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SOCIAL INNOVATION FOR ENHANCING DISASTER RISK REDUCTION IN SÃO LUIZ DO PARAITINGA, SÃO PAULO, BRAZIL

Miguel Angel Trejo Rangel

Doctorate Thesis of the Graduate Course in Earth System Science, guided by Drs. Victor Marchezini, and Daniel Andres Rodriguez, approved in March 30, 2022.

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MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÕES

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DEFESA FINAL DE TESE DE MIGUEL ANGEL TREJO RANGEL
BANCA Nº074/2022 REG 141844/2018

No dia 30 de março de 2022, as 14h00min, por teleconferência, o(a) aluno(a) mencionado(a) acima defendeu seu trabalho final (apresentação oral seguida de arguição) perante uma Banca Examinadora, cujos membros estão listados abaixo. O(A) aluno(a) foi APROVADO(A) pela Banca Examinadora, por unanimidade, em cumprimento ao requisito exigido para obtenção do Título de Doutor em Ciência do Sistema Terrestre. O trabalho deve incorporar as correções sugeridas pela Banca Examinadora, a critério e sob revisão final do(s) orientador(es).

Título: "Social Innovation for Enhancing Disaster Risk Reduction in São Luiz do Paraitinga, São Paulo, Brazil"

Dr. Celso von Randow - Presidente - INPE
Dr. Victor Marchezini - Orientador – Cemaden
Dr. Daniel Andres Rodriguez - Orientador – UFRJ
Dra. Samia Nascimento Sulaiman - Membro Externo – UFRN
Dr. Anderson Mululo Sato – Membro Externo - Universidade Federal Fluminense

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“Ensinar não é transferir conhecimento, mas criar as possibilidades para a sua própria produção ou a sua construção.”

Paulo Freire – Patrono da Educação no Brasil

To my husband, parents, family, colleagues, and friends.

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ABSTRACT

Climate-related events, such as floods, are increasing hazards for societies. They can become a disaster if actions are not taken. Worldwide, they represented around 91% of the total reported events between 1998 and 2017. In Brazil, drought-related events impacted 51% of the total number affected, followed by floods and landslides (33%). There is a growing recognition that societies contribute to worsening those events, but also to mitigate disasters through the implementation of social innovations, which are long-lasting innovative activities and services that are motivated by a social need. The objective of this research is to investigate how social innovations could enhance disaster risk reduction (DRR) related to hydrometeorological events in São Luiz do Paraitinga. A mixed-method approach was considered to collect qualitative and quantitative data. Among the main results, a diverse range of ten preventive social innovations were identified. The actions were proposed by different focus groups in different venues and voted through a survey. The social innovations are planned to be conducted by local actors, who need financial and technical resources, and the support of different stakeholders. Besides, it was identified that public policies could support the proposal and implementation of social innovations, which could also contribute to drafting public policies that must attend to social needs to build more resilient and sustainable communities.

Keywords: Social innovation. Prevention. Mitigation. Disaster. Resilience.

INOVAÇÃO SOCIAL PARA MELHORAR A REDUÇÃO DO RISCO DE DESASTRES EM SÃO LUIZ DO PARAITINGA, SÃO PAULO, BRASIL

RESUMO

Eventos relacionados ao clima, como inundações, são ameaças crescentes para as sociedades. Eles podem se tornar um desastre se as ações não forem tomadas. Em todo o mundo, eles representaram cerca de 91% do total de eventos notificados entre 1998 e 2017. No Brasil, os eventos relacionados à seca impactaram 51% do número total de afetados, seguidos por enchentes e deslizamentos de terra (33%). Há um crescente reconhecimento de que as sociedades contribuem para agravar esses eventos, mas também para mitigar desastres através da implementação de inovações sociais, que são atividades e serviços inovadores de longa duração que são motivados por uma necessidade social. O objetivo desta pesquisa é investigar como as inovações sociais podem melhorar a redução do risco de desastres (RRD) relacionados aos eventos hidrometeorológicos em São Luiz do Paraitinga. Uma abordagem de método misto foi considerada para coletar dados qualitativos e quantitativos. Entre os principais resultados, identificou-se uma gama diversificada de dez inovações sociais preventivas. As ações foram propostas por diferentes grupos focais em diferentes espaços e votadas mediante um questionário. As inovações sociais são planejadas para serem conduzidas por atores locais, que precisam de recursos financeiros e técnicos, e do apoio de diferentes stakeholders. Além disso, identificou-se que as políticas públicas podem apoiar a proposição e implementação de inovações sociais, o que também pode contribuir para a elaboração de políticas públicas que devem atender às necessidades sociais para construir comunidades mais resilientes e sustentáveis.

Palavras-chave: Inovação social. Prevenção. Mitigação. Desastre. Resiliência.

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LIST OF ABBREVIATIONS

DRR	Disaster Risk Reduction
CESP	Companhia Energética de São Paulo
CONPDEC	National Council of Protection and Civil Defense
CPTEC	Centro de Previsão do Tempo e Estudos Climáticos
IBGE	Brazilian Institute of Geography and Statistics
MASL	Meters above sea level
NGO	Non-governmental organization
P3DM	Participatory 3D model
P-EWS	Participatory Early Warning Systems
PNPDEC	National Policy of Protection and Civil Defense
SEDEC	National Secretariat of Civil Defense
SFDRR	Sendai Framework for Disaster Risk Reduction
SINPDEC	National System of Civil Defense and Protection
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Convention on Climate Change

CONTENT

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1 INTRODUCTION

The Earth System Science was defined in 1988 by the Earth National Aeronautics and Space Administration as the integrated study of physical, biological, chemical, and social processes that define the conditions on Earth (BOCKHEIM; GENNADIYEV, 2010). Those processes include climate-related events, which have increased with a large spatial and inter-annual variability due to the impact of natural processes, but mostly anthropogenic interactions (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2018).

Climate-related events, which consider floods, can represent a hazard for societies and can become disasters if actions are not taken. According to the United Nations Office for Disaster Risk Reduction (2018), climate-related disasters accounted for 91% of all 7,255 major recorded events between 1998 and 2017. Floods (43.4%) and storms (28.2%) were the two most frequent hazards.

In Brazil, where this research is focused, between 1991 and 2012, events related to droughts were responsible for 51% of the total number of people affected (126,926,656), which was followed by floods and flash floods (33%). However, in terms of death, flood-related disasters are associated with 54.15% of the total reported deaths, which is the largest toll (CENTRO UNIVERSITÁRIO DE ESTUDOS E PESQUISAS SOBRE DESASTRES, 2013).

Worldwide many studies have analyzed those hazards (ALEOTTI; CHOWDHURY, 1999; GUZZETTI et al., 2005; NAM et al., 2015; KVOČKA; FALCONER; BRAY, 2016). Other scholars have focused on the characteristics of the societies that are exposed to those hazards (KLEIN; NICHOLLS; THOMALLA, 2003; HAQUE; ETKIN, 2007; CUTTER; FINCH, 2008), thus, they have assessed vulnerability, which is based on the characteristics of the groups that figurate as receptors of hazards.

Therefore, it is still needed to research how societies respond to hazards and implement community-based actions, but with a preventive approach that could contribute to mitigate the impacts of hazards and enhance their resilience (DA

SILVA ROSA et al., 2013; FERNANDES; BOEHS; HEIDEMANN, 2013; JACOBI; MOMM-SCHULT; BOHN, 2013; ULTRAMARI, 2015; LOSEKANN, 2017; OLIVEIRA et al., 2017; PASSOS; COELHO; DIAS, 2017).

In the specific field of Earth System Science and Social Science, there are few studies that researched how societies, through social innovations, could enhance their resilience to prevent and be adapted to the impacts of climate-related events. For instance, in DUNLAP; BRULLE (2015)' book "Climate Change and Society: Sociological Perspectives", different examples of social actions are cited, such as the importance of the social movements to climate change activism and how important were those for promoting changes in the social organization. The roles of micro-level actions to mitigate climate change and its impacts were also mentioned, and some chapters questioned why it is still challenging to face climate change due to the inadequate programs that promote climate change adaptation at different levels.

Thus, this dissertation aimed to contribute to the social dimensions of climate change adaptation. It analyzed the role of social innovations, which are related to long-lasting activities motivated by a social need, to enhance climate resilience through a mixed-method approach applied and adapted due to the COVID-19 pandemic that started in Brazil on February 26, 2020. The dissertation encouraged participants to take part in the action research process by mobilizing their own local resources, capacities, and supporting public policies elaboration. São Luiz do Paraitinga, Brazil, was chosen as a "living lab" in this research process due to exposure to climate-related events, especially floods that have historically occurred in the city. Especially in 2010, when the city was tremendously impacted as result of lack of preparedness to these kinds of events.

1.1 Thesis objective

Investigate **how** social innovations could enhance disaster risk reduction (DRR) related to hydrometeorological hazards, particularly floods, in the city of São Luiz do Paraitinga, Brazil.

1.2 Particular objectives

- Research **what** social innovations could be implemented to enhance DRR.
- Investigate **how** those social innovations could be implemented as preventive measures rather than response actions.
- Analyze **how** public policies could support social innovations.

1.3 Document organization

This dissertation is organized in different chapters, which show how the objectives of this research project were addressed. Through the chapters, it will be noticed that some of the activities took place before the COVID-19 pandemic when even the structure of the research had a slightly different configuration. Therefore, as a self-adaptation strategy, a concept that is of special interest for this research, the methods were adapted to aim the initial objectives, and according to the global context, we all are still facing in February 2022:

- **Chapter 2** shows a contextualization of the general concepts, and an overview of the research methods adopted in this research.
- **Chapter 3** presents the first stages of the research implementation process and the results of a participatory 3D model used to promote intergenerational dialogue about DRR, and to explore **what** social innovation actions people identify as important.
- **Chapter 4** describes a participatory mapping activity to encourage children for identifying hazards and vulnerabilities, and to propose **how** to incubate DRR plans (what to do, how, when, with what resources, with whom etc.).
- **Chapter 5** presents how social innovation actions selection was done as well as **how** public policies elaboration processes could support the implementation of those measures.

- **Chapter 6** discusses the main outputs of the previous chapters and how they connect with each other, highlighting take-away messages in a short policy-brief to assist the local implementation.
- **Chapter 7** presents concluding remarks, further steps, and advice for future research.

2 THEORETICAL BACKGROUND

The objective of this research is to investigate how social innovations could enhance DRR related to hydrometeorological hazards in the city of São Luiz do Paraitinga, Brazil. Hence, it is important to start analyzing what flood events are, how they have been potentialized, why they can mean a hazard for societies, and what societies can do to be more resilient. Then, those questions are discussed in this chapter, which are followed by the description of the study area where this research was conducted.

2.1 Literature review

The focus of this research is to investigate how DRR could be enhanced thought social innovations. Disasters that are triggered due to the occurrence of a hazard. Then, it is important to define what a hazard is. According to international frameworks, such as the Hyogo Framework for Action (2005), and the Sendai Framework for Disaster Risk Reduction (2015), hazards are defined as latent conditions, which may represent future threats that can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards).

The definition of a hazard was updated by the United Nations Office for Disaster Risk Reduction - UNDRR (2017) as the process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation.

This research does not limit to a specific hydrometeorological hazard, but the city where this study was held is highly exposed to floods events, which according to the UNDRR (2017), are one of the different hydrometeorological events that have an atmospheric, hydrological or oceanographic origin. Flood-related hazards can have negative impacts in societies. It would depend on how exposed, vulnerable, and prepared societies are. Those different elements should be considered since not all societies face the same impacts, it depends on their characteristics and local context.

Peek (2008) and Petal et al. (2020) highlighted how children are also ignored and considered as passive victims, even when they are often impacted by hazards and are vulnerable. Kasperson and Kasperson (2001) mentioned that people of color, indigenous, and women are examples of social groups that are disproportionately vulnerable to the long-term effects of increased air pollution, extreme heat, drought, food, and water shortages, infectious disease, storms, and floods. They are more vulnerable to climate disruption due to discrimination, cultural expectations, and subordinate positions in social hierarchies. In this regard, Pachauri et al. (2014), stated that people living in poverty are exposed to persistent, intersecting, and entrenched structural inequalities, making them particularly vulnerable to harm from the hazards unleashed by climate change.

Thus, it is important to understand vulnerability since it is defined by physical, social, economic, political, cultural, and environmental factors or processes, which may increase the susceptibility of a community to the impact of hazards, and shape adaptive capacity (UNITED NATIONS, 2005; SMITH et al., 2006). Then, if we pay attention to these aspects, it can become a powerful analytical tool for describing states of susceptibility to harm, powerlessness, and marginality of both physical and social systems, and for guiding the normative analysis of actions to enhance well-being through reduction of risk (ADGER, 2005).

Then, what if we combine one or more hazards with vulnerability. Would it become a disaster? According to Wisner, Gaillard and Kelman (2012), disasters depend on those two variables plus the capacity to respond and mitigate actions related to preventive action and social protection, which in fact could be and should be supported by public policy processes. Then, if one or multiple hazards impact society with high vulnerability, poor capacity to respond and a few or no reduction actions, there is a larger chance for disasters to occur.

O’Keefe, Westgate and Wisner in 1976, remarked on the importance of taking out the naturalness of “natural disasters”. They pointed out how the media is playing an important role in the construction of “natural disasters” when a cyclone, earthquake, or drought occur, and which are directly related to death and destruction. The authors also considered that disasters mark the interface

between an extreme physical phenomenon and vulnerable human populations, highlighting that without people there is no disaster.

In that sense, Marchezini (2014) analyzed the paradigms that Claude Gilbert (1998) proposed: a) disaster as an external hazardous agent; b) disasters as the social expression of vulnerability, and c) disasters as the result of the uncertainties of the governmental institutions. But he mostly focused on the first two paradigms to explain why disasters are not natural. First, under the assumption that we are not able to control those external events, we could manage how those events will impact us, which would be related to how vulnerable human communities are, as it is considered in the second paradigm. That is also linked to how political-institutional practices work towards enhancing vulnerability or not. Therefore, the final potential disaster would be the product of social, historical, and territorial processes, and not of the external event itself.

Nonetheless, even if we consider climate-related events as external hazardous events, it should be considered that they could be potentialized by human activities. Dunlap and Brulle (2015) mentioned that climate change is clearly one of the most important issues of the twenty-first century, which sources, impacts, and potential amelioration are an inherently sociological concern. It is well established that the primary drivers of global climate change are social-structural and sociocultural phenomena. Then, sociology possesses considerable knowledge of social and cultural systems, and it has a great deal to offer in helping understand the societal origins of climate change, as well as how social, economic, political, and cultural factors are likely to affect efforts to both mitigate and adapt to climate change.

One example of what was just mentioned is related to hurricane Katrina that impacted New Orleans, Louisiana, and much of the Gulf Coast Region in August 2005. That event showed how social structure influenced the way events affected human communities. The catastrophe revealed the inequality in adaptive capacity between white and African American neighborhoods, the latter being poorly protected from potential storms. During this episode, there were reported over 1,800 deaths, thousands displaced, and billions of dollars in damage to

infrastructure and housing, and most of the official plans for rebuilding the city reflected long and deep racial and class divisions (BULLARD; BEVERLY, 2009).

Then, what can we do to mitigate disasters and their impacts? To answer this question, we would need to go back to what is proposed by Wisner, Gaillard and Kelman (2012), who mentioned that disasters depend on different variables (hazards, vulnerability, capacity, and mitigation action). Hence, one way would be lessening the adverse impacts of hazardous events. They often cannot be prevented fully, but their scale or severity can be lessened by strategies and actions as engineering techniques, hazard-resistant construction, environmental improvement, and social policies and public awareness (UNDRR, 2017).

Another alternative would be to adapt to hazards, so it would mean changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. According to the United Nations Framework Convention on Climate Change (2019), those changes should be led by countries and communities, who develop adaptation solutions, implement actions to respond, and become more resilient to climate change impacts. Thus, societies could improve a) the speed of recovery after a disaster; b) The magnitude of an event relative to a threshold that can be absorbed before the system changes its structure; and c) the capacity to learn, create, and transform (TONG; SHAW; TAKEUCHI, 2012; CUTTER; ASH; EMRICH, 2014).

There is a growing recognition that societies need to mitigate disaster risks, and it is essential to research how those social processes can take place and look at people as the main actors. Then, they can contribute to ongoing, constructed, and negotiated processes at many levels and scales also known as social innovations (LONG, 1990; NEWMAN; DALE, 2005).

Social innovations are also associated with the creation of long-lasting innovative activities and services that are motivated by the goal of merging a social need (MULGAN, 2006). They involve changing the relationships, positions, and rules between the involved stakeholders, through an open process of participation, exchange, and collaboration with relevant stakeholders, including end-users, thereby crossing organizational boundaries and jurisdiction (CHESBROUGH,

2003; HARTLEY, 2005; BASON, 2010; OSBORNE; BROWN, 2011; SORENSEN; TORFING, 2011).

Recently, the concept of social innovation has attracted widespread attention to categorizing processes that resolve unresolved social problems in a new way, and often by shaping new types of social relationships (LÉVESQUE, 2013). But also, as changes of attitudes, behavior, or perceptions, result in new social practices that rely on newness and the inherent purposeful actions oriented towards the desired result (CAJAIBA-SANTANA, 2014).

This research will contribute to support how social innovations could enhance resilience to climate-related impacts, which is a social need that requires groundbreaking solutions. It can be possible by working together and consolidating spaces of dependence such as social support networks as well as local bonding relationships that incorporate governments to expand spaces of engagement and outward-reaching networks (TOMPKINS; ADGER, 2004). Thus, the greater strategic imperative lies in the capacity of the collective for creative innovations that enhance resilience. It should also consider strong precautionary principles, which suggest that one takes no action unless sure it will do no harm (NEWMAN; DALE, 2005).

Social innovation can include community-based adaptation (CBA), an approach recently adopted by development and climate change professionals. It is based on the premise that local communities have the skills, experience, local knowledge, and networks to undertake locally appropriate activities that increase resilience and reduce vulnerability to a range of factors including climate change (DODMAN; MITLIN, 2011).

Nowadays, it is recognized the need to better incorporate this kind of approach due to the inclusion of social science analyses into climate change research efforts (CASTREE et al., 2014; WEAVER et al., 2014). This drives a shift in climate change research toward increasing receptivity for the social sciences, and a concomitant willingness by social scientists, and sociologists in particular, to incorporate climatic and other environmental factors into their research and

theorizing (ANTONIO 2009; DIETZ, ROSA, YORK 2010; MURPHY 2011 IN CARMIN et al., 2015), strengthening the social participation mechanisms.

