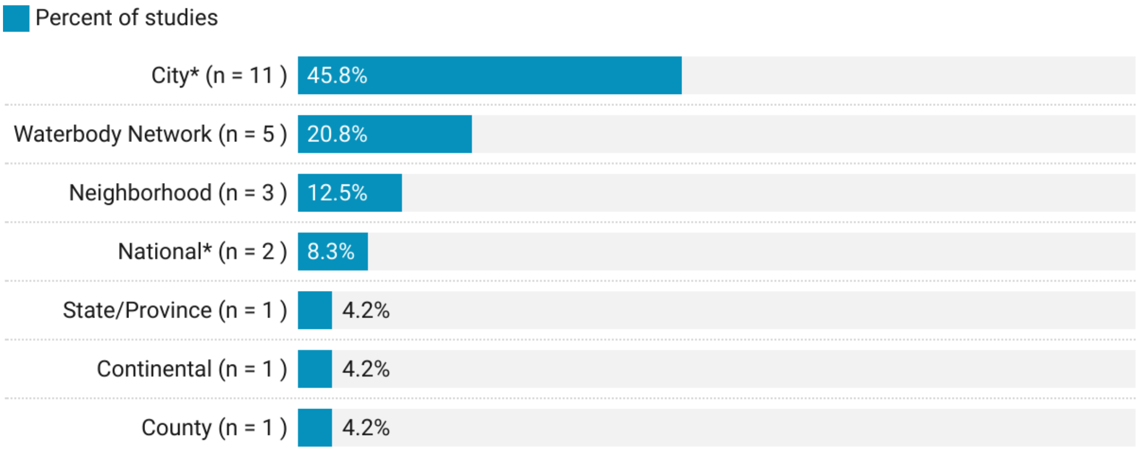


Source: Authors (2023).

The studies were developed mainly at the city scale (Figure 2.4), followed by applications addressing waterbody networks, which consist of study areas delimited by hydrological features. For instance, Domeneghetti et al. (2015) assessed flood risk on the middle and lower floodplains of the Pó River watershed. Only one study was conducted at a continental scale (HAER *et al.*, 2020), and no studies were observed on the global and social network scale (i.e. using social rather than administrative delimitations).

A qualitative analysis of the studies revealed that they often do not present a justification for the spatial scale used. Notably, the prevalent use of the city spatial scale appeared to be influenced by various practical considerations, such as its alignment with territorial management units, data availability at that level, and the relevance of the scale to the specific hazard being studied.

Figure 2.4 - Spatial extent of the studies



*Collenteur et al. (2015) research was developed at both national and city scales. Hence, it was counted in both categories.

Source: Authors (2023).

2.4.2 Methodological approaches used

The SDP and the LE were primarily studied using risk assessment methods, which evaluated the impact of risk mitigation policies on vulnerability, exposure and hazard. Empirical studies were predominant (n = 19), while conceptual ones were less frequent (n = 4). The methods used in these studies were heterogeneous (Figure 2.5) and ranged from observational investigation to numerical modelling. The majority of the studies employed quantitative research designs (n = 11), followed by qualitative (n = 6) and mixed methods (n = 6). The trend towards quantitative research can be attributed to the call by (SIVAPALAN; SAVENIJE; BLÖSCHL, 2012) to maintain socio-hydrology as a quantitative science. It is worth noting that many studies have not assessed the phenomena as their main goal.

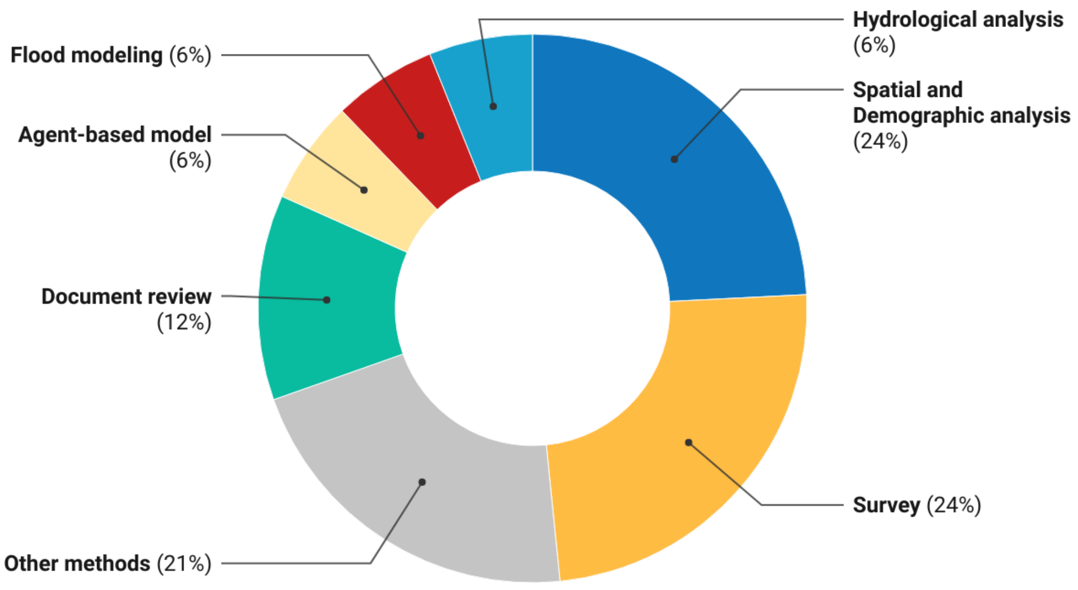
The quantitative studies (Table 2.4) primarily focused on exposure and hazard aspects of the SDP and LE rather than vulnerability. They often investigated the effects of mitigation measures on exposure and hazard levels. These studies employed models (e.g.: flood models, hydrological analysis, agent-based models, damage estimation, and policy network analysis) and statistical analysis (e.g. spatial and demographic analysis and surveys).

Studies following a qualitative research design were primarily published before 2012 and are typically exploratory in nature. They employ techniques such as literature reviews, document analysis and surveys to examine the impact of policies on human-water interactions (Table 2.4). Given the nature of these studies, they tend to require a significant amount of documentation data. Surveys were commonly used by qualitative research designs and provided a more comprehensive analysis of social variables, such as risk perception, when compared to quantitative research designs. However, it is worth noting that the studies which employed surveys (whether qualitative, quantitative or mixed approach) tended to lack transparency in their sampling methods due to the absence of a description of sample size and sampling techniques.

Mixed methods studies employed a combination of techniques (Table 2.4), such as conceptual modelling (system-dynamics model) and narrative analysis. This approach has been found to provide robust results by combining the strengths of both qualitative and quantitative methods (VANELLI *et al.*, 2022). Specifically, the qualitative component is typically used to investigate the false sense of safety and mitigation strategies, while the quantitative component focuses on measuring shifts in exposure, calculating damage, and assessing the impact of mitigation policies on vulnerability. This enables a more comprehensive assessment of the possible impacts of socio-hydrological phenomena.

Despite the increasing call for theoretically grounded research, only three studies employed a social theory. Michaelis, Brandimarte and Mazzoleni (2020) and Fox-Rogers *et al.* (2016) employed the Protection Motivation Theory, while Yu et al. (2020) the Robustness-Fragility Trade-Off and Cultural Multilevel Selection theories.

Figure 2.5 - Employed methods in the studies to assess the phenomena Others correspond to methods used in only one article, including private policy analysis)



Source: Authors (2023).

Table 2.4 - Methods and variables employed by selected studies. PD corresponds to primary data, whereas SD to secondary data. A list of the methods used in each study is presented in **Online Resource 1** (Appendix 1-I).

METHOD	DESCRIPTION	VARIABLES CONSIDERED
Agent-based model	Modelling of socio-hydrological coupled systems based on interactions of agents in a system.	SD: Flood inundation maps, hydrologic and hydraulic data, land use, socioeconomic and demographic data, economic data, protection standards, flood damage, risk perception, preparedness, and previous flood experience.
Conceptual modelling	Used for understanding and representing the socio-hydrological coupled systems via diagrams, models and equations.	SD: Drought awareness, flood awareness, hydrologic and hydraulic data, per-capita water demand, socioeconomic and demographic data.
Damage estimation	The process of assessing the economic damage caused by a disaster.	SD: Asset's economic value, flood inundation data, socioeconomic and demographic data, and land use maps.
Development project analysis	Used for evaluating proposed development projects regarding existing risk areas, assessing the reasons for building structures in risk areas, and the possible increase in demographic density in risk areas.	SD: Development projects, flood inundation maps, land use policy, risk insurance or compensation policy, and risk management policy.
Document review	The process of reviewing written documents (e.g. reports, bibliography, mitigation project documents) to verify land use change, the emergence of a false sense of safety, and the impact of policies in the study area.	SD: Building code policy, flood inundation maps, risk insurance or compensation policy, risk management policy, bibliography, socioeconomic and demographic data, land use policy, risk insurance or compensation policy, and risk management policy.
Flood modelling	The use of computer models to simulate floods, assess the hazard and create or update risk maps.	SD: Digital elevation model, hydrologic and hydraulic data, land use maps, and topographic maps.
Hydrological analysis	Used to assess the hydrological behaviour of a specific event or period, and/or changes in hydrological patterns over time.	PD: Hydraulic and hydrological data. SD: Digital terrain model, hydrologic and hydraulic data, satellite images, and flood inundation maps.
Narrative analysis	A set of methods for analyzing disaster narratives of individuals and communities to understand human behaviour. Leong (2018) employs the Q method, a quantitative methodology, to perform narrative analysis.	PD: Attitude towards flood relief works, protected by structural flood relief, and risk perception. SD: bibliography review.
Policy network analysis	A set of methods to assess the effects of policy integration on social aspects (e.g. vulnerability). Malecha, Woodruff, and Berke (2021) used the Plan Integration for Resilience Scorecard to perform policy network analysis.	SD: Environmental policy, land use policy, risk management policy, socioeconomic and demographic data, transportation, and flood inundation maps.
Private policy analysis	Used to analyze disaster-related policies and procedures (e.g. risk policies, disaster response protocols) of private organizations and companies to verify compliance and minimum standards.	SD: Environmental policy, private risk management plans, and risk management policy.
Social vulnerability index (SoVI)	A measure of a community's susceptibility to harm from external stressors, such as disasters related to natural hazards.	SD: Socioeconomic and demographic data.

METHOD	DESCRIPTION	VARIABLES CONSIDERED
Spatial and demographic analysis	A methodology for assessing the spatiotemporal dynamics of population distribution in risk areas and their correlation to public policies.	SD: Bibliography review, flood impacts database, flood inundation maps, hydrologic and hydraulic data, land cover change product, land use maps, levees - spatial data, risk insurance or compensation policy, risk management policy, roads - spatial data, satellite images, socioeconomic and demographic data, and topographic maps.
Survey	A method for gathering information from a sample of individuals through interviews, questionnaires, or focus groups to assess the false sense of safety and other social variables related to risk mitigation policies.	PD: Acceptance of flood damage, adaptation measures, attitude towards flood relief works, distance from rivers, distance from rivers, financial compensation, flood hazard, flood insurance, impacts of flooding, local government perception on policies, preparedness, previous flood experience, protected by structural measures, responsibilities, risk perception, socioeconomic and demographic data, trust, types of preparedness, and willingness to move-out.

Source: Authors (2023).

2.4.3 Evidence for socio-hydrological phenomena

Most of the reviewed studies (83.3%) explicitly cited the assessed hydrological phenomena, and the remaining cases mentioned it implicitly, presenting the effect with related terms as the false sense of safety (BLANCHARD-BOEHM; BERRY; SHOWALTER, 2001; DAHAL; HAGELMAN, 2011; SMITS; NIENHUIS; SAEIJS, 2006). The LE was the most investigated phenomenon (n = 17), which was assessed by all studies conducted in Asia (n = 6, 100%) and the majority of studies conducted in Europe (n = 5, 83.3%). The SDP (n = 6) was primarily examined in the Americas and accounted for the majority of studies conducted in the region (n = 5, 83.3%), corroborating Breen, Kebede and König (2022). Studies addressing other phenomena, such as the local government paradox (BURBY, 2006; CUTTER *et al.*, 2018), adaptation effect (LEONG, 2018; MICHAELIS; BRANDIMARTE; MAZZOLENI, 2020; RICHERT; ERDLENBRUCH; GRELOT, 2019), pendulum swing (YU *et al.*, 2020) and cry-wolf syndrome (DAHAL; HAGELMAN, 2011) were also identified in our sample of articles. However, as these were not the primary focus of this study, these phenomena were not analysed in detail.

All studies, except for Starominski-Uehara (2021), have confirmed the existence of the phenomena in their respective study areas. Starominski-Uehara (2021) verified that the households protected by a dam in Brisbane, Australia, take precautionary measures and do not present a false sense of safety, refuting the LE. This low vulnerability was attributed to prior flood experiences, especially the 2011 flood, which was exacerbated by dam operations. Additionally, the author indicated that the occupation of the dam's downstream area was due to the assurance of security provided by the authorities rather than the sense of security provided by the dam itself. This could suggest that the area presented the SDP until the 2011 flood.

Several studies (34.7%) partially addressed the SDP and LE by focusing solely on exposure and hazard aspects. However, as evidenced by Starominski-Uehara (2021), disregarding vulnerability, a false sense of security, and/or the aspects of damage assessment can lead to inaccurate results. To avoid these limitations, we considered these as partial assessments. Total or comprehensive assessments included vulnerability aspects and were predominantly observed in mixed approach and qualitative research designs (>80.0%).

It is worth noting that some studies have challenged the assumption that risk awareness leads to risk preparedness (FOX-ROGERS *et al.*, 2016; SCOLOBIG; DE MARCHI; BORGA, 2012). High risk awareness is often attributed to individual and community preparedness due to consistent risk knowledge/information. However, individuals with high awareness do not present a direct link with preparedness, indicating the need for a comprehensive assessment of social variables, such as previous disaster experiences and trust in institutions (SCOLOBIG; DE MARCHI; BORGA, 2012).

2.4.4 Non-structural measures and policies related to SDP

The relationship between the SDP and policies such as risk management plans and land use policies was evaluated by a few studies (n = 6, 26.0%). None of these examined policies alone, but they also considered structural measures (e.g. dams, levees). As such, it is difficult to disentangle the contribution of structural and non-structural measures on the SDP.

The public and private risk management policies addressed by these studies focused on evaluating the effectiveness of mitigation practices in reducing risk and regulating new and existing development over risk areas. It was observed that risk management plans can **reduce** adverse outcomes by raising awareness among residents about the risks associated with living in hazardous areas and inducing residents to apply adaptation measures outlined in the plans (RICHERT; ERDLENBRUCH; GRELOT, 2019). Conversely, they can **increase risk** and lead to the SDP if policies are lenient with new developments in hazardous areas and provide insufficient risk communication (MALECHA; WOODRUFF; BERKE, 2021; STEVENS; SONG; BERKE, 2010).

Some researchers investigated the effects of land use, environmental management and building codes to understand whether they encouraged the development and occupation of hazardous areas. These studies explored the relationship between policy and development in areas where a risk relief structure is already in place (BURBY, 2006; GISSING *et al.*, 2018; STEVENS; SONG; BERKE, 2010) as well as in areas not officially mapped as hazardous areas but affected by disaster events (MALECHA; WOODRUFF; BERKE, 2021). In summary, the studies found that these policies are necessary to manage existing risk zones effectively and prevent new developments while providing adequate use for unoccupied hazardous areas.

Studies that analysed risk insurance and compensation policies examined their impact on risk perception and development, as well as the factors influencing the acquisition of flood insurance. Burby (2006) and Stevens, Song and Berke (2010) indicated that insurance policies with low building standards for areas with structural protection may create a false sense of safety. Moreover, insurance policies that do not include specific building code requirements for protected areas also contribute to a false sense of safety and increase the potential for damage. Finally, flood insurance can stimulate the development in high-risk areas (CUTTER *et al.*, 2018). For instance, Burby (2006) indicated that the insurance scheme in New Orleans did not required building elevation in areas subjected to levee or dam failure, or in basins smaller than one square mile.

In summary, policies have a dual nature that can enhance and diminish socio-hydrological phenomena, especially when considering policies interplay. Burby (2006) indicated that lax land use regulations required by flood insurance schemes can stimulate development on flood-prone areas. Additionally, policies of smaller administrative scales (e.g.: neighbourhood, municipality) tended to prioritize development over DRR, development and transportation policies and for areas not delimited at risk areas were less inclined to reduce vulnerability (MALECHA; WOODRUFF; BERKE, 2021). Therefore, even policies that are not explicitly designed for DRR can influence risk dynamics.

It is crucial to direct policy attention towards undeveloped hazard-prone regions to prevent further occupation and mitigate population and asset exposure (BURBY, 2006). This is especially important given the dynamic nature of hazards, especially in light of climate change. Policies should consider hazards and risks as fluid and not static to a delimited area (MALECHA; WOODRUFF; BERKE, 2021).

2.5 DISCUSSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

In this paper, we conducted a systematic review of the literature to examine the occurrence of the SDP and its sub-phenomenon, the LE. We analysed 23 empirical and conceptual studies and verified the evidence to confirm or refute the SDP and the LE in different study areas. Despite the recent growth in research on this topic, a series of challenges remain.

Amongst the reviewed phenomena and disaster types, the studies extensively focused on the LE and flood and flash floods (Figure 2.3), as also observed by Breen, Kebede and König (2022). The trend can be attributed to the emergence and growth of urban centres in flood-prone areas, as well as the widespread use of structural measures for flood mitigation, as evidenced by Barendrecht, Viglione and Blöschl's (2017). However, urban growth may extend from the floodplains to hillsides, leading to different hydrological hazards such as mass movements. Consequently, unassessed hydrological hazards may hinder the comprehension of which factors or types of disasters may trigger or influence these phenomena.

Additionally, the complexity of the SDP was evidenced by the multiple methods and approaches to investigate the phenomena (Table 2.4) and highlights the need for an interdisciplinary approach. However, the diversity of methods hampers a meta-analysis or comparative analysis, as highlighted by Rufat *et al.* (2022) in the context of vulnerability and adaptation research.

About one-third of the studies have only partially assessed the SDP and LE, focusing on hazard and exposure aspects rather than the false sense of safety or vulnerability. To comprehensively assess the SDP and the LE, all risk components should be considered (ZIMMERMANN; KEILER, 2015). In this context, mixed-methods approaches are deemed more appropriate for assessing socio-hydrological systems (VANELLI *et al.*, 2021) as they enable comprehensive and complementary analyses of vulnerability and exposure.

The variables used to asses vulnerability, such as risk preparedness and perception, serve as the primary drivers of the SDP and the LE. Although, these variables present high complexity and interplay with different social factors that cannot be ignored. Further research is necessary to determine the effectiveness of DRR interventions addressing these variables. For instance, Seebauer and Babcicky (2020) indicate the importance of risk communication to enhance risk awareness and coping appraisal.

The SDP research mainly focuses on structural measures, as all the assessed studies presented a major flood protection structure. This emphasis hinders the ability to fully understand the potential adverse effects of the non-structural measures alone. However, a few studies have also assessed land use, and insurance policies, particularly the U.S. federal insurance scheme. For instance, Burby (2006) and Cutter et al. (2018) found that flood insurance can influence the occupation of levee-protected areas due to the low protection requirements for occupation and the lack of preparedness and adaptation by households who acquired the insurance. However, it remains unclear if non-structural measures would have a similar influence in scenarios without structural protection measures or for instance if land use management policies may promote a false sense of safety and increase exposure and vulnerability.

In addition, most the studies considered measures directly aimed at DRR, in other words, the studies focused on DRR measures (fixes) that influenced the SDP (backfire) (DI BALDASSARRE *et al.* 2023). However, as observed by Malecha, Woodruff and Berke (2021) the network of policies, such as risk management, recreation, development, transportation, environment, land-use, can influence physical vulnerability, consequently, risk dynamics. For instance, an extensive body of research indicates that land-use policy can increase disaster risks, especially exposure enabling urbanization and occupation of hazard-prone areas, due to the lack of integration of DRR instruments into land-use planning (BOGO, 2020; GLAVOVIC; SAUNDERS; BECKER, 2010; LÖSCHNER; NORDBECK, 2020; SUDMEIER-RIEUX *et al.*, 2015; VIEIRA, M. S.; ALVES, 2020). However, the substantial focus on intentional mitigation measure, and direction provided by the SDP definition hinder the assessment of non-intentional DRR measures to influence and promote the SDP.

Another obstacle to the research on the SDP is the need to expand the geographical scope to the Global South, which presented a lower number of studies (n = 6) compared to the Global North (n = 18). It is imperative to be aware that the scarcity of studies into the SDP and LE must not lead to the assumption that these phenomena do not occur in the Global South. It should thus be seen as an opportunity to promote further research in this field.

Considering the body of research on the SDP and LE and the aforementioned challenges, we propose the following recommendations for future studies:

- Verify if non-structural measures such as policies, land use, building codes, environmental, and risk management, could influence the SDP in areas without major structural flood protection;
- Assess non-intentional DRR policies impact and influence on the SDP;
- Test the SDP for different hydrological hazards types and multi-hazard;
- Conduct studies in different countries in the global South, such as Latin America, Africa and Asia;
- Address other phenomena, such as the adaptation effect, water injustice, and fixes that backfire to provide a holistic approach to the complexity of the disaster events and to address the Sustainable Development Goals;
- Verify the aspects that increase risk perception and preparedness in areas subjected to the SDP.

2.6 CONCLUSION

The present study contributes to the field of socio-hydrology by providing baseline assessments for the phenomena of SDP and LE. The systematic review showed that the empirical investigation on SDP and LE is still being consolidated, with emphasis on the levee effect and disaster typologies of flood and flash flood. We observed a focus on the negative impacts of historical structural flood mitigation measures that may be challenged by climate change. As such, to expand knowledge about the phenomena, the potential negative impacts of non-structural measures alone and non-intentional DRR measures must also be considered, as well as assessments of different hydrological and multi-hazard events.

A second significant contribution of this study entails a comprehensive synthesis of the methods and variables utilized to evaluate the phenomenon. The review evidenced a variety of methods, which hampers a meta-analysis but may enable assessment from multiple perspectives. We found that mixed-methods approaches provided more robust evidence for the SDP and LE. This is due to their ability to integrate qualitative methods to assess false sense of safety and mitigation strategies, as well as quantitative methods to measure shifts in exposure, calculate/estimate damages, and assess the impact of mitigation policies on vulnerability. Hence mixed methods provide a holistic assessment by integrating social and natural sciences, which is essential for a comprehensive understanding of the socio-hydrological system.

In summary, this study provides a foundation for investigating SDP and LE. We expect to raise awareness of persisting challenges in investigating socio-hydrological phenomena, which hamper an enhanced understanding of the mechanisms that generate adverse effects.

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3 ASSESSMENT OF THE SAFE DEVELOPMENT PARADOX IN REVOLVER BASIN, SOUTHERN BRAZIL

Abstract

In response to the escalating climate crisis, governments worldwide are adopting several adaptation measures to enhance safety. However, these well-intentioned efforts may inadvertently foster development in high-risk areas, a phenomenon known as the 'safe development paradox' (SDP). While the SDP has been extensively studied concerning structural measures, the potential influence of non-structural measures remains understudied. Additionally, we propose an expansion of the SDP concept to include both intentional and non-intentional disaster risk reduction (DRR) measures. Therefore, this study examined the impact of public policies on the occurrence of the SDP in the Revólver basin - a region in southern Brazil struck by hydrological disasters (such as landslides, debris flow, and flash flood) and the COVID-19 in 2020. Using mixed methods, including interviews, document analysis, and spatial analysis, we found through the protection motivation theory a community member preponderance of non-protective responses. Additionally, a false sense of safety was present among a third of the participants, fostered by high trust in the government and the consideration of building permits as safety indicators. Stakeholders with formal roles indicated that DRR actions were absent in the study area, primarily because it had been deemed secure until the 2020 disaster. Local policies, particularly the inadequate risk mapping, urban expansion over risk areas and the relaxation of riparian regulations, facilitated settlement in hazardous regions and influenced the false sense of safety, exacerbating the SDP. Therefore, local government policies influenced the SDP, especially in regions with rare disaster prevalence. This highlights the potential for non-structural policies directly or indirectly related to DRR to produce unintended effects on societal risk dynamics. Overall, this research broaden the concept of SDP, reinforces the need for intersectoral policy integration for DRR and draws attention to the potential of policies in inducing adverse effects.

Keywords: Safe development paradox; Disaster risk reduction; Hydrological disaster; Protection motivation theory; Public policies

3.1 INTRODUCTION

The human impact on the natural environment contributes to exacerbating hydrological disasters such as floods, flash floods, and mass movements (BELOW; WIRTZ; GUHA-SAPIR, 2009). Due to climate and land use change, such disasters have become more frequent and intense in several parts of the world (IPCC, 2022; MCDERMOTT, 2022). Brazil has also experienced an increase in flood frequency, particularly in the Amazon and the southern region (CHAGAS; CHAFFE; BLÖSCHL, 2022). In response to this growing concern, international organizations such as the Sendai Framework and the 2030 Agenda have been encouraging global efforts to mitigate damages and losses by promoting Disaster Risk Management (DRM) (RAJABI *et al.*, 2022; UNITED NATIONS, 2015; UNDRR, 2015)

DRM involves proactive measures aiming at prevention, mitigation, and preparedness rather than relying solely on reactive measures during or after a crisis (RAJABI *et al.*, 2022). However, it is important to recognize that even well-intended DRM actions or the absence of action (i.e. inertia) can lead to unexpected outcomes or lock-in conditions. One of them is the safe development paradox (SDP), where a false sense of safety arises from the implementation of either structural or non-structural measures aimed at disaster risk reduction (DRR). Paradoxically, this can reduce coping capacities and ultimately reduce society's resilience (BURBY, 2006; KATES *et al.*, 2006).

The SDP is a general socio-hydrological phenomenon encompassing sub-phenomena, such as the reservoir and the levee effect (LE) (DI BALDASSARRE *et al.*, 2019). The reservoir effect occurs when communities become too reliant on reservoirs for flood protection, which reduces their motivation to adapt and increases their vulnerability to drought-related damages (DI BALDASSARRE *et al.*, 2018b). The LE occurs when flood protection structures create a false sense of safety, leading to an increasing population in flood-prone areas and an increasing vulnerability to flooding. This overconfidence in mitigation measures can cause a lack of protective or adaptive behaviour, further increasing the risk of flood disasters (FERDOUS *et al.*, 2019; HUTTON; TOBIN; MONTZ, 2019; RICHERT; ERDLENBRUCH; GRELOT, 2019; TOBIN, 1995; WHITE, 1945). Additionally, SDP also relates to the local government paradox (LGP). An understudied paradox which refers to the local governments' lack of attention to natural hazards and potential risks, which results in lenient policies (increased institutional vulnerability (LÓPEZ-MARTÍNEZ *et al.*, 2019)) and the transfer the burden of dealing with risks to residents or other levels of government (BURBY, 2006; CUTTER *et al.*, 2018).

Existing literature on the SDP focuses mainly on the LE, examining the unintended outcomes of structural measures for flood risk reduction (BREEN; KEBEDE; KÖNIG, 2022). However, the SDP can also occur due to non-structural measures, such as flood insurance, land use, environmental, risk management, and development plans (BURBY, 2006; CUTTER *et al.*, 2018; MALECHA; WOODRUFF; BERKE, 2021). While previous studies showed that policies can either enhance or diminish the SDP, they often evaluate the SDP in the presence of a structural measure (BURBY, 2006; CUTTER *et al.*, 2018; GISSING *et al.*, 2018; RICHERT; ERDLENBRUCH; GRELOT, 2019; STEVENS; SONG; BERKE, 2010). Additionally, both intentional (e.g., mitigation measures) and unintentional measures (e.g., development, transportation, and land use policies) can influence the SDP as both measures can impact on risk dynamics. For instance, policies can increase exposure by directing and stimulating urbanization and human occupation of hazard-prone areas (BOGO, 2020; SUDMEIER-RIEUX *et al.*, 2015), impermeabilization promoted by human activities can increase runoff and increase hazard (CUTTER *et al.*, 2018; TUCCI, 2007), and policies may induce physical vulnerability (MALECHA; WOODRUFF; BERKE, 2021). However, the consideration of non-intentional measures as root cause of the SDP would require the concept to be expanded, which this study proposes to do.