The Sendai Framework for Disaster Risk Reduction 2015-2030 highlights the importance of the participation of the public and communities to mitigate climate-related disasters. Within the recommendations are to include public and communities in the disaster risk communication activities, collection data, knowledge building, elaboration of strategies, local networks engagement, promote and support the development of social safety nets, establish community centers, among others.

Nevertheless, it is still challenging to put into practice the Sendai Framework's recommendations, due to the lack of effective governance and coordination between different stakeholders. Conditions, which instead of facilitating the processes, represent barriers to involving people in participatory plans for climate change adaptation and disaster risk management, when it should be the opposite since that could play a role in ''scaling up'' social innovations (MARFAI; SEKARANOM; WARD, 2015).

In a more regional context, in Brazil, where this research took place, the DRR governance has a recent background dating back to 1994, when was implemented the General Coordination of Global Climate Change as part of the commitments assumed by the Brazilian Government in the United Nations Convention on Climate Change (UNFCCC). In the same year, it was inaugurated the Weather Prediction and Climatic Studies Center (Centro de Previsão do Tempo e Estudos Climáticos – CPTEC). Then, in 2007, the Brazilian Network for Global Climate Change Research (Rede Clima). Afterward, in 2008, the Earth System Science Center of the National Institute for Space Research.

The strategies for disaster risk governance in Brazil are organized as follows: at the federal level, the disaster management system is called the National System of Civil Defense and Protection (SINPDEC), that is coordinated by the National Secretariat of Civil Defense (SEDEC) of the Ministry of National Integration, which is traditionally commanded by retired army officers promoting policies and actions focused on disaster response. At the state level, there are State Civil defense

Units, which are integrated by military police or firefighter officers. At the Municipal level, there is also a Civil Defense system that does not receive enough support from SINPDEC, nor are the officers recognized as part of a formal career structure. Thus, the situation of institutional vulnerability is aggravated by job instability—after municipal elections, new mayors usually change their team, which disrupts the continuity of the work schedule (MARCHEZINI et al., 2017a).

In July 2011, the National Early Warning and Monitoring Center of Natural Disasters (Cemaden) was established by federal decree. Cemaden analyzes different types of data and issues warnings to SEDEC, that is responsible for forwarding the warnings to the Municipal Civil Defense that activates contingency plans and takes preparatory action for disasters related to landslides, floods, and flash floods, and droughts. They should inform people about the warnings, check the risk-prone areas, carry out evacuation plans, and so on.

Regarding the legal framework in Brazil that supports risk management, there is Law N°12,608 that was published on April 10, 2012. Its first article establishes that the National Policy of Protection and Civil Defense (PNPDEC) should support the National System of Protection and Civil Defense (SINPDEC) and the National Council of Protection and Civil Defense (CONPDEC), and it authorizes the creation of information and monitoring system for disasters and makes other arrangements.

The second article says that it is the duty of the Federal Government, the states, the Federal District, and the municipalities to take the necessary measures to reduce disaster risks. The third article establishes that the PNPDEC should cover prevention, mitigation, preparedness, response, and recovery actions aimed at civil protection and defense.

Besides that, there are other strategies and documents that promote DRR in Brazil as it is the case of the Technical Manual for Disaster Risk Reduction Applied in Urban Planning – Landslides. The manual was published by Ministério das Cidades (2018) and focuses on supporting municipalities on disaster risk prevention. It is also based on the Sendai Framework for Disaster Risk Reduction 2015-2030. The manual highlights the importance of social participation through

public consultations, as it is also mentioned in Law N°12,608, especially for contingency plans.

However, what are the actions that may be not institutionalized, but also contribute to resilience? For that, it was found in the literature that there are already some innovative actions to face different impacts that occurred in Brazil. Then, they were organized in the following Table 2.1.

Table 2.1 – Social innovations implemented in Brazil.

Hazard-related event	Action	Author(s) and year
Flood	• Participatory urban planning	JACOBI; MOMM-SCHULT; BOHN, 2013
Flood	• Donations and shelter	FERNANDES; BOEHS; HEIDEMANN, 2013
Landslides	• Drawings • Photography • Talks • Theater performances	DA SILVA ROSA et al., 2013
Landslides Floods	• Adopt structural changes in terms of new urban management practices • Adoption of new and more appropriate urban land-use rules and procedures • Creation of social networks • Enhance better conditions to boost the local economy • Internalize resources provided by international solidarity networks • Labor for reconstruction work • Solidarity	ULTRAMARI, 2015
Landslides	• Social networks • Territorial planning	DE FREITAS et al., 2016
Dam failure	• Participatory workshops • Public meetings • Representative commissions	OLIVEIRA et al., 2017
	•	
Dam failure	• Social networks • Mobilization in social media	LOSEKANN, 2017
Dam failure	• Civil society organizations • Local newspapers • Participatory urban planning	PASSOS; COELHO; DIAS, 2017

Source: Elaborated by the author.

Among the innovation actions already implemented in Brazil, we found supporting social networks. This action provides resources for coping with the consequences

of disasters and can minimize the adverse effects of the trauma, especially in relation to the losses. The networks usually become one of the frontline groups that respond immediately to support families' needs in the post-disaster period and can help to support emotional needs, which persists over time, strengthening the links from coexisting prior to the event (JACOBI; MOMM-SCHULT; BOHN, 2013). Studies emphasize the contributions of social networks in post-disaster recovery, especially in the relationships of surviving families with relatives, friends, and neighbors to promote community resilience (CRISTINA et al., 2017).

Besides social networks support, there is an additional factor, solidarity, which is linked to diverse actions that result from the involvement of individuals, and communities or institutional aid during the emergency management, reconstruction processes, and risk reduction planning measures. Hence, the individual needs to give selfless help to others for their individual development (ULTRAMARI, 2015). Being that actions associated with solidarity focus on social needs rather than personal interests, they can be considered as social innovations.

Overall, the actions found in the literature refer to non-structural measures. It means that they do not involve physical construction, but they use knowledge, practice, or agreement to reduce disaster risks and impacts, through policies and laws, public awareness-raising, training, and education. They also include building codes, land-use planning laws and their enforcement, research and assessment, information resources, and public awareness programs (UNDRR, 2017).

The actions shown on the table 2.1., are mostly related to response actions rather than preventive. Then, it is critical to investigate actions to avoid existing and new disaster risks. However, this requires actions like promoting and maintaining household disaster preparedness, installation and modernization of meteorological equipment such as radars and rain gauges capable of accurately predicting heavy rainfall, population warning mechanisms, improvement of organizational structure and assign responsibility, mapping of risk areas, and

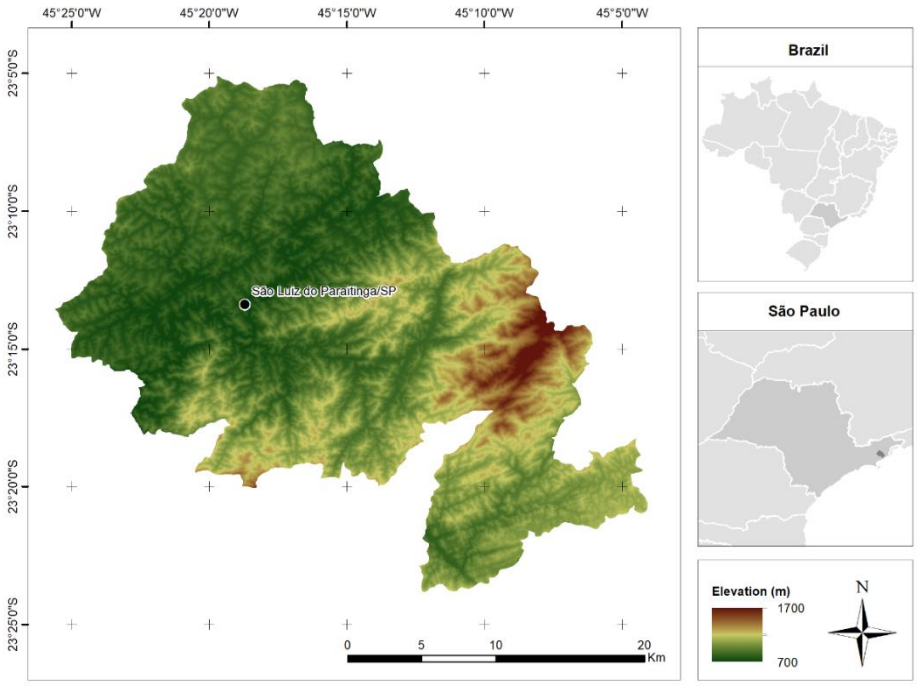
others (PATON, 2003; SUN; ZHANG; CHENG, 2012; JACOBI; MOMM-SCHULT; BOHN, 2013).

The literature consulted contributed to understand the context and how this research could be conducted in São Luiz do Paraitinga. Always paying attention at the national context and what is still needed for guarantying prevention of disaster risks.

2.2 Study area

São Luiz do Paraitinga City (23°13′19″S; 45°18′36″W) is located in the Southeast region of Brazil, Paraiba Valley Region, in the State of São Paulo, Brazil (Figure 2.1). It has an elevation that goes from around 700 meters above sea level (MASL) to 1,700 MASL. The lowest elevation is found in the Western part of the municipality where the biggest human settlement is and the highest elevation is in the Eastern part, where it is the State Park Serra do Mar.

Figure 2.1 - Municipality of São Luiz do Paraitinga, São Paulo, Brazil.



Source: Adapted from Japanese Aerospace Exploration Agency (2019).

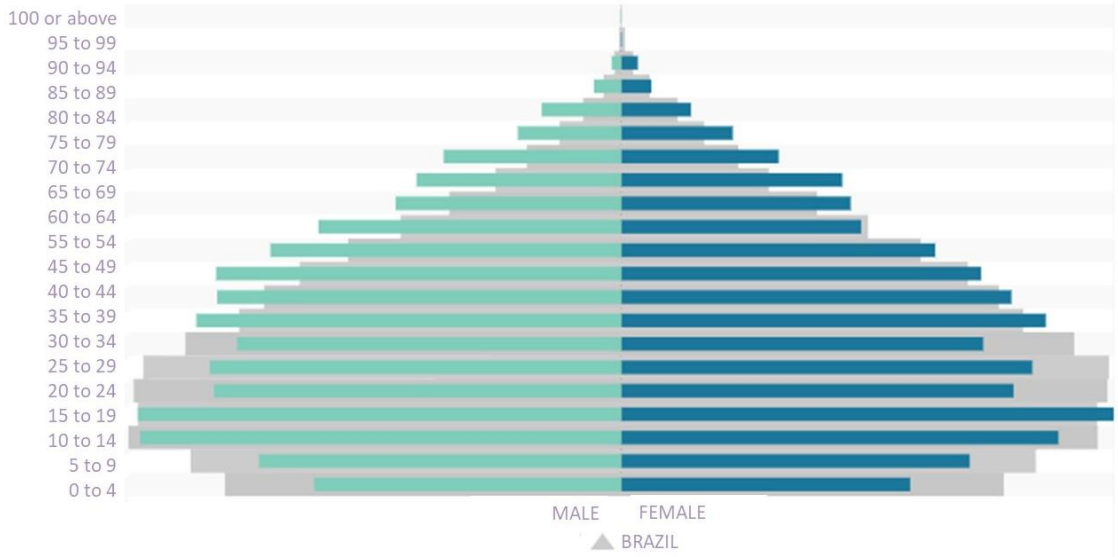
Since 1769, when the city was founded, its economy was interconnected to intensive agriculture that had sever impacts in the Atlantic forest that already lost 90% of the original cover (RUÍZ et al., 2018). However, in 1830, the city suffered major economic changes due to coffee monoculture in the Paraiba Valley region. That attracted a great migratory flow to the region, going from 105,679 inhabitants in 1836, being the most populated region in São Paulo State, to 338,537 inhabitants in 1886, more than tripled, over a period of fifty years. São Luiz do Paraitinga also followed this regional trend, going from 5,296 residents in 1836 to 17,368 inhabitants in 1886 (CAMPOS, 2011).

During that period (on April 30, 1857), São Luiz do Paraitinga was promoted as a city, and then, on June 11, 1873, it was denominated as “The Imperial City of São Luiz do Paraitinga”. Besides its agricultural activities, São Luiz do Paraitinga had one of the first textile factories in the state of São Paulo, the Santo Antônio Textile Factory, with 25 water-turbine-driven looms and 40 workers who operated on 450-ton cotton production in 1888 (SÃO LUIZ DO PARAITINGA, [s.d.]).

In the 1970s, the State authorities realized the importance of the cultural heritage of São Luiz do Paraitinga. However, it was until 2010 that it was declared as national cultural heritage by the National Institute of Historic and Artistic Heritage (IPHAN). Then, the city focused on tourism as its main economic activity, especially during Carnival that is held on the streets of the Historical Center. Besides, they also offer a diverse kinds of ecotourism activities such as rafting and biking tours, and other options to stay and eat like urban and rural inns, hotels, museums, and restaurants (MARCHEZINI; SARTORI; GONÇALVES, 2017).

Nowadays, when the city has a more touristic profile, it has an estimated population of 10,693 inhabitants according to the Brazilian Institute of Geography and Statistics (IBGE). As it can be seen in the following Figure 2.2, ranges with the highest percentages of the population in São Luiz do Paraitinga are from 10 to 14 years old (8.49% of the total population in 2010) and 15 to 19 years old (9.01%), followed by inhabitants between 35 and 39 years old (7.85%), either for women or men.

Figure 2.2 - Population pyramid in 2010.



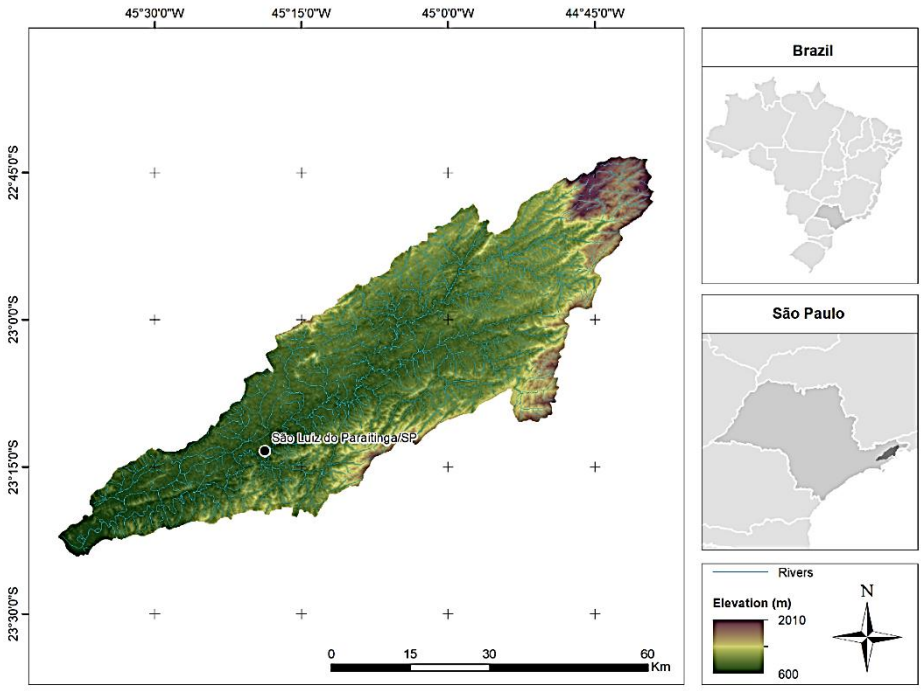
Source: IBGE (2017).

Even though most of the population are children (up to 19 years old according to the United Nations, 2019), demographic data shows that there is a particular gap in the population pyramid for those people between 20 and 34 years old, for both women and men. Age range that corresponds to when people can access to the university or get hired to work. Then, it shows that the trend of the number of inhabitants do not follow the pattern as it shows for the other ages.

The population is settled in a territory of 617,315 km^2, which is the total area of São Luiz do Paraitinga. The municipality is in the watershed of the Paraiba do Sul where the climate is characterized as warm subtropical, with an annual average temperature ranging between 18°C and 24°C. Maximum rainfall occurs at the headwaters of the basin and at the highest points of the Serra do Mar and Mantiqueira, reaching values of 2,250 mm/year (MARENGO; ALVES, 2005).

The main urban area and historic center of São Luiz do Paraitinga is located in a subbasin of the Paraiba do Sul, within the limits of the Paraitinga river watershed (Figure 2.3) that has a total extension of 2,380 km^2 (PAIVA ARGUELLO, 2017), and goes from the 600 MASL in the Southwestern region to the 2100 MASL in the Northeastern region where it is found the Serra do Mar. The Paraitinga river together with the Paraibuna River are tributaries of the Paraiba do Sul river, which is the main river in the Paraiba do Sul river valley region. At the confluence between these two rivers, there is the Paraibuna hydroelectric power plant that was built in the 1970s. It is operated by Companhia Energética de São Paulo (CESP), and it has two reservoirs: the Paraitinga reservoir, with a 47 km^2 surface, and the Paraibuna reservoir, with a 177 km^2 surface. Those two reservoirs provide energy, regulate water supply, and minimize the risk of flooding in the downstream areas of the dam (CESP, 2016).

Figure 2.3 – Paraitinga river basin.