Thus, this study evaluated the SDP in an area lacking major structural measures and determined its incidence. Specifically, we examined how public policies, both intentional or non-intentional, influenced the population's perception of hydrological disaster risk, such as flash floods, debris flow, and landslides. To accomplish these goals, we employed a mixed-methods approach comprising interviews and a document analysis within the Revólver basin, southern Brazil. This study area was selected because of the history of hydrological disasters. Apart from stream straightening and channelization for urban purposes, no significant structural measures have been implemented in this basin. Furthermore, the area presents a sparse population, and as such, the municipality has limited resources and fewer options for implementing measures to manage hydrological disasters.

3.2 PUBLIC POLICY FOR ADDRESSING HYDROLOGICAL DISASTERS

This section provides a concise review of the relationship between public policies and DRR in the context of hydrological disasters. The main objective of DRR is to minimize the negative impacts of such disasters on human life and property. This objective can be achieved through the implementation of specific public policies that directly aim to reduce vulnerability, exposure, or hazard, or through integrated management, in which DRR is treated as an intersectoral subject and tackled by different sectors (BOGO, 2020; GLAVOVIC; SAUNDERS; BECKER, 2010; LÖSCHNER; NORDBECK, 2020; SUDMEIER-RIEUX *et al.*, 2015; VIEIRA, M. S.; ALVES, 2020). Integrated management is especially relevant in normative scenarios with a sectorized approach to public problems (NOGUEIRA; FORTE, 2019). For instance, previous research o research has observed the relationship between sectorial policies and DRR in a variety of sectors, including sanitation (ALBUQUERQUE SANT’ANNA, 2018; DULAC; KOBIYAMA, 2017), land use management (ASSUMPÇÃO *et al.*, 2017; RODRIGUES, 2020; SUDMEIER-RIEUX *et al.*, 2015), education (PACHECO *et* *al.*, 2021; SILVA, A. R. C. Da; KOBIYAMA; VANELLI, 2021), social assistance (SILVA, E. L. e, 2020), and water management (DI BALDASSARRE *et al.*, 2019).

However, public policy is a complex subject that presents several definitions. One renowned definition is given by Dye (1972, p.2)[3], who defines public policy as “anything a government chooses to do or not to do” (apud HOWLETT; RAMESH; PERL, 2009). However, not acting cannot be classified as a public policy, even though the decision to not act is still a political process that can have effects similar to those of concrete actions (SECCHI, 2015). Therefore, we employ Secchi's (2015) definition which presents public policy as a directive to address a public problem. To understand public policies, there are various theoretical models, including the policy cycle (ARAÚJO; RODRIGUES, 2017). The policy cycle is a primary approach that considers public policies as a dynamic process composed of distinct steps (ARAÚJO; RODRIGUES, 2017; HOWLETT; RAMESH; PERL, 2009).

Agenda setting is a political process in which an issue or situation gains enough relevance and attention to be captured by actors with the resources to implement a public policy. Public problems are social constructs delineated according to actors' subjectivity, worldviews, and values (HOWLETT; RAMESH; PERL, 2009). According to (KINGDON, 2014) to gain the attention of policy resource holders, public problems must be noticed, which can occur through indicators, focal events (such as natural disasters or pandemics), or evaluation feedback.

Policy formulation is the process of creating options to address a public problem (HOWLETT; RAMESH; PERL, 2009). This process involves different actors and perceptions of the public problem and ways to tackle it, in which a clear understanding of the public problem’s root causes of the and the ways to address it are required.

Decision-making is the step in which one, multiple or none policy alternatives are debated and selected to form the official core of action (HOWLETT; RAMESH; PERL, 2009). The decision-making is dynamic and dependent on the organization level and actors involved (KINGDON, 2014). According to Howlett, Ramesh and Perl (2009) decision-making can result in implementation, halting the policy cycle process, or the public problem is not introduced in the agenda. While the latter may yield effects such as concrete actions, it does not constitute a public policy and is instead considered a public policy void (SECCHI, 2015).

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[3] DYE, Thomas R. **Understanding public policy**. Englewood Cliffs/NJ: Prentice-Hall, 1972.

Implementation is the phase in which the selected policy alternative is put into practice. This phase involves the development and execution of plans, programs, and projects (HOWLETT; RAMESH; PERL, 2009). And the last step in the policy cycle is **evaluation**. It involves the assessment of policy metrics, valuable to promote learning, corrections on the policy design, social control, and responsibility of actions (HOWLETT; RAMESH; PERL, 2009).

Public policies can be developed at different government levels, but the municipal level holds particular significance. This is primarily because local governments execute most policies and are more sensitive to disasters' impacts and people's needs due to the proximity (SILVA, E. L. e, 2020). However, many Brazilian cities, particularly less populated ones, face common challenges in implementing effective DRR measures due to limited resources, both human and financial (BRASIL, 2021a). In addition, the mere existence of a policy does not guarantee improved risk management (RIBEIRO *et al.*, 2022)

Considering DRR there are several approaches to policy development that depend on the subjectivity of the actors involved. Two commonly recognized approaches are the **protection paradigm**, which emphasizes the use of structural mitigation measures such as levees and dams for flood protection, and the **risk management approach**, which focuses on preventive actions and allows for the utilization of both non-structural and structural measures (WAGNER *et al.*, 2021). Additionally, the policy development process can be approached from either a **top-down** perspective, which adopts an economic paradigm by defining risk as the combination of hazard and monetary consequences, or a **bottom-up** perspective, which considers the social paradigm and defines risk qualitatively based on social well-being (BLÖSCHL; VIGLIONE; MONTANARI, 2013).

However, the product of a public policy, or even the absence of action, can produce undesirable outcomes, such as the LE or the SDP. Therefore, it is crucial to assess both intentional or non-intentional DRR policies and their outcomes to verify their potential adverse effects and correct them.

3.3 AN OVERVIEW OF THE PROTECTION MOTIVATION THEORY

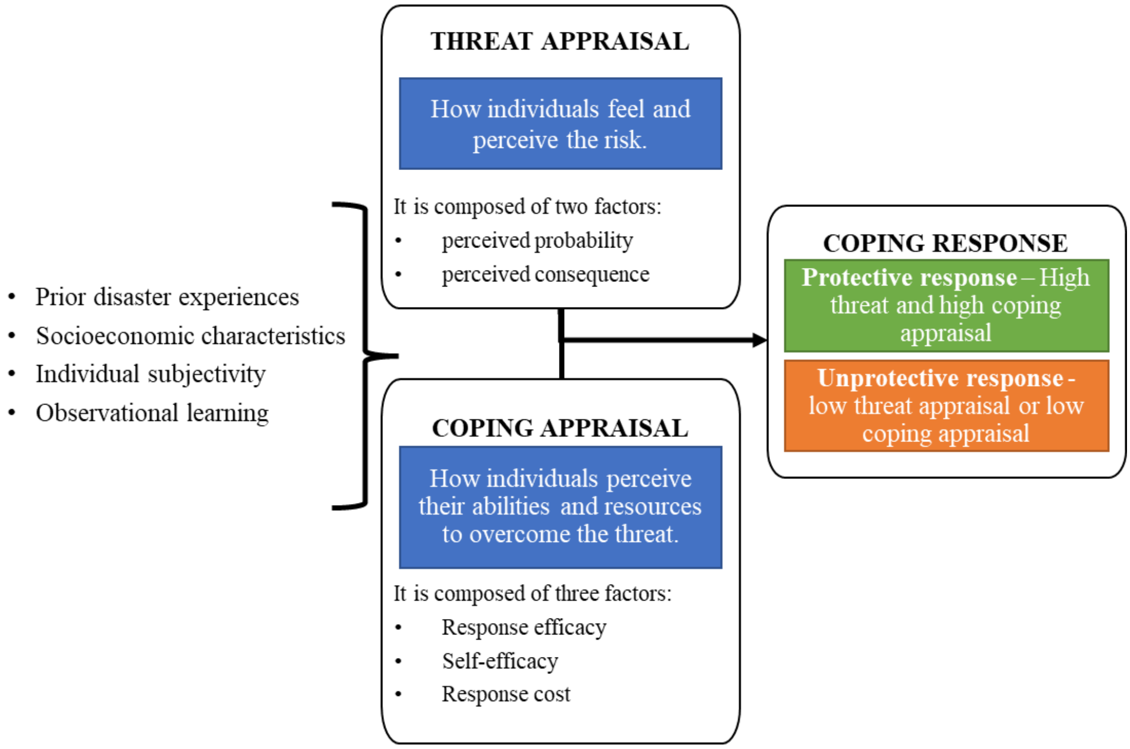
In this section, we continue the review and present the Protection Motivation Theory (PMT) as the chosen framework for assessing risk perception and protective behaviour in our study. The PMT effectively explores the connection between risk perception and protective behaviour, which is often considered weak, by considering coping appraisal (BUBECK;

BOTZEN; AERTS, 2012). Moreover, the PMT allows for comparisons with previous studies and enhances the overall strength of evidence (KUHLICKE *et al.*, 2023). The theory was initially developed by Rogers (1975, 1983) to understand health risk behaviour, but has been applied to various contexts such as flood adaptation, climate change (BUBECK *et al.*, 2013; BUBECK; BOTZEN; AERTS, 2012; CAO *et al.*, 2020; GROTHMANN; REUSSWIG, 2006; NOLL *et al.*, 2022; TWEREFOU *et al.*, 2019), and the levee effect assessment (BUBECK; BOTZEN; AERTS, 2012; DI BALDASSARRE *et al.*, 2018a; FOX-ROGERS *et al.*, 2016; MICHAELIS; BRANDIMARTE; MAZZOLENI, 2020).

The PMT conceptualizes coping responses as a cognitive product of threat appraisal and coping appraisal, which are influenced by fear arousal, observational learning, personality, and prior experience (Figure 3.1). The **threat appraisal** element evaluates how an individual interprets a certain risk, therefore is linked with risk perception (BUBECK; BOTZEN; AERTS, 2012). The evaluation is based on *perceived probability* and *perceived severity.* Additionally, threat appraisal consists of cognitive and affective subcomponents, referring to the assessment of the likelihood of exposure (probability x severity) and the feelings towards disasters (BABCICKY; SEEBAUER, 2019). **Coping appraisal** assesses the individual's belief in the ability to respond to a threat, comprising: *response efficacy*, which is the belief in the effectiveness of response actions; *self-efficacy*, which refers to the individual's confidence in implementing mitigation measures; and *response cost*, which encompasses financial, emotional, and time costs of mitigation measures (BUBECK *et al.*, 2013).

A protective response emerges if the individual perceives risks and believes to be able to cope with or avoid the risk. Otherwise, we observe a non-protective, that may include wishful thinking, avoidance, or denial, which can provide comfort but do not address the underlying risk (BUBECK *et al.*, 2013; ROGERS, 1975; ROGERS; ROGERS W., 1983).

Figure 3.1 - Schematic overview of PMT.



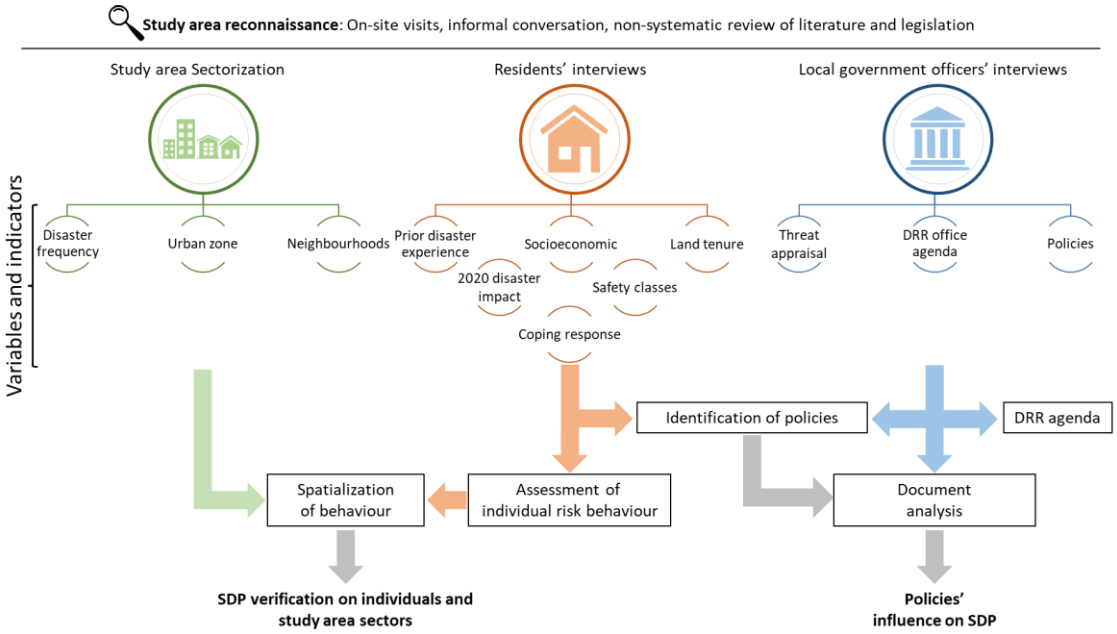
Source: Adapted from Bubeck, Botzen and Aerts (2012)

3.4 METHODS

A mixed-methods approach was adopted to investigate the study area as a complex composition of the social and physical systems (JOHNSON; ONWUEGBUZIE; TURNER, 2007; VANELLI *et al.*, 2022). Our methodological framework consisted of several steps (Figure 3.2), starting with a study area reconnaissance involving on-site visits, informal conversations (SWAIN; KING, 2022) with community members, and a non-systematic literature review of legislation and scientific publications to subside the methodology development (see Appendix 2-IV). Subsequently, the study area was divided into sectors to examine contextual spatial factors that potentially influence individuals' risk behaviour and the occurrence of the SDP.

To gain insights into community risk behaviour and management practices, we carried out semi-structured interviews in Portuguese with community members (see Appendix 2-II) and with local stakeholders with formal roles (LSR) (see Appendix 2-III). Based on this, we assessed the SDP at the individual level. Finally, we conducted a document analysis (BOWEN, 2009) to evaluate how local policies influenced making hazardous areas available for human occupation, thereby contributing to the SDP.

Figure 3.2 – Methodological procedure flowchart



Source: Authors (2023).

3.4.1 Study Area

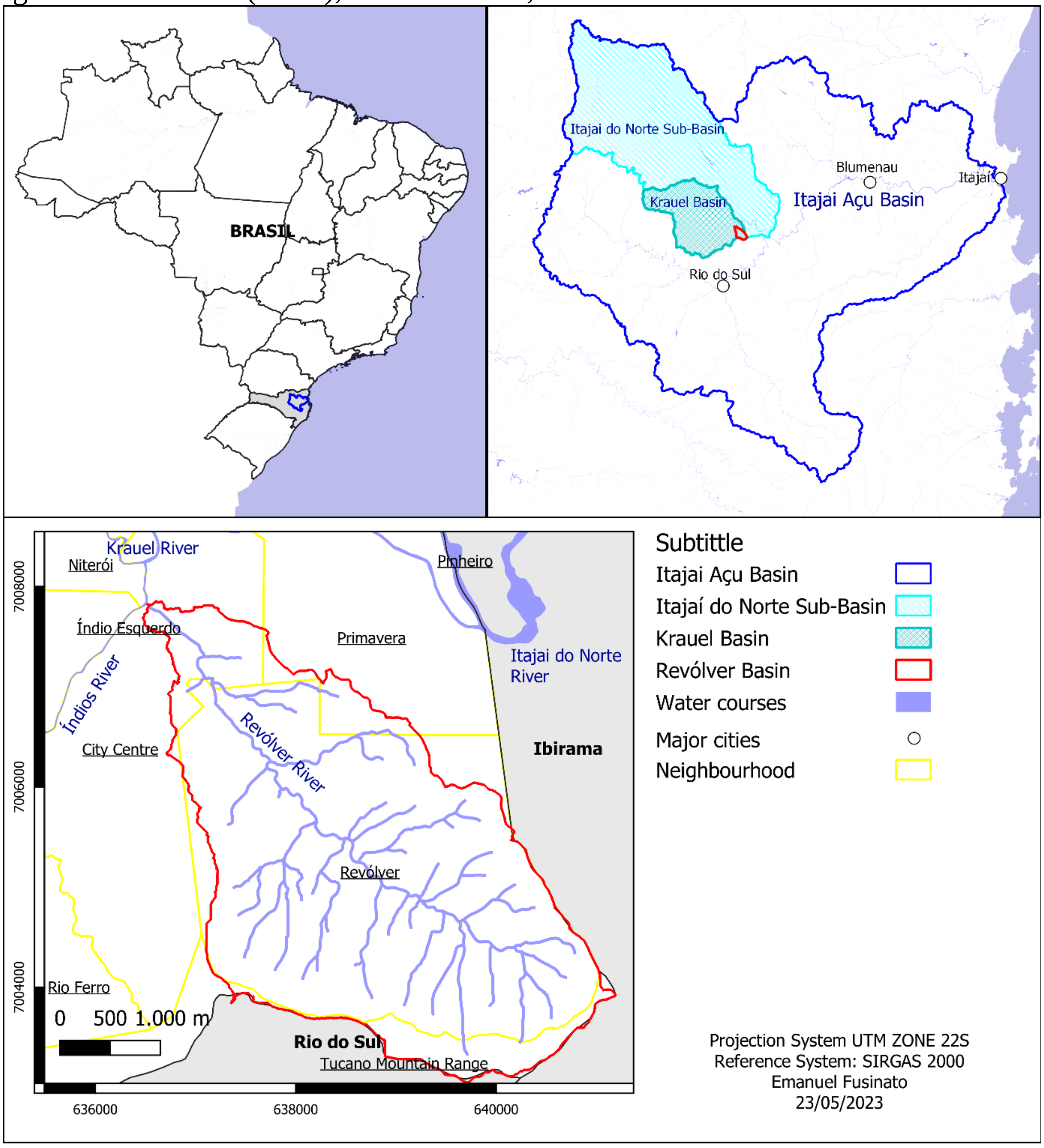
The study area is the Revolver basin (11,94 km²) within the Presidente Getúlio Municipality, Santa Catarina State, Brazil. The area encompasses the neighbourhoods of City Centre, Revólver, Primavera, and Tucano Mountain Range. The basin has altitudes ranging from 250 m to 810 m, and the Revólver River is the primary watercourse of the basin, a tributary of the Índios River, which flows into the Krauel River, forming part of the Itajaí Açu basin. The climate of the area is subtropical, mesothermic super humid, with an average annual rainfall between 1400 mm to 1500 mm (AUMOND; SEVEGNANI; FRANK, 2018). The basin has diverse land use and is predominantly covered by native forest formation (SOUZA *et al.*, 2020).

Located in the Upper Itajaí Açu Valley region, Presidente Getúlio Municipality presented 14,887 inhabitants in 2010 and an increase to 20,010 inhabitants in 2022 according to IBGE (2023). The study area – Revólver basin – comprise 603 residences and 1,798 residents in 2010 (IBGE, 2010). These figures include all residential properties in the Revólver neighbourhood and account for 20.04% of the City Centre's residences The Primavera and Tucano Mountain Range neighbourhoods have no inhabited areas within the study area.

Similarly to other cities in the Itajaí Açu Valley, Presidente Getúlio was established by European settlers, especially Swiss, Germans and Italians, on the floodplains of the main rivers

(ESPÍNDOLA; NODARI, 2013; FRANK; BOHN, 2018; WIESE, 2000). This geographical characteristic has made the municipality prone to flood events. The Índios and Krauel rivers, outside of the study area, have been responsible for numerous flooding incidents and subjected to various structural interventions (PRESIDENTE GETÚLIO, 2018; UFSC, 2016).

Figure 3.3 – Revolver Basin location map. The water courses were defined according to the digital terrain model (DTM), resolution 1 m, SIGSC Database[4].



Source: Authors (2023).

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[4] *Sistema de Informações Geográficas de Santa Catarina* – (SIGSC) is an online database providing public access to a comprehensive collection of high-precision geographic data for Santa Catarina State. This includes orthophotomosaics, digital elevation models, hydrological data, and more. http://sigsc.sds.sc.gov.br/.

Despite risk mapping, meander cut-offs, and overflow channel construction and other efforts (for more information refer to UFSC (2016) and Presidente Getúlio (2018)), hydrological disasters have been occurring in the municipality, with the 2020 compound disaster[5] event (hydrological and COVID-19) being significant. This event affected Presidente Getúlio municipality, and two neighbouring municipalities, Ibirama and Rio do Sul, however, the Revólver basin concentrated most losses and damages. According to Michel et al. (2021), the hydrological phenomena were triggered by concentrated precipitation over the highly humid soil of a headwaters region, leading to cascading phenomena, such as landslides, debris flow, and flash floods. The event caused extensive damage to infrastructure and society in Presidente Getúlio municipality, with 121 houses (80 destroyed and 41 damaged), and 151 public infrastructures affected (64 destroyed and 87 damaged), resulting in losses of R$ 34.71 million (MDR, 2022). Most of the damage to infrastructure and loss of human life was observed in the riparian Permanent Preservation Area (APP) which are legally protected zones in Brazil due to their ecological function (BRASIL, 2012b; MICHEL *et al.*, 2021).

3.4.2 Sectorization of the study area

The study area was sectorized to assess the spatial distribution of risk behaviour and identify the occurrence of the SDP. These sectors were determined by overlapping several spatial and physical criteria influencing individual behaviour (Table 3.1), except for riparian APP, which was assessed separately (Table 3.1 - item 5.). To establish the regions of disaster frequency, urban and rural zones, and neighbourhoods, we utilized available spatial data (Table 3.1 – items 1. to 4.) or extracted data using geoprocessing tools in the QGIS software (Table 3.1 – item 5.).

[5] According to Lukasiewicz and O’Donnell (2022) this event would be classified as compound.

Table 3.1 –Criteria used for defining study area sectors and respective data sources

CRITERIA	COMPONENTS	REASONING	DATA SOURCE
1. Neighbourhood delimitation	City Centre, Primavera, Revólver and Tucano Mountain Range neighbourhoods.	Individuals' risk perception may vary according to the neighbourhoods they reside. Until 2020, there was a belief that the Revólver neighbourhood was a flood-safe area (PRESIDENTE GETÚLIO, 1988).	Presidente Getúlio (2019).
2. Zoning	Urban and rural zones	Rural communities tend to exhibit a lower belief in the ability of technology to control natural phenomena, owing to their close relation to natural processes. Conversely, urban communities tend to believe more in technological solutions (DZIAŁEK; BIERNACKI; BOKWA, 2013). Urban zoning also influences human settlement density.	Presidente Getúlio (2022).
3. Disaster frequency	Frequent disaster region, rare disaster region and not mapped region.	Frequent short-term flood events increase individual risk perception (DI BALDASSARRE *et al.*, 2013a). In contrast, rare and intense disaster events neighbourhood may fail to increase individual risk perception (HOPKINS; WARBURTON, 2015).	Frequent region based on CPRM (2012, 2018), Rare region based on Michel *et al.* (2021)*.
4. Riparian APP**	Protected riparian APP and not protected riparian APP	Individuals inserted in the riparian APP are located closer to rivers, which may present higher risk perception due to the close contact with floods (RICHERT; ERDLENBRUCH; GRELOT, 2019; ULLAH *et al.*, 2020). Conversely, this area may present a higher incidence of impacts (KOBIYAMA *et al.*, 2020)	Santa Catarina, (2023), Brasil (2012b).

*The mapped mass movement was not considered in the sectorization process. This decision was based on the fact that the mapped landslides occurred in unoccupied areas, and not every identified debris flow was mapped.
** The watercourses status (natural or closed river sections) in urbanized areas was validated visually in the field.
Source: Authors (2023).

3.4.3 Semi-structured interviews

We conducted semi-structured interviews to evaluate the coping response (i.e., protective or non-protective behaviour) of both community members living in the study area and LSR based on PMT (section 5.3). To ensure a diverse range of participants, including individuals from different genders and socioeconomic backgrounds, as well as marginalized groups (to surface hidden voices) and powerful actors (those with an agency). The interviews were approved by the Research Committee at the Institute of Hydraulic Research, Federal University of Rio Grande do Sul (Annex I). They were conducted in person from October 21st to November 24th, 2022, during workdays, holidays and weekends, mostly from 9:00 a.m. to

6:30 p.m., with interested individuals over 18 years old who agreed to participate (see Appendix 2-I for the consent form).

For the interviews with community members, we considered their sense of safety, which refers to the subjective feeling of protection from harm in a given place and situation (GROMEK, 2021). Additionally, we examined the perceived impact of the 2020 disaster in terms of human and property damages and losses (DIAKAKIS *et al.*, 2017). This includes impacts such as house flooding, disaster-related illnesses or injuries, and COVID-19 during the recovery process or while in shelters. For more details on the interview protocol, please refer to Appendix 2-II. A sample size of 150 was defined based on Sampieri, Collado and Lucio's (2013) recommendation for ethnographic studies, observations, and interviews, and similar to Blanchard-Boehm, Berry, and Showalter (2001) and Martins e Nunes (2020) studies. We utilized a quota sampling method (SAMPIERI; COLLADO; LUCIO, 2013) based on the study area's spatial characteristics and the number of residences in each neighbourhood (IBGE, 2010). The delimited quotas comprised 51.8% for the Revólver neighbourhood and 48.2% for the City Centre. To ensure the effectiveness of the interview questions, a pilot interview was conducted with 20 community members. The interviews were conducted in person, and the location of the community members' residences was georeferenced.

The interviews conducted with Presidente Getúlio LSRs aimed to identify their risk perception and the perceived relation between disaster events and the municipal departments' current policies and agenda. We selected the departments related to DRR, such as risk management (RICHERT; ERDLENBRUCH; GRELOT, 2019), environmental management (MALECHA; WOODRUFF; BERKE, 2021), land use management (BURBY, 2006; BURBY; FRENCH, 1981; STEVENS; SONG; BERKE, 2010) and education and culture (SILVA, A. R. C. Da; KOBIYAMA; VANELLI, 2021). The departments that participated included: Administration; Agriculture, Livestock and Environment; Education, Culture and Sports; Health; Municipal Civil Defence; Planning and Economic Development; Social Assistance; Urban Works and Services; and Water Supply and Sewage Treatment Service. We used the opportunity sampling method (SAMPIERI; COLLADO; LUCIO, 2013) to select one or two stakeholders of each department based on their availability and interest.

The gathered interview responses from both the community members and LSR interviews were used as variables (Table 3.2) for qualitative and quantitative analysis (for statistical analysis, see item 3.4.5) and for the development of indicators (see item 3.4.3).

Table 3.2 – Variables included in the community members and LSRs interviews. Variables 1. to 18. were used as explanatory variables for posterior statistical analysis.

COMMUNITY MEMBERS' INTERVIEWS	
VARIABLE	**VARIABLE COMPOSITION (Interview question)**
1. Prior disaster experience (only hydrological)	• How many times have you personally experienced hydrological disasters in your lifetime?
2. Socioeconomic variables	• Age • Household income • Gender • Property year of construction (the oldest building used as a residence) • Living situation • Person per household • Place of birth • Education level and schooling years • Years residing in the household • Years residing in the municipality
3. Tenure (Property owners)	• Does your land have property registration or title deed? • Do the buildings on your land have building and occupancy permits?
4. Perceived disaster probability	• How likely do you believe you will be affected by hydrological disasters (flood, flash flood, landslides, debris flow) in the next 5 years, on a scale of 1 to 5? (5 very likely, 1 impossible)
5. Perceived disaster severity	• Do you think you could suffer damages due to a hydrological disaster? If so, why? On a scale of 1 to 5, how severe do you think these damages would be? (5 very severe, 1 no damage)
6. Response efficacy	• Do you believe you can take any action to reduce damages from hydrological disasters to your property and your family? If yes, why? What actions would you take?
7. Self-efficacy	• If hydrological disasters were to occur, do you believe you could implement measures to reduce damages to your property and your family? Why?
8. Response cost	• Would you be willing to invest time or money to make your home and property more resistant to hydrological disasters? • How much would you invest in making your property more resistant? • How much would you invest in training to know how to act in the event of hydrological disasters?
9. 2020 disaster impact	• Were you personally affected by the December 2020 disaster? If yes, what were the damages to your property, human lives, services, and others?
10. Trust on land use policies to reduce damages	• On a scale of 1 to 5, how much do you agree that land use laws can reduce damages from hydrological disasters? (5 strongly agree, 1 strongly disagree)
11. Trust in the government's capability to reduce damages	• On a scale of 1 to 5, how much do you agree that the government (municipal, state, federal) is capable of reducing damages caused by hydrological disasters? (5 strongly agree, 1 strongly disagree) • What actions, policies, or infrastructure measures could the government (municipal, state, and federal) implement to reduce damages from hydrological disasters?
12. Safety emitted by building permits	• On a scale of 1 to 5, how much do you agree with the statement: Having a building permit indicates that the location is suitable and safe for habitation. (5 strongly agree, 1 strongly disagree)
13. Sense of safety	• On a scale of 1 to 5, how safe do you feel in your current home regarding hydrological disasters? Justify your ranking.
14. Adaptation-oriented respondents*	• Is your house adapted to withstand hydrological disasters? Why? • On a scale of 1 to 5, how prepared do you feel to face hydrological disasters? Justify your answer.