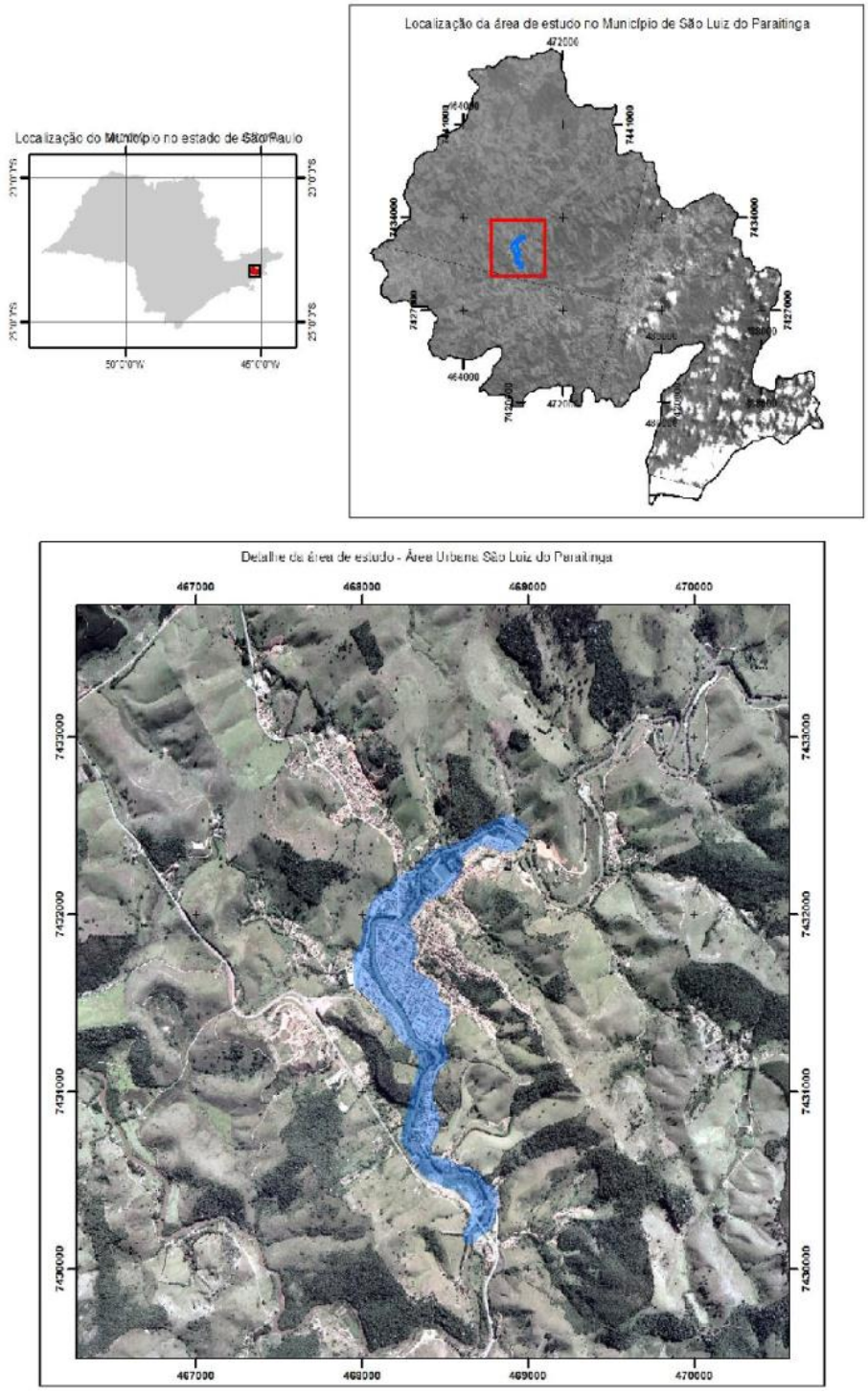
Source: Adapted from Japanese Aerospace Exploration Agency (2019).

The urban area of the municipality is exposed to flood hazards. The first reported flood occurred during the night of January 11 to 12, 1863. This event reached the main entrance of the central church of São Luiz do Paraitinga (SAIA, 2009). Then, it was until 1967, when it was reported another flood covered the central area of the city and reached 5.80m above the mean river level. Afterward, there was another flood in 1971, and from 1967 to 1980, floods occurred more frequently, and then in 1996, the municipality reported three flood events (MORADEI, 2016).

However, it was in December 2009, when rainfall in the region reached 605 mm, which was considerably higher than the monthly average (195 mm). Besides, the Paraitinga river's tributaries also received large amounts of water in a short period, and the river rose about 12 m above the mean river level on the first day of 2010, and the city experienced a major flood (Figure 2.4) that covered about 80% of its urban area (GRAMANI; GOMES, 2011; MARCHEZINI; SARTORI; GONÇALVES, 2017). Fortunately, there were no casualties during the flood event. The aftermath was mostly reflected in the population's living conditions,

the economic performance of the municipality, mainly tourism-related activities, and historical heritage (CORSI; AZEVEDO; GRAMANI, 2012; MORADEI, 2016).

Figure 2.4 - 2010 flood extent.



Source: Corsi, Azevedo and Gramani (2012).

In response to the 2010 flood event, the population organized networks of neighbors, friends, and workers to clean and remove debris and mud from houses, commercial establishments, churches, and rescue images of saints, books, and photographs (MARCHEZINI, 2018).

According to Oliveira et al., (2016), after the 2010 event, the historical center of São Luiz do Paraitinga was in ruins and social participation was essential for the reconstruction stage. There were public hearings with local people and stakeholders to decide how the recovery of the affected area was going to be done. Those activities would be useful to enhance local governance for disaster risk in São Luiz do Paraitinga. However, as Marchezini (2018) reported, they were more informative rather than participatory since they were organized by external governmental agencies and used technical and scientific terms that were not understandable by the locals.

Nonetheless, all the social innovation actions led by locals were to respond and recover from the event. Then, it is still important to look for preventive and preparedness actions that contribute to reducing future disasters and to investigate how public policies can support those processes. That is independent of the continuing changes that may occur in the local administrations, which can hamper processes to aim for continued resilience building (MARCHEZINI; SARTORI; GONÇALVES, 2017).

To look for those preventive and preparedness actions and how public policies can support them, we needed to consider a transdisciplinary approach. It is a holistic approach that goes beyond the perspectives of distinct disciplines to create a common conceptual-theoretical-empirical structure for research (GEORGE, 2005; CHOI; PAK, 2006). Then we can be able to engage during the process professionals from different disciplines, but also actors from that are not necessarily involved in the academic world, but who belong to different organizational levels. That was possible due to the implementation of mixed methods that will be presented in the following chapters. It is needed to complement data collection and to complement each other's findings (MCCLINTOCK et al., 2016; SKRYABINA et al., 2020).

3 PARTICIPATORY 3D MODEL TO PROMOTE INTERGENERATIONAL ENGAGEMENT FOR DISASTER RISK REDUCTION[1]

This chapter investigated how a participatory 3D model mixed with other research methods (semi-structured interviews, round tables, discussions, and presentations) can promote local intergenerational dialogues on disaster risk to identify what social innovations are prioritized by the locals. The research methods were carried out with three focus groups (general public, high-school employees, and children). As main results, participants were able to identify potential hazards and vulnerabilities and they also came out with proposals of DRR measures.

3.1 Introduction

In a recent article published in *Nature*, Gaillard and Peek (2019) highlighted the unintended impacts of the convergence of researchers on disaster zones and their effects on the local survivors. The authors argue that a code of conduct is necessary for scholars to reduce *research fatigue* on the local survivors due to the influx of scientists that want to collect data. *Research fatigue* occurs when individuals or groups become tired of engaging with research (CLARK, 2008, 2010; SUKARIEH; TANNOCK, 2013).

Interestingly, the city of São Luiz do Paraitinga, Brazil, faced a similar phenomenon of fatigue since journalists, emergency management personnel, and researchers came to the city in the aftermath of an extreme flood that affected half of the total population (10,000 inhabitants) in January 2010 (MARCHEZINI, 2015). An influx of external researchers came to the city to conduct their studies (SARTORI, 2015; MARCHEZINI, 2019), and local researchers affected during floods also carried out dissertations and thesis about the disaster recovery process (DOS SANTOS, 2016; MORADEI, 2016). In spite of numerous studies conducted in the city, children were neglected in the DRR research agenda

[1] This chapter is based on Trejo-Rangel et al. (2021).

(PEEK, 2008). Children (from 0 to 14 years old) represent 14% of the total city's population and are also exposed to future floods.

Approximately 33% (2.5 million) of the global population are children (United Nations, 2019). However, they are largely voiceless, and many of them live in poor conditions, with less access to proper facilities and services (CADAG et al., 2017). Children tend to be invisible in the DRR processes, and the situation is even worse if they come from marginalized and poor families (HUTTON, 2010). Several studies recommend developing culturally and comprehensive DRR approaches to increase children's participation, reducing the power imbalances between adults and children (PEEK, 2008; CUMISKEY et al., 2015; RONAN et al., 2016). Children are not considered to be passive victims but are actors who can become agents of change to reduce risks and increase resilience within households, schools, and communities (PETAL et al., 2020).

The dialogue, participation and engagement of different audiences is essential for DRR. The community engagement in DRR requires to determine how, if at all, the community judges their levels of vulnerability to one or more environmental hazards. Also, how they would like to move forward in identifying an integrated strategy to reduce their vulnerability and improve their capacities (MERCER et al., 2010). Capacities refer to the combination of all the strengths, attributes, and resources available within an organization, community, or society to manage and reduce disaster risks and strengthen resilience (UNDRR, 2017).

Community engagement is key to enhancing capacities and resilience, which can be understood as the ability of a community or society exposed to hazards to resist, absorb, accommodate, adapt, transform, and recover from the effects of a hazard in a timely and efficient manner (UNDRR, 2017). To ensure community engagement, people need to be able to trust the DRR process since there is a real possibility that local groups will be encouraged to make adaptive responses (DODMAN; MITLIN, 2011; OLIVATO; GALLO JUNIOR, 2020).

In the South American context, several studies have analyzed pathways to engage communities in participatory DRR (HARDOY; PANDIELLA; BARRERO, 2011; BERROETA; RAMONEDA; OPAZO, 2016; MARCHEZINI et al., 2018).

Aravena, Romero-Toledo, Opazo (2018), for instance, identified a lack of dialogue between academics and the Andean communities and the need for a DRR language that can be understood by locals. Hardoy; Pandiella; Barrero (2011) studied how the DRR program in Manizales, Colombia, could include community participation for preparedness, education, institutional coordination, research, and particular initiatives to reduce vulnerability and enhance resilience.

Despite these studies of community engagement in DRR, children are still invisible in the DRR research agenda in South America (TRAJBER et al., 2019). This is especially worrying in research fatigue environments where children are often left behind. How can the intergenerational engagement for DRR be promoted in an environment of research fatigue?

The objective of this study was to investigate how participatory 3D mapping can promote local intergenerational engagement for DRR. This engagement followed the recommendations of Clark (2008, 2010) and Sukarieh and Tannock (2013) who suggested promoting participation through individual or group *curiosity* and *enjoyment*. To do so, we built a 3D model of the city of São Luiz do Paraitinga and invited children and adults to engage with the models as communication tools to visualize and understand local hazards, vulnerabilities, capacities, and DRR measures.

3.2 Methods

The methods presented in this work are the first part of a broader empirical study that seeks to explore how social innovation can enhance flood resilience in São Luiz do Paraitinga, Brazil, which was already submitted and approved by the Research Ethical Committee of the Brazilian Government.

The reason we decided to adopt the participatory 3D model (P3DM) of the historic center for São Luiz do Paraitinga is for the following: i) it is a communicative facilitation method that can be used as a tool to involve people's participation in characterizing their own territory; ii) it facilitates knowledge of how people interpret hazards, vulnerabilities, capacities and disasters; iii) it contributes to the

discussion about DRR measures; and, iv) it facilitates grassroots participation in spatial problem analysis and decision-making (RAMBALDI et al., 2007; VALENCIO et al., 2009; GAILLARD et al., 2013; TEXIER-TEIXEIRA et al., 2014).

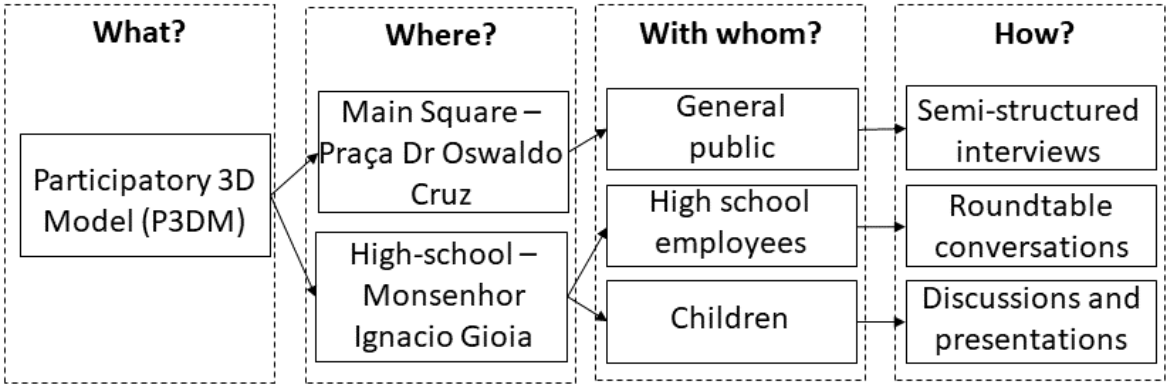
The P3DM can be used as a tool to promote the ability to think, organize, produce narratives, and listen to others by enriching the interpretation of all the people who are involved in the activity. While it may seem like a game, it is aligned to how social needs can take place (FREIRE, 1996; YAMORI, 2008; GIRALDO, 2015; GIBSON; WISNER, 2016). The P3DMs can also contribute to raise local awareness of territories, provide stakeholders with powerful mediums for land-use management and serve as an effective community-organizing tool (RAMBALDI; CALLOSA-TARR, 2002). The method is credible for the locals who help to build the map and plot most of the information, as well as for the scientists and local government representatives who can easily overlap their own data and plans on scaled and geo-referenced maps (GAILLARD et al., 2013).

The P3DM method fits within the consulting approaches, which refer to the collection of information from different groups, but only the research group decides on the best course for the use of that information (DYBALL; BROWN; KEEN, 2007). Therefore, for this study, we played the role of facilitators, and the participants were the ones who provided knowledge and information to identify concerns regarding DRR. During the entire research process, we paid attention to the ethical aspects due to possible differences in our cultural background. Then, it was important to know how to interact with locals without adding to those people's problems (GAILLARD; PEEK, 2019).

The P3DM was used to allow participants to characterize areas at risk, to develop their ideas about how they could increase their capacities, and to explore what types of DRR measures could be implemented. We worked with three focus groups (Table 3.1): i) the general public; ii) the high school employees (specially schoolteachers and staff memebers), and iii) high school students from the last grades. In total, we conducted the activities with 131 participants which is 2.6% of the 5,000 people affected in 2010 (MARCHEZINI, 2015). The activities were organized before going to the field and were supported by *concept notes*

prepared in advance, which guided us for collecting the data. We also decided beforehand which role each member of the research team would have (note-taker, facilitator, interviewer & photographer).

Table 3.1 - Methods that were applied with different focus groups.



Source: Trejo-Rangel et al. (2021).

The first focus group, the general public, included any participant that was willing to participate in the activity in July 2019. This included the young and elderly, who were curious and interested in the activity that had been set up in a public space (the main square “Praça Dr Oswaldo Cruz”). They were the first group we interacted with because we wanted to consider different available resources and knowledge from the community to respond to disasters (ROLSTED; RAJU, 2020). Thus, we did not restrict the group to specific demographic and socioeconomic conditions, but instead we chose to make this session more like an *ice-breaker* activity.

As a secondary method to approach the general public, we conducted 30 semi-structured interviews (Appendix A.1) of about one hour in length, consisting only of adults. These participants were kept anonymous to protect their identities. All the interviews were recorded with the participants’ consent in order to collect the data and were complemented by field notes taken by the research team.

The second focus group was suggested by participants from the first activity, who highlighted the importance of involving local schools during the activities as students are in an age that could get knowledge about DRR. Then, high school employees (teachers and staff memembers) were contacted, and they become in the second focus group. With this group, we also used the P3DM method as a communication tool, and as a secondary method, we conducted roundtable conversations (following the same guiding questions of the semi-structured interviews). Notes were taken about the local hazards, vulnerabilities, capacities, and DRR proposals. This activity took place in July 2019 and involved 20 high school employees at the facilities of the High School Monsenhor Ignacio Gióia, which is the only high school in the municipality. This group was the bridge to the high school students. The high school employees found the P3DM interesting and suggested applying the educational activity in the high school.

The P3DM with children was conducted in August 2019 at the High School Monsenhor Ignácio Gióia. The 81 high school students between 14 and 19 years old were indicated by the school principal. We mostly focused on this group because there is still a limited amount of knowledge about how high school students engage with DRR, an issue that will shape and define their generation. They are also the most vulnerable to the legacy of decisions made by older generations (Corner *et al.*, 2015). Therefore, we considered it valuable to give them a chance to be engaged. During the day-sessions, we facilitated three workshops, where besides presenting the P3DM, participants had the opportunity to work in teams, to discuss and to present their ideas on flipcharts, which we collected to analyze the data.

At the moment we decided to work with children, we considered different aspects, like honesty and respect throughout the research process. Thus, we considered ethical approaches discussed by Farrell (2005), which are related to principles (what is the right thing to do), rights (how we can best respect and protect people) and outcomes (what might be the benefits to promote and the harms to avoid).

For this study, the P3DM did not actively engage participants in the earlier stages such as the elaboration of the relief and its elements, as reported by other studies

(RAMBALDI et al., 2007; GAILLARD et al., 2013; RAMIREZ-GOMEZ et al., 2017), but they had the opportunity to place the elements freely. The P3DM was made of low-cost materials. The relief was made of polystyrene foam, painted, and covered the central area of São Luiz do Paraitinga. It had a scale of 1:5,000 and was based on contour lines for every 20 meters of altitude difference. This kind of relief can be made of locally available inexpensive materials that allow people to overlap thematic layers of geographic information (TEXIER-TEIXEIRA et al., 2014).

For the area characterization, we went to the field and took photos of local landmarks and critical infrastructure (such as churches, schools, square) and other environmental elements (such as the river and vegetation). Elements that were considered as *fixed* (Figure 3.1), which could be allocated by participants. The materials used for those elements were paper, colors, paints, and even toothpicks.

Figure 3.1 - Main church of São Luiz do Paraitinga.