LOCAL STAKEHOLDERS WITH FORMAL ROLES INTERVIEWS	
15. LSR's prior disaster experience	• How many times have you witnessed hydrological disasters, whether at home, work, or through volunteering?
16. Time in the formal role	• How long have you been employed by the city/town?
17. Perceived probability of disasters in the study area	• On a scale of 1 to 5, what is the likelihood of the study area experiencing a disaster in the next 5 years? (5 very likely, 1 impossible)
18. Perceived severity of disasters in the study area	• On a scale of 1 to 5, how severe do you believe future disaster damages in the study area would be? (5 very severe, 1 none)
19. Role in DRR	• What is the role of your department for DRR?
20. Department DRR activities	• What are the main regulations in the municipality regarding Disaster Risk Reduction (DRR)? • What regulations, policies, and actions has the department taken to reduce disaster risk in the municipality? • Are there any DRR measures that could be implemented? • Are there any specific constructions or policies implemented by the institution for DRR in the Revólver basin?
21. Related actions to the 2020 disaster	• Could any construction or policies have influenced the 2020 disaster in the Revólver basin?
22. Study area safety pre- and post-2020 disaster	• Did the department consider the Revólver basin a safe area before December 2020? Why? And how about now? Why?
23. Study area development and the feeling of safety	• On a scale of 1 to 5, how much do you agree with the statement: The Revólver neighbourhood developed because it was believed to be a safe area in terms of disasters. Please explain your reasoning. (5 strongly agree, 1 strongly disagree)

*The adaptation-oriented respondents comprised individuals who reside on the elevated or upper floor; have flood valves or similar devices installed, or employ response or mitigation practices specifically designed to minimize risks in their homes.
Source: Authors (2023).

3.4.4 Development of indicators based on the interviews

To evaluate the occurrence of the SDP in the study area, we developed indicators (Table 3.3) by aggregating the interview variables (Table 3.2). A detailed description of the indicators' construction procedure is provided in Appendix 2-V.

The 'threat appraisal' and 'coping appraisal' indicators were constructed based on the PMT explanatory variables. These indicators were categorized as high, neutral, or low by tabulating the result of each variable in a matrix. For instance, when a respondent perceives both a high probability and a high severity of floods, flash floods landslides or debris flow, their 'threat appraisal' is classified as high. In cases where the response falls within the neutral range, a qualitative assessment was conducted. The 'coping response' indicator was determined by the relationship between 'threat appraisal' and 'coping appraisal'. A protective response was considered present if the individual presented high levels of both threat and coping appraisal, otherwise, the individual was classified as having a non-protective response (BUBECK *et al.*, 2013; ROGERS, 1975; ROGERS; ROGERS W., 1983).

To assess and classify the ‘perceived impact of the 2020 disaster’ for each community member, we utilized Diakakis *et al.* (2017) approach. This involved evaluating the severity of human impacts and property/patrimonial impacts using predefined severity classes, based on Diakakis *et al.* (2017), ranging from 0 (no impact) to 5 (extreme impact) based on the responses to the interviews. The highest severity ranking was considered, for instance, if an individual did not experience any property impact (score of 0) but experienced a minor human impact (score of 1), their ‘perceived impact of the 2020 disaster’ would be categorized as minor (score of 1).

The safety classes indicator represents the relationship between an individual's subjective and objective safety. Subjective safety was evaluated using quantitative and qualitative responses based on participants' sense of safety. Objective safety was determined by verifying the 2020 disaster’s direct impact on residences (property impact severity ≥ 1), which we considered as individuals ‘directly affected’ by the 2020 disaster. We also consulted the municipality’s official risk map before 2020 (PRESIDENTE GETÚLIO, 2019) to verify community members residing in frequent disaster regions. We did not based the objective safety solely on the existent risk maps or 2020 disaster reports, as these studies either underestimate, overestimate or did not represent the 2020 disaster-affected area (CPRM, 2021; MICHEL *et al.*, 2021; PRESIDENTE GETÚLIO, 2019; SANTA CATARINA, 2021). Finally, we combined each individual subjective and objective safety and classified them according to Gromek's (2021) safety classes.

Table 3.3 – Assessed indicators. The matrices used for constructing each variable are provided in Appendix 2-V;

INDICATOR	INDICATOR COMPOSITION	INDICATOR CLASSES/GROUPS
THREAT APPRAISAL	Perceived probability (community members’ variable 4; LSRs variable 17).	High, neutral or low.
	Perceived severity (community members’ variable 5; LSRs variable 18).	
COPING APPRAISAL	Response efficacy (variable 6)	High, neutral or low.
	Self-efficacy (variable 7)	
	Response Cost (variable 8)	
COPING RESPONSE	Threat appraisal	Protective response, neutral, or non-protective response.
	Coping appraisal	
PERCEIVED IMPACT OF THE 2020 DISASTER	2020 disaster impact (variable 9)	Diakakis et al. (2017) severity classes: 0-No impact, 1-minor impact, 2-weak impact, 3-moderate impact, 4-strong impact, or 5-extreme impact.

INDICATOR	INDICATOR COMPOSITION	INDICATOR CLASSES/GROUPS
SAFETY CLASS	Sense of safety (variable 13) Pre-2020 mapped risk areas (PRESIDENTE GETÚLIO, 2019) 2020 Disaster impact (variable 9)	Gromek's (2021) safety classes: State of false safety: directly affected by the 2020 disaster or inserted in a risk-mapped area and present safety feeling. State of unsafety: directly affected by the 2020 disaster or inserted in a risk mapped area and unsafety feeling. State of unsafety obsession: not directly affected by the 2020 disaster, not inserted in a risk-mapped area and with a feeling of unsafety. State of safety directly not affected by the 2020 disaster, not inserted in a risk-mapped area, and safety feeling.

Source: Authors (2023).

To assess the emergence of the SDP in the study area, we assessed community members' coping response, safety class and variables for each study area sector.

3.4.5 Statistical analysis

The interview variables (Table 3.2) and indicators (Table 3.3) were quantitatively analysed using the Statistical Package for the Social Sciences (SPSS) software through descriptive statistics and comparing of groups. The statistical tests employed consisted of Chi-Square for Independence (Exact test), Fisher's Exact Test, Mann-Whitney, and Kruskal-Wallis, performed according to Pallant (2016) (more details on Appendix 2-VI). The critical significance value (*p-value*) was set at 0.05 following usual conventions. With this, we aimed to investigate whether or not the indicators (i.e. dependent variables) differed depending on the characteristics of each sector and participant characteristics (i.e. explanatory variables). For the analysis, we considered valid answers, and the sectors were required to present a minimum of 5 respondents to be considered valid for the statistical assessment.

3.4.6 Qualitative document analysis

The Qualitative Document Analysis (QDA) is a systematic methodology employed to extract meaning from documentary evidence, focusing on identifying underlying meanings, themes, and patterns (BOWEN, 2009). It involves sampling, data collection, data analysis (skimming, reading, and coding), and interpretation (BOWEN, 2009; WOOD; SEBAR; VECCHIO, 2020).

We applied a simplified QDA approach combined with LSR's interviews to qualitatively evaluate whether local policies had an impact on the SDP. Specifically, we examined if these policies facilitated occupation, increased feelings of safety, and/or reduced risk perceptions in hazardous areas. The policies which were analysed were selected based on the conducted interviews and the study area reconnaissance (i.e. on-site visits, informal conversations, etc) (Table 3.6). We considered the documents as active actors that both influence and are influenced by social reality (BOWEN, 2009; WOOD; SEBAR; VECCHIO, 2020). Therefore, the document analysis was based on thematic analysis to assess themes and patterns emergent from policies (SHARMA *et al.*, 2022; WOOD; SEBAR; VECCHIO, 2020). Additionally, the interpretation with LSR's interviews helped us better understand the political and social events that constitute the policy cycle. This enriches the findings with information that was not presented in the documents, enhancing the reliability of our conclusions (BOWEN, 2009; WOOD; SEBAR; VECCHIO, 2020).

3.5 RESULTS

3.5.1 Characterization of the community members and reported impacts

A total of 151 community members were interviewed (Table 3.4). Most respondents were women and within the age groups of 35-39 and 55-59 years. Male and younger respondents were underrepresented compared to the 2010 Census data in IBGE (2010). Moreover, the interviewees exhibited higher levels of education and household income than the census population. Regarding residency, 49.0% of interviewed residents migrated to Presidente Getúlio from other cities. In addition, 88.7% (n = 134) of the interviewees were residing in their current residence during the disaster.

The 2020 disaster affected 96% of respondents, who reported health, property, or service disruptions, and 52.3% of the respondents were directly affected, meaning that their property was affected by the disaster. In addition, 9.9% (n = 17) of the interviewed were classified in strong or extreme severity, presenting building (partial or total) destruction and/or fatalities of family members (Table 3.4). The fatalities were predominantly caused by hydrological phenomena (MICHEL *et al.*, 2021), while two additional fatalities were COVID-19 related, due to reconstruction activities or shelter periods as reported by community members. We observed uneven perceived impact distribution according to prior disaster experiences (Fisher's exact test[6] $\chi 2 = 44.428$; $p < 0.001$). Individuals with one experience, primarily the 2020 disaster, presented more severe impacts (18.6% presenting strong or extreme impact), followed by individuals with two or more experiences (7.9%), and those with no experience (2.8%).

The participants exhibited high trust in government land use policies (78.1%) and capacity (48.6%) to address hazards and ensure safety (Table 3.4). The majority (48.6%) also strongly believed in building permits as a guarantee of safety. This trust was based on the reported perception of the technical capability and responsibility of the government (municipal, state, and federal) to assess hazards and ensure safety.

[6] For this assessment we binned the ‘prior disaster variable’ in three classes ‘no prior experience’, ‘one prior experience’, and ‘two or more prior disaster experience’.

Table 3.4 – Characterization of community members. ‘n’ value are valid answers out of the 151 participants The highest percentage for each variable/indicator is highlighted.

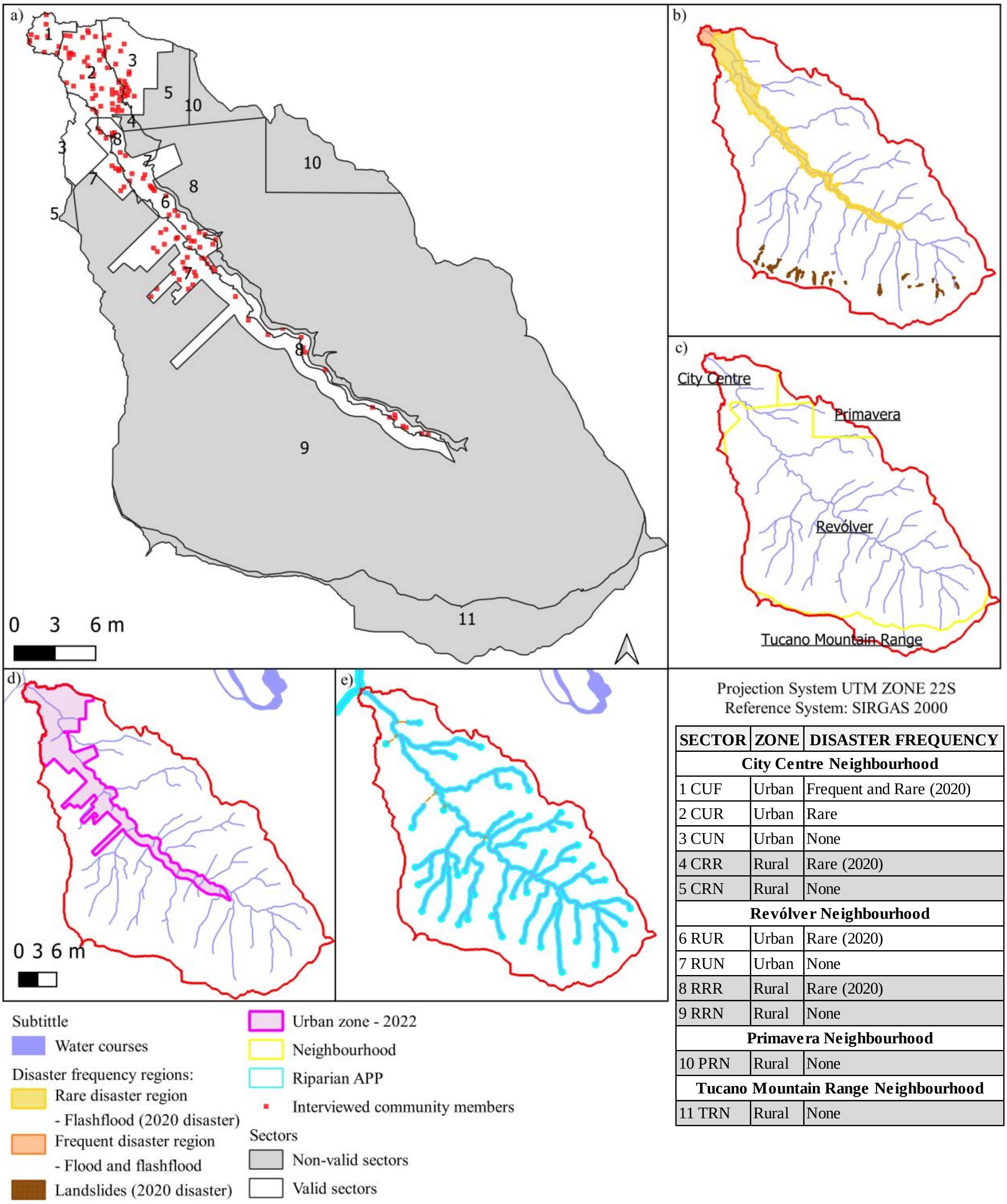
VARIABLE OR INDICATOR	GROUP/CLASS	VALUE
Age group (n = 151)	18-29	14.6%
	30-39	**21.2%**
	40-49	14.6%
	50-59	**21.2%**
	60-69	15.9%
	70-79	9.9%
	>80	2.6%
Household income in minimum wages[1] (n = 148)	< 3	**40.5%**
	3-5	34.5%
	5-10	14.2%
	> 10	10.8%
Gender Ratio (n = 151)	Male/Female	0.76
Living situation (n = 148)	Rent	14.2%
	Own	**85.8%**
Property year of construction - Property owners (n = 115)	Average ± standard deviation	1995±21.5
Person per household (n = 151)	Average ± standard deviation	3.17 ± 1.3
Place of birth (n = 151)	Native City	**51.0%**
	Neighbouring cities[3]	14.6%
	Same state, different cities	23.8%
	Other states	10.6%
Level of education of persons over 25 years (n = 138)	No education	31.2%
	Middle School	8.7%
	High School	**39.1%**
	Higher Education	21.0%
Years in the municipality (years) (n = 151)	Average ± standard deviation	32.7 ± 20.3
Years residing in the property (years) (n = 151)	Average ± standard deviation	17.8 ± 15.6
Prior disaster experience (n = 151) (Hydrological disasters)	No prior experience	28.5%
	1 experience	**42.4%**
	2 experiences	5.3%
	3 experiences	4.6%
	4 experiences	4.6%
	5 or more experiences	14.6%
Tenure - Property owners (n = 117)	Regular	**82.9%**
	Irregular	17.1%
Perceived impact of the 2020 disaster[2] (n = 133)	No impact	4.5%
	Minor impact	**39.1%**
	Weak impact	15.8%
	Moderate impact	29.3%
	Strong impact	6.0%
	Extreme impact	5.3%
Trust on land use policies to reduce damages (n = 151)	Low (1-2)	7.3%
	Neutral (3)	14.6%
	High (4-5)	**78.1%**
Trust in the government's capability to reduce damages (n = 146)	Low (1-2)	18.5%
	Neutral (3)	32.9%
	High (4-5)	**48.6%**
Belief in safety emitted by building permits (n = 140)	Low (1-2)	20.7%
	Neutral (3)	30.7%
	High (4-5)	**48.6%**

[1] 2022 minimum wage was R$ 1,212.00.
[2] Indicators are detailed in section 3.4.3 and Appendix 2-V.
[3] Neighbouring municipalities: Dona Emma, Ibirama, José Boiteux, Laurentino, Rio do Oeste and Rio do Sul.
Source: Authors (2023).

3.5.1.1 Contextual spatial factors and the community characteristics

The study area was assessed based on the riparian APP and 11 sectors constructed over neighbourhoods, zoning, and disaster frequency (Figure 3.4). We obtained five valid sectors (with a minimum of five respondents) 1-CUF, 2-CUR, 3-CUN, 6-RUR, and 7-RUN. The City Centre neighbourhood was intersected by both frequent (1-CUF), rare (2-CUR), and not mapped (3-CUN). It had 11 hydrological disasters registered between 1975 and 2022 related to the Índios and Krauel rivers floods. (See Appendix 2-IV). In contrast, the Revólver neighbourhood is intersected by rare (6-RUR), and not mapped (7-RUN) disaster regions, and had 5 registered hydrological disasters. Other neighbourhoods and rural zoning did not present valid sectors.

Figure 3.4 – Sectorization of the study area: a) Study area sectors; b) Disaster frequency, the frequent disaster region was overlapped by the rare disaster frequency (2020 disaster flash flood mapped area); c) Neighbourhoods; d) Urban zone; and e) Riparian APP – not employed in the sectors construction.



SECTOR	ZONE	DISASTER FREQUENCY
City Centre Neighbourhood		
1 CUF	Urban	Frequent and Rare (2020)
2 CUR	Urban	Rare
3 CUN	Urban	None
4 CRR	Rural	Rare (2020)
5 CRN	Rural	None
Revólver Neighbourhood		
6 RUR	Urban	Rare (2020)
7 RUN	Urban	None
8 RRR	Rural	Rare (2020)
9 RRN	Rural	None
Primavera Neighbourhood		
10 PRN	Rural	None
Tucano Mountain Range Neighbourhood		
11 TRN	Rural	None

Source: Author (2023).

Statistical analysis revealed significant differences ($p < 0.05$) among the valid sectors concerning the explanatory variables and indicators (Table 3.5).

Interviewees residing in the Revólver neighbourhood presented significantly lower levels of schooling years (Mann-Whitney U = 1,885.000; $p = 0.001$), lower household income (Mann-Whitney U = 1,998.500; $p = 0.002$) when compared to the City Centre. Similar differences were observed at the sector level, with sector 2-CUR having the highest levels of schooling years (Kruskal-Wallis $\chi2(4) = 12.983$; $p = 0.011$) and household income (Kruskal-Wallis $\chi2(4) = 12.014$; $p = 0.017$) and sector 7-RUN the lowest.

Both frequent and rare disaster regions had a high perceived impact compared to the low impact observed in the unmapped disaster areas (Fisher's exact test $\chi2 = 27.814$; $p < 0.001$). Similarly, sectors 3-CUN had the lowest perceived impact and sector 6-RUR had the highest values (Fisher's exact test $\chi2 = 39.023$; $p = 0.001$). As expected, interviewees in regions with frequent disasters presented the highest number of prior experiences than rare and unmapped disaster regions (Kruskal-Wallis $\chi2(2) = 20.229$; $p < 0.001$), with sector 1-CUF having the highest level of prior experience among sectors (Kruskal-Wallis $\chi2(4) = 20.675$; $p < 0.001$).

Protected riparian APP presented a higher concentration of older buildings (Mann-Whitney U = 1,212.000; $p = 0.044$), and a higher level of perceived impact (Fisher's exact test $\chi2 = 33.482$; $p < 0.001$), concentrating the majority of moderate (56.4%), strong (75.0%) and extreme (100%) perceived impact of the 2020 disaster. Corroborating the characteristics of riparian APP as susceptible areas (KOBIYAMA *et al.*, 2020). Additionally, protected riparian APP also presented a higher concentration of irregular properties (Fisher's exact test $\chi2 = 12.951$; $p = 0.001$), in which sector 6-RUR had the highest incidence of irregular properties.

3.5.2 Community members' coping response

We utilized the PMT and its constituents – 'threat appraisal' and 'coping appraisal' - to analyse the community members' interview responses. Then, we examined the 'coping response', as the protective response may counteract the false sense of safety, and avoid the SDP. The coping response refers to the proactive efforts and actions individuals undertake to mitigate the impact of disasters.

We found that most participants exhibited **low 'threat appraisal'** (n = 71; 51.0% of valid answers) followed by high and neutral threat appraisal (both with n = 34, 24.5%). This indicates that most viewed hydrological disasters as a remote possibility with low severity, similar to Mendonça and Gullo (2017). They also expressed wishful thinking and disbelief in the likelihood of a similar event reoccurring due to the reported perception that similar events would take a long time to reoccur, and disasters mostly reoccur in the frequent disaster region.

Additionally, respondents demonstrated a prevalent **low 'coping appraisal'** (n = 59, 45.0%) followed by high (n = 49, 37.4%) and neutral coping appraisal (n = 23, 17.6%). The community members exhibiting low coping appraisal reported no need for coping actions, or related to feeling unable to handle perceived threats due to their age, diseases, disaster velocity, or a lack of belief in the effectiveness of mitigation and response measures. Consequently, the '**coping response'** resulted mainly in non-protective responses (n = 90, 73.8%) followed by protective (n = 27, 22.1%) and neutral responses (n = 5; 4.1%). This may imply that most respondents have a limited ability to cope with perceived threats or may not consider themselves susceptible to such threats. Therefore, individuals have a reduced inclination to adopt protective measures and may rely on comforting emotions like denial and optimism (BUBECK; BOTZEN; AERTS, 2012)

When comparing the participants 'coping response' across variables and indicators, we observed that individuals with two or more disaster experiences exhibited a predominantly protective response (prior disaster experience - Mann-Whitney U = 1,545.000; p = 0.023), as did younger respondents (age - Mann-Whitney U = 802.000; p = 0.007). On the other hand, individuals who were never affected or affected once, primarily by the 2020 disaster event, exhibited non-protective responses. This was largely due to their low threat appraisal (Fisher's exact test $\chi 2$ = 6.024, p = 0.047). No other variables or indicators showed significant statistical differences between protective and non-protective responses, p > 0.05.

Furthermore, '**coping appraisal'** (Fisher's exact test $\chi 2$ = 10.440; p = 0.031) and '**coping response'** (Fisher's exact test $\chi 2$ = 9.850; p = 0.035) presented statistical differences across the study area sectors. Conversely, **'threat appraisal'** did not differ significantly spatially, with an overall low level of threat appraisal (Table 3.5).

The region with neither rare nor frequent disasters (Figure 3.4.a) (3-CUN and 7-RUN) and areas with frequent disasters (1-CUF) presented **high 'coping appraisal'**, whereas the sectors with rare disasters (2-CUR and 6-RUR) presented predominant **low 'coping appraisal'**. In terms of coping response, the findings revealed a **lack of adaptive behaviour,** particularly in sectors 2-CUR and 6-RUR, even though both presented high perceived impacts (Table 3.5). In contrast, sector 1-CUF presented a **predominant protective response**.

Table 3.5 – Variables and indicators distribution over neighbourhoods, disaster frequency, Permanent Preservation Area (APP) and study area sectors. For the 'n', we considered only valid answers. The colours are coded based on the percentage value: lower percentages are represented in white, while higher percentages are depicted in red.

Indicator or Variable / Classes		***Disaster frequency***			***Neighbourhood***		***APP***		***Sector***				
		Frequent	***Rare***	***Not mapped***	***City Centre***	***Revólver***	***Protected***	***Unprotected***	***1-CUF***	***2-CUR***	***3-CUN***	***6-RUR***	***7-RUN***
Number of interviews		9	91	51	79	72	58	93	9	45	18	43	33
Tenure - house and land (owner) (n = 117)	Regular	100.0%	77.9%	87.8%	93.3%	71.9%	65.9%	92.1%	100.0%	97.3%	80.0%	60.7%	92.3%
	Irregular	0.0%	22.1%	12.2%	6.7%	28.1%	34.1%	7.9%	0.0%	2.7%	20.0%	39.3%	7.7%
Perceived impact of the 2020 disaster (n = 133)	No impact	0.0%	4.9%	4.8%	9.1%	0.0%	0.0%	7.3%	0.0%	9.5%	13.3%	0.0%	0.0%
	Minor impact	11.1%	26.8%	69.0%	39.4%	38.8%	19.6%	51.2%	11.1%	31.0%	80.0%	24.3%	63.0%
	Weak impact	22.2%	17.1%	11.9%	18.2%	13.4%	11.8%	18.3%	22.2%	21.4%	6.7%	13.5%	14.8%
	Moderate impact	55.6%	35.4%	11.9%	25.8%	32.8%	43.1%	20.7%	55.6%	28.6%	0.0%	40.5%	18.5%
	Strong impact	11.1%	8.5%	0.0%	6.1%	6.0%	11.8%	2.4%	11.1%	7.1%	0.0%	10.8%	0.0%
	Extreme impact	0.0%	7.3%	2.4%	1.5%	9.0%	13.7%	0.0%	0.0%	2.4%	0.0%	10.8%	3.7%
Prior disaster experience (n = 151)	Average	4.44	1.33	1.53	1.93	1.27	1.38	1.71	4.44	1.4	2	1.28	1.27
	Median	5	1	1	1	1	1	1	5	1	0.5	1	1
	Std.	1.13	1.34	1.95	1.98	1.38	1.25	1.95	1.13	1.57	2.3	1.12	1.78
Theat appraisal (n = 139)	Low	37.5%	52.9%	50.0%	58.7%	44.7%	45.5%	54.8%	37.5%	62.8%	58.3%	43.9%	46.9%
	Neutral	25.0%	25.3%	22.7%	20.6%	27.6%	29.1%	21.4%	25.0%	18.6%	25.0%	29.3%	21.9%
	High	37.5%	21.8%	27.3%	20.6%	27.6%	25.5%	23.8%	37.5%	18.6%	16.7%	26.8%	31.3%
Coping appraisal (n = 131)	Low	28.6%	53.2%	33.3%	40.3%	49.3%	49.0%	42.5%	28.6%	55.3%	11.8%	50.0%	46.4%
	Neutral	28.6%	16.5%	17.8%	24.2%	11.6%	15.7%	18.8%	28.6%	21.1%	29.4%	13.2%	10.7%
	High	42.9%	30.4%	48.9%	35.5%	39.1%	35.3%	38.8%	42.9%	23.7%	58.8%	36.8%	42.9%
Coping response (n = 122)	Non-protective response	42.9%	80.5%	65.8%	78.2%	70.1%	71.4%	75.3%	42.9%	91.9%	54.5%	70.3%	70.4%
	Neutral	14.3%	2.6%	5.3%	3.6%	4.5%	4.1%	4.1%	14.3%	0.0%	9.1%	5.4%	3.7%
	Protective Response	42.9%	16.9%	28.9%	18.2%	25.4%	24.5%	20.5%	42.9%	8.1%	36.4%	24.3%	25.9%

Indicator or Variable / Classes		*Disaster frequency*			*Neighbourhood*		*APP*		*Sector*				
		Frequent	*Rare*	*Not mapped*	*City Centre*	*Revólver*	*Protected*	*Unprotected*	*1-CUF*	*2-CUR*	*3-CUN*	*6-RUR*	*7-RUN*
Number of interviews		9	91	51	79	72	58	93	9	45	18	43	33
Safety classes (n = 124)	State of safety	0.0%	26.3%	71.8%	44.6%	32.2%	8.9%	55.7%	0.0%	39.0%	86.7%	12.1%	62.5%
	State of unsafety	44.4%	34.2%	0.0%	26.2%	22.0%	40.0%	15.2%	44.4%	31.7%	0.0%	36.4%	0.0%
	State of false safety	55.6%	38.2%	20.5%	27.5%	40.7%	51.1%	24.0%	55.6%	26.8%	13.3%	51.5%	25.0%
	State of safety obsession	0.0%	1.3%	7.7%	1.5%	5.1%	0.0%	5.1%	0.0%	2.4%	0.0%	0.0%	12.5%

[2]Minimum wage

Source: Author (2023).

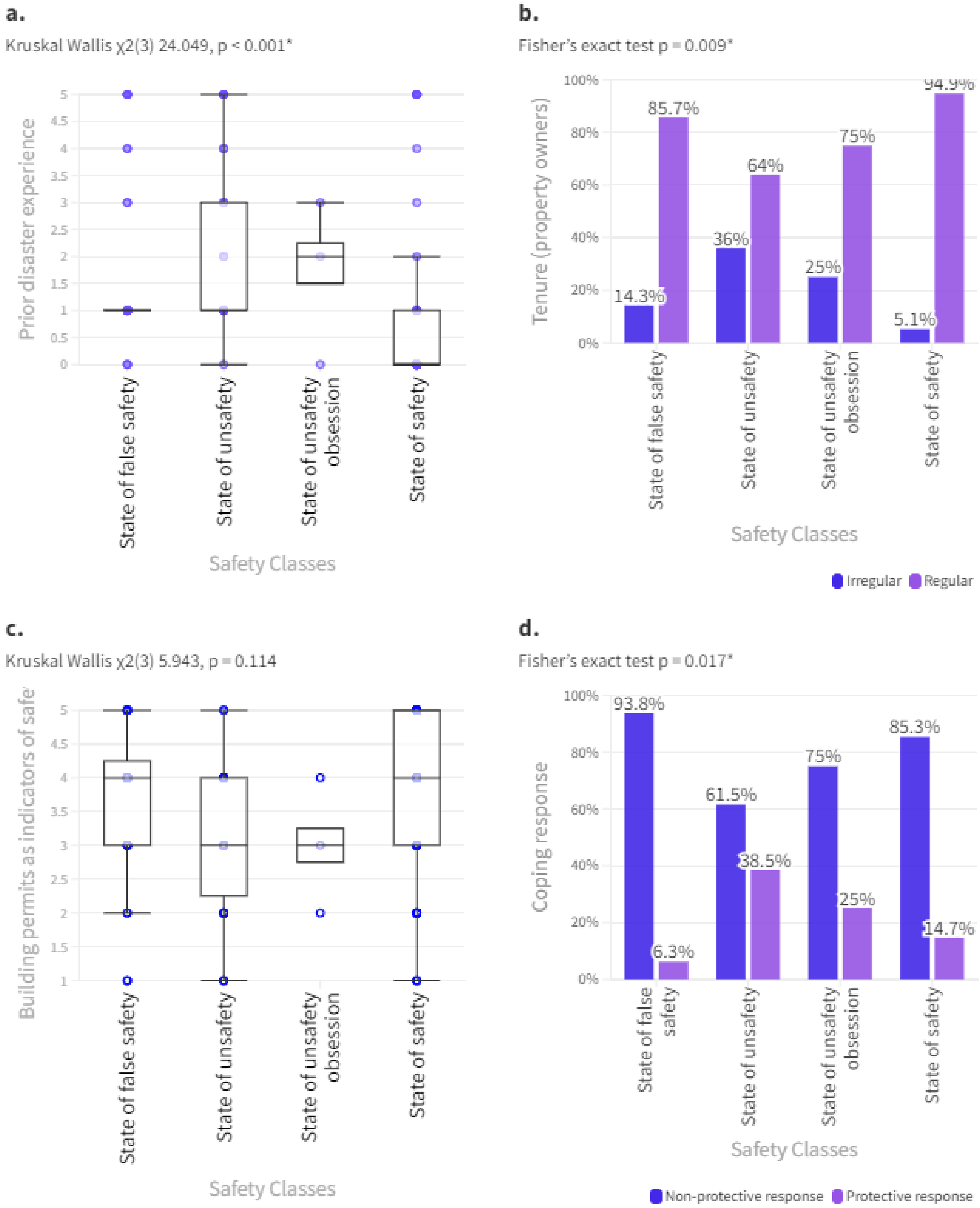
3.5.3 Community members' safety classes and the SDP

Here, we investigated the safety classes (see Table 3.3), which refers to a classification assigned to each participant reflecting their perceived 'sense of safety', and the 'objective safety', determined based on the 2020 disaster-affected areas and frequent disaster regions.

Our results revealed that the majority of respondents fell into the **'state of safety'** class (n = 48, 38.7%), indicating that they felt safe, were not directly affected by the 2020 disaster, and do not reside in risk areas according to official maps (PRESIDENTE GETÚLIO, 2019). Conversely, 33.9% of the respondents (n = 42) were grouped under the **'state of false safety'** class. They reported feeling safe despite residing in hazard-prone areas, suggesting a lack of accurate hazard assessment. Approximately a quarter of the respondents were classified in the **'state of unsafety'** (n = 30, 24.2%), expressing feelings of being unsafe and experiencing hazards, indicating their awareness of the existing risks. Lastly, a small proportion of individuals (n = 4, 3.2%) were classified under the **'state of unsafety obsession'** class. Despite not being exposed to any mapped hazard, these individuals exhibited feelings of unsafety. The limited number of respondents within this class hinders our understanding of its dynamics.

Significant differences in the distribution of the 'safety classes' were found according to the respondents' prior disaster experience' (Figure 3.5a), 'tenure' (Figure 3.5b), 'coping response' (Figure 3.5c), and sectors (Fisher's exact test $\chi 2 = 51.133$; $p < 0.001$). Indeed, respondents with more disaster experiences, with a protective response, or those with irregular tenure tend to accurately assess their safety, reducing the false sense of safety.

Figure 3.5 – Distribution of a. prior disaster experience, b. tenure, c. belief in safety due to building permits and d. coping appraisal across safety classes – state of false safety; state of unsafety; state of unsafety obsession, and state of safety.



*Statistically significant.

Source: Authors (2023).

The majority (58.3%) of those directly affected by the 2020 disaster were classified as being in the 'state of false safety'. Most of these individuals had only experienced the 2020 event, suggesting that this disaster experience alone did not increase their safety assessment accuracy. Instead, they displayed low threat and coping appraisals and the highest level of non-protective behaviour (Figure 14d). They were also more likely to believe that building permits are indicators of safety than those in the ‘state of unsafety’ (Mann-Whitney U = 375.500; p = 0.028), but their belief was similar to those in the "state of safety" (Mann-Whitney U = 783.000; p = 0.791). Therefore, the individuals in the ‘state of false safety’ are a result of the SDP effect, as government actions such as the building permit and the sense of safety based on experiences maintained the narrative of high safety. This is especially evident in sector 6-RUR, which presents a prevalent false sense of safety, non-protective response, and the narrative of being a ‘flood-free’ area (PRESIDENTE GETÚLIO, 1988)

On the other hand, the remaining 41.7% of the directly affected individuals were classified as ‘state of unsafety’. This class was more likely to adopt protective measures against future disaster events among the ‘safety classes’ (Figure 3.5d). They reported unsafety, along with anxiety and concern due to heavy rains, and a higher number of previous disaster experiences (Figure 3.5a). This class was more sceptical of the significance of building permits as safety indicators (Figure 3.5c). They reported limited trust in the government's oversight and assessment capabilities and were concerned that political factors influenced permit issuance. They also reported that the purpose of permits was to increase tax revenue. Additionally, a greater percentage of irregular properties was reported in this class (Figure 3.5b). This could have increased their safety assessment accuracy, as they had to assess the hazards of their properties without any official endorsement or guarantee from the government.

The ‘state of safety’ was the most common response among individuals who had not experienced a direct impact from the 2020 disaster event nor resided in frequent disaster regions (92.3%). These individuals had the lowest number of prior disaster experiences (Figure 3.5a), and their lack of experience may have contributed to their high sense of safety. Additionally, they were more likely to believe that building permits indicate safety. This belief may have emerged or been maintained because they were not subjected to the negative emotions resulting from the direct impact of the disaster (WACHINGER *et al.*, 2013). The ‘state of safety’ was most prevalent in sectors 3-CUN and 7-RUN.

Finally, 3 respondents who implemented structural adaptation (e.g.: raised residences) were classified in the ‘state of false safety’ class, presenting a non-protective response. This contradictory finding aligns with Van Valkengoed and Steg (2019), which indicated that past adaptation measures can reduce individual risk perception and enhance the feeling of safety. For instance, sector 1-CUF presented individuals with a prevalent ‘state of false safety’ and non-protective behaviour, which stemmed from the belief that their raised residences (past adaptations) provided sufficient safety.

3.5.4 LSR's interviews and the SDP

Ten LSRs with an average of 9 years of experience (range = 3-21 years), participated in interviews. Similar to the community members, the LSR shared the belief that the Revólver basin was immune to hydrological disasters, with 60% indicating a low-threat appraisal before the 2020 event. In fact, they attributed the prosperity of the Revólver neighbourhood, among other factors, to this sense of safety. This low-threat appraisal may be attributed to the reduced occurrence of major disasters in the basin. Notably, the LSR seemed to overlook the frequent events occurring at the basin outlet. Furthermore, the LSR reported that the population in the Índios and Krauel flood-prone region (region with recurrent floods) appears to be adapted or prepared to cope with recurring floods as long as they receive an early warning, usually emitted by the municipal civil defence. Most residents (n = 118, 78.1%) reported that there was no early warning for the 2020 event.

In general, the LSR disregarded the possibility of disasters occurring in the basin, even though susceptible areas had been identified (CPRM/IPT, 2015). This perception underwent a drastic shift after the 2020 disaster, which increased the LSRs' threat appraisal. Currently, 70% of the LSRs consider the basin unsafe. The disaster also catalysed disaster risk reduction (DRR) efforts, such as educational campaigns, an updated municipal contingency plan, and notification of landowners inhabiting risky areas.

The LSRs reported that the occurrence of the 2020 disaster was related to limited resources in terms of finances, technical expertise, and personnel. These limitations hampered the effective enforcement of land use and environmental regulations, thereby contributing to a surge in irregular properties. In addition, two LSR attributed the event to the natural phenomena' unpredictability, and one linked the disaster to the emergence of a natural dam during the event, resulting from the inadequate storm drainage system, although this was not previously reported (MICHEL *et al.*, 2021).

In summary, our findings indicate a reactive approach by the local government, primarily driven by a sense of safety rather than a proactive assessment. For instance, hazardous areas were considered safe and left unassessed, contributing to their unrestrictive occupation. Furthermore, the staff shortage and administrative organization may have contributed to the occupation of hazardous areas, as the Municipal Civil Defence, responsible for risk management, operated with just one voluntary staff member until 2023.

3.5.5 Effect of public policies on the SDP

We conducted a document analysis of 35 legislative documents and reports to verify their impact on SDP (Table 3.6). It is important to highlight that the assessed policies present interrelation and dependencies due to the federal framework that stimulates integrated risk management (RODRIGUES, 2020). For instance, the Municipal Master Plan is required to identify areas susceptible to disasters (BRASIL, 2012a), the relaxation of protected riparian areas APP requires the absence of risk areas (BRASIL, 2021b), and land tenure regularization requires the assessment of hazards and risks (BRASIL, 2017).

Table 3.6 – Summary of the policies analysed.

GROUP	GROUP DESCRIPTION
Civil Defence policies (n = 13)	Policies aimed at disaster prevention, reduction, preparedness for, response to, and recovery for civilian safety and security. Policies require integration with a divert of sectorial policies (BRASIL, 2012a). Policies related to the Department of Municipal Civil Defence, Education, Culture and Sports, and Health.
Environmental policies (n = 9)	Policies that address and manage environmental issues and promote sustainable practices to promote sustainable development (BRASIL, 1988). This group also includes policies related to the municipal department of Agriculture, Livestock and Environment, and Water Supply and Sewage Treatment Service.
Territorial planning policies (n = 13)	Policies that aim to establish or modify the spatial organization cohesively and logically (MAFRA; SILVA, 2004). Policies related to the municipal departments of Administration, Planning and Economic Development, and Social Assistance.

For the list of policies, the reader is referred to Appendix 2-VII.

Source: Authors (2023).

In general, the observed key topics consisted of local government policies that have 1) demonstrated misuse and/or lack of effective hazard and risk mapping, 2) reduced regulation of official risk areas occupation and 3) facilitated occupation in susceptible areas. Regarding the first topic, the municipality presented seven risk-related maps between 2013 and 2021, including two named susceptibility maps (CPRM/IPT, 2015; UFSC, 2016); and five named risk maps (CPRM, 2012, 2018, 2021; PRESIDENTE GETÚLIO, 2019; SANTA CATARINA, 2021). However, the risk maps did not consider vulnerability and focused on recurrent or visible events. As a result, these maps can be considered inventories or "stationary mapping" (PRALLE, 2019) and lack comprehensive assessment. They serve more as reactive rather than preventive measures. The official risk map considered only floods and landslides

(PRESIDENTE GETÚLIO, 2019), disregarding other typologies such as debris flow identified by CPRM/IPT (2015). Therefore, exacerbating the local government's misuse of the existing mappings perpetuates the unknown status of the actual risk areas as a comprehensive risk assessment has not been conducted. Furthermore, the incomplete risk mapping potentially allowed unrestricted human settlement in hazardous regions, and might have induced a false sense of safety for map users, as the not mapped areas are perceived as safe (AULIAGISNI; WILKINSON; ELKHARBOUTLY, 2022; PRALLE, 2019)

In regards to the second topic, the municipal regulatory construction guidelines for the mapped risk area offer limited criteria, heavily relying on the subjective judgment of municipal analysts. For instance, the main requirements primarily involve conducting risk assessment studies for land levelling (fill and cut) in areas prone to floods and mass movements (PRESIDENTE GETÚLIO, 2019). Furthermore, the urban zoning was expanded over the 2020 disaster-affected areas, allowing for denser occupation. According to the LSR interviews, the urban expansion was proposed as a solution to increase available urban lots, and reduce informal occupation. Additionally, the expansion was approved by a public hearing (PRESIDENTE GETÚLIO, 2022), indicating lack of change on policies, differently from Freitas *et al*. (2016).

Lastly, the local policies on riparian APP have allowed human settlement in susceptible areas due to a historically flexible environmental regulation compared to federal norms. This controversy is observed in the municipality since the 1988 Municipal Master Plan, which introduced the protected riparian APP with more lenient standards than the federal legislation (BRASIL, 1965, 1979; PRESIDENTE GETÚLIO, 1988). Over time, federal legislation has become more stringent, particularly with the introduction of Federal Law nº 12.651/2012 – named Native Vegetation Protection Law (NVPL) (BRASIL, 2012b), whereas the municipal regulations have consistently adopted less restrictive standards. 2018 the municipality conducted a socio-environmental diagnosis that provided the basis for flexed riparian APP regulation even in the Revólver basin mapped risk areas (PRESIDENTE GETÚLIO, 2018). However, after the 2020 disaster, the municipality adopted the federal regulation, while the new socio-environmental diagnosis incorporates updated maps (CPRM, 2021; SANTA CATARINA, 2021) and adheres to the current federal legislation, which now allows the municipality to implement flexible riparian APP regulations in consolidated urban areas (BRASIL, 2021b). Nonetheless, this controversy is common for most municipalities in Santa Catarina state. According to Locatelli (2020), approximately 20% of municipal regulations on riparian APP comply with federal legislation.

The topics identified in our study played a significant role in shaping the social and constructed environment. The local government actively participated in this process by assessing, approving, and enabling projects based on the municipality's existing risk maps and environmental regulations. As previously discussed, community members perceive government actions, such as issuing building permits, as an indication of safety due to the perceived government's capacity and responsibility to assess potential risks. However, our observations revealed that certain policies made hazardous areas either available or safer for the community members. The local government presented both intentional actions such as the flexibilization of riparian APP, or omission due to lack of effective risk mapping production.

3.6 DISCUSSION

This study found evidence for the occurrence of the SDP within an area without major structural protection measures. By using a mixed-methods approach, we identified the SDP in both individuals and a specific sector of the study area. Similarly to Malecha, Woodruff and Berke (2021), our assessment of the SDP considered not only policies directly aimed at DRR, but also sectorial policies such as environmental and territorial, as these policies can have an impact on societal risk dynamics. We observed that the SDP was influenced by a combination of (1) non-protective response community members, (2) high trust in the government, and (3) weak public policies.

Non-protective responses were prevalent among community members (73.8%), stemming from low threat and coping appraisals. It also emerges from the adoption of comforting feelings such as wishful thinking, denial, or fatalism to deal with perceived threats. Since, these feelings do not increase coping or adapting capacities, and lead to a feedback loop that reduces threat appraisal (BABCICKY; SEEBAUER, 2019). Furthermore, this feedback loop can potentially induce a false sense of safety, as individuals may perceive themselves as safe despite the existence of hazards. These misconceptions may stem from individuals modelling future disaster events based on past experiences and observations, therefore, rare events (high intensity) or different disaster typologies are mostly disregarded (BURNINGHAM; FIELDING; THRUSH, 2008; HOPKINS; WARBURTON, 2015). Consequently, individuals subjected to less predictable events are not likely to adopt preparedness and adaptation measures (KATES, 1962). This behaviour is termed the ‘prison of experience’ (KATES, 1962), and was especially true for the community members who have been affected by a disaster once (Figure 3.5a), as they may perceive disasters as being locked to the regions where they normally occur.

In regards to the high government trust, we found that the majority of the community members (48.6%) believe in the government's capacity to reduce damages from disasters and perceive building permits as indicative of safety. This trust is reflected in the way that people assess their safety, with those in the 'state of false safety' displaying similar levels of trust to those who have not been affected by the 2020 disaster (state of safety), and higher levels of trust than those who have been affected (state of unsafety). This suggests that trust can act as a pillar to maintain people's feeling safe, even in the face of hazards. Since, trust can reduce the complexity of the environment (SIEGRIST, 2019), it can reduce the personal motivation for self-protection (SCOLOBIG; DE MARCHI; BORGA, 2012; WACHINGER *et al.*, 2013). This is similar to other forms of external protection sources such as social capital expectations (BABCICKY; SEEBAUER, 2017) and trust in flood protection structures (FOX-ROGERS *et al.*, 2016). Additionally, high trust can also present adverse effects when policies to promote safety are inadequate, as individuals and society shape the environment based on these policies. On the other hand, government mistrust hampers risk communication strategies and can lead to increased negative consequences. (CISTERNAS *et al.*, 2023; SIEGRIST, 2019).

Lastly, the SDP was influenced by both mitgation measures (risk mappings) and non-intentional measures (land use policies). These weak policies enabled a local government-authorized exposure increase and perpetuated the false sense of safety among residents, exacerbating the influence of both active (lenient environmental and territorial policies) and omissive local government decisions (delay to produce a comprehensive risk assessment) in forming the risk areas. These policies emit a signal of safety, similarly to structural measures. However, while structures provide visible information (BABCICKY; SEEBAUER, 2019), policies (DRR intended or not) can enhance a narrative of safety by authorizing occupation, informing the absence of risks, or not informing at all. In the study area, the narrative of safety was evident and perpetuated by policies, that fostered development as the area was considered mostly "hazard-free", influencing a false sense of safety and therefore the SDP. In addition, the reduced citizen risk perception possibly hampered DRR entrance in the policy agenda, as well as the focus on short-term economic gains avoiding impeding the maximum use of lots (SALVADOR et al., 2022; SUDMEIER-RIEUX et al., 2015).

We highlight the recent empowerment of Brazilian municipalities to define the riparian APP in consolidated urban areas by Federal Law nº 14.285/2021 (BRASIL, 2021b) is a policy that could result in the emergence of the SDP in other municipalities. Along with other threats as presented by Azevedo-Santos *et al.* (2023). Particularly, due to the lack of adequate human and financial resources for formulating sustainable policies, especially in less populated cities (RIBEIRO *et al.*, 2022), and interpreting risk-related products. In addition, smaller administrative policies are more inclined to prioritize economic growth over vulnerability reduction (MALECHA; WOODRUFF; BERKE, 2021).

Therefore, this study highlights the importance of addressing the adverse effects of non-structural measures in DRR. However, our study had some limitations. First, it is cross-sectional, meaning that we captured individuals' coping responses, sense of safety, government trust, and emotions at a specific moment in time and space. However, these factors can change over time due to contextual elements such as health, economic conditions, experience with disasters, and feelings like wishful thinking or denial. For example, the accuracy of risk perception can influence the adoption of preventive policies, and government trust can be influenced by ideological background and shifting political landscapes (MOTTA; ROHRMAN, 2021). To address these limitations, future longitudinal studies on the SDP are encouraged (DI BALDASSARRE *et al.*, 2018a).

A second limitation refers to the predictive power of the threat appraisal element of PMT. Studies have shown that the affective aspect of risk perception (emotions, feelings) is more predictive of behaviour than the cognitive aspect (probability x severity) (BABCICKY; SEEBAUER, 2020; NOLL *et al.*, 2022). We addressed this to some extent, by employing mixed methods, assessing both cognitive and affective aspects.

Lastly, the use of existent disaster mapping presented some limitations in terms of the necessary accuracy of the phenomena. For example, sector 2-CUR presented not affected individuals included in rare disaster regions due to the used mapping. Therefore, we suggest mapping hazards and the phenomena of interest according to the required accuracy, considering the specific context of the study. By recognizing and addressing these aspects, future studies, policymakers and stakeholders can enhance communities' protection from disasters.

3.7 CONCLUSION

Our assessment of the SDP in the Revólver basin found that public policies have the potential to induce the phenomenon. Lenient regulations, a failure to assess hazards and vulnerability, and a narrative of safety from the local government have all led to a false sense of safety and the SDP.

The assessment of the phenomenon presents relevance as we observe the growing relevance of policies in DRR, which is the result of a shifting focus on structural protection measures. However, Policies can present adverse unexpected results, and it is important to assess the full range of potential impacts.

Hence, we propose expanding the concept of the SDP to encompass the assessment of both direct or indirect DRR measures, as well as actions that make areas safer or viable for development. The expansion would enable a holistic assessment of structural and non-structural policies and their influence over socio-hydrological phenomena, and necessary policy feedback to avoid, revert or correct the adverse effects, especially at the municipality level, which is the scale of policy implementation.

The assessment of socio-hydrological phenomena provides insights into the complex relationship between society and the physical system. This information can be used to inform relations that require attention, strengthening, or modification. For example, the observed absence of comprehensive risk assessment and the community members' incorrect safety assessment can be used to inform future policies and risk communication actions. Therefore, the assessment of the phenomena can promote the effective intersectoral incorporation of DRR measures in the context of climate change and the increasing frequency and intensity of extreme events.

3.8 REFERENCES

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4 CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

This study conducted a review of the SDP and the investigation of the phenomenon in a specific study area. The systematic review revealed that the historical approach of flood protection remains dominant in the SDP studies, due to the focus on floods, flash floods and structural measures (specific goal 2). Through the use of a diversity of methods and variables, the studies were able to provide evidence proofing or refuting the phenomena, specifically spatial analysis, surveys and document review (specific goal 1). Through the provided evidence we observed the relevance of surveys as a method to assess individual vulnerability, the presence of a false sense of safety, and coping response. Therefore, surveys provide information on individual behaviours that can mitigate the adverse effects of the SDP (specific goal 2).

In the Revólver basin case study, we observed the emergence of the SDP in the community members and spatialized in one sector of the study area absent of major structural measures (6-RUR) (specific goal 3). Most of the affected individuals by the 2020 disaster presented a false sense of safety and non-protective behaviour, and belief that a similar event would not recur. In addition, the community members presented predominant high government trust, however, local government policies presented a limited assessment of hazards and risks, enabled occupation of hazardous areas, and maintained a narrative of safety (specific goal 4). For instance, the government through action or omission enabled the formation of risk areas. Consequently, in this case study, high government trust may have negative effects, as government-led development was based on limited risk assessment and a common sense of safety.

In contrast to typical applications of the SDP, we examined the potential influence of public policies without major structural measures interplay. Consequently, we observed that not only policies aimed at DRR may influence the phenomena, but policies in general, as they can produce changes in risk dynamics by influencing vulnerability and exposure.

Therefore, this study suggests expanding the concept and assessment of the SDP to encompass interconnected policies. Such an approach would facilitate a comprehensive evaluation of the SDP from multiple perspectives involving different stakeholders and scientific disciplines. This aligns with efforts to promote integrated risk management and foster intersectoral collaboration.

4.2 RECOMMENDATIONS

For future studies over socio-hydrological phenomena, the SDP, and Presidente Getúlio municipality, we recommend:

- To promote new studies to verify the non-structural measures (such as land-use, environmental, risk management, housing policies) influence on the SDP in areas without major structural protection;
- To test the SDP for different hydrological disaster types and multi-hazard risks;
- To conduct studies in different countries in the global South, especially in Latin America, Africa and Asia;
- To address other phenomena, such as the adaptation effect, water injustice, and fixes that backfire to provide a holistic approach to the complexity of the disaster events and to address the Sustainable Development Goals;
- To verify the aspects that increase risk perception and preparedness in areas subjected to the SDP.
- To explore strategies to enhance the protective response and adaptive behaviour, particularly for low-frequency, high-magnitude disaster events.
- To investigate the transition from an adequate sense of safety to a false sense of safety and identify the factors influencing this change.
- To examine the relationship between government trust, sense of safety, and protective response to identify avenues for increasing or decreasing the protective response.
- To consider prior disaster experiences frequency and intensity for risk perception and coping responses assessment (HOPKINS; WARBURTON, 2015; LAUDAN; ZÖLLER; THIEKEN, 2020).
- To assess whether the 2020 disaster event acted as a focusing event (BIRKLAND, 2016), leading to changes in local and regional public policies related to risk management, environment, and land use.
- To explore why local government fostered the narrative of hazardous areas as safe regions. For instance, verify if DRR actions were suppressed by more pressing problems in the agenda, or if actions were not even considered.

In addition, for stakeholders involved in risk, environmental, water resources and land use management, we recommend:

- To promote and strengthen the integration of DRR, environmental, water resources and land use policies, to tackle disaster risk from different fronts and perspectives.
- To develop comprehensive hazard, vulnerability and risk assessments of areas densely occupied or prospected for development expansion. Therefore, promote the development of environmental monitoring and data collection.
- To promote risk communication campaigns within the community based on comprehensive risk assessments, emphasizing risk perception and individual adaptation, with a focus on the most vulnerable segments of society.
- To formulate policies with active community participation and based on comprehensive risk assessments and scientific studies.

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APPENDIX

APPENDIX 1-I – LIST OF THE REVIEWED STUDIES

Table 1 - List of papers by country and methodological approach.

PAPER	TITLE	COUNTRY
1 - Blanchard-Boehm *et al.* (2001)	Should flood insurance be mandatory? Insights in the wake of the 1997 New Year's Day flood in Reno-Sparks, Nevada	USA
2 - Burby (2006)	Hurricane Katrina and the paradoxes of government disaster policy: Bringing about wise governmental decisions for hazardous areas	USA
3 - Collenteur *et al*. (2015)	The failed-levee effect: Do societies learn from flood disasters?	USA
4 - Cutter *et al.* (2018)	Flash Flood Risk and the Paradox of Urban Development	USA
5 - Dahal and Hagelman (2011)	People's risk perception of glacial lake outburst flooding: a case of Tsho Rolpa Lake, Nepal	Nepal
6 - Domeneghetti *et al.* (2015)	Evolution of flood risk over large areas: Quantitative assessment for the Po River	Italy
7 - Ferdous *et al.* (2019)	The levee effect along the Jamuna River in Bangladesh	Bangladesh
8 - Ferdous *et al*. (2020)	The interplay between structural flood protection population density and flood mortality along the Jamuna River Bangladesh	Bangladesh
9 - Fox-Rogers *et al.* (2016)	Is there really "nothing you can do"? Pathways to enhanced flood-risk preparedness	Ireland
10 - Gissing *et al.* (2018)	Flood levee influences on community preparedness: A paradox?	Australia
11 - Haer *et al.* (2020)	The safe development paradox: An agent-based model for flood risk under climate change in the European Union	European Union
12 - Hutton *et al.* (2019)	The levee effect revisited: Processes and policies enabling development in Yuba County California	USA
13 - Leong (2018)	The Role of Narratives in Sociohydrological Models of Flood Behaviors	India
14 - Malecha *et al.* (2021)	Planning to Exacerbate Flooding: Evaluating a Houston Texas Network of Plans in Place during Hurricane Harvey Using a Plan Integration for Resilience Scorecard	USA
15 - Massazza *et al.* (2021)	Recent changes in hydroclimatic patterns over medium Niger river basins at the origin of the 2020 flood in Niamey (Niger)	Niger
16 - Mazzoleni *et al.* (2021)	Water management, hydrological extremes, and society: Modelling interactions and phenomena	Australia
17 - Michaelis *et al.* (2020)	Capturing flood-risk dynamics with a coupled agent-based and hydraulic modelling framework	Italy
18 - Richert *et al.* (2019)	The impact of flood management policies on individual adaptation actions: Insights from a French case study	France
19 - Smits *et al.* (2006)	Changing estuaries, changing views	Netherlands
20 - Starominski-Uehara (2021)	How structural mitigation shapes risk perception and affects decision-making	Australia
21 - Stevens *et al.* (2010)	New Urbanist developments in flood-prone areas: Safe development or safe development paradox?	USA
22 - Toshiharu and Narantsetseg (2019)	Long-term changes in flooding around Gifu City	Japan
23 - Yu *et al.* (2020)	Socio-hydrology: an interplay of design and self-organization in a multilevel world	USA; Bangladesh

Source: Authors (2023).