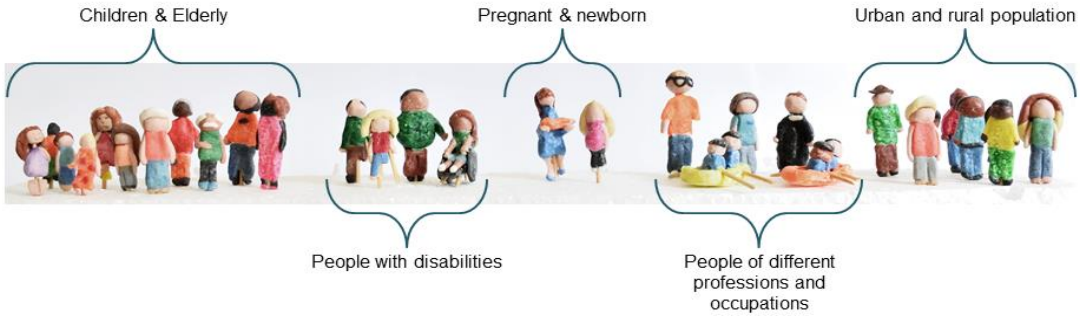
On the left-side is a photo of the main church (Igreja matriz), which was one of the historical buildings of São Luiz do Paraitinga that was destroyed during the flood event, and which was rebuilt afterwards in the same place.

Source: Prefeitura de São Luiz do Paraitinga (2020) and Oliveira (2021).

We also made *unfixed* elements of playdough to represent cars and boats, and humans (Figure 3.2). Humans were especially important because we wanted to promote self-identification, and inclusiveness of social groups that are reported in the DRR literature. Some aspects we considered for doing so were gender, age, race, disabilities, religion, and occupational status (PEEK, 2008; FERNANDEZ; SHAW, 2013; CADAG et al., 2017; REY et al., 2019; NORSTRÖM et al., 2020).

Some of the key groups that we represented were children up to 18 years old, which corresponds to 30% (3,067 people) of the total population (10,397), elderly people, who are above 65 years old, 11.16% (1,160 people), and religious groups, such as Catholics, which correspond to 32.03% (3,330 people) (BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS - IBGE, 2017). We also characterized different stakeholders, such as civil defense agents and rafting members, who played an important role in past flood events (MARCHEZINI, 2015).

Figure 3.2 – Unfixed elements.



Unfixed elements, which represent some of the vulnerable groups, people representing different professions and occupations, urban and rural population. Race and gender were additional aspects that were considered to make unfixed elements, which were made of playdough.

Source: Elaborated by the author and Oliveira (2021).

For the P3DM, we also considered elements such as water and soil. Both were made of paper, and we used them to represent potential floods and landslide hazards. Additionally, and to give participants a chance to represent anything we may be missing, we provided them with materials (paper, playdough, glue, paint, etc.). For instance, pets which we did not represent, and which should be considered in the emergency management plans (DEYOUNG et al., 2020). Once introduced to all the elements in the 3D model, participants evaluated disaster risk based on hazards, treated assets, vulnerabilities, and capacities (CADAG; GAILLARD, 2012; GAILLARD et al., 2013).

The steps that we followed in each of the activities were: (i) Asking participants to place elements on the territory by the chronological order that they were appearing through the history; (ii) based on their experience and knowledge, participants characterized potential hazards and identified people more vulnerable to these hazards; and finally, (iii) we asked them to recommend actions that the local community could take before, during and after hazards. The data collected was organized and analyzed according to four main topics: i) local hazards; ii) vulnerabilities; iii) capacities; and iv) DRR measures.

3.3 Results

The P3DM was a communication tool that facilitated the interaction between facilitators and participants independently of the focus group they belong to, and independent of their sociodemographic characteristics. After the research activities we asked participants for their feedback, and they always recommended applying the activity with another group. In this sense, the P3DM was useful in promoting intergenerational engagement, thereby avoiding the *research fatigue* for the participants. However, we are aware that we could better evaluate the *research fatigue* with a more detailed tool rather than only informally asking what they thought of the activity.

The P3DM can also be combined with different secondary research methods. In the upcoming subsections we present the main findings identified in each focus group, and then, the general overview of the main research results.

3.3.1 What did we find among the general public?

During the first activity that we facilitated with the general public, who were people from a diverse range of ages (children, adults, and elderly), in the main square, people were curious about the 3D model and approached to ask: *"What is that?"* (Figure 3.3). They showed their interest and got engaged in the activity that was facilitated in a public space to allow everyone's participation and to avoid conflict of interests as it could be the case if the activity would have taken place in the public library for instance. A building that was rebuilt after the 2010 flood event, however locals did agree on how was conducted the rebuilding process.

We had the participation of adults, elderly, governmental officials, and school employees, all from different ages and backgrounds. During the activity we also worked with children who were accompanied by their parents. This activity helped us, as a research team, to talk with people and to better understand their sense of place, the local hazards, the land use changes, the vulnerabilities, the capacities, and their proposals for DRR (GIBSON; WISNER, 2016).

Figure 3.3 – P3DM activity at the public square.

On the left photo, there is a group of children, who were placing the elements on the P3DM, and on the top side of the same photo, there are a couple of people having an interview. On the right photo, there is a participant, who was being interviewed, and another couple that approached to know about what was going on, who were also interviewed.

Source: Marchezini (2019).

During this session, participants were able to place on the relief *fixed* elements, such as the city Hall, the church, the municipal market, and the library. However, we had participants (mostly children) who went more in detail to represent their own houses, and even family members and pets, which we did not consider. For instance, a group of girls created their pets and placed them in the model, close to their houses on the hill of Morro do Cruzeiro, considering pets as part of their family, and characterizing each member of their family (family with grandmother, for instance), as well as giving details about their houses, such as the number of rooms, and the address. Regarding to the pets, we initially did not include, even when it is important to consider them in the emergency management plans as recommended by DeYoung et al. (2020). Then, it was useful to provide participants with materials in order to not limit them. Some children and their parents played with the P3DM for more than two hours, creating new elements and painting their houses.

When participants were asked to identify potential hazards, they mostly identified floods and landslides. They seemed to be familiar with flood events since they were aware that the Paraitinga river used to flow where the main church is located today, in the main square where the P3DM activity was organized. Participants mentioned that some of the current settlements are either on the floodplain or on the hill Morro do Cruzeiro, which is a landslide-prone area. Participants also talked about the urban development that the city experienced after flood events like the one in 1996, when a new neighborhood called Verde-Perto was developed on the right bank of the Paraitinga river.

During this activity we learned more about the local perspectives and how locals faced previous hazards, especially the 2010 flood event, which was the one they mostly mentioned during the activities. They shared their memories using and placing the elements of the P3DM to describe and visualize the history of the 2010 flood:

> *"...the water was rising. But nobody thought what would happen, but when the water was starting to arrive in the [main] square, people started to move to get their things out of the houses and there were still some that were stubborn, and they waited for the water [from the river] to flood the entire first floor of their house. Then, they had to go to the second*

floor, but the water levels reached the second floor too…" (Participant's interview, June 2019).

During the conversations, they recalled facts about the evacuation measures and emergency management, indicating the locations of the houses used as temporary shelters, as well as the actions and responsibilities shared by the community as "zero responders" (BRIONES; VACHON; GLANTZ, 2019): *"... we took the cars out of the garage, then people could sleep there, and my mother cooked for the people. An average of 20 to 22 people stayed at my house." (Participant's interview, June 2019).*

Elderly people also talked about the coping strategies during the emergency and the social changes in the aftermath of the 2010 flood. This social capacity is summarized in what the locals call the "spirit of solidarity". They supported each other and showed their ability to recover from the disaster impacts:

"I have always lived here. I am 75 years old, and before the [2010] flood event, there did not seem to be solidarity. There was no community spirit in the sense that we are used to imagining. However, it was during the [2010] flood event, and after, that we saw how people keep a spirit of solidarity..." (Participant's interview, June 2019).

Other actions that were identified, and which took place during the 2010 flood hazard were related to logistical planning, donations, evacuation and even rescue activities. Rescuing was an activity where the community participated in and even led thanks to the local rafting group, known as the "Rafting Angels", who supported several people.

"it was the rafting people [...] that rescued him [a man that could not leave his house], he was inside his room and he left by boat, then he managed to leave since during the flood, people were leaving the way they could, without clothes, without documents…" (Participant's interview, June 2019).

As part of the interviews, we conducted with the participants, we elaborated the following synthesis map (Figure 3.4) that bridges the transformation of the urban territory from 1950 to after the 2010 flood, and the local memories of this critical event. On the maps we included some of the statements that grabbed our attention from the interviews we conducted. The statements referred to how people faced the 2010 flood, their vulnerabilities, coping strategies and

capacities. We found that to be an interesting way to present the memories that participants shared with us during the P3DM, connecting art and science.

Figure 3.4 - Synthesis map of Sao Luiz do Paraitinga.

The synthesis map of Sao Luiz do Paraitinga, where we considered data collected in the P3DM interviews and Moradei's (2016) study on urban sprawl (“fases da expansão urbana”, in Portuguese) which took place from 1950 (salmon color) to post 2010 flood (light blue colour), close to the Paraitinga river (“Rio Paraitinga”, in portuguese). The numbers (From 1 to 8) show the location of the main churches (1- Igreja Matriz; 2- Igreja Nossa Senhora; 3- Capela das Mercês), the school (5- EE Monsenhor Ignacio), the City Hall (8-Prefeitura), and the highways (SP-163 and SP-125). The sentences highlighted in yellow point out the collective memories shared by the locals

Source: Oliveira (2020).

3.3.2 How was our experience in the local high school?

The P3DM activity in the only local high school was recommended by some participants who were with us in the first session in the central square, especially teachers. The research activities combined the P3DM and the roundtable

conversations (Figure 3.5). The activity engaged with 20 employees (teachers and staff members willing to participate), and they were able to talk about the occupation on the floodplain of Paraitinga river, to allocate elements on the territory, identify local hazards, vulnerabilities, and capacities, as well as their proposals for DRR. During the activity with high school employees, they all mentioned floods as the most dangerous hazard they are exposed to, for which they proposed eight DRR measures which they believe could be useful to promote children's participation. One of the DRR actions suggested by school employees was the elaboration of maps that indicate the flood-prone areas and the more vulnerable people. They also talked about the need of an information platform that compiles the scientific studies carried out in the city. Additionally, they highlighted the need for promoting partnerships to enhance their capacities to cope with floods, and to create a collaborative monitoring network where local students could be proactively involved.

This focus group was crucial to building the bridge between children and adults since they are in everyday contact. Participants, especially teachers, told us that there are no subjects that include DRR topics in the high school curricula.

Figure 3.5 – P3DM activity with high school employees.

P3DM activity with employees of the high school Monsenhor Ignácio Gióia, São Luiz do Paraitinga, Brazil.

Source: Elaborated by the author.

In relation to the high school students, we facilitated three workshops in August 2019, where besides presenting the P3DM, participants had the opportunity to work in teams, to discuss and to present their ideas on flip charts that we collected to analyze the data. During the activities, they were able to place elements (as their school, City Hall, and main church) on the territory, but some of them had difficulties, especially the ones who were not living in the urban area that was chosen for the P3DM activity.

Children were divided into groups of 5-6 people to discuss the local hazards and to delimitate the hazard-prone areas (Figure 3.6). They remembered in particular the 2010 flood event, when most of them were 5-6 years old. However, by using the P3DM, the groups had the opportunity to re-imagine the disaster, the coping strategies adopted by people at that moment and to collectively propose measures (nine in total) to reduce the damages. This activity was aligned with the suggestions of Mercer et al., (2010) who reported the importance of understanding if the local community indeed find themselves exposed to potential hazards, and if so, how they could contribute to planning a DRR strategy. The

different groups of students discussed and proposed DRR actions, selected what they considered to be a priority and drafted an action plan for one DRR measure.

Figure 3.6 – P3DM activity with high school students.

On the left photo, children allocated blue paper to represent the area that was flooded in 2010. On the right photo, students spatialized their disaster memories of evacuation measures by relocating human elements to the higher altitudes to the hills located on both sides of the Paraitinga river, where people fled during the 2010 flood event.

Source: Elaborated by the author.

One group focused on measures that they knew were adopted when the 2010 flood occurred. The group proposed improving the temporary shelter administration, which was managed by locals during previous floods. Another group mentioned rescue activities that were led by the local rafting group, while a third group suggested the logistical planning of donations that could be managed by their own community. Some groups suggested proposals related to disaster risk prevention. For instance, awareness campaigns were proposed by two groups. Both considered that they could lead these awareness campaigns in the high school and other public spaces like the main square. One of the groups also identified key partners that could support the awareness campaigns, such as the local governmental actors, represented by the local Civil Defense.

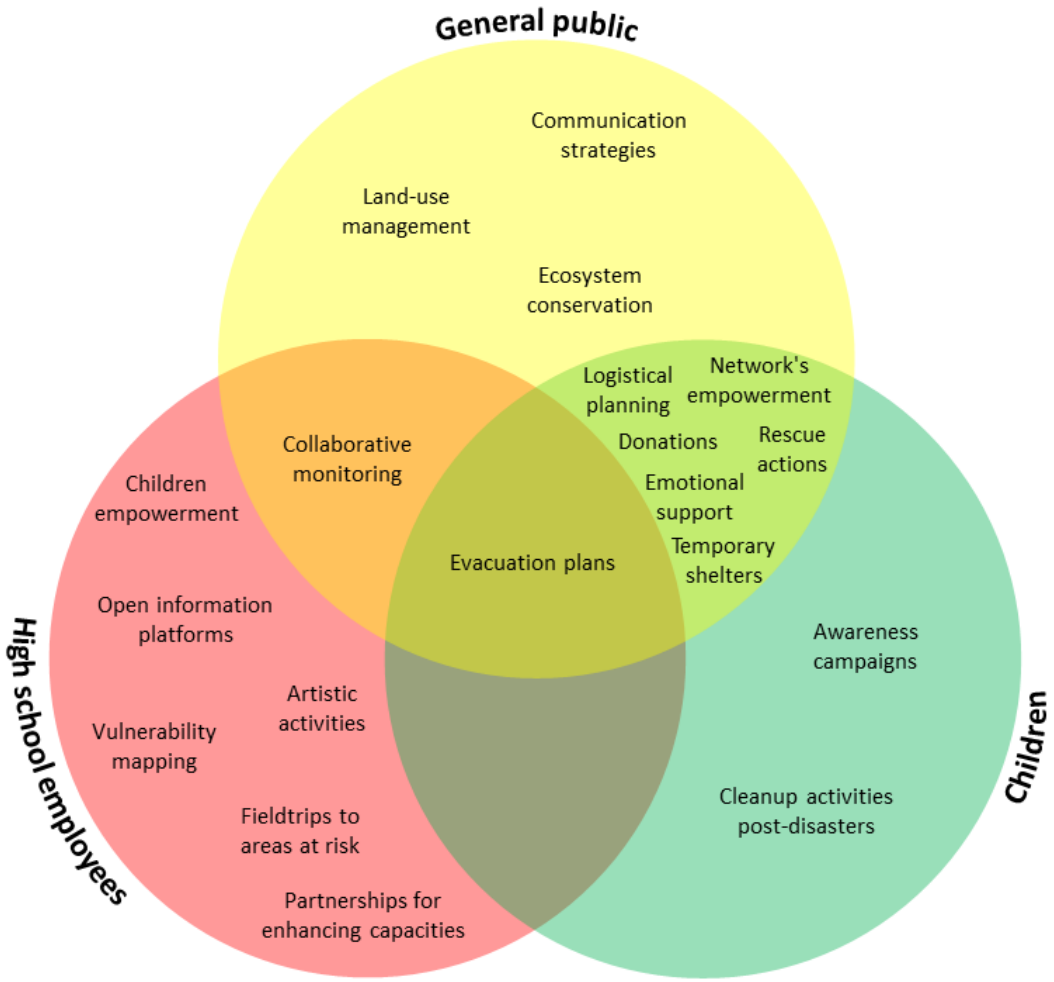
All the ideas were presented on schemes and designs that were elaborated on the flipcharts and received feedback from their peers. Then, we facilitated the

dialogue about what could be improved and how the improvements could be implemented. This was a collaborative process that helped immensely, especially because participants felt part of the process. However, there were still questions on how they could take forward their ideas, including the need to involve actors that don't belong to their generation, but from whom they could acquire knowledge and experience.

3.3.3 Proposals for DRR

Finally, this section will summarize the main findings regarding the DRR measures proposed by focus groups, which also represent social innovations. The measures were grouped according to the focus groups that mentioned them independently. In some cases, measures were identified by more than one of the groups, therefore, they are located in shared areas as can be seen in Figure 3.7. In total we identified 19 different DRR measures, which were mostly (18 out of the total) non-structural measures that could include actions which use knowledge, practice, or agreement with DRR and impacts, through policies and laws, raising public awareness, training, and education (UNDRR, 2017). Only one measure - the temporary shelters organization - was identified as a structural measure because it could be classified as a physical initiative to reduce the impacts of hazards (UNDRR, 2017).

Figure 3.7 - DRR measures proposed by the three focus groups.



Source: Trejo-Rangel et al. (2021).

One of the DRR measures that was mentioned by more than one of the groups (high school employees and the general public) was collaborative monitoring. Both groups identified the need for collaboration of specialists on DRR, but also the importance of the locals. The high school employees identified the need of feeding the open information platforms with data collected in situ, but also suggested that locals could support the ways the information is communicated to the different social groups in urban and rural areas. Another measure suggested by the three focus groups was the formulation evacuation plans. They consider this fundamental because the community should know where they have to go when a hazard occurs, and what evacuation routes are the safest and fastest.

Several participants told us that they have no clear idea what the safest places in the city are and they are unsure about what route to take.

Overall, 12 of the 19 measures proposed were “new”, because they were not adopted in previous disasters. Seven measures were performed during the 2010 flood, such as the logistical planning, donations, emotional support, rescue actions, temporary shelters, network empowerment, and post-disaster clean-up. It means that there is the potential to discuss, propose and implement actions and where the community could be involved, and which could promote intergenerational engagement.

3.4 Discussions

The P3DM can be used as an inclusive method, which engages social participation in a comprehensive way (RAMBALDI et al., 2007). This was also found by other authors, such as Gaillard et al. (2013), who used this method for studies related to DRR and climate change impacts, and by Ramirez-Gomez et al. (2017), who applied a similar approach with marginalized communities for assessing ecosystem services in order to render tangible outputs and outcomes that would influence land use decision-making processes.

In our case study, we noticed that some participants (especially children) had difficulties placing elements on the P3DM. This was especially true with those not from the urban area. This finding emphasizes the importance of involving young stakeholders in discussing and identifying local needs, and to think, debate and propose DRR measures, especially of those voiceless groups such as children, who could potentially become active agents (PETAL et al., 2020).