Table 2 - List of papers by employed methodological approach, methods data type and research design

PAPER	MET. APPROACH	METHOD	DATA TYPE AND VARIABLES CONSIDERED: PRIMARY DATA (PD), SECONDARY DATA – (SD)	RESEARCH DESIGN
1 - Blanchard-Boehm et al. (2001)	Empirical	Survey - Questionnaire with Households – Telephone – samples size: 380; response rate: 0.5184;	PD: Flood Insurance; Previous Flood experience; Risk Perception; Preparedness; Socioeconomic and demographic data;	Quantitative
2 - Burby (2006)	Empirical	Document review - focus on insurance policy effects	SD: Building Code policy; Land use policy; Risk insurance or compensation policy; Risk management policy; Bibliography;	Qualitative
3 - Collenteur *et al*. (2015)	Empirical	Spatial and Demographic analysis	SD: Flood impacts Database; Flood inundation maps; Hydrologic and hydraulic data; Satellite images; Socioeconomic and demographic data;	Quantitative
4 - Cutter *et al*. (2018)	Empirical	Document review - focus on city development;	SD: Building Code policy; Flood inundation maps; Risk insurance or compensation policy; Risk management policy; Bibliography; Socioeconomic and demographic data	Mixed approach
		Social vulnerability index (SoVI)	SD: Socioeconomic and demographic data	
5 - Dahal and Hagelman (2011)	Empirical	Survey - Interview with Households – In-person – samples size: not presented; response rate: 62 responses	PD: Attitude towards flood relief works; Risk Perception; Socioeconomic and demographic data;	Qualitative
6 - Domeneghetti et al. (2015)	Empirical	Damage estimation;	SD: Assets economic value; Flood inundation maps; Socioeconomic and demographic data; Land use maps	Quantitative
		Hydrological analysis;	SD: Digital elevation model - TINITALY/01; Flood inundation maps; Hydrologic and hydraulic data	
		Spatial and Demographic analysis;	SD: Flood inundation maps; Socioeconomic and demographic data; Land use maps	
7 - Ferdous *et al*. (2019)	Empirical	Spatial and Demographic analysis	SD: Flood inundation maps; Levees - Spatial data; Roads - Spatial data; Satellite images - CEGIS; Socioeconomic and demographic data;	Mixed approach
		Survey - Questionnaire with Households and business – In-person – samples sizes: -; responses: 560 and 65, respectively;	PD: Adaptation measures; Attitude towards flood relief works; Previous Flood experience; Protected by structural measures; Risk Perception; Socioeconomic and demographic data; Distance from rivers; Impacts of flooding;	
8 - Ferdous *et al*. (2020)	Empirical	Spatial and Demographic analysis	SD: Flood impacts Database; Flood inundation maps; Satellite images - CEGIS and Landsat; Socioeconomic and demographic data;	Quantitative

PAPER	MET. APPROACH	METHOD	DATA TYPE AND VARIABLES CONSIDERED: PRIMARY DATA (PD), SECONDARY DATA – (SD)	RESEARCH DESIGN
9 - Fox-Rogers *et al.* (2016)	Empirical	Survey - Focus groups with Households – In-person – samples size: 24-48; response rate: 0.75 - 0.375	PD: Attitude towards flood relief works; Risk Perception; Adaptation measures; Preparedness; Previous Flood experience; Protected by structural measures; Responsibilities; Trust; Types of preparedness;	Qualitative
10 - Gissing *et al.* (2018)	Empirical	Private policy analysis.	SD: Environmental policy; Private risk management plans; Risk management policy;	Qualitative
		Survey - Questionnaire with Business – Telephone – samples size: -; responses: 65; and interview with 1 flood consultant and 1 key government officer;	PD: Preparedness; Protected by structural measures; Risk Perception; Flood hazard;	
11 - Haer *et al.* (2020)	Conceptual	Agent-based model	SD: Flood inundation maps; Hydrologic and hydraulic data; Land use; Socioeconomic and demographic data; Economical Data; Protection standards	Quantitative
12 - Hutton et al. (2019)	Empirical	Spatial and Demographic analysis	SD: Flood inundation maps; Land cover change product; Levees - Spatial data; Socioeconomic and demographic data;	Quantitative
13 - Leong (2018)	Empirical	Narrative analysis.	PD: Attitude towards flood relief works; Protected by structural flood relief; Risk Perception SD: Bibliography	Mixed approach
		Survey - Interview with households – In person – Sample Size: -; responses: 50;	PD: Attitude towards flood relief works; Protected by structural flood relief; Risk Perception	
14 - Malecha et al. (2021)	Empirical	Policy network analysis	SD: Environmental policy; Land use policy; Risk management policy; Socioeconomic and demographic data; Transportation; Flood inundation maps	Quantitative
15 - Massazza et al. (2021)	Empirical	Spatial and Demographic analysis	SD: Satellite images - sentinel; Bibliography	Quantitative
		Hydrological analysis	PD: Hydraulic and Hydrological data; SD: Digital terrain model - drone; Hydrologic and hydraulic data; Satellite images - sentinel;	
16 - Mazzoleni *et al.* (2021)	Conceptual	Conceptual modelling - development of equations	SD: Drought awareness; Flood Awareness; Hydrologic and hydraulic data; Per-capita water demand; Socioeconomic and demographic data;	Mixed approach
17 - Michaelis et al. (2020)	Conceptual	Agent-based model;	SD: Socioeconomic and demographic data; Flood damage; Risk Perception; Preparedness; Previous Flood experience;	Mixed approach
		Flood modelling - 2D hydraulic model LISFLOOD-FP	SD: Digital elevation model - SRTM; Hydrologic and hydraulic data;	
18 - Richert et al. (2019)	Empirical	Spatial and Demographic analysis	SD: Risk insurance or compensation policy; Risk management policy; Flood inundation maps	Quantitative

PAPER	MET. APPROACH	METHOD	DATA TYPE AND VARIABLES CONSIDERED: PRIMARY DATA (PD), SECONDARY DATA – (SD)	RESEARCH DESIGN
		Survey - Interview with Households – In-person – samples size: -; responses: 331;	PD: Socioeconomic and demographic data; Adaptation measures; Distance from rivers; Impacts of flooding; Previous Flood experience; Protected by structural measures; Financial compensation;	
19 - Smits et al. (2006)	Empirical	Document review - focus on a mitigation project	SD: Bibliography;	Qualitative
20 - Starominski-Uehara (2021)	Empirical	Survey - Questionnaire with Households – Mail – samples size: 1796; response rate: 0.2611	PD: Attitude towards flood relief works; Financial compensation; Protected by structural measures; Socioeconomic and demographic data; Acceptance of flood damage; Willingness to move out;	Quantitative
21 - Stevens et al. (2010)	Empirical	Development project analysis	SD: Development projects; Flood inundation maps; Land use policy; Risk insurance or compensation policy; Risk management policy;	Mixed approach
		Survey - Questionnaire with Local officers – Mail – samples size: 87; response rate: 0.7586;	PD: Local government perception on policies;	
22 - Toshiharu and Narantsetseg (2019)	Empirical	Flood modelling - iRIC Nays 2D Flood;	SD: Hydrologic and hydraulic data; Land use maps; Topographic maps;	Quantitative
		Spatial and Demographic analysis	SD: Land use maps; Topographic maps;	
23 - Yu *et al.* (2020)	Empirical	Document review - robustness-fragility trade-off and cultural multilevel selection theories	SD: Bibliography;	Qualitative

Source: Authors (2023)

Table 3 - List of papers by employed social theory, spatial scale, and disaster event typology.

PAPER	SOCIAL THEORY(IES) EMPLOYED	SPATIAL SCALE	DISASTER EVENT TYPOLOGY
1 - Blanchard-Boehm et al. (2001)		City	Flood
2 - Burby (2006)		City	Flood, Hurricane
3 - Collenteur *et al*. (2015)		National; City	Flood
4 - Cutter *et al.* (2018)		City	Flash-flood
5 - Dahal and Hagelman (2011)		Waterbody network	Flood - glacial lake outburst
6 - Domeneghetti et al. (2015)		Waterbody network	Flood
7 - Ferdous *et al*. (2019)		Neighbourhood	Flood, riverbank erosion
8 - Ferdous *et al*. (2020)		Neighbourhood	Flood
9 - Fox-Rogers *et al.* (2016)	Protection Motivation Theory (PMT)	City	Flash-flood

PAPER	SOCIAL THEORY(IES) EMPLOYED	SPATIAL SCALE	DISASTER EVENT TYPOLOGY
10 - Gissing *et al.* (2018)		City	Flood
11 - Haer *et al.* (2020)		Continental (EU)	Flood
12 - Hutton et al. (2019)		County	Flood
13 - Leong (2018)		City	Flood
14 - Malecha et al. (2021)		Neighbourhood	Flood, hurricane
15 - Massazza et al. (2021)		Waterbody network	Flood
16 - Mazzoleni *et al.* (2021)		City	drought-to-flood
17 - Michaelis et al. (2020)	Protection Motivation Theory (PMT)	Waterbody network	Flood
18 - Richert et al. (2019)		City	Flash-flood
19 - Smits et al. (2006)		State	Flood
20 - Starominski-Uehara (2021)		City	Flood
21 - Stevens et al. (2010)		National	Flood
22 - Toshiharu and Narantsetseg (2019)		City	Flood
23 - Yu *et al.* (2020)	Robustness- Fragility Trade-Off (RFTO); Cultural Multilevel Selection (CMLS)	Waterbody network	Flood

Source: Authors (2023)

Table 4 - List of papers by employed assessed phenomena (safe development paradox or levee effect), measures considered (structural or non-structural), assessment of the effect of the measures, proof of the phenomena, and policies assessed by the study.

PAPER	PHENOMENA	MEASURES CONSIDERED	STRUCTURAL MEASURES OR NON-STRUCTURAL MEASURES REDUCED DISASTER FREQUENCY	PROOF OR REFUTATION OF THE PHENOMENA	POLICIES ASSESSED BY THE STUDY
1 - Blanchard-Boehm et al. (2001)	Safe development paradox	Structural	Unclear	Confirmed	
2 - Burby (2006)	Safe development paradox	Structural, non-structural	Yes	Confirmed	risk management, risk insurance or compensation, building codes, land use
3 - Collenteur *et al.* (2015)	Levee effect	Structural	Unclear	Confirmed	
4 - Cutter *et al.* (2018)	Safe development paradox	Structural, non-structural	Yes	Confirmed	risk management, risk insurance or compensation, building codes
5 - Dahal and Hagelman (2011)	Levee effect	Structural	Unclear	Confirmed	

PAPER	PHENOMENA	MEASURES CONSIDERED	STRUCTURAL MEASURES OR NON-STRUCTURAL MEASURES REDUCED DISASTER FREQUENCY	PROOF OR REFUTATION OF THE PHENOMENA	POLICIES ASSESSED BY THE STUDY
6 - Domeneghetti et al. (2015)	Levee effect	Structural	Unclear	Confirmed	
7 - Ferdous *et al*. (2019)	Levee effect	Structural	Yes	Confirmed	
8 - Ferdous *et al*. (2020)	Levee effect	Structural	Yes	Confirmed	
9 - Fox-Rogers *et al.* (2016)	Levee effect	Structural	Unclear	Confirmed	
10 - Gissing *et al.* (2018)	Levee effect	Structural, non-structural	Unclear	Confirmed	risk management, environmental management
11 - Haer *et al.* (2020)	Safe development paradox	Structural, non-structural	Yes	Confirmed	
12 - Hutton et al. (2019)	Levee effect	Structural	Unclear	Confirmed	
13 - Leong (2018)	Levee effect	Structural	Unclear	Confirmed	
14 - Malecha et al. (2021)	Safe development paradox	Structural, non-structural	Yes	Confirmed	risk management, risk insurance or compensation, building codes, land use, environmental management, and transportation
15 - Massazza et al. (2021)	Levee effect	Structural	Unclear	Confirmed	
16 - Mazzoleni *et al.* (2021)	Levee effect	Structural, non-structural	Yes	Confirmed	
17 - Michaelis et al. (2020)	Levee effect	Structural, non-structural	Yes	Confirmed	
18 - Richert et al. (2019)	Levee effect	Structural, non-structural	Unclear	Confirmed	risk management, risk insurance or compensation
19 - Smits et al. (2006)	Levee effect	Structural	Yes	Confirmed	
20 - Starominski-Uehara (2021)	levee paradox	Structural	Yes	Refuted	
21 - Stevens et al. (2010)	Safe development paradox	Structural, non-structural	Unclear	Confirmed	risk management, risk insurance or compensation, land use
22 - Toshiharu and Narantsetseg (2019)	Levee effect	Structural	Yes	Confirmed	
23 - Yu *et al.* (2020)	Levee effect	Structural	Yes	Confirmed	

Source: Authors (2023)

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APPENDIX 2-I – CONSENT TERM TO INTERVIEW

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
PROGRAMA DE PÓS-GRADUAÇÃO EM RECURSOS HÍDRICOS E SANEAMENTO AMBIENTAL

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO – TCLE

1. Você está sendo convidado a participar de uma pesquisa intitulada "*PARADOXO DO DESENVOLVIMENTO SEGURO: ESTUDO DE CASO DA CAPACIDADE DE ADAPTAÇÃO A DESASTRES NO MUNICÍPIO PRESIDENTE GETÚLIO - BRASIL"* e está associada ao projeto de mestrado de Emanuel Fusinato, orientado pelo professor Dr. Masato Kobiyama, do Programa de Pós-Graduação em Recursos Hídricos e Saneamento Ambiental.
2. **Objetivo da pesquisa**: A pesquisa tem como objetivo verificar como as políticas públicas vigentes influenciam a capacidade de adaptação da população e a percepção dos desastres hídricos na Bacia do Revólver – Presidente Getúlio – Brasil.
3. **Justificativa da pesquisa**: A pesquisa é justificada pela necessidade de identificar os possíveis efeitos adversos das políticas públicas atuais sob a percepção de risco, capacidade de adaptação e vulnerabilidade de populações sujeitas e dos agentes municipais a risco de desastres hidrológicos.
4. **Participação no estudo:** A sua participação no estudo é voluntária. Ao aceitar participar, você concorda em participará de uma entrevista semiestruturada conforme este termo. O tempo estimado para a realização da entrevista é de aproximadamente 40 minutos.
5. **Esclarecimentos sobre benefícios**: autoconhecimento e reflexão sobre os aspectos de vulnerabilidade e capacidade de adaptação a desastres hidrológicos. E para comunidade, a identificação pontos para aperfeiçoamento das políticas públicas municipais, a fim de promover maior segurança para a população da área de estudos e município. Bem como a garantia no acesso a pesquisa realizada.
6. **Esclarecimento sobre riscos**: No decorrer da pesquisa podem ocorrer riscos de desconfortos emocionais e sociais associados à sua participação como desconforto com alguma pergunta do roteiro de entrevista, cansaço ou aborrecimento sendo resguardado o direito de desistência do consentimento para realização da pesquisa, conforme item IV.3b e item V da Resolução 466/2012. Para minimizar a ocorrência de qualquer evento desfavorável, os voluntários serão questionados após a realização das entrevistas se deseja retirar ou ocultar alguma informação que foi registrada durante a entrevista.
7. Os participantes podem sentir eventual cansaço ou desconforto quanto a duração da entrevista. Logo, um intervalo de descanso será sugerido, caso os participantes manifestem esta necessidade.
8. **Com o intuito de protegê-lo, em termos éticos, vale ressaltar que**: (i) é seu direito desistir, a qualquer momento, da atividade proposta ou retirar seu consentimento de participação; (ii) sua desistência não resultará em nenhum prejuízo na relação com o pesquisador responsável ou com a Instituição desta; (iii) as informações obtidas através desta pesquisa serão confidenciais, portanto, está assegurado o sigilo sobre sua participação, não havendo a identificação de nenhum participante da pesquisa, conforme item IV.3 da Resolução 466/2012; (iv) você não terá quaisquer despesas em decorrência de sua participação, apenas o investimento de parte de seu tempo nas atividades; (v) você pode recusar ou retirar o seu consentimento sem quaisquer penalizações, em qualquer momento, a qual pode se dar

conhecimento por meio do endereço eletrônico: emanuel.fusinato@ufrgs.br conforme item IV.3 d da Resolução 466/2012.

9. **Contato**: Os pesquisadores envolvidos com o estudo são: Dr. Masato Koyiama (pesquisador responsável), e-mail masato.kobiyama@ufrgs.br; Emanuel Fusinato (mestrando), emanuel.fusinato@ufrgs.br.

10. É garantido ao participante da pesquisa quaisquer esclarecimentos com relação às suas características em momento anterior ou durante a sua execução, nos termos do que prevê o item IV,IV.1,IV.2 da Resolução 466/2012.

11. É garantida a entrega de uma via do presente Termo ao participante da pesquisa.

12. Importante esclarecer que os pesquisadores serão os únicos a ter acesso aos dados obtidos por meio do roteiro de entrevista e tomarão todas as providências necessárias para manter o sigilo das informações, mas sempre existe a remota possibilidade da quebra do sigilo, mesmo que involuntário e não intencional cujas consequências serão tratadas nos termos da lei.

13. Os resultados deste trabalho poderão ser apresentados em trabalhos científicos em geral, como encontros, revistas científicas, dissertação e mostrarão apenas os resultados obtidos como um todo, sem revelar seu nome, instituição ou qualquer informação relacionada à sua privacidade.

14. O pesquisador responsável, que também assina esse documento, compromete-se a conduzir a pesquisa de acordo com o que preconiza a Resolução 466/12 de 12/06/2012, que trata dos preceitos éticos e da proteção aos participantes da pesquisa.

Eu ___________________________, li este documento e obtive dos pesquisadores todas as informações que julguei necessárias para me sentir esclarecido e optar por livre e espontânea vontade participar da pesquisa. Assim, manifesto meu livre assentimento em participar, estando totalmente ciente de que caso eu tenha novas perguntas sobre este estudo, ou pensar que houve algum prejuízo pela minha participação, posso contatar a qualquer hora o professor Prof. Dr. Masato Kobiyama, ou o estudante de Pós-Graduação (mestrando) Emanuel Fusinato ou, ainda, o Comitê de Ética e Pesquisa da UFRGS (CEP-UFRGS), nos meios já informados. Desse modo, acredito ter sido suficientemente informado(a) a respeito da pesquisa, ficando claros para mim quais os propósitos do estudo, os procedimentos a serem realizados, as garantias de confidencialidade e de esclarecimentos permanentes em qualquer etapa da pesquisa.

Eu, Emanuel Fusinato, redigi este documento e obtive dos participantes todas as informações para a adequada realização da pesquisa.

________________________________ ________________________________

Emanuel Fusinato
Mestrando

Participante da pesquisa

APPENDIX 2-II - COMMUNITY MEMBERS SEMI-STRUCTURED INTERVIEW

1 Avaliação de Ameaças

1.1 Atualmente você considera sua casa em uma área de risco a desastres de inundação, enxurrada, deslizamento ou fluxo de detritos?

	Sim		Não		Não sabe responder (NSR)

1.2 Quando você se mudou para a atual casa ou construiu a sua casa, você acreditava ou sabia estar dentro ou fora de uma área de risco a desastres de inundação, enxurrada, deslizamento ou fluxo de detritos?

	Sim - sabia que estava dentro de uma área de risco
	Sim - sabia que estava fora de uma área de risco
	Não - não sabia que estava em uma area de risco
	NSR

1.3 Em uma escala de 1 a 5, quão seguro você se sente em sua casa atualmente em relação a desastres de inundação, enxurradas, deslizamentos e fluxos de detritos? Por que?

1	Muito insegura	2	Insegura	3	Neutro	4	Seguro	5	Muito Seguro

____
____
____
____

1.4 Em uma escala de 1 a 5, quanto você acredita que pode ser atingido por um desastre de inundação, enxurradas, deslizamentos e fluxos de detritos nos próximos 5 anos?

1	Impossíve l	2	Pouco possível	3	Neutro	4	Possível	5	Muito Possível

1.5 Você acredita que pode sofrer danos em um desastre de inundação, enxurradas, deslizamentos e fluxos de detritos no futuro? Por quê?

	Sim		Não		NSR		Outro

____
____
____
____

1.6 Em uma escala de 1 a 5, quão severo seriam estes danos?

1	Não severo	2		3		4		5	Muito severo

Observações gerais da seção
____
____
____
____

2 - Experiências passadas com desastres hidrológicos

2.1 Quantas vezes você foi atingido por desastres de inundação, enxurrada, deslizamentos e/ou fluxos de detritos?

____

2.1.1 Qual o ano e o tipo de evento que você já foi atingido?

2.2 Em uma escala de 1 a 5, quão severo foi o último desastre que você sofreu?

[1] Não severo [2] [3] [4] [5] Muito severo

Observações gerais da seção

3 - Aprendizado Observacional

3.1 O que causa os desastres de inundação, enxurradas, deslizamentos e fluxos de detritos?

3.2 Em uma escala de 1 a 5, quanto você concorda com a frase: a frequência dos desastres ligados a chuva está aumentando. Justifique.

1	Discordo muito	2	Discordo	3	Neutro	4	Concordo	5	Concordo Muito

3.3 Como você considera o seu conhecimento sobre perigos, e desastres de origem natural como inundações, enxurradas, deslizamentos e fluxos de detritos?

1	Baixo	2	Médio	3	Alto

3.4 Quais são seus meios de obter informações sobre riscos de desastres (previsão de eventos, como prevenir danos, o que e como fazer durante um evento de desastre) (cursos, redes sociais, conversa com a prefeitura), e quais as fontes (amigos, jornais, influenciadores, governo)?

Meios

	Curso		Redes sociais		Alertas		Conversas		Jornal, TV, Rádio

Outros

Fontes

	Amigos		Governo		Influen ciador		Jornais		Inst. de ensino

Outros

3.5 Você já recebeu alguma informação que o seu terreno estaria em uma área de risco de desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

☐ Sim ☐ Não ☐ NSR ☐ Outro

3.5.1 Se sim, quem lhe informou? (Se não, indicar eventuais observações)

3.6 Caso você precise evacuar a sua casa devido à uma inundação, enxurrada, deslizamento ou fluxo de detritos, você conhece as rotas de evacuação?

☐ Sim ☐ Não ☐ NSR ☐ Outro

3.7 Você conhece os possíveis abrigos que você poderia ir? Se sim, qual?

☐ Sim ☐ Não ☐ NSR ☐ Outro

3.8 Em uma escala de 1 a 5, quanto você concorda que o governo (municipal, estadual, federal) é capaz de reduzir os danos de novos desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

1	Discordo muito	2	Discordo	3	Neutro	4	Concordo	5	Concordo Muito

3.8.1 Quais ações, políticas ou normas que o governo local, estadual ou federal poderia realizar para reduzir os danos de desastres?

3.9 Em uma escala de 1 a 5, quanto você concorda que as leis de ocupação que permitem a ocupação em algumas áreas, proíbe em outros, e indica como as obras e aterros devem ser feitas, podem reduzir de reduzir os danos de desastres de inundação, enxurradas, deslizamentos e fluxos de detritos.

1	Discordo muito	2	Discordo	3	Neutro	4	Concordo	5	Concordo Muito

3.10 Em uma escala de 1 a 5, quanto você concordaria com alguma intervenção inconveniente do governo em seu terreno que ocasionasse a redução de risco de desastres para a comunidade? Como indicar áreas que não possam ser construídas, solicitar alterações na edificação, solicitar a remoção de parte da edificação.

1	Discordo muito	2	Discordo	3	Neutro	4	Concordo	5	Concordo Muito

Observações gerais da seção

4 Preparação para desastres

4.1 A sua casa está preparada para enfrentar de desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

☐ Sim ☐ Não ☐ NSR ☐ Outro

4.2 Quão preparado você se sente para enfrentar desastres de inundação, enxurrada, deslizamento e fluxo de detritos? Em uma escala de 1 a 5.

☐ 1 Não preparado ☐ 2 ☐ 3 Neutro ☐ 4 ☐ 5 Muito preparado

4.2.1 Por que? Casa adaptada, sabe o que deve ser feito, etc.

Observações gerais da seção

5 - Avaliação de enfrentamento

5.1 Você acredita que alguma medida que você possa fazer (como barricadas contra água, elevar os moveis) pode reduzir os danos de desastres de inundação, enxurrada, deslizamento e fluxo de detritos para sua propriedade e para sua família? Por quê? E qual ação ou obra seria?

☐ Sim ☐ Não ☐ NSR ☐ Outro

5.2 Em caso de desastres de inundação, enxurrada, deslizamento e fluxo de detritos você acredita que conseguiria implantar medidas para reduzir danos e para sua propriedade e para sua família? Por quê?

☐ Sim ☐ Não ☐ NSR ☐ Outro

5.3 Você investiria tempo ou dinheiro para tornar sua casa e patrimônio mais resistente a desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

☐ Sim ☐ Não ☐ NSR ☐ Outro

5.3.1 Se sim, quanto você investiria para tornar sua casa e patrimônio mais resistente a desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

5.4 Você investiria tempo e dinheiro em capacitações, cursos ou treinamentos para saber como agir em caso de desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

5.4.1 Se sim, quanto você investiria em capacitações, cursos ou treinamentos para saber como agir em caso de desastres de inundação, enxurrada, deslizamento e fluxo de detritos?

Observações gerais da seção

6 - Desastre de 2020

6.1 Você presenciou o evento de desastre de dezembro de 2020?

☐ Sim ☐ Não

6.2 Você recebeu algum alerta de vizinhos, amigos, governo, rádio sobre a possibilidade de ocorrência do desastre?

☐ Vizinhos ☐ Rádio ☐ Outros
☐ Amigos ☐ Governo ☐ Nenhum aviso

6.3 Você foi afetado pelo desastre de dezembro de 2020? Quais foram os danos de patrimônio (listar itens e R$), humanos, serviços (água, luz e internet), outros

☐ Sim ☐ Não

6.4 Você já reparou e/ou reconstruiu o que foi danificado pelo desastre de dezembro de 2020?

☐ Sim ☐ Não ☐ NSR ☐ Outro ☐ Parcial

6.4.1 Você acredita que o que foi recuperado está:

☐ Mais resistente,
☐ Igual a antes, ou
☐ Menos resistente do que antes de 2020
☐ NSR

6.5 Você recebeu algum apoio financeiro, material ou psicológico após o desastre de dezembro de 2020 (o que, como, e de quem)? Descreva

6.6 Antes da ocorrência do desastre de dezembro de 2020 você se sentia seguro em relação a desastres?

☐ Sim ☐ Não ☐ NSR ☐ Outro

6.7 Você acredita que alguma ação, prática, lei ou similar possa ter influenciado o desastre de 2020?

☐ Sim ☐ Não ☐ NSR ☐ Outro

6.7.1 Se sim, quais, e de que forma?

6.8 Em uma escala de 1 a 5, quanto você concorda com a frase: receber autorização para construir indica que o local é apropriado e seguro para morar.

[ ] 1 Discordo muito [ ] 2 Discordo [ ] 3 Neutro [ ] 4 Concordo [ ] 5 Concordo Muito

6.8.1 Justifique a sua resposta.

6.9 Situação da moradia

[ ] Própria [ ] Aluguel [ ] NSR [ ] Outro

6.10 Seu terreno possui matrícula/escritura?

[ ] Sim [ ] Não [ ] NSR [ ] Outro

6.11 As edificações do seu terreno tem alvará de construção, habite-se?

[ ] Sim [ ] Não [ ] NSR [ ] Outro

6.12 Qual o ano de construção das edificações?

Observações gerais da seção

7 Características sociodemográficas e Localização Geográfica

7.1 Quanto tempo mora nesta casa?

___

7.2 Quanto tempo mora em Presidente Getúlio? Em caso de moradia em outra localidade a menos de 3 anos, indicar endereço aproximado.