The interaction with the participants was an opportunity to start the conversation and to apply the secondary methods (semi-structured interviews, roundtable discussions and group discussion and presentation about action plans) in a more relaxed way without forcing them to provide information. Participants were able to “travel” their territory by following the spatial information presented on the model (GUILLEMETTE et al., 2017).

The application of the P3DMs engaged people in a dynamic way to talk about sensitive and controversial topics such as floods and landslides (DOS SANTOS, 2016; MORADEI, 2016; MARCHEZINI, 2019). Talking about hazards could take participants back to traumatic memories due to the experience they had with the 2010 flood event. In fact, we noticed they are still talking about the 2010 flood event and how shocking it was. Although our main intention was to mostly focus on preventive actions for future hazards, people kept talking about the 2010 flood which allowed them to propose future actions. The P3DM helped them to express their memories and can be useful to cope with the research fatigue that connected us, as external and local researchers, survivors and/or policymakers.

The methodological approach allowed for inclusiveness of different audiences and focus groups' perceptions, which was a challenge faced by previous research studies. For instance, Guillemette et al. (2017) identified difficulty in encouraging specific focus groups during the discussion phase. In that sense, we noticed that the interviews, which were conducted individually with the general public, allowed participants to feel more confident about externalizing their point of view.

The P3DM can be a tool to promote local intergenerational engagement since we noticed that independently of the age range that participants belong to, they wished to participate and to discuss DRR measures. Thus, we gave the opportunity to groups, including children, who tend to be invisible, enabling them to speak out and make their voice heard when we talk about DRR (TRAJBER et al., 2019). However, it is important to point out that people, especially younger generations, were aware of the need to consider the experience and knowledge from the older generations.

3.5 Conclusions

In this study, we investigated the opportunities of applying a P3DM as a communication tool. The use of secondary methods was fundamental for data collection. This allowed us to explore DRR measures that could engage local participation from different age groups from different backgrounds, in the DRR

process. This experience could be useful to guide future studies and others in the region to use this approach.

Participants provided valuable information to identify measures for enhancing DRR. They were based on what was done in the past, but also what people can do for future events. Most of the measures were focused on non-structural actions to attend response and recovery stages, rather than preventive measures. Therefore, it would be interesting to investigate in future research to understand how measures could be effectively implemented by locals, including children, and which would be supported by State actors and public policies in order to go beyond the theoretical approach.

Lastly, it is also important to facilitate dialogue between adults and children to increase intergenerational social participation and knowledge to better develop and implement the potential DRR measures. It is also important that for further research, to also include the rural area, particularly for the cities that have a close relation with those areas.

4 GIVING VOICE TO THE VOICELESS: CONNECTING GRADUATE STUDENTS WITH HIGH SCHOOL STUDENTS BY INCUBATING DISASTER RISK REDUCTION PLANS[2]

This chapter aims to encourage graduate students to facilitate a participatory mapping activity with high school students to have their voice heard in the DRR agenda. The participatory method allowed participants to contribute to the debate about local hazards and vulnerabilities, and to discuss how to implement their social innovation proposals through five incubation projects for enhancing DRR in the city.

4.1 Introduction

International frameworks such as the New Urban Agenda Habitat III (2017) and the 2030 Agenda for Sustainable Development (UNITED NATIONS, 2015; 2017) point out the importance of enhancing sustainability. These frameworks also highlight the importance of involving children to discuss pathways to reduce their vulnerabilities to disasters and climate change. Similarly, the Sendai Framework for Disaster Risk Reduction (SFDRR) mentions that people-centered preventive approaches to disaster risk should engage young people in the design of policies, plans, and standards. In this regard, article 12 of the Convention on the Rights of the Children (1989) declares that children have the right to express their views freely in all matters affecting them. Then, those younger generations, up to 30 years of age, should have access to life-long learning opportunities that help them to acquire the knowledge and skills needed for becoming more resilient (UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION, 2015).

To achieve this, studies have analyzed the participation of children in DRR. For instance, Back, Cameron, Tanner (2009) investigated how this group can be engaged in DRR in Africa, the Americas, and Asia, using different educational

[2] This chapter is based on Trejo-Rangel et al. (2022).

activities (e.g., photography and videography). Those authors found that children's enthusiasm can be raised, enabling their engagement in planning and decision-making for DRR. In a different study, Towers et al. (2014) promoted child participation in policy development and decision-making with the support of interactive filming and screening workshops, which allowed participants to enable a process of advocacy and mobilization to discuss DRR. Thus, if children are provided with the right knowledge, tools, and support from adults, they can create significant change for themselves and their communities (AMRI et al., 2018).

In the specific case of Brazil, where our study area (São Luiz do Paraitinga) is located, Trajber and Mochizuki (2015) analyzed children participation from a different perspective. The authors reviewed policy documents and conducted interviews with young people that attended national educational conferences on climate change. These authors stated the importance of providing these spaces to allow for more active participation of young people in the DRR. Marzhezini et al. (2017b) created methods to include young people in Participatory Early Warning Systems (P-EWS), where high school students acted as local researchers to interview inhabitants of flood and landslide-prone areas. As a result, the authors found barriers and institutional vulnerabilities to the implementation of P-EWS, such as overly centralized control of data and information about disasters.

Despite the efforts, children are still often voiceless and left behind in DRR (PETAL et al., 2020), even though they represent a valuable resource to nurture change and mobilize for disaster preparedness, response, recovery, and resilience at the individual, family, and community level (PFEFFERBAUM; PFEFFERBAUM; VAN HORN, 2018). Moreover, a dearth of evidence limits efforts to provide age-appropriate services and roles (NEWNHAM et al., 2019).

In response to that, some studies have proposed participatory mapping to include young people in the analysis of hazards, vulnerabilities, and risks (KIENBERGER, 2014; ROBINSON et al., 2016). This people-centered activity fosters children's willingness to contribute to proposing long-term strategies on disaster prevention (SAKURAI; SATO; MURAYAMA, 2020), and places children

as experts in their environments, providing an important counterpoint to the privilege of adultism (WILSON et al., 2019).

Participatory mapping can strengthen children and young people's capabilities in voicing out their ideas since it is an instrument of visual communication with diverse possibilities of communicating geographical content and is useful for delineating vulnerable areas exposed to hazards (BENSON; TWIGG; ROSSETTO, 2007; MARCHEZINI et al., 2017b). Thus, the objective of this study was to investigate whether and how a youth-led participatory mapping can be used to empower children to express their views about floods and landslides that are impacting their territory, and to discuss what they could do for contributing to DRR.

4.2 Methods

This research took place in São Luiz do Paraitinga, Brazil. A city that is often impacted by flood events, being the 2010 flood event of the most recent and severe reported (MARCHEZINI, 2015). This research proposal was already evaluated and approved by the Brazilian Ethical Research Committee.

Our main local partner was the High School Monsenhor Ignacio Gióia, of which one of its teachers is a collaborator of this reserach. The school was a key connection with local students and the organizer of the workshop (Figure 4.1) that facilitated the data collection for this research. The working research group was also integrated by eight master and doctoral students from the Postgraduate Program on Disaster Science at São Paulo State University (UNESP). The graduate students were trained to be facilitators and mentors of the high school students during the participatory mapping activity and following the inspiring principle of “youth teach youth” to make participants feel more comfortable in their interaction, and where youth lead the activities conducted with other younger people (TRAJBER et al., 2019).

Graduate students learned in advance basic concepts of *Sociology of Disasters* and participatory mapping. A method that required accessible geographical

information, and the participation of specialists to communicate spatial and technical data to high school students (BENSON; TWIGG; ROSSETTO, 2007; MARCHEZINI; SARTORI; GONÇALVES, 2017).

The participatory mapping was facilitated during an hour-workshop on October 29, 2019, where participants were asked to identify hazard-prone areas and social groups with higher vulnerability, to then propose DRR measures. The focus group was integrated by 22 students from the local high school Monsenhor Ignácio Gióia between 15 and 17 years old. They were selected based on quota sampling, which is a non-probability sampling technique, where we had to identify specific categories among the population (NEUMAN, 2014).

The participatory mapping activity was implemented following six steps (Figure 4.1):

Figure 4.1 – Steps followed for the participatory mapping.

Source: Trejo-Rangel et al. (2022).

i. Training: A session was held in advance during the *Sociology of Disaster* class. There, a teacher acted as a facilitator to train and explain to graduate students the steps of participatory mapping methods, and the basic concepts, and codes. For instance, hazard, vulnerability, exposure, capacity, mitigation, and disaster risk, but also legends, scale, study area, and landmarks. The role of the teacher was to simulate how the participatory mapping activity would be conducted with the high school students.

ii. Teams: Then, the graduate students traveled to São Luiz do Paraitinga and conducted the activity with 22 students from the local high school Monsenhor

Ignácio Gióia under the teacher's supervision on October 29, 2019. The activity was facilitated by a graduate student with the assistance of the other seven graduate students. These assistants took notes and helped to collect the data. The role of the facilitator was to introduce concepts, codes, and the objective of the activity. Participants were divided into five teams, each of which had at least one graduate student serving as a mentor who supported the team throughout the activity.

iii. Mapping: Participants mapped areas at risk on a printed map that contained the city center base map from *Google Earth*. These areas were selected based on vulnerability aspects and potential hydrometeorological hazards which historically occur in the city of São Luiz do Paraitinga, Brazil. Different materials were made available such as chart board paper, markers, stickers, and printed maps of the urban area of the city. High school students identified the flood and landslide-prone areas, as well as the location of groups who are exposed to those hazards, such as elderly people in retirement homes and schools.

iv. Ideas' discussion: the teams of high school students were asked to discuss and decide on a measure for enhancing DRR then related to the hazard they identified. Each group was asked to draft a plan for the implementation of the measure they proposed: a) for what the measure would be; b) how it would be implemented; c) who would be the partners, and d) what kind of resources they would need. The groups proposed preliminary plans referred to as "incubation ideas" because they still need to be catalyzed.

v. Ideas' presentation: groups presented their incubation ideas to the audience, which included an advisory board with two guests: the head of the local civil defense, and an anthropologist of a local non-governmental organization (NGO) Akarui. The final presentations and feedback were recorded to, later, be analyzed.

vi. Results communication: the proposed actions, resulting from this activity, were included in a survey, which was shared with the general public in São Luiz do Paraitinga. Nonetheless, data will be analyzed later on.

4.3 Results

This research found that the “youth teach youth” methodology (TRAJBER et al., 2019) successfully enhanced children's participation in this short-term activity. Graduate students facilitated the process of engaging the high school students to identify areas at risk (Figure 4.2) and formulate five different actions (Table 4.1) to mitigate disasters in São Luiz do Paraitinga, which according to the participants, is exposed to floods and landslides.

The participatory action research method focused on reflection, data collection, and action that required a strong support system. It should include different stakeholders (e.g., teachers, community leaders, local government, and NGOs), who could provide guidance and resources for the implementation of the proposed actions (FERNANDEZ; SHAW, 2013). Need that was strongly highlighted during the high school students’ presentations.

Figure 4.2 – Participatory mapping example.

This is one example of the five participatory maps elaborated by high school students. The green stickers (with the letter “A”) refer to low flood risk areas and low landslide risk areas (with the letter “D”). The yellow dots are the zones at medium risk, either for floods (with the letter “A”) or landslides (with the letter “D”). The red stickers (with the letter “A”) represent the high flood risk area, which is by the river where the historical center is located. The high landslide risk areas (with the letter “D”) are located where the steepest slopes of the urban area are.

Source: Trejo-Rangel et al. (2022).

The areas that are exposed to floods, according to the participants, coincide with what was reported by Moradei (2016) for the 2010 flood assessment. In turn, areas exposed to landslides were located where there is a stepper difference in relief. For reducing risks to those hazards, participants discussed and formulated five different incubation ideas (Table 4.1) based on non-structural DRR actions,

which were inducted by the capacities and resources they have access to. This result was different from those reported by Almoradie et al. (2020), whose participants proposed mainly structural DRR measures. This answer should be inducted because of the focus on people-centered actions in this research. This request could have influenced them to focus on non-structural rather than structural actions.

Table 4.1 - Incubation plans.

Team	What?	For what?	How?	Who?	What resources?
1	Intercity Communication Committee	For monitoring rainfall and floods	Public talks and presentations for raising awareness. Communication strategies between the cities within the basin	Local high-school students, local authorities (civil defense and municipality) and federal authorities (National Center for Monitoring and Warnings of Natural Disasters).	Human
2	Territorial planning	For avoiding and relocating human settlements in areas at risk	Supervision of future and previous developments	NGO's, civil defense and municipal authorities.	Human
3	Multi action DRR plan: Ecosystem restoration, evacuation plans, recovery actions, territorial planning.	For mitigating landslides and floods impacts	Implementation of Nature Based Solutions, relocation of vulnerable settlements, and reconstruction of damaged or destructed infrastructure	Private sector (industry), civil defense and municipal authorities.	Human and financial
4	DRR App	For improving communication when rain and/or floods occur	By providing recommendations from the civil defense to know what to do.	Private sector (industry), civil defense and municipal authorities	Human and financial
5	Social preparedness	For being better prepared to face floods and landslides	Campaigns and talks for sharing recommendations and enhancing awareness	Community, civil defense, environmental and municipal authorities.	Human and financial

Source: Trejo-Rangel et al. (2022).

As can be seen in Table 4.1, all the measures that represent social innovations and which were proposed to reduce and prevent disaster risk. Some of the measures (teams 1, 4, and 5) were related to risk communication, which according to Rollason et al. (2018) has two phases. Firstly, identify hazard-prone areas, which was done in the participatory mapping, and secondly, let those at risk know when the floods and landslides may occur, and what actions can be

proposed and implemented. Usually, risk communication is often carried out by experts (scientists) and political and economic actors who often have conflicting views and interests (SALMAN; LI, 2018). In this study, we gave voice to other actors such as the graduate students and the local high school students, who played together, thought about disaster risks, and reflected to increase their coping capacity.

Local high school students also discussed and formulated measures related to territorial planning (ideas 2 and 3). Those measures are key to mitigating some urban risk drivers such as urban sprawl in hazard-prone areas. This dialogue can contribute to planning how the city can be reorganized to avoid conflicts (FOLHES et al., 2015; SISTO; LOPOLITO; VAN VLIET, 2018) and disaster risk intensification.

For implementing and developing the proposed actions, especially those related to risk communication, the high school students identified that it is essential to include the participation of actors from their school, as well as other partners such as NGOs, civil defense, municipal authorities, and the private sector. Nonetheless, one of the main challenges which participants faced was related to what resources were needed to put their incubation ideas into action.

Finally, in this study, students actively participated not only in mapping risks but also in the formulation and planning of DRR measures. This planning exercise can be important to raise awareness about the value of children's participation to reduce personal and community vulnerabilities and to improve their capacities (LOPEZ et al., 2012).

4.4 Discussions

Our role as researchers was to support and promote children's participation in DRR in a proactive way as suggested by Back; Cameron; Tanner (2009); Robinson et al. (2016); and Marchezini et al. (2017b). This study allowed us to encourage the engagement of graduate students and high school students in DRR through interactive methods related to children participation in policy development, decision making, and risk communication (TOWERS et al., 2014).

Graduate students and high school students were able to discuss and formulate incubating ideas that could be supported by schools, NGOs, and local partners, especially for funding and means of implementation. This can facilitate local-level involvement in mitigation and preparedness, increasing community participation in operational planning, education, and training (BURNSIDE-LAWRY; CARVALHO, 2015).

It is vital to recognize the importance of studies of children's participation in DRR, especially those that involve collaboration between NGOs and academia (AMRI et al., 2018). In that sense, this research made use of strategies that could provide children with opportunities to express their needs. The participation of local actors, such as the Civil Defense and the NGO Akarui, contributed to giving suggestions and supporting the students' incubation proposals, due to the different capacities and knowledge they have. For instance, the NGO Akarui suggested that the local urban plan should organize public audiences to involve children in thinking about the future of cities, as recommended by the New Urban Agenda Habitat III (UNITED NATIONS, 2017).

As mentioned, the proposed measures were mostly based on risk communication since it was one of the principal weaknesses during the devastating 2010 flood. The school curricula can also contribute to promoting risk communication by including content that endorses prevention combined with different subjects (e.g., history and natural science), but also by creating official interactive spaces, within the institutions, where children could be heard. Then, those so-called vulnerable groups can be empowered to actively mitigate their vulnerabilities.

4.5 Conclusions

This research highlighted the importance of involving underrepresented and often voiceless groups in DRR discussion. It was confirmed that youth can teach children, but also that children could contribute to drawing their future when they have the chance to express their views. To achieve this goal, it was important to give children prominence, facilitate affordable channels of communication and

hear what they were thinking to enhance DRR in their territory that is often decided by adults without consulting them.

This study promotes the reduction of power imbalances between intergenerational groups since they had differences based on class, gender and/or race. The participatory mapping was a useful communication method to promote critical thinking, discussion, and formulation of incubation ideas for DRR. The inclusion of other participatory methods enhanced research potential, performing a successful strategy. The participatory processes that involve youth for facilitating, and local teachers and other partners from different sectors to support the DRR configures a mixed responsibility. Lastly, since there is still a lack of knowledge about children's points of view in DRR, we extend the invitation to researchers to continue giving children the opportunity to be part of the DRR through participatory approaches. We recommend including local stakeholders to supply the information and support young people to put their ideas into practice. In addition, it was noticed that considering the basin as study area would help to propose more integral measures that were already identified by participants.

5 INCORPORATING SOCIAL INNOVATIONS IN THE ELABORATION OF DISASTER RISK REDUCTION POLICIES[3]

Climate crisis requires intergenerational groups' participation to reduce their vulnerabilities and to promote disaster risk reduction public policies. This chapter analyzes what and how social innovations can nurture DRR public policies to enhance flood resilience in small cities. A mixed-methods approach, which considered a survey applied with 231 participants and the facilitation of a seminar with participatory methodologies, was conducted between August and October 2021, engaging municipal secretariats, civil defense, an NGO, schools, and residents. Research partners identified, in the survey, their main hazards, vulnerabilities, and capacities, as well as suggested and prioritized social innovation actions to face the disaster risks. The survey's results were shared during a seminar that also included serious gaming activities to identify implementation pathways (how, when, with whom, with what resources) for the social innovation actions that were prioritized. Among the actions are prevention plans, natural areas restoration and conservation plans, risk areas tours, children and youth engagement, and evacuation plans.

5.1 Introduction

There is evidence that disasters are increasing due to the rise of social vulnerabilities and natural hazards, which are products of the current capitalist system that engendered the social and climate crisis (DUNLAP; BRULLE, 2015; CHMUTINA et al., 2021; WORLD METEOROLOGICAL ORGANIZATION, 2021; LAHSEN; RIBOT, 2022). Climate change becomes seriously self-evident, reduction of vulnerability and susceptibility must be a paramount priority against a consequently increasing incidence of disasters (LEWIS, 2014). In addition, there is still a lack of effective public policies that contribute to DRR, especially in

[3] This chapter is based on the research paper *Incorporating social innovations in the elaboration of disaster risk reduction measures*, which was submitted for publication in the International Journal of Disaster Risk Reduction.

those regions which are more exposed to hazards (ALBUQUERQUE SANT'ANNA, 2018; MÉJEAN et al., 2020), such as Latin America and the Caribbean (LAVELL et al., 2020; ALCÁNTARA-AYALA et al., 2021).

It is crucial to continue working on how DRR could be implemented, considering an approach that includes local communities as active members, rather than following the traditional top-down approach (SCOLOBIG et al., 2015; HAYNES; BIRD; WHITTAKER, 2020). Supporting ongoing, socially constructed, and negotiated processes, also defined as social innovations, and not just the execution of already specified plans of action with anticipated outcomes (LONG, 1990). The social innovations should be long-lasting outcomes motivated by the goal of merging a social need (MULGAN, 2006). It means to change the relationships, positions, and rules between the involved stakeholders, through an open process of participation, including end-users, and crossing organizational boundaries and jurisdiction (CHESBROUGH, 2003; HARTLEY, 2005; BASON, 2010; OSBORNE; BROWN, 2011; SORENSEN; TORFING, 2011).

Social innovations should be promoted to go beyond what external agendas and researchers propose and should consider local realities and interests. Then, it is needed to support local people to retain power in leadership and decision-making as is proposed in the Disaster Studies Manifesto[4]. Especially because DRR policies and researchers still do not fully consider local actors' participation, who can be impacted during disasters (WEICHSELGARTNER; PIGEON, 2015; LÓPEZ MARRERO; HEARTSILL SCALLEY, 2021). Resulting in little (if any) benefit and disempowerment of the people being studied, missing the involvement of local researchers in the research process, and promoting extractivist and non-inclusive approaches.

In this regard, Gibson, and Wisner (2016) highlighted, in their Frontline method[5], the importance of promoting a structured conversation that captures people's priorities based on asking four questions: i) what threats they faced; ii) the

[4] Power, Prestige, and Forgotten Values: A Disaster Studies Manifesto (https://www.ipetitions.com/petition/power-prestige-forgotten-values-a-disaster).
[5] Bottom-up mirror of a top-down monitoring approach used by the United Nations at the Hyogo Framework for Action Monitor.

consequences of those threats; iii) the potential actions that could be taken locally to overcome these threats; and iv) the barriers they perceived to acting. It is important to promote people's engagement in discussing current gaps and deficits in DRR, integrating (a) knowledge based on local experience, which includes local priorities, (b) target-oriented methods of communication, and (c) trans-disciplinary approaches to research (SPIEKERMANN et al., 2015).

The objective of this study was to investigate what and how social innovations could be implemented by public policies to promote flood resilience in São Luiz do Paraitinga, Brazil. The following section presents the adopted mixed-method approach. Then, the key results of the application of those methods, followed by a discussion of what was found and finalizing with some main conclusions with recommendations for future studies.

5.2 Methods

The mixed-methods approach employed in this research, and presented in the following subsections, includes a survey and a seminar as a participatory technique to collect qualitative and qualitative data. The different types of data collection were used to complement each other's findings (MCCLINTOCK et al., 2016; SKRYABINA et al., 2020). The methods were partially conducted remotely to respect physical distancing during the global pandemic COVID-19 and are part of the final stage of doctoral research conducted since 2018. The overall research objective was to investigate how social innovations could enhance DRR. The project was submitted and approved by the Research Ethical Committee of the Brazilian Government.

5.2.1 Survey

Surveys are applied as data collection instruments useful to profiling a situation, and to develop overall partners. They consider a larger number of people, and the data gathered could contribute to generating findings that are more generalizable (ROWLEY, 2014; LUND, 2021). The survey (Appendix 2), applied

in São Luiz do Paraitinga, was elaborated in the platform Google forms for collecting quantitative data and for reaching a larger audience. It included 26 questions that were divided into the following sections: (i) demographics (eight questions), (ii) disaster risk perception (seven questions), (iii) social innovation actions (two questions), (iv) actions implementation (two questions), (v) incentives (four questions), and (vi) any other additional information (three questions).

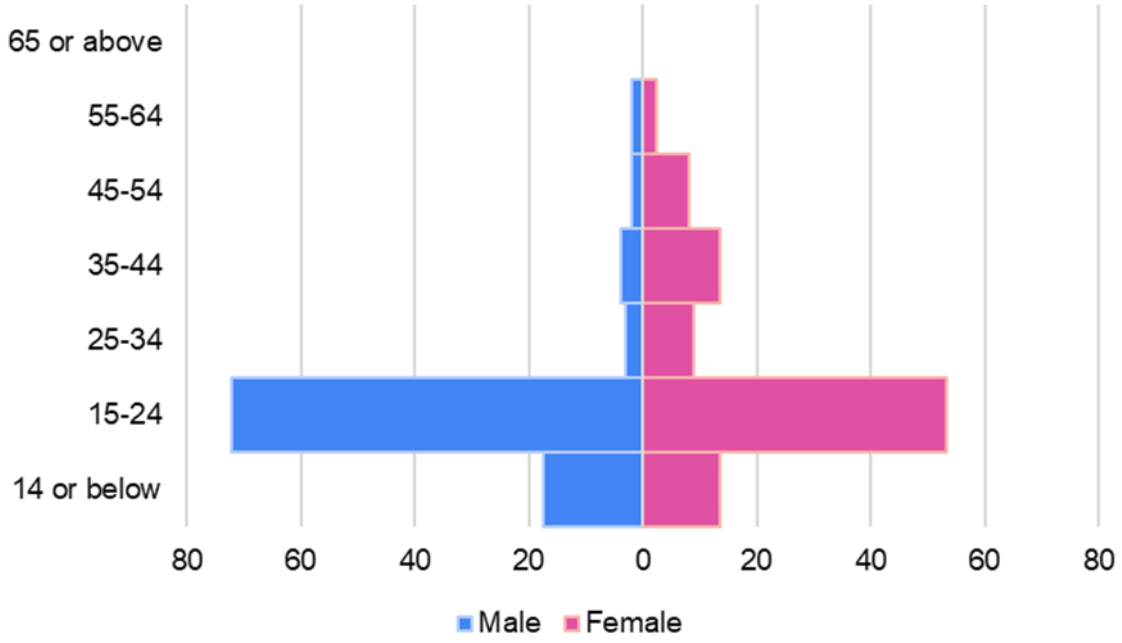
The survey included open-ended and closed-ended questions. Most of them were closed-ended (14 out of the 26 items) to increase the response rate (ROWLEY, 2014). For validating the content and structure, a pilot was run by five volunteers (AGINAKO et al., 2021). Then, the survey was openly shared among community members through WhatsApp, Facebook, Instagram, computer facilities of the local high school, and a printed version to facilitate the access of it to people without access to the internet. The survey was carried out from June 9 to August 27, 2021, and adopted a non-probabilistic sample, specifically, convenience and snowball. It means that the sample was built from cases that were accessible or individuals that were selected and asked to contact or recommend other groups and/or individuals (ROWLEY, 2014).

However, as Rowley (2014) mentioned, getting a response is an art! And indeed, it was a challenging task, especially because even after sharing the online survey, only 22 responses were collected during the first weeks. Therefore, it was needed to mobilize local contacts (high school and elementary employees) to ask if we could visit them directly to facilitate the survey either in a printed version for the students' relatives, as it was the case in the elementary school, and the online version, as it was the case for the elementary school, where students were guided to answer in the school facilities. Thus, we were able to get a total of 231 responses, around 4.6% of the total number of inhabitants (~5,000) impacted by the 2010 extreme flood.

Most of the participants (54%), who answered the survey were women, followed by men (45%), and 1% did not identify themselves in any of the previous choices. The participants were mostly (68%) people of 24 years or younger, and only 32%

of the responders were 25 or older (Figure 5.1), which may be related to the fact that our main partners were linked to local schools.

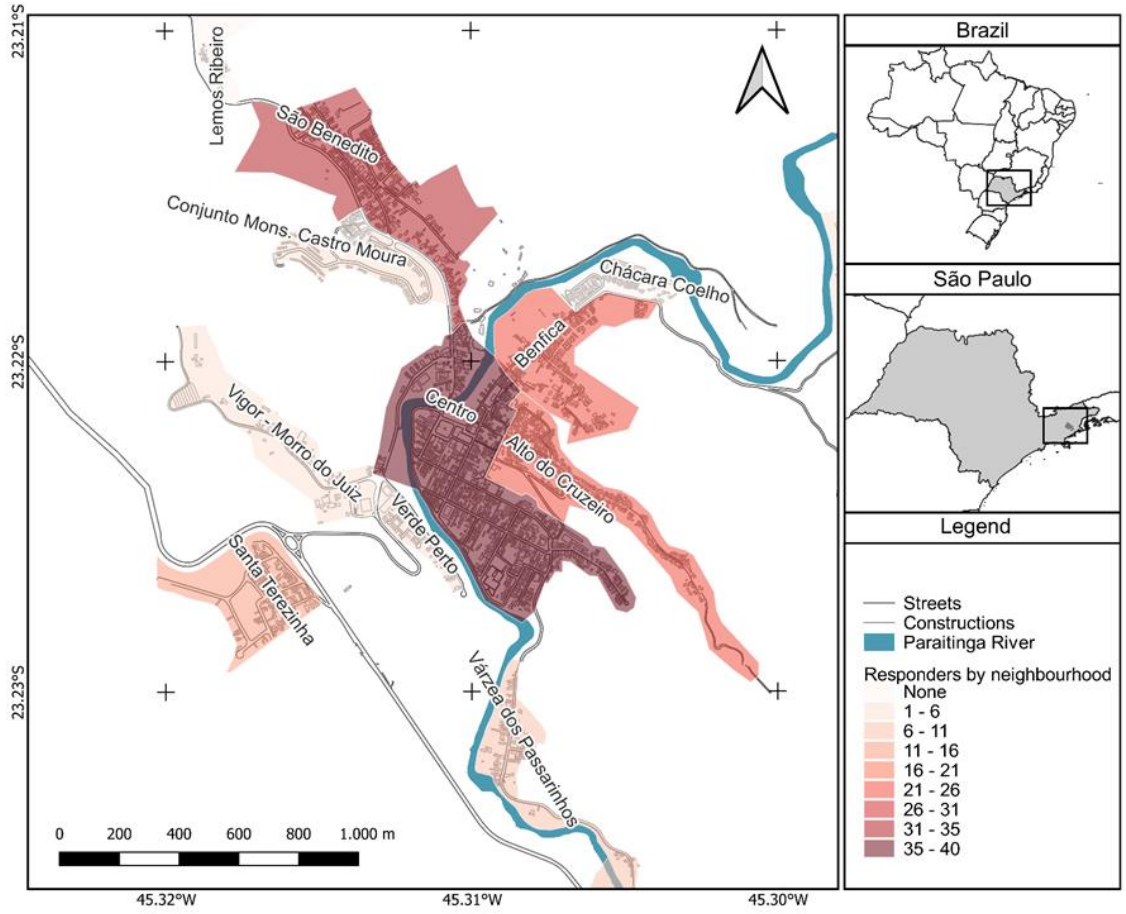
Figure 5.1 - Age-sex responders' pyramid.



Source: Elaborated by the author.

Most of the responders (96%) live in São Luiz do Paraitinga, and 50% of them are settled in the urban neighborhoods of the city center, and surroundings (Figure 5.2). The neighborhoods, from which more participants are, include the Centro (16.45%), followed by Sao Benedito (13.85%), Benfica (10.40%), Alto do Cruzeiro (9.52%), and Santa Terezinha (6.06%).

Figure 5.2 - Number of survey responders by neighborhood.



Source: Elaborated by the author.

The collected data was organized in a Geographic Information System Software. Data were organized to characterize responders. The social innovations that were most voted on were shared in the seminar, which was also facilitated to collect qualitative data.

5.2.2 Seminar

The seminar “Disaster Risk Reduction in São Luiz do Paraitinga” was a hybrid (in-person and online) two-day event that was held on the morning of September 30 and on the afternoon of October 1, 2021, at the facilities of the High-School Monsenhor Ignácio Gióia and streamed on the school’s Facebook page of the school. The proposed activities were:

(i) Opening session: a brief session to explain the seminar's objective, which was to investigate how social innovations could be implemented by public policies to promote flood resilience in São Luiz do Paraitinga, Brazil. During this session, the Major of the City participated and received a high-resolution map (Figure 5.3) of the Paraitinga river. The map included the contour lines of different water levels (2, 3, 5, 7, 9, 11, and 13 meters above the mean river level) that delimitates potential flood-prone areas. The major also received a synthesis map that includes urban sprawl in hazard-prone areas and testimonials of participants about their memories of the 2010 flood (TREJO-RANGEL et al., 2021).

Figure 5.3 – Opening ceremony.

High-resolution and synthesis maps delivered to the major.

Source: Elaborated by the author.

(ii) Roundtable: this activity lasted one hour and a half and was conducted by a high-school teacher. The guest speakers were the Mayor of the City, a local researcher, who is currently involved in the master urban

plan, and the head of the local civil defense. The seminar started with a discussion with some trigger questions (Appendix 3) related to DRR in the city, which were prepared by the research team. What is the city's performance regarding DRR? What is still needed in the city to enhance DRR? What are the main challenges for doing what is still needed? How can the population contribute? And what could public policies do to support the population?

(iii) Music presentation: conducted by a local professor and musician since it is well known in the region that São Luiz de Paraitinga has a rich cultural heritage.

(iv) Photographic exhibition: high-school students were asked to take photos in advance of the areas at risk in the city. The photos were exhibited in the school's mural during the seminar's activities to all the students.

(v) Serious gaming: it was presented the survey's outcomes to the 52 high school students that participated in a problem-solving game that was contextualized to the city's reality, and where participants collectively reflected and discussed what could be done in their community to be more prepared for floods (SOLINSKA-NOWAK et al., 2018; FLEMING et al., 2020). The stages of this activity were as follows (Figure 5.4):

Figure 5.4 – Serious gaming steps.

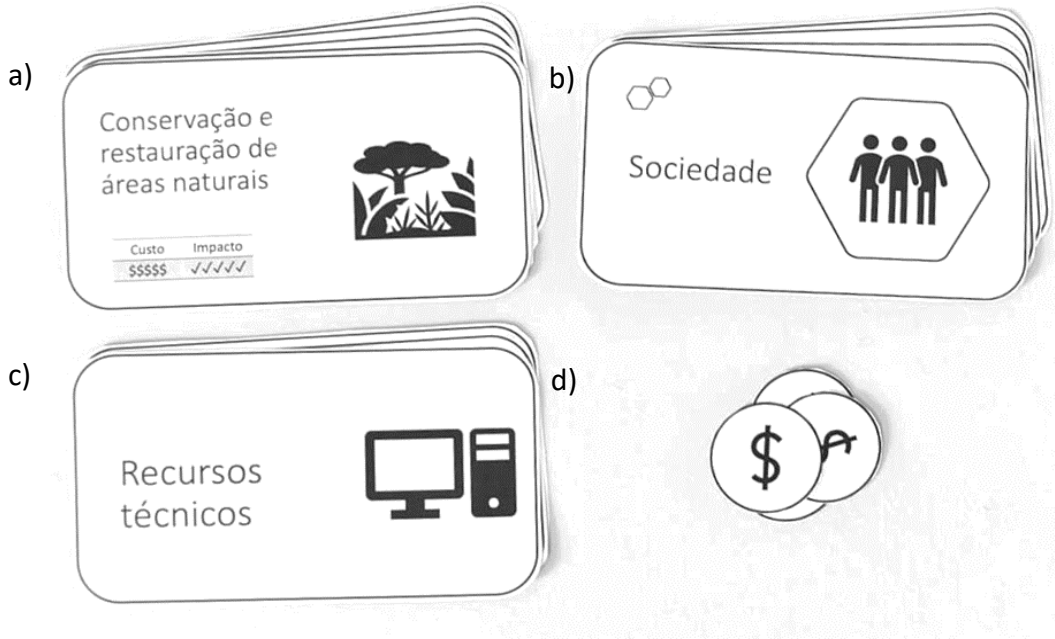
Source: Elaborated by the author.

a. Participants stayed in their classrooms where there was at least one person from the facilitators' team.

b. The six classrooms were divided into smaller groups of four or five students.

c. Each subgroup was provided with a set of cards, which were elaborated based on the data that were collected in the previous methods, such as interviews, participatory mapping (TREJO-RANGEL et al., 2021, 2022), and surveys. The cards (Figure 5.5) included the 10 DRR measures (which were the most voted in the surveys) and their estimated costs, seven potential partners, three kinds of resources (technical, human, and financial), and 10 coins that simulated the budget that each group could invest in DRR measures.

Figure 5.5 - Serious gaming cards.



The cards set included: a) 10 DRR measures, b) seven possible partners, c) three different kinds of resources, and d) limited among of money (10 coins).

Source: Elaborated by the author.

d. After understanding the set of cards, they were asked to decide by teams in 30 minutes, what measures they would like to implement in their city, what would be the three main partners that could help in the implementation, and what kind of resources they would need. Their decisions should consider a scenario of a limited budget (10 coins per group).

e. After agreeing on the measures, partners, and resources, each team presented their ideas to the other groups, and then, it was run a second round, but at this time, the teams were informed that they would have an unequal number of coins. However, they had the opportunity to donate to the teams that had fewer coins.

f. Lastly, they present the final proposals to a board which was integrated by a member of the local NGO Akarui, the head of the local civil defense, and the headteacher at the high school, who made their comments about the final proposals.

All the activities were photographed and recorded. Then, the collected data was analyzed, organized, and summarized to make recommendations to local policymakers. The data collected in the serious gaming activities were analyzed using the following categories: measures, partners, and resources.