___

7.3 Sua naturalidade

☐	Presidente Getúlio	☐	Outros: ___

7.4 Número de moradores na casa

___

7.5 Sua idade?

___

7.6 Sua escolaridade?

☐	Sem Instrução	☐	EF-Inc	☐	EF-C.	☐	EM-Inc	☐	EM-C.
☐	ES-inc.	☐	ES-C.	☐	PG-inc.	☐	PG-C.	☐	NSR

EF – Ensino Fundamental; EM – Ensino Médio; ES – Ensino Superior; PG – Pós Graduação;
Inc – Incompleto; C. – Completo;
NSR – Não soube responder

7.7 Faixa de Renda familiar (R$) SM – Salários Mínimos

☐	<3.636	☐	3.636-6.060	☐	6.060-8.484	☐	8.484-12.120	☐	>12.120
	< 3 SM		3-5 SM		5-8 SM		8-10 SM		>10 SM

7.8 Chefe de família (detalhar, exemplo: casal, um membro do casal com filhos)

___

7.9 Você é parte de algum grupo vulnerável? (idoso, gestante, portador de PCD)

☐	Idoso	☐	PCD	☐	Outros:
☐	Gestante	☐	Crianças	☐	

PCD – Pessoa com Deficiência

7.9.1 Há pessoas vulneráveis no seu grupo familiar? (Idoso, criança, gestante, PCD)

☐	Idoso	☐	PCD	☐	Outros:
☐	Gestante	☐	Crianças	☐	

PCD – Pessoa com Deficiência

Observações gerais da seção

___

___

___

Identificação da Entrevista

Código da entrevista

___

Duração da entrevista

___

Coordenadas geográficas; Rua e nº da casa

Coordenadas geográficas; Rua e nº da casa

APPENDIX 2-III – LOCAL STAKEHOLDERS WITH FORMAL ROLES SEMI-STRUCTURED INTERVIEW

1 - Conhecimento de Conceitos sobre Riscos de Desastre

1.1 Setor/Secretaria/Órgão da Prefeitura Municipal de Presidente Getúlio

___

1.2 Você trabalha na prefeitura a quanto tempo?

___

1.3 Qual o seu município de residência?

☐ Presidente Getúlio ☐ Outro:______________

1.4 Quantas vezes você já presenciou (em casa, no trabalho, voluntariado) inundações, enxurradas, deslizamentos ou fluxos de detritos?

☐ Sim ☐ Não

1.5 Como você considera o seu conhecimento sobre vulnerabilidade, perigo e risco de desastres?

Vulnerabilidade - As condições determinadas por fatores ou processos físicos, sociais, econômicos e ambientais que aumentam a suscetibilidade de um indivíduo, uma comunidade, propriedades ou sistemas aos impactos dos perigos. (UNDRR, 2022)

Perigo - Processo, fenômeno ou atividade humana que pode causar perda de vidas, lesões ou outros impactos à saúde, danos à propriedade, perturbações sociais e econômicas ou degradação ambiental. (UNDRR, 2022)

Risco - risco é o resultado da combinação de três fatores, perigo, vulnerabilidade e exposição (UNDRR, 2022)

Desastre - Interrupção grave do funcionamento de uma comunidade ou sociedade em qualquer escala devido a eventos perigosos que interagem com condições de exposição, vulnerabilidade e capacidade, levando a um ou mais dos seguintes: perdas e impactos humanos, materiais, econômicos e ambientais. (UNDRR, 2022)

☐ Baixo ☐ Médio ☐ Alto

2 - Percepção de Risco (Avaliação de Ameaças) - no Município

2.1 Quais são os principais tipos de desastres/perigos no município?

___

___

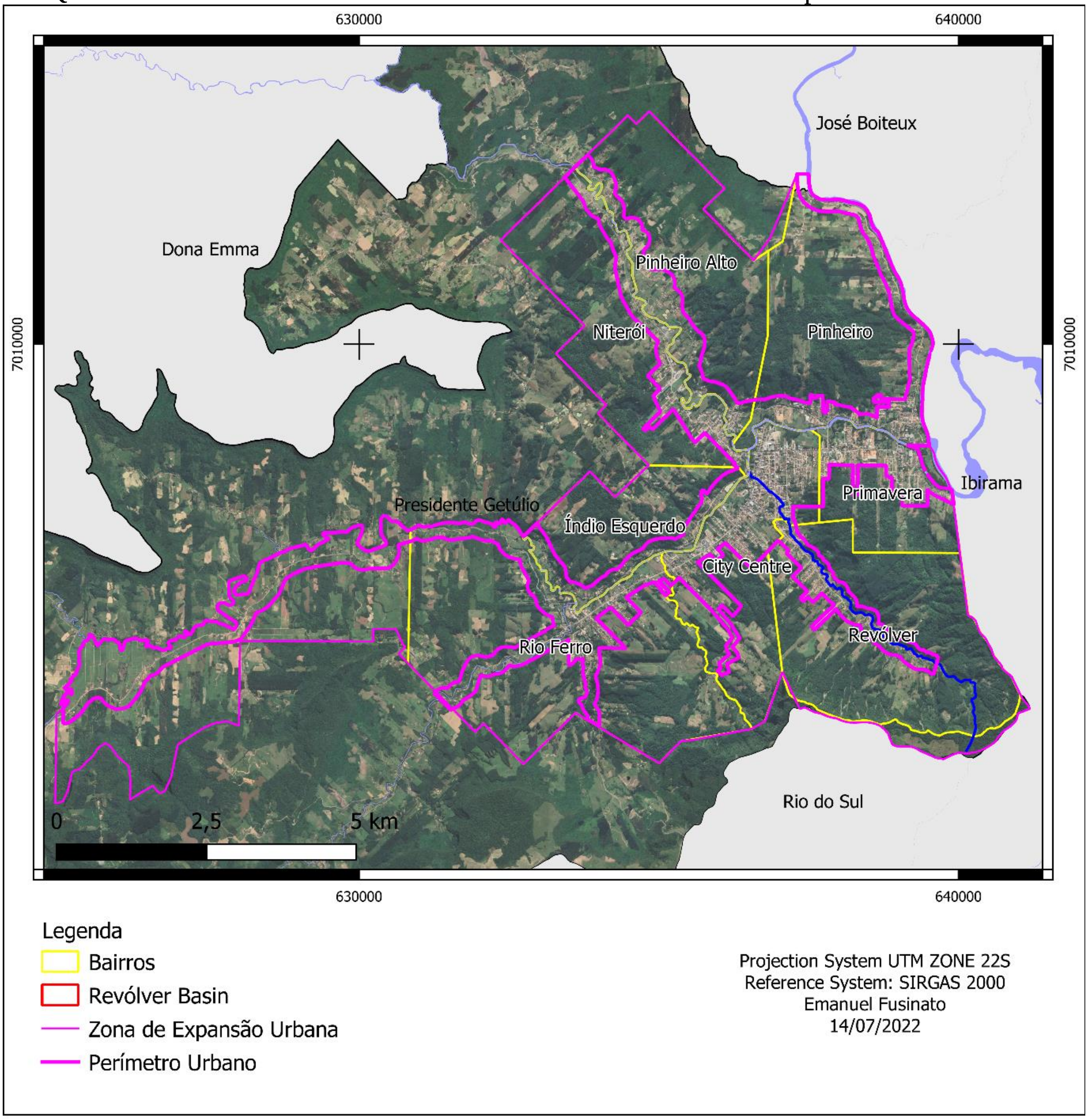
2.1 Qual a probabilidade de o município sofrer com um desastre nos próximos 5 anos, em uma escala de 1 a 5.

☐ 1 Impossível ☐ 2 ☐ 3 Neutro ☐ 4 ☐ 5 Muito possível

2.3 Quão severo você acredita que seriam estes danos? Em uma escala de 1 a 5.

1	Não severo	2	3	4	5	Muito severo

2.4 Quais são as áreas de risco do município? Indicar no mapa.
2.5 Quais são as áreas mais suscetíveis a sofrer danos? Indicar no mapa.



2.6 Em uma escala de 1 a 5 quanto você concorda com a frase: A frequência dos desastres ligados a chuva excessiva está aumentando. Por que?

1	Discordo Muito	2	Discordo	3	Neutro	4	Concordo	5	Concordo Muito

3 - Relação com Desastres e as políticas e ações da secretaria - no Município

3.1 Qual é o papel da secretaria para redução do risco de desastres?

3.2 Quais são as principais normas no município para a redução de risco de desastres? E quais normas, políticas e ações da secretária/órgão/setor para redução de risco de desastres para o município?

3.3 Alguma obra, norma, ação, ou prática pode ser realizada para reduzir danos no caso da ocorrência de eventos naturais danosos?

3.4 De quem é o papel de promover a redução de riscos de desastres?

☐ Governo ☐ População ☐ Ambos

4 - Percepção de Risco (Avaliação de Ameaças) - na Área de Estudos

4.1 A bacia do Ribeirão Revólver (antes de dezembro de 2020) era considerada uma área segura pela secretaria/órgão/setor? Por quê?

☐ Sim ☐ Não ☐ NSR

4.2 Hoje a bacia do Ribeirão Revólver é considerada uma área segura pela secretaria/órgão/setor? Por quê?

☐ Sim ☐ Não ☐ NSR

4.3 Qual a probabilidade da area apresentada sofrer com um desastre nos próximos 5 anos, em uma escala de 1 a 5.

1 Impossível 2 3 Neutro 4 5 Muito possível

4.4 Quão severo você acredita que seriam estes danos? Em uma escala de 1 a 5.

1 Não severo 2 3 4 5 Muito severo

4.5 Em uma escala de 1 a 5, quanto você concorda com a frase: O Bairro Revólver se desenvolveu por acreditar ser uma área segura quanto a desastres. Por que?

1	Discordo Muito	2	Discordo	3	Neutro	4	Concordo	5	Concordo Muito

____

____

5 - Relação com Desastres e as políticas e ações da secretaria - na Área de Estudos

5.1 Há alguma norma, obra, prática ou ação da secretaria para redução de riscos de desastres na bacia do Ribeirão Revólver?

____

____

____

5.2 Alguma obra, prática, norma ou ação pode ter influenciado na ocorrência do desastre de 2020 na bacia do Ribeirão Revólver?

____

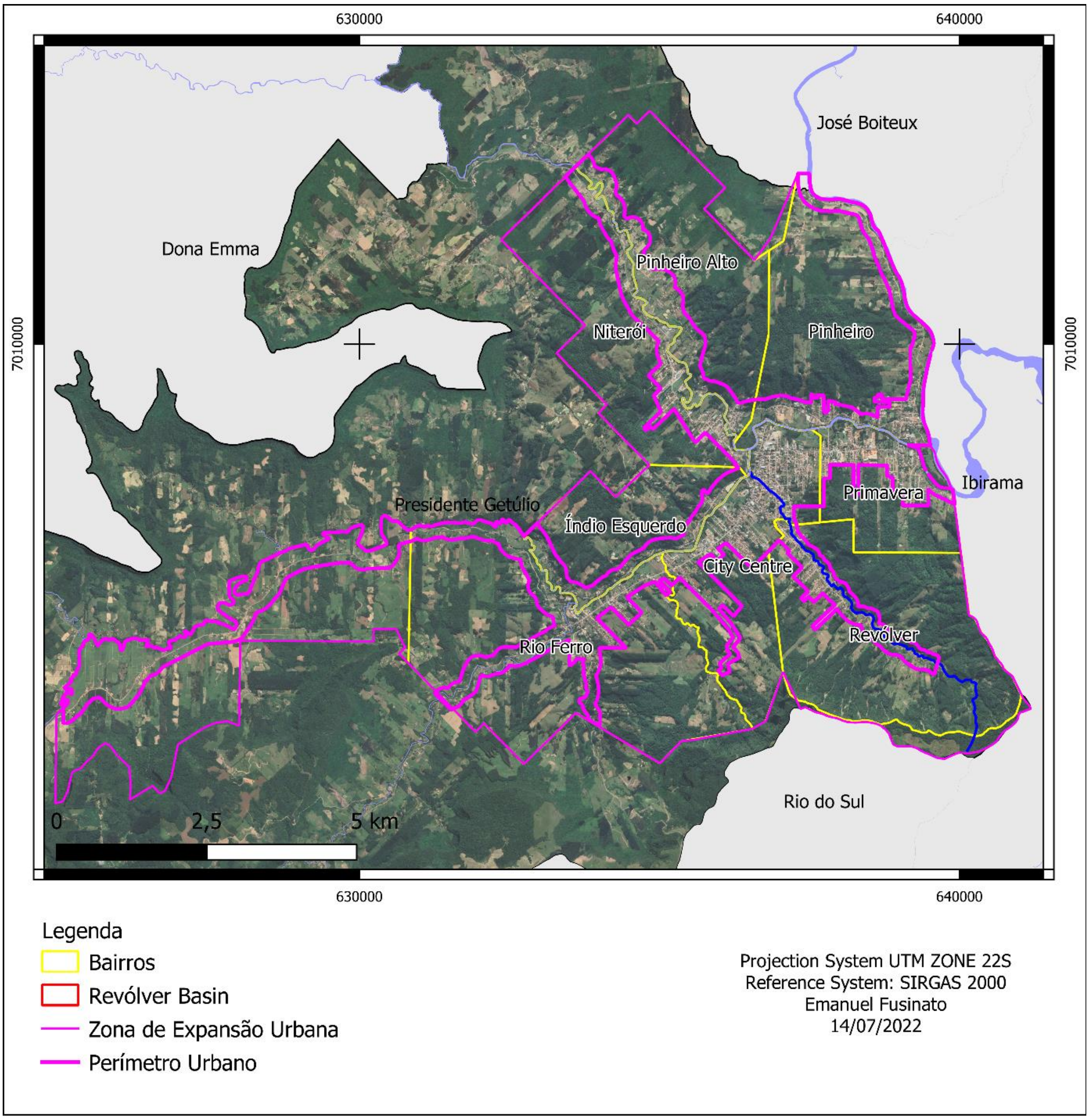
____

____

Apresentação da Área de Estudos

A área de estudos consiste na Bacia Hidrográfica do Ribeirão Revólver. A bacia possui 11,94 km² e localiza-se inteiramente no município de Presidente Getúlio. Suas nascentes localizam-se na Serra Mirador e foz no Rio Índios.

A bacia localiza-se abrange principalmente os bairros Revólver e Centro, e uma pequena parcela do bairro Primavera. A bacia abrange perímetro urbano e rural, mas está totalmente inserida na macrozona urbana (área de expansão urbana). De acordo com os dados do IBGE (2010) a área apresenta aproximadamente 600 domicílios e 1800 habitantes. Em dezembro de 2020 a bacia foi fortemente atingida por um desastre hidrológico.


630000
640000
7010000
José Boiteux
Dona Emma
Pinheiro Alto
Niterói
Pinheiro
Ibirama
Primavera
Presidente Getúlio
Índio Esquerdo
City Centre
Revólver
Rio Ferro
Rio do Sul
0
2,5
5 km
Legenda
Bairros
Revólver Basin
Zona de Expansão Urbana
Perímetro Urbano
Projection System UTM ZONE 22S
Reference System: SIRGAS 2000
Emanuel Fusinato
14/07/2022

APPENDIX 2-IV – PRESIDENTE GETÚLIO MUNICIPALITY DISASTER REGISTER

Presidente Getúlio municipality disaster registers' according to the Ministry of Regional Development (MDR, 2022) and municipal legislation, which resulted in 42 registers of disasters and situations of abnormalities due to hazardous phenomena, ranging from 1975 to July 2023.

The considered documents consisted on municipal decrees of abnormality (emergency and calamity) and the registers in the Regional Development Ministry (MDR), which is responsible for the recognition and providing federal support for response and reconstruction. In the MDR database, we could observe events only registered therefore not submitted to recognition, and recognized disasters.

Table 1 – Presidente Getúlio's disaster registers and summary description from 1975 to July of 2023.

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
Municipal decree: 14/1975 Situation: Emergency MDR: no register	01/10/1975	Hydrological: Flash Flood	Not presented.
Municipal Decree 08/1983 Situation: Emergency MDR: no register	18/05/1983	Hydrological: Flash Flood; Mass movement (wet): Landslide	**Affected Areas**: not presented;
			Human Impact: not presented.
			Material Impact: Public – damage to the transport and drainage system - isolation of communities; Private - damage to farming activities.
			Economic Loss: Not presented.
Municipal Decree: 11/1983 and 10/1983 Situation: Calamity MDR: no register	06/07/1983	Hydrological: Flood; Mass movement (wet): Landslide	**Affected Areas**: not presented;
			Human impact: not presented.
			Material impact: Public - damage to the transport and drainage system - isolation of communities; Private - damage to retail, industry, and farming activities.
			Economic loss: Not presented.
Municipal Decree: 26 and 27/1984 Situation: Calamity MDR: no register	05/08/1984	Hydrological: Flood; Mass movement (wet): Landslide	**Affected Areas:** not presented;
			Human impact: not presented.
			Material impact: Public - damage to the transport and drainage system - isolation of communities; Private - damage to retail, industry, and farming activities.
			Economic loss: Not presented.
Municipal Decree:22a/1988 Situation: Emergency MDR: no register	08/09/1988	Climatological: Drought	Not presented.

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
Municipal Decree: 27/1988 Situation: Emergency MDR: no register	12/10/1988	Meteorological: Storm (hail)	**Affected Areas:** not presented; **Human impact:** not presented. **Material impact:** Public - building damages; Private - damage to farming activities. **Economic loss:** Not presented.
Municipal Decree: 20/1992 Situation: Emergency MDR: only register	29/05/1992	Hydrological: Flood; Mass movement (wet): Landslide	Índios and Krauel flooding; **Affected areas**: not presented; **Human impact:** several people were dislodged. **Material impact**: Public - damage to the transport and drainage systems; Private - damage to residences and for retail, industry, and farming. **Economic loss**: Not presented.
Municipal Decree: 28/1992 Situation: Emergency MDR: no register	01/07/1992	Hydrological: Flood; Mass movement (wet): Landslide	Índios and Krauel flooding; **Affected Areas:** not presented; **Human impact:** a number of people were dislodged. **Material impact:** Public - damage to the transport and drainage systems; Private - damage to residences and retail, industry, and farming activities. **Economic loss:** Not presented.
Municipal Decree: 1/1995 Situation: Emergency MDR: only register	09/01/1995	Hydrological: Flash Flood	Not presented.
Municipal Decree: 45/1995 Situation: Emergency MDR: no register	02/10/1995	Economical	Not presented.
Municipal Decree: 51 e 51a/1995 Situation: Emergency MDR: only register	16/11/1995	Meteorological: Storm (hail)	**Affected Areas**: Urban areas: Mirador, Rio Ferro, Índios Esquerdo, Revolver; Rural areas: Serra São José, Caminho Helvécia, Santa Rosa, Distrito Mirador, Ribeirão da Onça, Rio Ferro, Índios Esquerdo, Ribeirão Paca, Revolver, Jacutinga, Rio Krauel, Tamanduá, Urú, Leão, Boa Vista, Quadro Novo, **Human impact**: not presented **Material impact**: Public - not presented; Private - residences, agricultural and livestock properties damages, as well as, production damages. **Economic loss:** Not presented.
Municipal Decree: 7/1996 Situation: Emergency MDR: only register	05/02/1996	Hydrological: Flash Flood; Mass movement (wet): Landslide	**Affected Areas**: Rural area: São João, Caminho Helvecia, Santa Rosa, Serra dos índios, Caminho Papanduva, Caminho do Bico, Tatete, Ribeirão da Onça, São José, Caminho Helvécia, Serra dos Índios,

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
			Human impact: not presented.
			Material impact: Public - damage to transport and drainage system; Private: damage to agricultural and livestock production
			Economic loss: Not presented.
Municipal Decree: 4/1997 Situation: Emergency MDR: only register	31/01/1997	Hydrological: Flash Flood; Mass movement (wet): Landslide	**Affected Areas**: Not presented.
			Material impact: Public - damage to the transport and drainage systems; Private - not presented.
			Economic loss: Not presented.
Municipal Decree: 26/1997 Situation: Emergency MDR: no register	14/07/1997	Economical	Not presented.
Municipal Decree: 1/1998 Situation: Emergency MDR: only register	02/01/1998	Hydrological: Flood; Mass movement (wet): Landslide	**Affected Areas**: Urban area and rural area;
			Human impact: not presented.
			Material impact: Public - damage to the transport and drainage systems; Private - residences damages
			Economic loss: Not presented.
Municipal Decree: 79/2001 Situation: Emergency MDR: only register	30/09/2001	Hydrological: Flood	**Affected Areas**: Urban and rural areas;
			Human impact: 2110 people were directly affected.
			Material impact: Public - damage to the transport, drainage, and telephonic system. Interruption of educational activities. Private - destruction of residences.
			Economic loss: Not presented.
Municipal Decree: 113/2002 Situation: Emergency MDR: only register	21/11/2002	Hydrological: Flood; Mass movement (wet): Landslide	**Affected Areas**: Urban and Rural areas;
			Human impact: 41 people were directly affected - 21 people dislodged or unsheltered.
			Material impact: Public - damage to transport systems, with isolation of communities; Private - 4 houses were flooded.
			Economic loss: Not presented.
Municipal Decree: 144/2003 Situation: Emergency MDR: only register	11/12/2003	Hydrological: Flash Flood;	**Affected Areas**: Urban area and rural area;
			Human impact: not presented.
			Material impact: Public - interruptions on the electrical system, damages to the transport system (especially bridges); Private - damages to residences, and agricultural and livestock production
			Economic loss: Not presented.
Municipal Decree: 9/2004	01/03/2004	Climatological: Drought;	**Affected Areas**: not presented;
			Human impact: Not presented

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
Situation: Emergency MDR: disaster recognized			**Material impact:** Public - not presented; Private - farming activities damage.
			Economic loss: Not presented.
Municipal Decree: 36/2005 Situation: Emergency MDR: disaster recognized	16/03/2005	Climatological: Drought	**Affected Areas**: not presented;
			Human impact: Not presented
			Material impact: Public - not presented; Private - damage to farming activities; lack of water for human needs in rural areas.
			Economic loss: Not presented.
Municipal Decree: 90/2005 Situation: Emergency MDR: no register	13/09/2005	Meteorological: Storm	**Affected Areas**: not presented;
			Human Impact: Not presented
			Material impact: Public - damage to the transport and drainage systems; Private - damage to agricultural economical activities and properties
			Economic loss: Not presented.
Municipal Decree: 28/2006 Situation: Emergency MDR: disaster recognized	02/05/2006	Climatological: Drought	**Affected areas**: not presented;
			Human impact: Not presented
			Material impact: Public - Not presented; Private: damage to farming activities
			Economic loss: Not presented.
Municipal Decree: 62/2006 Situation: Emergency MDR: disaster recognized	28/07/2006	Meteorological: Storm (hail)	**Affected areas**: not presented;
			Human impact: Not presented
			Material impact: Public - not presented; Private - damage to residences, retail and farming buildings, as well as loss of economic activities
			Economic loss: Not presented.
Municipal Decree: 89/2007 Situation: Emergency MDR: only register	22/07/2007	Hydrological: Mass movement (wet): Landslide;	**Affected Areas:** 4 residences on Revólver Neighbourhood - Rudolfo Evers and Diomira Censi streets;
			Human impact: 15 people were directly affected.
			Material impact: Public - not presented; Private - damage to residences
			Economic loss: Not presented.
Municipal Decree: 86/2008 Situation: Emergency MDR: no register	13/08/2008	Hydrological: Mass movement (wet): Landslide	**Affected Areas**: Rural area: Serra dos Índios;
			Human impact: not presented.
			Material impact: Public - damage to transport system; Private - not presented
			Economic loss: Not presented.
Municipal Decree: 134/2008 Situation: Emergency MDR: only register	22/11/2008	Hydrological: Flash Flood	River Indios and Krauel floods, due to high precipitation;
			Affected Areas: Urban area: Pinheiro, City Centre, Niterói;

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
			Rural area: Serra Vencida, São José, Caminho Helvecia, Santa Rosa, Serra dos Indios, Papanduva, Caminho do Bico, Ribeirão da Onça, Caminho da Paca, Caminho Leão, Caminho Tamanduá, Quadro Novo, Caminho Floresta.
			Human impact: not presented
			Material impact: not presented
			Economic loss: Not presented.
Municipal Decree: 176/2009 Situation: Emergency MDR: disaster recognized	26/09/2009	Hydrological: Flash Flood	Not presented.
Municipal Decree: 258/2009 Situation: Emergency MDR: no register	26/12/2009	Hydrological: Flash Flood	Not presented.
Municipal Decree: 44/2010 Situation: Emergency MDR: disaster recognized	22/04/2010	Hydrological: Flash Flood	River Indios and Krauel floods, due to high precipitation;
			Affected Areas: Urban area: City Centre, Niterói, Pinheiro; Rural Area: Mirador, São José, Serra dos Indios, Caminho Papanduva, Serra Vencida, Urucurana, Serra do Tucano, Caminho Peroba, Caminho Helvecia, Barra da Jucutinga, Canelinha, Caminho da Paca, Quadro Novo, Boa Vista.
			Human impact: not presented
			Material impact: not presented
			Economic loss: Not presented.
Municipal Decree: none/2010 Situation: Emergency MDR: only register	28/12/2010	Hydrological: Flash Flood	Not presented.
Municipal Decree: 6/2011 Situation: Emergency MDR: disaster recognized	16/01/2011	Hydrological: Flash Flood	Highly concentrated precipitation over the urban area, with strong winds;
			Affected Areas: Part of the urban area
			Human impact: not presented
			Material impact: not presented
			Economic loss: Not presented.
Municipal Decree: 90/2011 Situation: Emergency MDR: no register	30/08/2011	Hydrological: Flash Flood	Not presented.
Municipal Decree: 94/2011 Situation: Emergency MDR: no register	06/09/2011	Hydrological: Flash Flood	**Affected Areas**: The entire city;
			Human impact: not presented.
			Material impact: Public - damages on transport, water supply, energy supply and communication system.
			Economic loss: Not presented.

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
Municipal Decree: 101/2013 and 102/2013 Situation: Emergency MDR: disaster recognized	20/09/2013	Hydrological: Flash Flood; Mass movement (wet): Landslide	Flash flood on Índios and Krauel rivers;
			Affected Areas: Rural areas: Ribeirão Ferro, Rural Mirador; Urban areas: Rio Ferro, Niterói, City Centre, Urban Mirador.
			Human impact: 208 people were directly affected - residents were directed to shelters.
			Material impact: Public - Damage to public infrastructures - sewage, electricity distribution, transport system. Interruption of essential educational services. Private - Damage to industrial, agricultural, livestock, and retail properties and production.
			Economic loss: Not presented.
Municipal Decree: 79/2014 and 80/2014 Situation: Calamity MDR: disaster recognized	05/06/2014	Hydrological: Flash Flood; Mass movement (wet): Landslide	Flash floods on the main rivers and streams of the city;
			Affected Areas: Urban area: City Centre, Revolver, Niterói, Rio Ferro, and Mirador;
			Rural Area: Ribeirão Revolver, Ribeirão Tucano, Ribeirão Ferro, Serra Vencida, Urucurana, Serra do Tucano, Caminho Helvecia, São José, Serra dos Indios, Caminho Papanduva, Caminho do Bico, Santa Rosa, Jucutinga, Ribeirão da Onça, Ribeirão Tatete, Lagarta, Ribeirão da Paca, Canelinha, Mirador, Caminho Leão, Indio Esquerdo, Tamanduá, Ribeirão Uru, Quadro Novo, Boa Vista, Pinheiros Alto, Caminho Caçador, Rio Krauel, Floresta,
			Human impact: 3750 people directly affected - 937 dislodged or unsheltered.
			Material impact: Public - damage to the rain drainage system, transport system (especially bridges) - isolation of communities, interruption of essential services such as education, health, water, and garbage collection; Private - damages to residences, industrial, retail, agricultural and livestock properties and production.
			Economic loss: Not presented.
Municipal Decree: 105/2015 Situation: Emergency MDR: disaster recognized	22/10/2015	Hydrological: Flash Flood	Flash flood on Índios and Krauel rivers;
			Affected Areas: Rural areas: Caminho Papanduva, Serra dos Indios, São José, Santa Rosa, Caminho Helvécia, Caminho Peróba, Serra Vencida, Serra do Tucano, Urucurana, Ribeirão Sabia, Jacutinga, Ribeirão da Onça, Ribeirão Tatete, Mirador, Lagarta, Ribeirão da Paca, Tamandua, Caminho Leão, Ribeirão uru, Indio Esquerdo, Quadro

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
			novo, Boa vista, Pinheiro Alto, Caminho Caçador, Krauel II, Ribeirão Ferro e Ribeirão Tucano; Urban areas: Rio Ferro, Niterói, Revolver, Pinheiro, City Centre, Mirador.
			Human impact: 4680 people were directly affected - 200 were directed to shelters, and 482 were dislodged.
			Material impact: Damage to public infrastructures, interruption of essential educational and health services. Damage to industrial and agricultural production and properties. Road system blockages. Also damage to retail
			Economic loss: Public - R$ 1,84 mi; Private - R$ 12,90 mi
Municipal Decree: 88/2018 Situation: Emergency MDR: no register	21/05/2018	Economical	Not presented.
Municipal Decree: 58/2020 Situation: Emergency MDR: disaster recognized	17/03/2020	Biological: Epidemic: Viral Infectious Diseases	Not presented.
Municipal Decree: none/2020 Situation: Emergency MDR: disaster recognized	30/06/2020	Meteorological: Storm (strong winds)	Not presented.
Municipal Decree: 262/2020 Situation: Calamity MDR: disaster recognized	16/12/2020	Hydrological: Flash Flood; Mass movement (wet): Landslide	River Revólver, Ferro, Indios and Krauel floods, due to high precipitation;
			Affected Areas: Urban area - totally affected, especially: City centre, Revólver, Niteroi, Rio Ferro, Rural area - totally affected.
			Human impact: 14890 people directly affected - 171 people directed to shelter, 1600 dislodged, 12 injured; 18 deaths.
			Material impact: Public - partial destruction of utility systems (water, sewage, electricity); severe damage to public buildings, and fleet. Private - total destruction of houses, industrial buildings, damage to retail, agriculture, livestock and industrial properties
			Economic loss: Public - R$ 5,37 mi; Private - R$ 29,23 mi
Municipal Decree: none/2021 Situation: Emergency MDR: disaster recognized	27/04/2021	Biological: Epidemic: Viral Infectious Diseases	Not presented.
Municipal Decree: none/2022	04/05/2022	Hydrological: Flood	**Affected Areas**: Urban areas: City Centre, Niterói, Pinheiro;

DOCUMENT	DATE	DISASTER TYPOLOGY	DESCRIPTION
Situation: Emergency MDR: only register			**Human impact**: 69 people were directly affected - 20 were directed to shelters, and 49 were dislodged.
			Material impact: not presented;
			Economic loss: Not presented.

Source: Authors (2023)

REFERENCES

MDR - MINISTÉRIO DO DESENVOLVIMENTO REGIONAL. **Sistema Integrado de Informações sobre Desastres**. [S. l.], 2022. Available: https://s2id.mi.gov.br/. Accessed on: 30 jul. 2023.

APPENDIX 2-V – VARIABLES CONSTRUCTION

PERCEIVED IMPACT OF THE 2020 DISASTER

To evaluate the impact, an analysis was conducted based on the population and building impact classes, as outlined in the study by Diakakis *et al.* (2017). Other categories such as vegetation, pollution, geomorphology, transportation and utilities, and effects on mobile objects were excluded as they mainly pertain to the overall impact of the disaster. To determine the 2020 impact classification, the highest severity class of human and patrimonial impact for each individual was taken into account.

Table 1 – Human and patrimonial impact severity classes.

SEVERITY CLASS	HUMAN IMPACT	PATRIMONIAL/PROPERTY IMPACT
0 – No impact	No related impacts	No related impacts
1 - Minor impacts	Daily commute / everyday activities affected	Yard / Garden / Pilotis suffer inundation. Minor cracks occur on yard walls and fences. Minor damages by absorbed moisture on walls. Damages only outside the residence.
2 - Weak impacts	House or business affected by flood and related psychological issues	The residence suffers minor flooding (usually <20 cm) causing minor damages to household furniture, utensils or equipment. damages on walls, garage doors, and floor tiles. Yard walls and fences suffer significant damage.
3 - Moderate impacts	Evacuation needed / Injuries / Rescues / /Individuals under risk, emergency or entrapment	The residence suffers flooding (usually <180 cm) that causes significant or complete damage to household utensils or equipment, including wall and floor tiles, and door and window frames. Slight crevices appear in supporting elements
4 - Strong impacts	Fatalities 1–10 locally	Complete damage of household utensils or equipment by flooding (usually > 180 cm). Major crevices or holes, settlements, deformations or partial collapses appear in supporting walls or slabs. Replacement of supporting elements required.
5 - Extreme impacts	Over 10 fatalities locally	Significant damage with the structural collapse of supporting walls, slabs, leading to the collapse of the building or major parts of the building. Demolition of the building is required.

Source: Adapted from (DIAKAKIS *et al.*, 2017)

SAFETY CLASSES

The safety classes indicator represents the relationship between an individual's subjective sense of safety and the real or objective safety, determined by experts (GROMEK, 2021). To evaluate the participants' sense of safety, we requested each respondent to rate their perceived level of safety on a scale ranging from 1 (unsafe) to 5 (safe) about the potential hydrological hazards, along with justifying their rating. For neutral responses (rated as 3), we conducted a qualitative analysis to further investigate and reclassify them as either unsafe, safe, or neutral. Responses expressing fear or worry were reclassified as feeling unsafe, whereas those indicating trust, hope, or optimism were reclassified as feeling safe. Inconclusive responses were categorized as neutral and disregarded.

Real safety is established as the expert delimitation of safety (GROMEK, 2021). Therefore, we considered the 2020 event's direct impact according to interview answers. Direct impact consisted of respondents who presented patrimonial severity impact classification equal and higher than 1 (presented damages in the property but only outside the residence itself). We did not utilize the existent risk-related maps or 2020 disaster reports since they either overestimated or underestimated the flood-affected area. In addition, we verified individuals inserted in frequent disaster areas, according to the municipality's official risk maps before 2020 (PRESIDENTE GETÚLIO, 2019). Therefore, we avoided classifying an individual not affected by the 2020 disaster event but in a frequent disaster area as safe.

According to Gromek's approach, we adapted safety classes that captured different perceptions of safety among participants. These classes included:

- state of safety: for individuals who perceived themselves to be safe and were not affected by the 2020 disaster or were not living within mapped risk areas;
- state of false safety: for individuals who believed they were safe but were affected by the 2020 disaster or living within mapped risk areas;
- state of unsafety obsession: for individuals who believed they were unsafe but were not affected by the 2020 disaster or were not living within mapped risk areas; and
- state of unsafety: for individuals who perceived themselves to be unsafe and were affected by the 2020 disaster or were living within mapped risk areas.

To verify the incidence of SDP, it was assessed both safety classes and coping responses in each of the study area sectors. Further research was to verify the influence of public policies on safety feeling, especially the false sense of safety. Therefore, questions related to the government's potential for disaster risk reduction were observed, both in terms of policies and action.

- (Q3.8) On a scale of 1 to 5, how much do you agree that laws of occupation that allow occupation in some areas, prohibit it in others, and indicate how works and embankments should be made, can reduce the damage of flooding, flooding, landslides and debris flows disasters? (Quantitative)
- (Q3.8.1) What actions, policies, or regulations could the local, state, or federal government implement to reduce the damages of disasters? (Qualitative)
- (Q3.9) On a scale of 1 to 5, how much do you agree that the government is capable of reducing the damage of new flooding, flash floods, landslides and debris flows? (Quantitative) Spontaneous observations (Qualitative)
- (Q6.8) How much do you agree with the statement: having received authorization to build indicates that the location is suitable and safe to live in? (Quantitative) Justify the answer (Qualitative).

PROTECTION MOTIVATION THEORY VARIABLES

To assess the components of the Protection Motivation Theory (PMT), we developed indicators for threat appraisal, coping appraisal, and coping response based on interview responses.

For the determination of threat appraisal, we employed a mixed-methods approach incorporating both quantitative and qualitative elements. Perceived probability and severity were quantitatively evaluated through the diagram.

Table 2 – Community members' interview questions employed for the threat appraisal indicator and diagram.

Perceived probability	• How likely do you believe you will be affected by hydrological disasters in the next 5 years, on a scale of 1 to 5? (5 very likely, 1 impossible)
Perceived severity	• Do you think you could suffer damages due to a hydrological disaster? If so, why? On a scale of 1 to 5, how severe do you think these damages would be? (5 very severe, 1 no damage)

		Perceived probability		
		Low (1-2)	Neutral (3)	High (4-5)
Perceived severity	Low (1-2)	Low	Low	Medium
	Neutral (3)	Low	Medium	High
	High (4-5)	Medium	High	High

Source: Author (2023)

Additionally, cases classified as medium were subjected to a qualitative analysis. Within this analysis, medium cases exhibiting certain characteristics were reclassified as low threat appraisal. These characteristics included denial of the possibility of a future disaster, the belief that no actions could be taken to mitigate future damages, minimization of potential disaster consequences, and considering one's home as a safe place despite being impacted by the 2020 disaster. On the other hand, if a case demonstrated verification of unsafety in regards to disasters and a fear of future disasters, it was reclassified as high threat appraisal. Inconclusive cases remained as medium threat appraisal.

The second PMT indicator coping appraisal was structured considering three factors: response efficacy, self-efficacy, and response cost. In our study, response cost was considered a positive variable for coping appraisal, as it reflected the willingness to invest in protection and preparedness. To assess threat appraisal, we employed a quanti-qualitative approach.

The coping response indicator was categorized into three levels: high, medium, and low. Cases were classified as having a high coping response when they exhibited positive response efficacy, self-efficacy, and response cost (both structural and non-structural). We also included cases where individuals showed negative responses to structural investment but had recently made investments. On the other hand, a low coping appraisal was associated with negative response efficacy, self-efficacy, and response cost. Cases that did not fit into the high or low categories but had one or two negative elements were assigned a neutral coping appraisal. For these cases, we conducted a qualitative assessment based on descriptive responses and reclassified the answers as low, high, or neutral coping appraisal. Therefore, a low coping appraisal was attributed to cases indicating a lack of response or risk mitigation capability due to health conditions or age, expressions of fatalism, or insufficient time or knowledge to promote mitigation or preparedness. A high coping appraisal was attributed when existing adaptations were indicated. Cases remained classified as neutral coping appraisal when they did not provide conclusive descriptive answers or indicated that no further adaptations or measures were deemed necessary.

Table 3 – Community members' interview questions employed for the coping appraisal indicator.

Response efficacy	• Do you believe that any measures you can take (such as barricades against water, or elevating furniture) can reduce the damage from floods, flash floods, landslides, and debris flow to your property and family? (Yes/No) Why? What action would it be? (Descriptive)
Self-efficacy	• In the event of floods, flash floods, landslides, and debris flow, do you believe you could implement measures to reduce damage to your property and family? (Yes/No) Why? (Descriptive)
Response cost	• Would you invest time or money to make your home and property more resistant to flooding, flash floods, landslides, and debris flow? How much? (Yes/No) • Would you invest time or money in training courses or training to know how to act in case of flooding, flash floods, landslides, and debris flow? How much? (Yes/No)

Source: Author (2023)

Finally, based on threat appraisal and coping appraisal, the coping response can be categorized as either protective or non-protective. A protective response is exhibited when an individual perceives a high or neutral level of threat and also possesses a high or neutral level of coping appraisal, consistent with Bubeck et al. (2012) findings. In this case, the individual weighs the potential benefits of acting and responds in a manner that mitigates the perceived risk. This protective response requires a belief in their ability to avoid the risk (coping appraisal), coupled with a high threat appraisal. Conversely, a non-protective response is characterized by a low level in at least one component, such as low coping ability and high threat perception or high coping ability and low threat perception.

Table 4 – Classification of coping responses based on the combination of threat appraisal and coping appraisal.

Protective response	High coping appraisal + High threat appraisal High coping appraisal + Neutral threat appraisal Neutral coping appraisal + High threat appraisal
Non-protective response	Low coping appraisal + Low threat appraisal Low coping appraisal + High threat appraisal High coping appraisal + Low threat appraisal Low coping appraisal + Neutral threat appraisal Neutral coping appraisal + Low threat appraisal

Source: Author (2023)

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APPENDIX 2-VI – STATISTICAL CHARACTERIZATION OF THE SAMPLE AND COMPARISON OF GROUPS ACROSS DIFFERENT VARIABLES

SAMPLE AND POPULATION COMPARISON

In the table, we present a comparison of the community member sample and the population of the census tract intersected by the study area. However, some data were only available at the municipality level.

Table 1 – Summary of community members' characterisation, in which std. stands for standard variation, and V.A. for valid answers.

VARIABLE OR INDICATOR			POPULATION	SAMPLE
Socioeconomic variables	Age Groups[2] V.A. = 151	18-29	**27.5%**	14.6%
		30-39	20.8%	**21.2%**
		40-49	18.9%	14.6%
		50-59	13.2%	**21.2%**
		60-69	10.4%	15.9%
		70-79	5.9%	9.9%
		>80	3.2%	2.6%
	Household income minimum wage (MW)[2]* V.A. = 148	Up to 3 MW	**85.3%**	**40.5%**
		3-5 MW	9.0%	34.5%
		5-10 MW	4.6%	14.2%
		Above 10 MW	1.1%	10.8%
	Gender Ratio[2] V.A. = 151 (men/women)		0.92	0.76
	Living situation[2] V.A= 148	Rent	26.6%	14.2%
		Own	**73.4%**	**85.8%**
	Person per household [2] V.A. = 151	Average	2.96	3.17 ± 1.3
	Schooling - Level of education of the population over 25 years old[1] V.A. = 138	No education	**59.2%**	31.2%
		Middle School	17.2%	8.7%
		High School	16.3%	**39.1%**
		Higher Education	7.3%	21.0%

Population based on IBGE (2010) for total population data[1] and intersected census tract data[2].

*Population's minimum wage in 2010 was R$ 510.00, whereas sample's minimum wage in 2022 was R$ 1,212.00.

Source: Author (2023).

GROUP COMPARING

To verify the existence of a significant difference of macro sectors, sectors indicators and variables, we employed group comparing. More attention was given to the PMT indicators and safety classes, which present specific assessments. We highlight that prior experience was based on the number of times the individual was affected by an hydrological event, similar to Babcicky and Seebauer (2017).

The statistical tests used were Mann-Whitney, Kruskal-Wallis and Chi-Square for independence (Exact test). The assumption employed for the Chi-square for independence test was no cell presenting an expected count below 10, which includes the maximum of 25% of cells that had an expected count below 5. If assumptions are violated, we employed Fisher's exact test. For the Chi-square and Fisher's test, we assessed the standardised residual to gain a better understanding of the relation over the compared elements. Cells that present a standardized residual higher than [1.96] are considered significant, which (+) indicate a positive relation and (–) a negative relation (SHARPE, 2015).

Table 2 – Group comparing across variables and indicators

VARIABLE OR INDICATOR	SECTORS	MACRO SECTORS		
		NEIGHBOURHOOD	DISASTER FREQUENCY	APP
V1. Prior disaster experience	**Kruskal-Wallis $\chi^2(4)$ = 20.675; p < 0.000***	Mann-Whitney U = 2,465.500; p = 0.137	**Kruskal-Wallis $\chi^2(2)$ = 20.229; p < 0.001***	Mann-Whitney U = 2,808.000; p = 0.654
V2. Socioeconomic variables				
• **Age**	Kruskal-Wallis $\chi^2(4)$ = 7.290; p = 0.121	Mann-Whitney U = 2,447.000; p = 0.138	Kruskal-Wallis χ2(2) = 1.886; p = 0.389	Mann-Whitney U = 2,355.500; p = 0.190
• **Household income**	**Kruskal-Wallis $\chi^2(4)$ = 12.014; p = 0.017***	**Mann-Whitney U = 1,998.500; p = 0.002***	Kruskal-Wallis χ2(2) = 2.295; p = 0.317	Mann-Whitney U = 2,331.500; p = 0.274
• **Gender**	Fisher's exact test χ^2 = 2.132; p = 0.726	Exact Chi-square for independence χ^2 = 0.000; p = 1.000	Fisher's exact test χ^2 = 2.217; p = 0.316	Exact Chi-square for independence χ^2 = 1.050; p = 0.316
• **Property year of construction**	Kruskal-Wallis $\chi^2(4)$ = 5.047; p = 0.283	Mann-Whitney U = 1,178.500; p = 0.701	Kruskal-Wallis χ2(2) = 4.811; p = 0.090	**Mann-Whitney U = 1,212.000; p = 0.044***
• **Living situation**	Fisher's exact test χ^2 = 2.718; p = 0.604	Fisher's exact test χ^2 = 0.194; p = 0.814	Fisher's exact test χ^2 = 0.463; p = 0.857	Fisher's exact test χ^2 = 0.195; p = 0.809
• **Person per household**	Kruskal-Wallis $\chi^2(4)$ = 4.493; p = 0.343	Mann-Whitney U = 3,072.000; p = 0.383	Kruskal-Wallis χ2(2) = 3.475; p = 0.176	Mann-Whitney U = 2,790.500; p = 0.714

VARIABLE OR INDICATOR	SECTORS	MACRO SECTORS		
		NEIGHBOURHOOD	DISASTER FREQUENCY	APP
• **Education level (Schooling years)**	**Kruskal-Wallis $\chi^2(4)$ = 12.983; p = 0.011***	**Mann-Whitney U = 1,885.000; p = 0.001***	Kruskal-Wallis χ2(2) = 2.796; p = 0.247	Mann-Whitney U = 2.279.500; p = 0.149
• **Years residing in the household**	Kruskal-Wallis $\chi^2(4)$ = 4.563; p = 0.335	Mann-Whitney U = 2,502.000; p = 0.227	Kruskal-Wallis χ2(2) = 1.914; p = 0.384	Mann-Whitney U = 2,801.00; p = 0.690
• **Years residing in the municipality**	Kruskal-Wallis $\chi^2(4)$ = 2.461; p = 0.652	Mann-Whitney U = 2,647.000; p = 0.463	Kruskal-Wallis χ2(2) = 1.038; p = 0.595	Mann-Whitney U = 2,910.000; p = 0.415
V3. Tenure (house owners only)	**Fisher's exact test χ^2 = 17.369; p = 0.001***	**Fisher's exact test χ^2 = 9.449; p = 0.003***	Fisher's exact test χ^2 = 2.846; p = 0.212	**Fisher's exact test χ^2 = 12.951; p < 0.001***
V10. Trust on land use policies to reduce damages	Kruskal-Wallis $\chi^2(4)$ = 1.790; p = 0.774	Mann-Whitney U = 2,880.500; p = 0.884	Kruskal-Wallis χ2(2) = 1.777; p = 0.411	Mann-Whitney U = 2,330.500; p = 0.133
V11. Trust in the government's capability to reduce damages	Kruskal-Wallis $\chi^2(4)$ = 0.846; p = 0.932	Mann-Whitney U = 2,501.000; p = 0.517	Kruskal-Wallis χ2(2) = 0.485; p = 0.785	Mann-Whitney U = 2,531.000; p = 0.905
V12. Safety emitted by building permits	Kruskal-Wallis $\chi^2(4)$ = 6.199; p = 0.185	Mann-Whitney U = 2,070.000; p = 0.113	Kruskal-Wallis χ2(2) = 1.836; p = 0.399	Mann-Whitney U = 2,360.000; p = 0.867
Threat Appraisal	Fisher's exact test χ2 = 3.871; p = 0.426	Exact Chi-square for independence χ^2 = 1.775; p = 0.214	Fisher's exact test χ2 = 1.447; p = 0.501	Exact Chi-square for independence χ^2 = 0.350; p = 0.667
Copping appraisal	**Fisher's exact test χ2 = 10.440; p = 0.031***	Exact Chi-square for independence χ^2 = 0.069; p = 0.847	Fisher's exact test χ2 = 5.572; p = 0.061	Exact Chi-square for independence χ^2 = 0.355; p = 0.562
Coping response	**Fisher's exact test χ2 = 9.850; p = 0.035***	Exact Chi-square for independence χ^2 = 0.967; p = 0.382	Fisher's exact test χ2 = 5.018; p = 0.067	Exact Chi-square for independence χ^2 = 0.267; p = 0.658
Perceived impact of the 2020 disaster	**Fisher's exact test χ2 = 39.023; p < 0.001***	Fisher's exact test χ2 = 10.623; p = 0.053	**Fisher's exact test χ2 = 27.814; p < 0.001***	**Fisher's exact test χ2 = 33.482; p < 0.001***
Safety classes	**Fisher's exact test χ2 = 51.133; p < 0.001***	Fisher's exact test χ2 = 4.101; p = 0.262	**Fisher's exact test χ2 = 43.056; p < 0.001***	**Fisher's exact test χ2 = 34.004; p < 0.001***

Source: Author (2023)

PMT indicators

For the assessment of PMT, we compared the socioeconomic variables, impact classification and prior experience across threat appraisal groups (low and high), coping appraisal (low and high) and coping response (protective and non-protective). Neutral responses of threat appraisal, copping appraisal and coping response were disregarded in the statistical analysis.

Threat appraisal assessment of difference of age, household income, gender, house, age, impact classification, living situation, prior disaster experience, schooling, tenure, years since residing in the household, and years in the municipality variables across low threat appraisal and high threat appraisal

Table 3 – Statistical comparison of threat appraisal with variables and indicators.

VARIABLES	PEARSON CHI-SQUARE / MANN-WHITNEY U*	DF	P-VALUE
Age[3]	1,145.000*	1	0.670
Gender[1]	13.049		**< 0.001**
Household income[3]	735.000*	1	**0.002**
Living situation*	0.001	1	1.000
Perceived impact of the 2020 disaster[2]	4.639		0.451
Prior disaster experience[3]	1,149.500*	1	**0.045**
Property year of construction[3]	759.000	1	0.546
Schooling years[3]	960.500*	1	0.155
Tenure[1]	6.641		**0.020**
Years in the municipality[3]	1,030.500*	1	0.227
Years since residing in the household[3]	1,138.000*	1	0.636

[1] Exact Chi-square test

[2] Fisher exact test

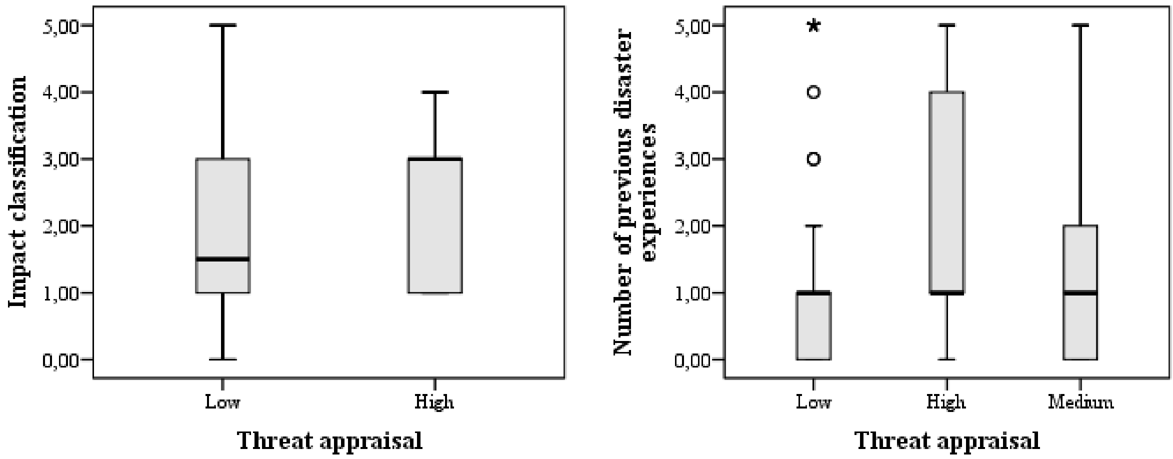
[3] Mann-Whitney U test

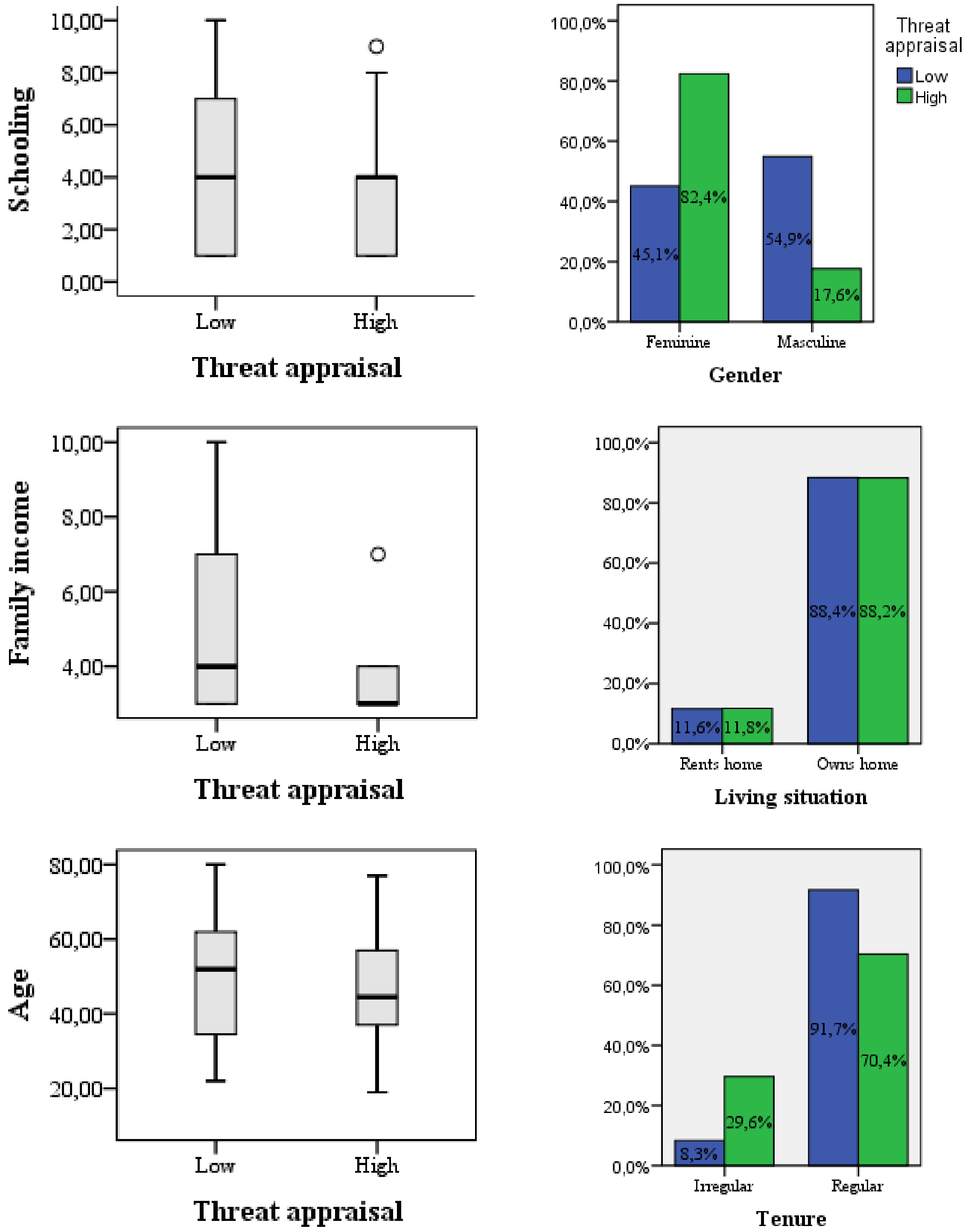
[4] Kruskal-Wallis test

Medium threat appraisal was not considered for the analysis;

Source: Author (2023)

Figure 1 – Distribution of threat appraisal and impact, prior disaster experience, and socioeconomic variables.