5.3 Results

The mixed methods that were utilized in this study contributed to investigating, first, what social innovation could be applied in São Luiz do Paraitinga according to the participants, and then to explore how they can be implemented. It was also researched the role of public policies to make that possible. In this section, the results are presented by the chronological order that methods were conducted.

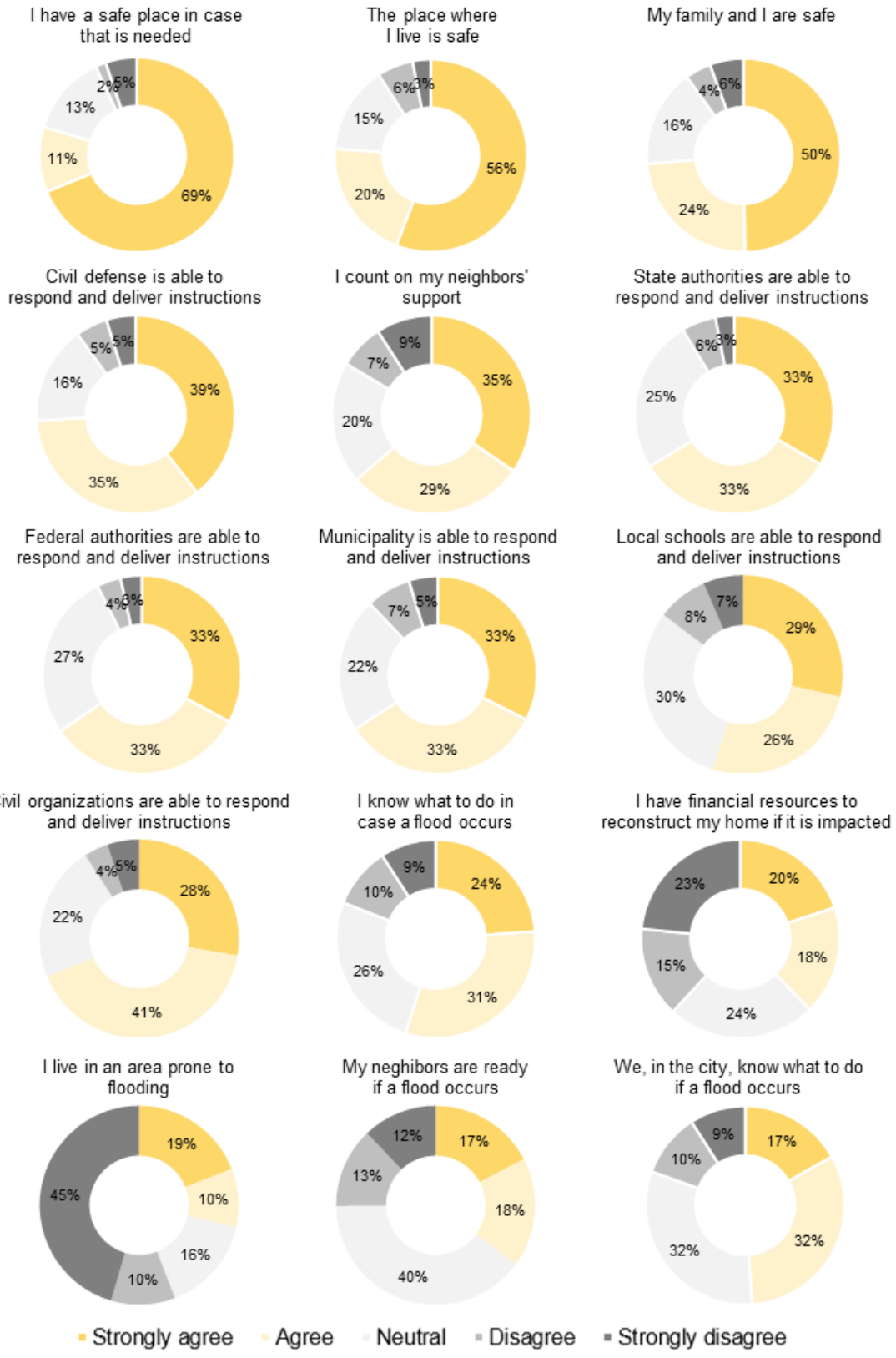
5.3.1 Hazards and preparedness

Firstly, to contextualize what kind of hazards can trigger disasters in the city, people were asked about potential hazards. 205 (89%) out of the 231 participants agreed on floods. Followed by landslides (6%) and cold waves, fires, and droughts (5% in total). Participants responded that about 35% of them were impacted, specifically during the previous largest flood event in 2010.

For investigating how responders were prepared for floods, several statements were raised (Figure 5.6) and organized according to the level of agreement. Among the statements that participants agreed with, the most were related to the safeness of their family and places. Followed by statements that were related to third parties, such as civil defense, neighbors, state, federal, and municipal authorities, schools, and civil organizations. Either for support, respond, or deliver instructions.

However, when it was asked if their neighbors and the people in the city would know what to do in case a flood occurs, the level of agreement was reduced. Additionally, less than half of them consider that they have financial resources in case they need to reconstruct their homes.

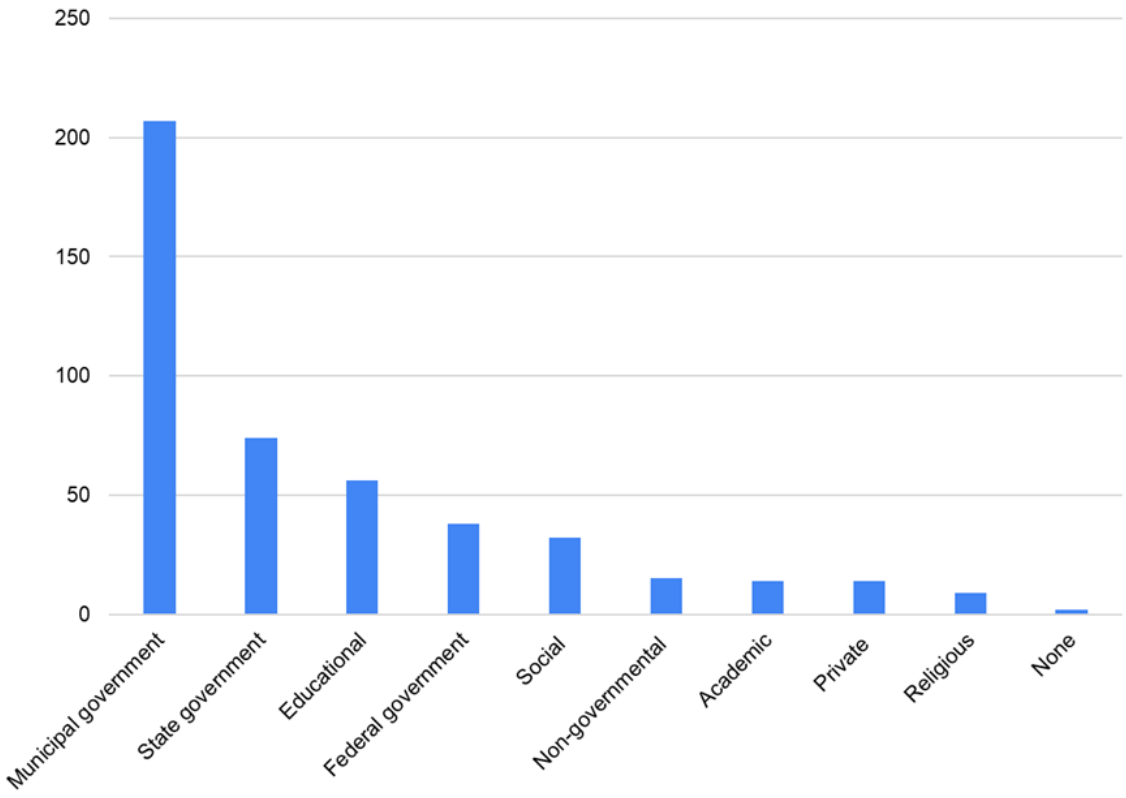
Figure 5.6 - Statements to characterize preparedness to reduce disaster risks.



Source: Elaborated by the author.

Regarding the different sectors (Figure 5.7) that should be involved in flood prevention in the city, 207 out of the 231 (around 90%) participants believe that the municipal authorities are the main sector. It is followed by the state authorities (selected by 71 responders), educational (56 responders), the federal government (38), society (32), among other sectors.

Figure 5.7 - Sectors that should be involved in flood prevention.



Source: Elaborated by the author.

5.3.2 Social innovations for enhancing DRR related to flood events

The survey had 17 different DRR options, which were defined based on previous interviews in the first phase of this research project (TREJO-RANGEL et al., 2021, 2022). In the survey, participants could choose as many DRR proposals as they wanted to up to the 17 available. The 10 most voted (Table 5.1) were measures that fit within the different stages of the disaster risk management cycle

(risk analysis, preparedness and early warning, emergency relief, and recovery). For the risk analysis stage, vulnerable areas mapping and tours in areas at risk were two actions that responders would be interested in participating in. After the risk is known, responders agreed that they would be interested in some preventive actions, such as the elaboration of prevention, evacuation, territorial and land-use plans, natural areas restoration and conservation, children engagement, and DRR measures communication. Finally, to warn the city before a flood event occurs, responders were interested in community monitoring of the Paraitinga river as well as the rainfall of the region.

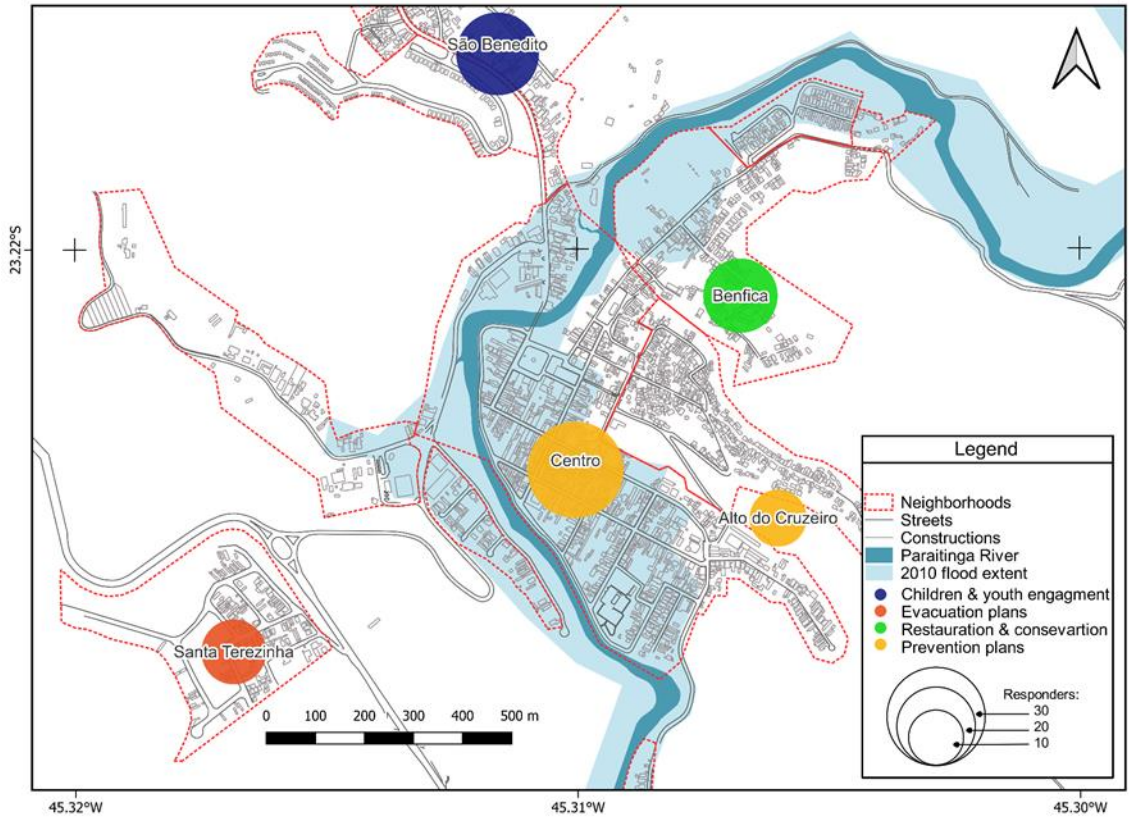
Table 5.1 - Top 10 DRR measures ordered by responders' interests.

Action	Strongly interested	Interested	Neither interested nor disinterested	Disinterested	Strongly disinterested
Prevention plans	48%	24%	20%	2%	5%
Natural areas conservation and restoration	45%	26%	19%	5%	6%
Risk areas tours	43%	23%	22%	4%	7%
Children and youth engagement	43%	24%	23%	4%	7%
Evacuation plans	41%	26%	23%	3%	6%
Vulnerable areas mapping	41%	20%	28%	6%	6%
Community monitoring of Paraitinga river	39%	26%	22%	8%	6%
Mitigation measures communication	37%	26%	27%	4%	6%
Territorial and land-use planning	36%	23%	24%	8%	8%
Community rainfall monitoring	36%	24%	27%	5%	9%

Source: Elaborated by the author.

Overall, the measure that responders most selected was prevention plans, followed by natural areas conservation and restoration, risk areas tours, children, evacuation plans, and so on. The neighborhoods chose and prioritized different DRR measures (Figure 5.8). Prevention plans were mostly supported in the Centro and Alto do Cruzeiro neighborhoods, while children engagement were prioritized in São Benedito. Natural areas restoration and conservation were most selected in Benfica, and evacuation plans were in the first place in Santa Terezinha.

Figure 5.8 - DRR actions selected by neighborhoods.



The map includes DRR actions selected by neighborhoods, the Paraitinga river and the 2010 flood extent.

Source: IBGE (2010).

According to the responders, the DRR measures implementation should include the participation of different sectors, but mostly the municipal authorities. The State authorities appeared in second place, followed by the society and federal government, and other sectors mentioned on the table (5.2) below.

Table 5.2 - Sectors to implement DRR measures.

Sectors	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Municipal government (E.g. Municipality, civil defense)	85%	8%	4%	1%	2%
State government (E.g. São Paulo State Government)	61%	23%	13%	1%	2%
Social (E.g. population)	51%	23%	15%	5%	6%
The federal government (E.g. CEMADEN)	45%	25%	21%	4%	4%
Educational (E.g. municipal and state schools)	40%	29%	19%	6%	6%
Non-governmental (E.g. NGOs, civil societies)	35%	30%	19%	6%	10%
Private (E.g. tourism, restaurants, business)	31%	22%	24%	9%	14%
Academic (E.g. universities, research institutions)	28%	29%	28%	6%	9%
Religious (E.g. Churches, temples)	22%	19%	29%	13%	17%

Source: Elaborated by the author.

Besides the human resources that are included in the different sectors, responders also agree that technical (equipment, knowledge, etc.) and financial resources (monetary investment) are also important to implement the DRR measures. In addition, they recognized that incentives (Table 5.3) are fundamental to endure people's participation in the DRR measures implementation.

Table 5.3 - Incentives to implement DRR measures.

Incentives	Extremely important	Very important	Moderately important	Slightly important	Not at all important
Social recognition	68%	22%	8%	1%	1%
Trainings	68%	22%	9%	1%	0%
Institutional Support	58%	29%	9%	2%	2%
Continuity of proposals	55%	26%	15%	2%	2%
Conversation spaces	46%	30%	18%	3%	3%

Source: Elaborated by the author.

5.3.3 Social innovations as inputs to elaborate public policies

The findings shared in the previous subsection were disseminated during a seminar in the High School Monsenhor Gióia, on September 30 and October 1, 2021, which was attended by 119 people among students, teachers, policymakers, public servants, and people who watched the seminar on the school Facebook page. The seminar was mostly organized by the high school employees, who drafted the agenda, invited the speakers, included special sessions with music and an exhibition, and co-organized the serious gaming session with the students. During the roundtable, facilitated by a local teacher, and with the participation of the mayor, an urban planning expert, and the head of the municipal civil defense (Figure 5.9), was debated and discussed: What is the city's performance regarding DRR? What is still needed in the city to enhance DRR? What are the main challenges for doing what is still needed? How can the population contribute? And what could public policies do to support the population?

Figure 5.9 - Roundtable participants.

The roundtable participants were the civil defense head, a local researcher, the city mayor (the three on the left), and the moderator, a high-school teacher (the one on the right).

Source: Elaborated by the author.

According to the roundtable participants, the fact of having experienced a flood event pushed them to be more prepared for future events. Nowadays, they can identify areas at risk, which are fundamental to deciding where people can construct new buildings. They also mentioned that there are some areas in the city where the lands are “frozen”, which means that no buildings can be constructed. However, they emphasized that they are still struggling to avoid new irregular constructions, which is a constant concern they still must attend to.

In addition, participants mentioned the relevance of considering and managing rural areas and even territories of other municipalities. The Paraitinga river basin extension also includes the municipality of Cunha, which is located upstream. Thus, it is crucial to promote initiatives in the rural areas to preserve them, such as the Conexão Mata Atlântica project[6]. The project focuses on payment to farmers and landowners to take care of their land, which provides environmental services, including flood and climate change mitigation.

To prepare the population, the municipal authorities and civil defense have run drills with the population. The simulations provide information to the community on what to do when a flood event can occur. In this regard, it was also mentioned the importance of enhancing risk communication. The municipal civil defense has created WhatsApp groups to announce information about the weather conditions as well as for instructions on what to do in an emergency.

The roundtable participants mentioned that popular knowledge should be considered as well as scientific knowledge, and DRR topics should be included in the school curricula at an early age since children live in an area exposed to risks and they should not forget about it. In that sense, the photographic exhibition (Figure 5.10) is one of the many activities that could be done with the local students. For this activity, students photographed areas exposed to floods and landslides. However, it was noticed that in most of the photos (11 out of the 14) landslides were photographed. The other three photos referred to flood-prone

[6] Conexão Mata Atlântica (https://conexaomataatlantica.mctic.gov.br/cma/portal/).

areas, which is probably due to the fact that floods are events that can be perceived when they are already happening.

Figure 5.10 - Photographic exhibition.