Source: Author (2023)

Coping appraisal assessment of difference of age, household income, gender, house, age, impact classification, living situation, prior disaster experience, schooling, tenure, Years since residing in the household, Years in the municipality variables across low coping appraisal and high coping appraisal

Table 4 – Statistical comparison of coping appraisal with variables and indicators

VARIABLES	PEARSON CHI-SQUARE / MANN-WHITNEY U	DF	P-VALUE
Age[3]	960.500*	1	**0.003**
Gender[1]	0.355	1	0.562
Household income[3]	1,660.500*	1	0.112
Living situation[1]	2.008		0.182
Perceived impact of the 2020 disaster [2]	4.433		0.500
Prior experience[3]	1,705.500*	1	0.087
Property year of construction [3]	1,001.500*	1	0.069
Schooling years[3]	1,824.000*	1	**0.009**
Tenure[1]	0.025		1.000
Years in the municipality[3]	1,319.000*	1	0.435
Years since residing in the household[3]	1,262.000*	1	0.257

[1] Exact Chi-square test

[2] Fisher exact test

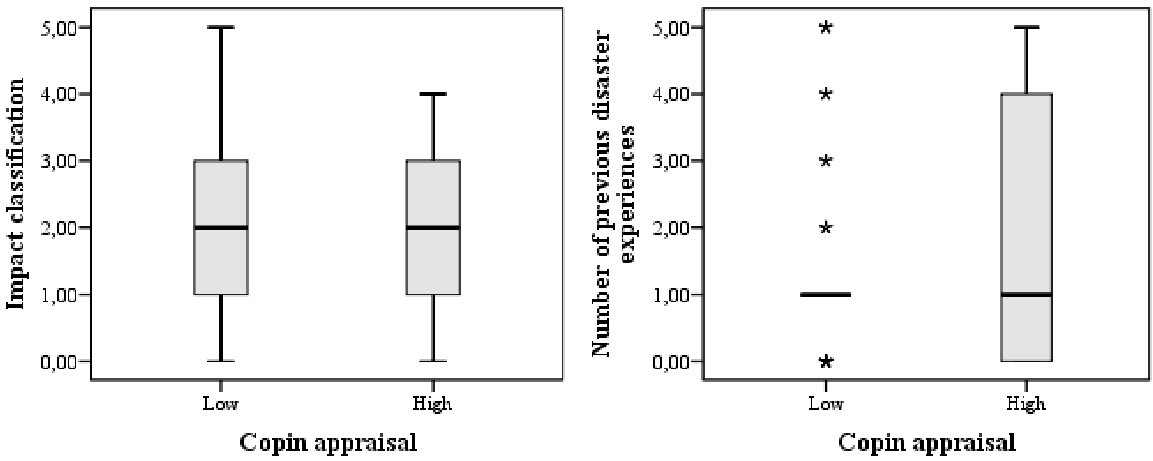
[3] Mann-Whitney U test

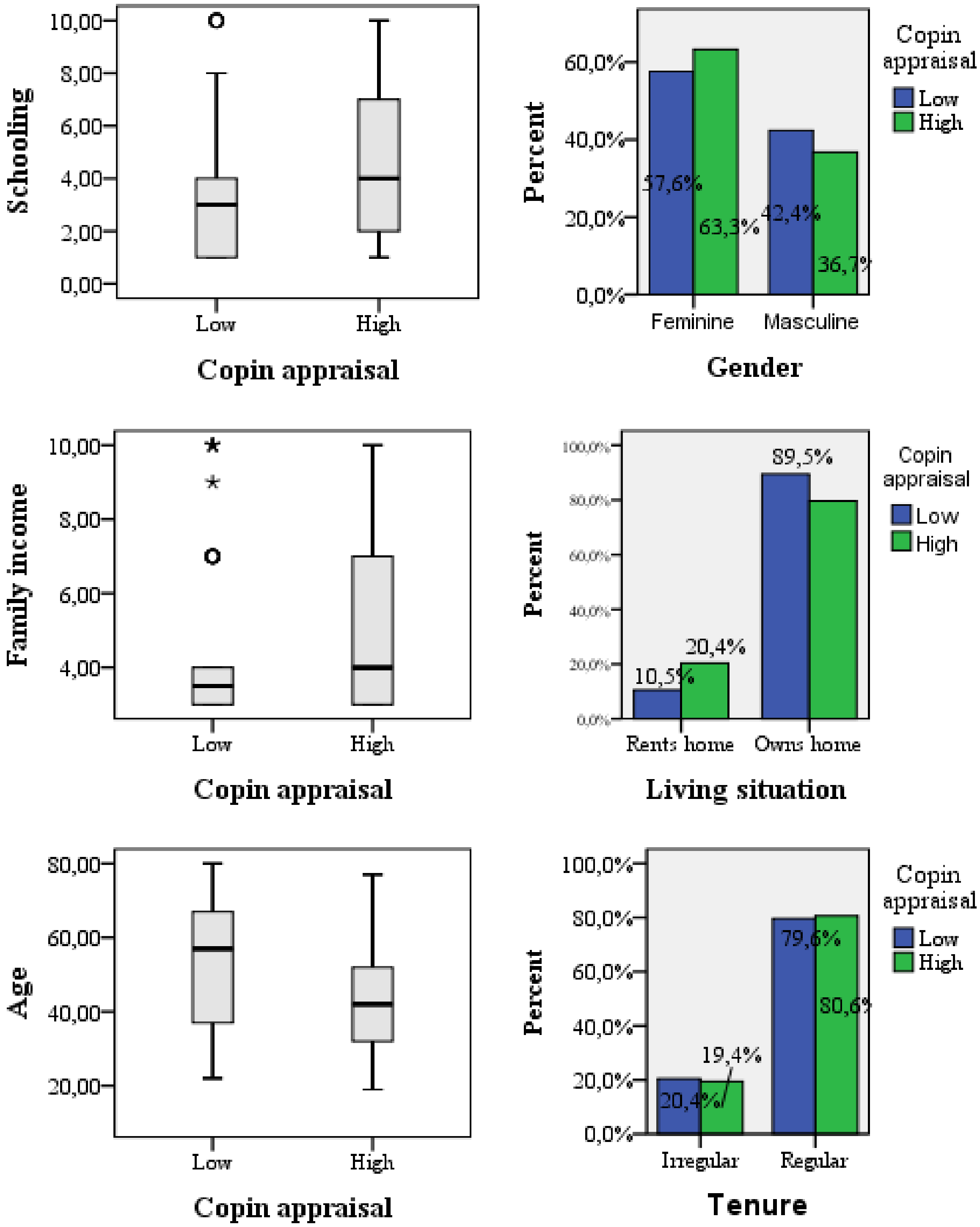
[4] Kruskal-Wallis test

Medium coping appraisal was not considered for the analysis;

Source: Author (2023)

Figure 2 - Distribution of coping appraisal and impact, prior disaster experience, and socioeconomic variables.





Source: Author (2023)

Coping response assessment of difference of age, household income, gender, house, age, impact classification, living situation, prior disaster experience, schooling, tenure, years since residing in the household, and years in the municipality variables across non-protective response and protective response.

Table 5 – Statistical comparison of coping response with variables and indicators

VARIABLES	PEARSON CHI-SQUARE / MANN-WHITNEY U	DF	P-VALUE
Age[3]	802.000*	1	**0.007**
Gender[2]	2.964	1	0.117
Household income[3]	1,121.000*	1	0.798
Living situation[2]	1.550		0.225
Perceived impact of the 2020 disaster [2]	3.874		0.539
Prior experience[3]	1,545.000*	1	**0.023**
Property year of construction [3]	813.500*	1	0.109
Schooling years[3]	1,346.500*	1	0.328
Tenure[2]	1.0715		0.329
Years in the municipality[3]	1.020.500*	1	0.208
Years since residing in the household[3]	1,005.500*	1	0.177

[1] Exact Chi-square test

[2] Fisher exact test

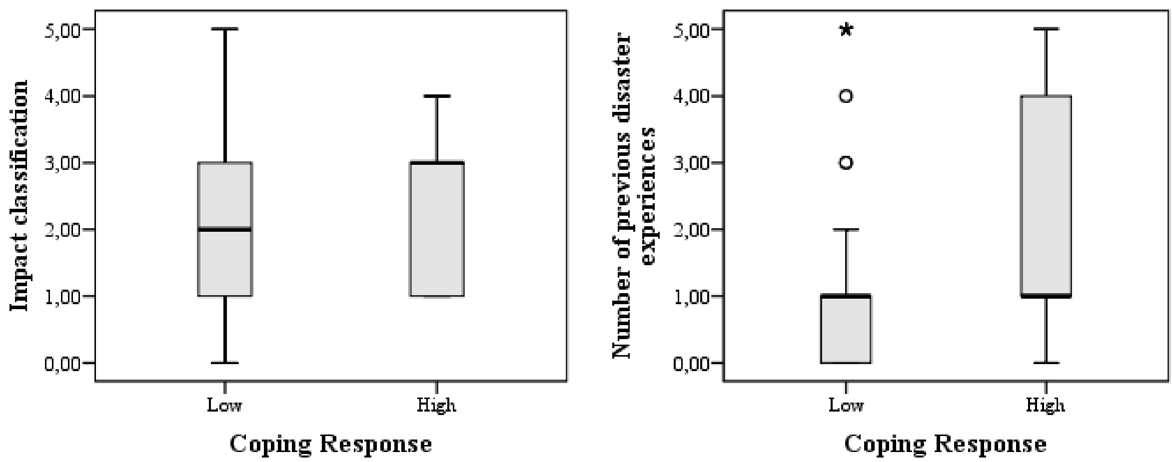
[3] Mann-Whitney U test

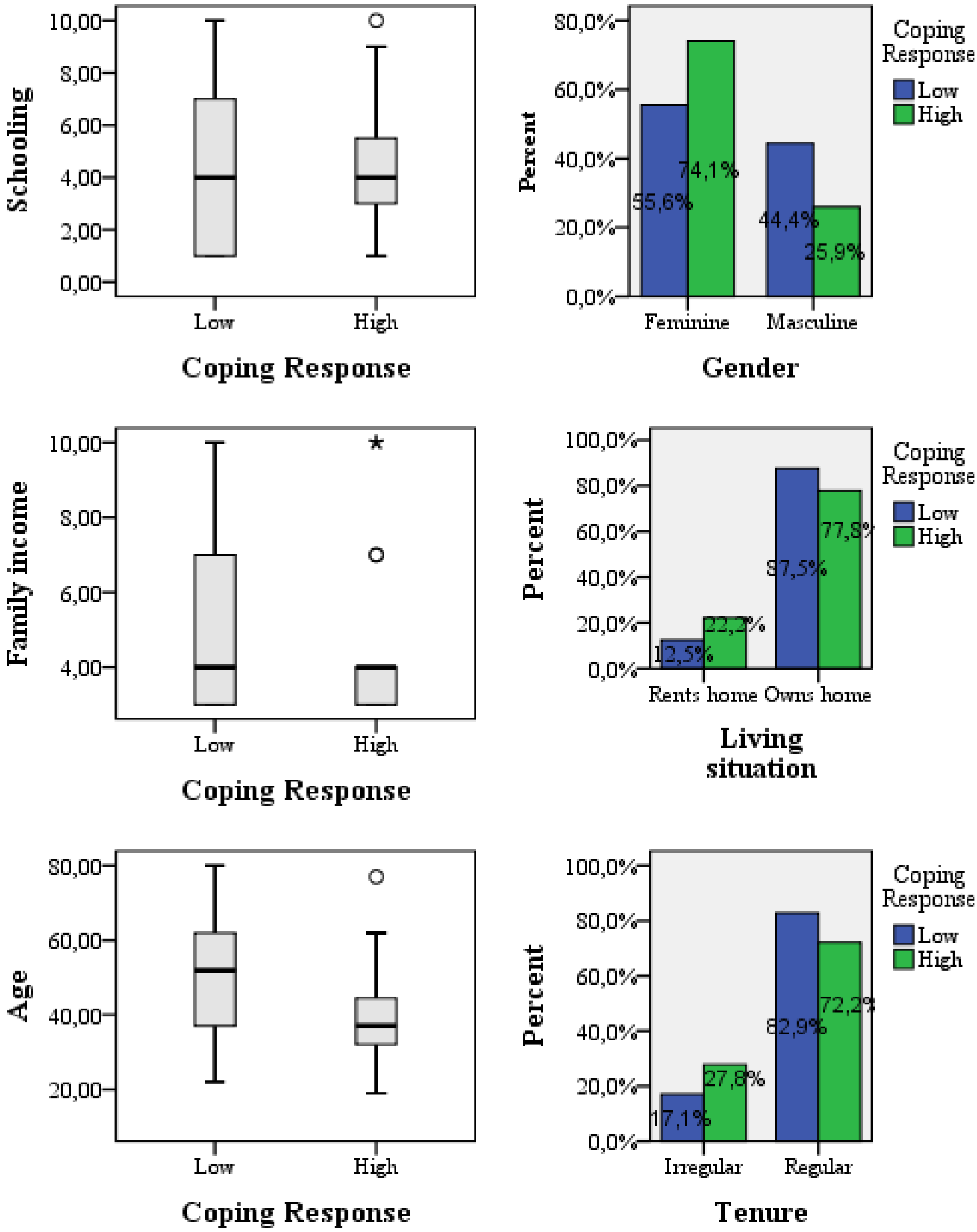
[4] Kruskal-Wallis test

Medium coping response was not considered for the analysis;

Source: Author (2023)

Figure 3 - Distribution of coping response and impact, prior disaster experience, and socioeconomic variables.





Source: Author (2023)

Table 6 – PMT summary table

THREAT APPRAISAL		
High	34	24.5%
Medium	34	24.5%
Low	71	51.0%
Valid	139	100.0%
Perceived probability		
High	25	16.7%
Neutral	38	25.3%
Low	87	58.0%
Valid	150	100.0%
Perceived severity		
High	51	36.4%
Neutral	29	20.7%
Low	60	42.9%
Valid	140	100.0%

COPING APPRAISAL		
High	49	37.4%
Medium	23	17.6%
Low	59	45.0%
Valid	131	100.0%
Response Efficacy		
High	61	44.9%
Low	75	55.1%
Valid	136	100.0%
Self-efficacy		
High	101	69.7%
Low	44	30.3%
Valid	145	100.0%
Response cost		
High	88	58.28%
Medium	41	27.15%
Low	22	14.57%
Valid	151	100.0%

COPING RESPONSE		
Protective response	27	22.1%
Non-protective response	90	73.8%
Neutral/Inconclusive	5	4.1%
Valid	122	100.0%

Source: Author (2023)

Safety Classes indicator

Table 7 – Statistical comparison of safety classes with variables and indicators

VARIABLES	PEARSON CHI-SQUARE	DF	P-VALUE
Age[4]	4.147	3	0.246
Gender[2]	4.903		0.174
Household income[4]	7.545	3	0.056
Living situation[2]	0.500	3	0.948
Prior experience[4]	24.049	3	**0.000**
Property year of construction	6.589	3	0.086
Schooling[4]	5.606	3	0.132
Tenure[2]	10.590	3	**0.009**
Years in the municipality[4]	4.871		0.661
Years since residing in the household[4]	1.592		0.182

[1] Exact Chi-square test

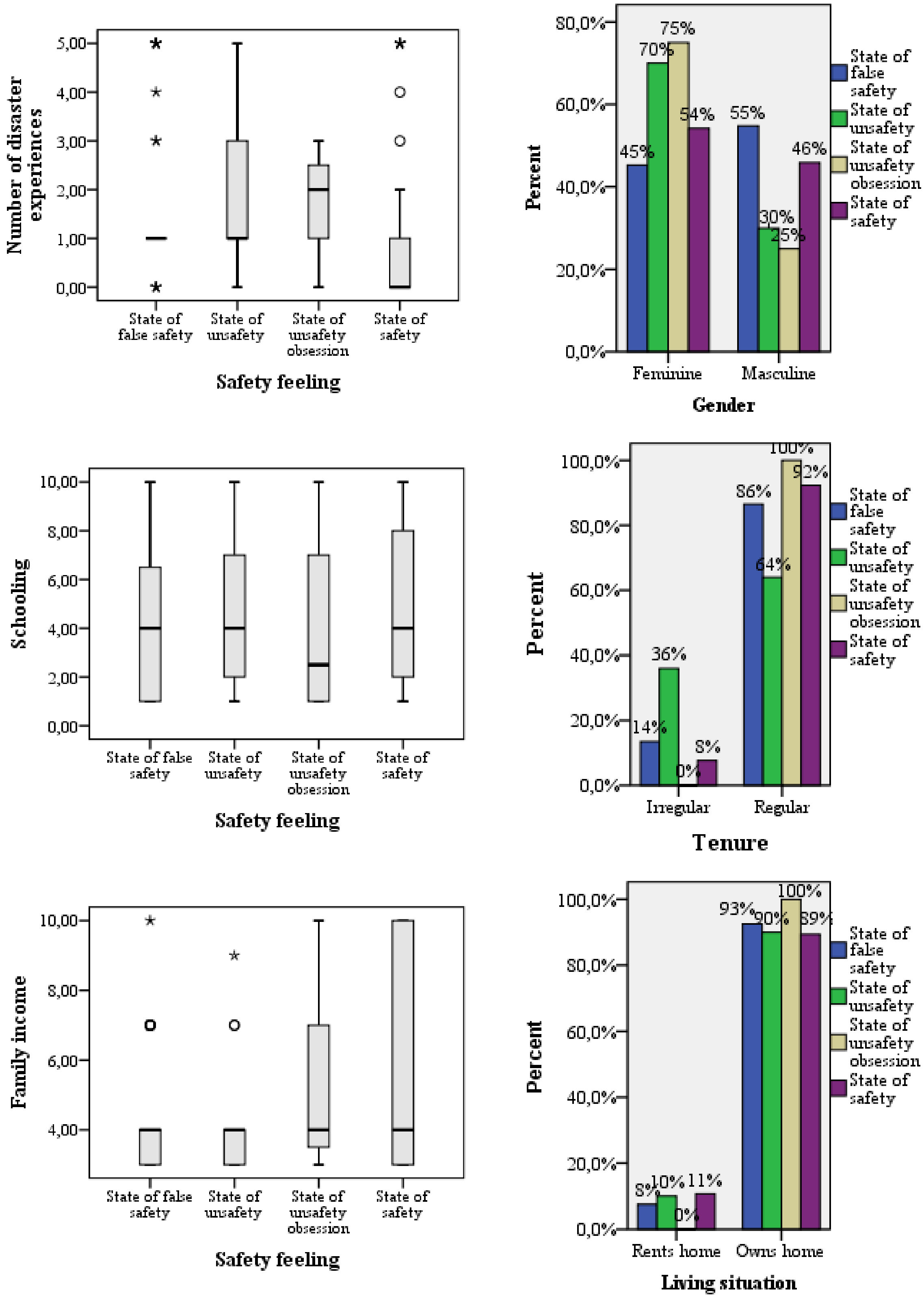
[2] Fisher exact test

[3] Mann-Whitney U test

[4] Kruskal-Wallis test

Source: Author (2023)

Figure 4 - Distribution of safety classes and correlation with prior disaster experience, and socioeconomic variables.



Source: Author (2023)

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APPENDIX 2-VII – LIST OF ASSESSED POLICIES

Table 1 - List of assessed policies.

Document title	Date	Author	Source	Document Type	Subject
Decree No. 33/1973. Organizes the Municipal Civil Defence Commission (COMDEC) and provides other provisions.	07/08/1973	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Administrative structure
Law No. 843/1979. Establishes the Municipal Council for Environmental Defence (CONDEMA).	16/10/1979	Presidente Getúlio Municipality	Online	Legislation	Environment - Administrative structure
Law No. 1,180/1988. Provides for the Physical Territorial Urban Master Plan of Presidente Getúlio and establishes other provisions.	28/12/1988	Presidente Getúlio Municipality	Online	Legislation	Territorial - Urban Land Regularisation
Law No. 1,181/1988. Establishes the Building Code of the Municipality of Presidente Getúlio - SC.	28/12/1988	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Land use plans and zoning
Law No. 1,182/1988. Provides for urban land subdivision in the municipality of Presidente Getúlio and establishes other provisions.	28/12/1988	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Land use plans and zoning
Law No. 1,626/1997. Establishes the Municipal Civil Defence Commission of the municipality of Presidente Getúlio/SC and provides other provisions.	19/08/1997	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Administrative structure
Decree No. 36/1997. Approves the regulations of Law No. 1,626/1997 of August 19, 1997, which establishes the Municipal Civil Defence Commission - COMDEC.	19/09/1997	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Administrative structure
Law No. 2,186/2004. Establishes the Municipal Council for Environmental Defence (COMDEMA) and provides for other provisions.	21/06/2004	Presidente Getúlio Municipality	Online	Legislation	Environment - Administrative structure
Law No. 2,434/2006. Amends the wording of Article 1 and adds clauses to Articles 1 and 2 of Law No. 2,186/2004, which established the Municipal Council for Environmental Defence, and provides for other provisions.	21/11/2006	Presidente Getúlio Municipality	Online	Legislation	Environment - Administrative structure
Complementary Law No. 2,292/2008. Provides for the Evaluation, Revision, and Updating of the Physical Territorial Master Plan of Presidente Getúlio, (SC) and its Adaptation to the City Statute, and establishes other provisions.	10/11/2008	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Land use plans and zoning
Law No. 2,672/2009. Establishes a municipal program for the conservation and restoration of riparian forests and provides for other measures.	09/09/2009	Presidente Getúlio Municipality	Online	Legislation	Environment - Incentives
Law No. 2,667/2009. Establishes the Municipal Basic Sanitation Policy and provides for other measures.	25/09/2009	Presidente Getúlio Municipality	Online	Legislation	Environment - Sanitation

Document title	Date	Author	Source	Document Type	Subject
Emergency action for delimitation of areas at high and very high risk of floods and mass movements: Presidente Getúlio, Santa Catarina	01/08/2012	CPRM	Online	Mapping	Civil defence - Susceptibility and Risk mapping
Law No. 2,931/2013. Creates the Municipal Civil Defence System (SIMDEC), the Municipal Civil Defence Council (COMDEC), the Municipal Civil Defence Fund (FUMDEC), and the Municipal Civil Defence Coordination (COOMDEC) in the municipality of Presidente Getúlio – SC.	04/06/2013	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Administrative structure
Law No. 2,978/2013. Establishes the Municipal Basic Sanitation Plan, aimed at guiding the provision of public basic sanitation services to the principles of universality, continuity, regularity, efficiency, tariff affordability, and sustainability to the population of the municipality of Presidente Getúlio over a 20-year horizon.	19/12/2013	Presidente Getúlio Municipality	Solicitation	Legislation	Environment - Sanitation
Decree No. 153/2014. Creates and appoints a commission to analyse the consolidated urban area in the Protected Area of the municipality of Presidente Getúlio, and establishes other provisions.	19/09/2014	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Socio-environmental diagnosis
Susceptibility map for gravitational mass movements and floods in the municipality of Presidente Getúlio - SC (2013, updated 2015)	31/03/2015	CPRM/IPT	Online	Mapping	Civil defence - Susceptibility and Risk mapping
Development of geotechnical suitability maps for urbanization in the face of natural disasters in the municipality of Presidente Getúlio, state of Santa Catarina	31/12/2016	UFSC	Online	Mapping	Civil defence - Susceptibility and Risk mapping
Decree No. 007/2017. Creates and appoints a commission to analyse the consolidated urban area in the Protected Area of the municipality of Presidente Getúlio, and establishes other provisions.	20/01/2017	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Socio-environmental diagnosis
Law No. 3,229/2018. Establishes in the municipality of Presidente Getúlio the urban land regularization (REURB) as provided by Federal Law No. 13,465/2017, to be carried out under the denomination of Terra Legal Program, and provides other measures.	07/08/2018	Presidente Getúlio Municipality	Online	Legislation	Territorial - Urban Land Regularisation
Law No. 3,026/2014. Amends provisions of Law No. 2,186/2004, dated June 21, 2004, which established the Municipal Council for Environmental Defence (COMDEMA) and provides for other provisions.	05/09/2018	Presidente Getúlio Municipality	Online	Legislation	Environment - Administrative structure

Document title	Date	Author	Source	Document Type	Subject
Sectorization of areas at high and very high risk of mass movements, floods, and inundations: Presidente Getúlio, SC	01/10/2018	CPRM	Online	Mapping	Civil defence - Susceptibility and Risk mapping
Law No. 3,238/2018. Establishes the socio-environmental diagnosis and delimits the consolidated urban area of the municipality of Presidente Getúlio, and provides other measures.	16/10/2018	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Socio-environmental diagnosis
Decree No. 215/2018. Establishes procedures for the processing and analysis of urban land regularization (REURB) procedures instituted by Municipal Law No. 3,229/2018 and provides other measures.	13/11/2018	Presidente Getúlio Municipality	Online	Legislation	Territorial - Urban Land Regularisation
Complementary Law No. 2,416/2019. Provides for the Evaluation, Revision, and Updating of the Physical Territorial Master Plan of Presidente Getúlio, (SC) and its Adaptation to the City Statute, and establishes other provisions.	05/11/2019	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Land use plans and zoning
Law No. 3,367/2021. Provides for the exemption of fees for those directly affected by the flood on December 17, 2020, in the municipality of Presidente Getúlio - and provides for other measures.	26/03/2021	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Post-disaster
Complementary Law No. 2,435/2021. Grants a reduction in the calculation basis for properties affected by the disaster on December 16 and 17, 2020, to assess the property tax (IPTU) exclusively for the year 2021, and provides for other measures.	29/04/2021	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Post-disaster
Decree No. 117/2021. Regulates the registration and cadastre revision of APP and non-aedificandi strips, provides economic incentives for land subdivision, green property tax (IPTU) benefits, industrial classification for IPTU purposes, and establishes guidelines for the collection of real estate transfer tax (ITBI).	10/05/2021	Presidente Getúlio Municipality	Online	Legislation	Environment - Incentives
Technical report on risk mapping: Mapping and classification of risk - Presidente Getúlio - SC (2021);	07/06/2021	Santa Catarina State Civil Defence	Solicitation	Mapping	Civil defence - Susceptibility and Risk mapping
Sectorization of geological risk areas: Presidente Getúlio, Santa Catarina (2021);	01/09/2021	CPRM	Online	Mapping	Civil defence - Susceptibility and Risk mapping
Complementary Law No. 2,451/2022. Provides for the creation of the position of Municipal Civil Defence Coordinator and provides other provisions.	08/03/2022	Presidente Getúlio Municipality	Online	Legislation	Civil defence - Administrative structure
Decree No. 173/2022. Establishes procedures for the processing and analysis of Urban Land Regularization	29/08/2022	Presidente Getúlio Municipality	Online	Legislation	Territorial - Urban Land Regularisation

Document title	Date	Author	Source	Document Type	Subject
processes (REURB) instituted by Municipal Law No. 3,229/2018 and provides other measures.					
Law No. 3,450/2022. Establishes the municipal program for the preservation and restoration of riparian forests called "Seeding Water" and provides for other measures.	27/09/2022	Presidente Getúlio Municipality	Online	Legislation	Environment - Incentives
Complementary Law No. 2,466/2022. Expands the urban perimeter of the municipality of Presidente Getúlio, as determined by Municipal Complementary Law No. 2,416/2019, dated November 7, 2019, and establishes other provisions.	22/11/2022	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Land use plans and zoning
Decree No. 33/2023. Establishes the Commission for the preparation of the Socio-Environmental Diagnosis of the municipality of Presidente Getúlio, and establishes other provisions.	31/01/2023	Presidente Getúlio Municipality	Online	Legislation	Territorial planning - Socio-environmental diagnosis

Source: Author (2023)

ANNEX

PARECER n° 34/2022 COMISSÃO DE PESQUISA INSTITUTO DE PESQUISAS HIDRÁULICAS UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
INSTITUTO DE PESQUISAS HIDRÁULICAS
COMISSÃO DE PESQUISA

PARECER nº 34/2022

O presente parecer trata sobre a avaliação do projeto de pesquisa submetido por professor do Instituto de Pesquisa Hidráulicas da Universidade Federal do Rio Grande do Sul.

INFORMAÇÕES DO PROJETO:

- Título do Projeto: PARADOXO DO DESENVOLVIMENTO SEGURO: ESTUDO DE CASO DA CAPACIDADE DE ADAPTAÇÃO A DESASTRES DO MUNICÍPIO PRESIDENTE GETÚLIO - BRASIL
- Número do Projeto: 43181
- Pesquisador responsável: Prof. Dr. Masato Kobiyama
- Instituição: INSTITUTO DE PESQUISAS HIDRÁULICAS IPH-UFRGS
- Área temática: Avaliação, preservação e gestão dos recursos hídricos
- Duração prevista: 22/09/2022 – 20/08/2023

DESCRIÇÃO DO PROJETO DE PESQUISA:

Trata-se de um projeto de pesquisa que tem como objetivo verificar como as políticas públicas vigentes influenciam a capacidade de adaptação da população e a percepção dos desastres hídricos na Bacia do Revólver – Presidente Getúlio – Brasil. Para o estudo de caso, foi selecionada uma pequena bacia – Bacia do Revólver - no município de Presidente Getúlio – Brasil, que foi acometida por um desastre hidrológico devido a eventos em cascata - desde deslizamento de terra, fluxo de detritos a inundação de detritos – em dezembro de 2020.

MÉRITO:

O projeto de pesquisa é pertinente às linhas de pesquisa do IPH; apresenta introdução, justificativa, objetivos e revisão bibliográfica. É descrita a metodologia a ser aplicada, resultados esperados e cronograma de atividades. A equipe prevê financiamento do projeto com recursos próprios. O projeto conta com a participação de alunos da pós-graduação.

Não há necessidade de aprovação pelo Comitê de Ética em Pesquisa (CEP), ou Comissão de Ética no Uso de Animais (CEUA), pois as análises não contemplam testes com animais.

CONCLUSÃO

Face ao exposto, e de acordo com a Resolução 01/2013 da CamPesq, a Comissão de Pesquisa do Instituto de Pesquisas Hidráulicas da Universidade Federal do Rio Grande do Sul APROVA o projeto proposto.

Porto Alegre, 28 de setembro de 2022.

[redacted]

Professora Maria Cristina de Almeida Silva
Coordenadora da ComPesq-IPH