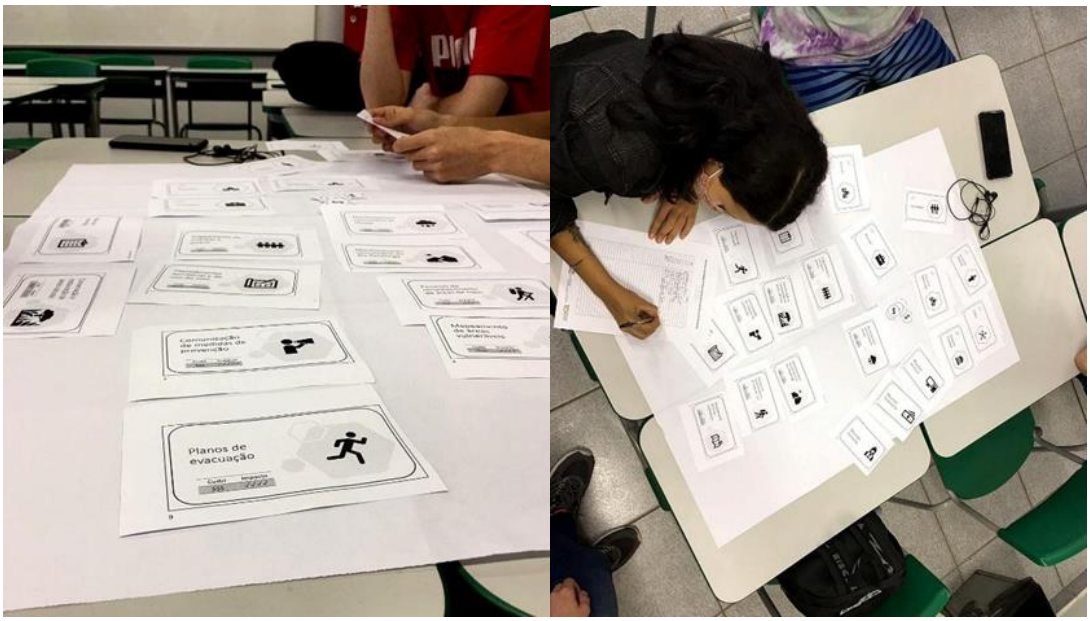
A photographic exhibition with contributions from high-school students that took photos of areas that are exposed to landslides and floods.

Source: Elaborated by the author (2021).

By asking students to photograph areas at risk, they were empowered to identify where and what could be at risk, and they became the main actors, who besides looking at their environment, were also able to document and share with others the areas at risk in the city where they live.

As a final activity, the serious gaming activity caught the attention of 52 students. During the activity, they discussed what measures are interesting for the city (Figure 5.11). They became part of the solution by designing what is needed for the implementation and contributing to the policies elaboration for enhancing DRR.

Figure 5.11 – Serious gaming activity.



High students working on preparing the proposals for mitigating disasters related to flooding hazard events.

Source: Elaborated by the author (2021).

From the 15 different DRR proposals that we collected, 60% (9) of them mentioned communication as one of the actions they find interesting to be implemented. Communication-related proposals were linked to the different governmental levels (municipal, state, and federal), social and school participation. The needed resources for implementation were weighed in technical aspects.

Then, in 40% (6) of the proposals, the mentioned actions were evacuation plans, natural areas restoration and conservation, and children engagement. Those proposals included the participation of governmental actors at the different levels, plus the NGOs, social, and private sectors engagement, and mostly financial resources for their implementation.

Prevention plans were mentioned in 33% (5) of proposals, vulnerable areas mapping in 13% (2), and community monitoring of the Paraitinga river only in 7% (1). From the 10 measures that were initially shared, risk areas tours, territorial

and land-use planning, and community rainfall monitoring were not considered in any of the proposals.

Overall, the main partners, which according to the participants should be part of the implementation process, are the society and municipal government, which appeared in 60% of the proposals. Then, schools (53%), NGOs and State government (40%), Federal government (27%), and the private sector (13%). Besides those human resources, participants agreed that they would need financial and technical resources to implement the DRR measures.

Finally, when the team budgets were reduced, the participants limited themselves to select the actions which would be more beneficial to mitigate disasters in terms of cost benefit. For instance, actions related to natural areas restoration and conservation, communication, prevention plans, and children engagement were selected by participants due to the benefit that they mean, considering costs and the limited resources they had.

5.4 Discussions

This research gives an overview of participants' perceptions on how prepared they are and what they need to improve DRR through social innovations, which are motivated by local social needs (MULGAN, 2006). In order for those actions to take place, locals can lead and be supported by other stakeholders as equal partners, valuing the local knowledge that they hold and thus increasing the efficacy of the campaign or initiative in question for ''creating systemic changes'' so that people are less vulnerable to disasters (WEICHSELGARTNER; PIGEON, 2015; HAYNES; BIRD; WHITTAKER, 2020).

One possibility is to engage local communities more strongly in shaping local development, including its evaluation, so that material impacts of any policy interventions are recognized and promoted from within (BOSWORTH et al., 2016). It is important that locals first recognize their priorities and needs. Then, propose and leverage social innovations based on their capacities to enhance DRR as it was done in this research and recommended by Kruse et al. (2019),

who conducted research on the humanitarian sector, and remarked on the importance of continuing to provide evidence of social innovations' positive impacts.

Communities usually come out with actions during the recovery stage, rather than adopting a preventive approach to avoid disasters (WACHTENDORF; KENDRA; DEYOUNG, 2018). Social innovations should be considered and reflected in actions to mitigate risks and supported by public policies and decision-makers with a preventive approach as it was proposed in this research. Hence, there is the need to move towards learning and transforming the current social production of risk information to co-produced risk knowledge that is understandable and actionable by different kinds of users (WEICHSELGARTNER; PIGEON, 2015). It can reduce the knowledge gap by a confrontation with the nature of knowledge so that innovative ways to overcome social, functional, and institutional barriers to the production, transfer, and application of knowledge can be identified (SPIEKERMANN et al., 2015).

Local authorities' engagement was fundamental in this research to promote the participation of different actors beyond the ones that used to make decisions without consulting end-users. Traditionally, public policy focus is reflective of institutional and more immediate interest of carrying public or political favor, which is in contrast with focusing on activities that reduce vulnerability, given that these require a longer and more arduous process that will take time to yield results (DE LEON; PITTOCK, 2017). It is needed to avoid difficulties related to responsibility sharing, communication, and conflict of interests among stakeholders in disasters management (SCOLOBIG et al., 2015).

The research heightens the capacity at the local level and remarks the importance of adequate financial and personnel resources, an appropriate political system and climate, and organizational structures that can respond and adapt to dynamic contexts and circumstances (SCOLOBIG et al., 2015). Thus, promoting a culture of shared responsibilities, as it was the case when NGOs, local authorities, schools, and the local population were involved, but also

constructing the relationships between data, information, knowledge, and wisdom (SCOLOBIG et al., 2015; WEICHSELGARTNER; PIGEON, 2015).

5.5 Conclusions

People can identify the hazards they are exposed to. They also should be heard to understand how prepared they feel in their current context. In this study, participants felt more prepared when it comes to aspects that are directly linked to them like their houses and family context. However, when third parties were mentioned that level of trust decreased. Even when they believe that authorities at different levels should be mostly involved in disaster prevention.

Among the social innovations, participants identified a diverse range of measures that can be implemented. Some of them are prevention plans, nature-based solutions, territorial land-use planning, and others that help to prevent the impacts of disasters. Implementing disaster DRR actions can lay under the responsibility of societies but need the support of authorities and other stakeholders to put the actions into practice.

The approach used in this research that looked for social innovations, prioritized and discussed implementation is necessary and should be considered in the public policies elaboration and supported by policies. Thus, they can ensure and legitimize engagement and shared co-responsibility with end-users, who are groups that should be considered as actors with the capacity to build their future beyond being seen only as vulnerable groups. In that sense, it is important to rethink how public policies are proposed and analyze if they are actually effective to encourage DRR.

6 GENERAL DISCUSSIONS

As for this research, it was aimed to enhance DRR through social innovations. Thus, it was necessary to first identify them jointly with local actors, to then investigate how social innovations could be implemented as preventive measures to avoid future flood events impacts. Finally, explore how public policies could support them.

Looking for social innovations for enhancing flood resilience to improve DRR is a complex duty. Nevertheless, it is possible to do so by implementing different mixed and inclusive methods in a comprehensive way to allow and promote the participation of different stakeholders, especially children (BACK; CAMERON; TANNER, 2009; ROBINSON et al., 2016; MARCHEZINI; SARTORI; GONÇALVES, 2017). They, who are often ignored, need to be heard and must actively participate in the proposal and implementation of DRR actions (RAMBALDI et al., 2007; AMRI et al., 2018; TRAJBER et al., 2019; PETAL et al., 2020).

In order to look for the social innovations that were found in this research, it was first conducted mixed methods that were innovative and interactive and help to collect quantitative and qualitative data (RAMBALDI et al., 2007; GAILLARD et al., 2013; TOWERS et al., 2014; RAMIREZ-GOMEZ et al., 2017; SOLINSKA-NOWAK et al., 2018; FLEMING et al., 2020). Thus, participants had the opportunity to “travel” their territory and to contribute in a dynamic way to identify social innovations, which can become in solutions to face flood-related hazards in their city (DOS SANTOS, 2016; MORADEI, 2016; GUILLEMETTE et al., 2017; MARCHEZINI, 2019). It certainly facilitated local-level involvement in DRR, and increased community participation in the generation of measures (BURNSIDE-LAWRY; CARVALHO, 2015). The research took place in different venues that facilitated the participation of different groups, and it was not restricted to a specific focus group. It allowed a diverse range of measures to enhance flood resilience from different groups with a diverse range of backgrounds.

In addition, the fact of conducting a survey as a data collection tool, allowed to reach a wider audience and prioritize what measures are interested in

responders. Then, what resources and incentives are needed to make those actions possible. Besides, the support of different stakeholders that value local knowledge increases the potential of the initiative in question (MULGAN, 2006; WEICHSELGARTNER; PIGEON, 2015; HAYNES; BIRD; WHITTAKER, 2020).

The path followed in this research is a proposal of how social innovations could be identified, but it is needed to legitimize that process. Then, public policies should recognize and leverage local communities' engagement and social innovations to increase DRR (BOSWORTH et al., 2016; WACHTENDORF; KENDRA; DEYOUNG, 2018; KRUSE et al., 2019). Otherwise, the negative impacts of natural-related hazards are bound to happen again and again. Social innovations should be considered and reflected in actions to mitigate risks and be supported by public policies and decision-makers with a preventive approach as it was proposed in this research.

To increase DRR, it is needed to consider other approaches rather than only top-down. They often neglect local contexts and capacities to mitigate disaster risk. It is essential for moving towards learning and transforming the current social production of risk information to mitigate them (WEICHSELGARTNER; PIGEON, 2015).

Through the execution of this research, it was understood that some of the reasons why policies do not consider social participation is because they do not follow particular political interests. Remembering that social innovations must be based on social needs rather than institutional or political favors and avoiding conflict of interests (SCOLOBIG et al., 2015; DE LEON; PITTOCK, 2017). However, if we continue thinking in the same way, we will hardly come out with policies that actually attend to what societies need, and disasters will continue happening over and over. Thus, promoting a culture of shared responsibilities and constructing the relationships between data, information, knowledge, and wisdom could contribute to harmonizing the different stakeholders' interests to effectively mitigate disaster risks (SCOLOBIG et al., 2015; WEICHSELGARTNER; PIGEON, 2015).

It is important to make sure that the outcomes, which resulted from researchers, reach decision-makers, local actors, and the general public. Thus, some of the research's outputs were shared on the Agência FAPESP's website[7] and replicated in a lot more websites (Appendix 4). A policy brief (Appendix 5) was elaborated with the main findings and recommendations. The document was shared with local authorities and the participants that make this four-year project possible, and the webinar "Vozes locais na gestão de riscos de desastres em São Luiz do Paraitinga"[8] was organized and streamed on March 4, 2022. During the online event, local actors, who were part of the research, had the opportunity to share their thoughts, to assess the impact of this research and share their experience in participating in the project.

[7] Agência FAPESP (https://bit.ly/3HW17tK)
[8] Webinar: "Vozes locais na gestão de riscos de desastres em São Luiz do Paraitinga" (https://youtu.be/C3mPSkS6uwM).

7 CONCLUSIONS AND FURTHER RECOMMENDATIONS

This research found several potential social innovations that were identified by participants through different mixed methods that were conducted from São Luiz do Paraitinga. Most of the measures are non-structural actions that could reduce the impacts of flood hazards; however, they are not limited to that and can even mitigate floods through the implementation of nature-based solutions that were proposed by participants. According to what is reported in the literature (DA SILVA ROSA et al., 2013; FERNANDES; BOEHS; HEIDEMANN, 2013; JACOBI; MOMM-SCHULT; BOHN, 2013; ULTRAMARI, 2015; LOSEKANN, 2017; OLIVEIRA et al., 2017; PASSOS; COELHO; DIAS, 2017), social innovations come out during response and recovery stages of disaster risk management. Hence, this research focused on looking for social innovations that can take place as DRR measures with a preventive approach. Then, disasters can be reduced a priori, and their impacts can be avoided or at least reduced.

Different focus groups had the opportunity to participate in different venues to look for social innovations. Among the measures are land use management, communication strategies, natural areas restoration and conservation, collaborative monitoring, and others, which are related to how they responded in previous events. During the activities, participants remembered their past experiences and discussed what they could do to prevent future events. But some of the groups were a lot younger and did not remember in detail, so it was essential to recreate potential hazards through interactive ways to engage the younger generations in the discussions. Then, they could share their information, be more informed, and could have their voices heard.

To understand how social innovations can take place and be preventive actions, it is needed to involve and promote local stakeholders' participation. It will contribute to understanding local contexts and needs and legitimize the process of what is being proposed to mitigate disaster risks since they are who are shaping their own future. In that sense they are also responsible for what is being decided for their territory, and decisions are shared and consider everyone's interests.

Participants recognized that for implementing social innovations they need the support from different partners such as federal, state, and municipal authorities, schools, NGOs, schools, academia, and the private sector. Implementation is a duty, which although can be led by the social sectors, requires the support of multiple sectors that also have the capacity and would benefit if disaster risk is mitigated. The different sectors could contribute with technical, financial, and even human resources.

In addition to the partners and resources, public policies can promote social innovations implementation, but also policies should consider social innovations to create themselves. Public policies need to attend to social needs, hence, in essence public policies are social policies. However, it should be reconsidered if in fact public policies are being created based on those social needs or they are attending to political favors and interests that do not ensure social safety. Public policies elaboration is a long and continuous process that should attend needs beyond the governmental terms we are immersed in. Thus, we can ensure a more sustainable development that safeguards present and future generations that can suffer the impacts of the decisions of what is being currently decided.

In that sense, this research contributed to the debate on what could be done. The engagement of local authorities, during the seminar, promoted the discussion of what they could do and how to support social innovations. Participants also had the opportunity to analyze what they are doing so far to reduce disaster risks and how they could continue doing to support the proposals without necessarily depending of other actors to promote that process.

Last, but not least, with this research the invitation is extended to conduct inclusive and innovative approaches to further research on how to mitigate flood or any other type of natural-hazard resilience. Besides, consider transdisciplinary approaches that include the participation of professionals with different backgrounds, but mostly the participation of vulnerable groups, who can be directly impacted by socially constructed disasters, but who have the capacity to shape their futures.

REFERENCES

ADGER, W. N. Vulnerability. **Global environmental change**, v. 16, n. 3, p. 268–281, 2005.

AGINAKO, Z.; PEÑA-LANG, M. B.; BEDIALAUNETA, M. T.; GURAYA, T. Analysis of the validity and reliability of a questionnaire to measure students' perception of inclusion of sustainability in engineering degrees. **International Journal of Sustainability in Higher Education**, ahead-of-print, 24 jun. 2021.

ALBUQUERQUE SANT'ANNA, A. Not so natural: unequal effects of public policies on the occurrence of disasters. **Ecological Economics**, v. 152, p. 273–281, 2018.

ALCÁNTARA-AYALA, I.; BURTON, I.; LAVELL, A.; MANSILLA, E.; MASKREY, A.; OLIVER-SMITH, A.; RAMÍREZ-GÓMEZ, F. Editorial: Root causes and policy dilemmas of the COVID-19 pandemic global disaster. **International Journal of Disaster Risk Reduction**, v. 52, e101892, 2021.

ALEOTTI, P.; CHOWDHURY, R. Landslide hazard assessment: summary review and new perspectives. **Bulletin of Engineering Geology and the Environment**, v. 58, n. 1, p. 21–44, 1999.

ALMORADIE, A.; BRITO, M. M.; EVERS, M.; BOSSA, A.; LUMOR, M.; NORMAN, C.; YACOUBA, Y.; HOUNKPE, J. Current flood risk management practices in Ghana: gaps and opportunities for improving resilience. **Journal of Flood Risk Management**, v. 13, n. 4, 2020.

AMRI, A.; HAYNES, K.; BIRD, D. K.; RONAN, K. Bridging the divide between studies on disaster risk reduction education and child-centred disaster risk reduction: a critical review. **Children's Geographies**, v. 16, n. 3, p. 239–251, 2018.

ARAVENA, H. R.; ROMERO-TOLEDO, H.; OPAZO, D. Topoclimatología cultural y ciclos hidrosociales de comunidades andinas chilenas: híbridos geográficos para la ordenación de los territorios. **Cuadernos de Geografía: Revista Colombiana de Geografía**, v. 27, n. 2, p. 242–261, 2018.

BACK, E.; CAMERON, C.; TANNER, T. **Children and disaster risk reduction:** taking stock and moving forward. Brighton. 2009. Available from: <https://www.preventionweb.net/files/15093_12085ChildLedDRRTakingStock1.pdf>.

BASON, C. **Leading public sector innovation**. Bristol: Policy Press, 2010.

BENSON, C.; TWIGG, J.; ROSSETTO, T. **Tools for mainstreaming disaster risk reduction:** guidance notes for development organisations. [S.l.: s.n.], 2007.

BERROETA, H.; RAMONEDA, A.; OPAZO, L. Sentido de comunidad, participación y apego de lugar en comunidades desplazadas y no desplazadas postdesastres: Chaitén y Consitución. **Universitas Psychologica**, v. 14, n. 4, p. 1221, 2016.

BOCKHEIM, J. G.; GENNADIYEV, A. N. Soil-factorial models and earth-system science: a review. **Geoderma**, v. 159, n. 3–4, p. 243–251, 2010.

BOSWORTH, G.; RIZZO, F.; MARQUARDT, D.; STRIJKER, D.; HAARTSEN, T.; AAGAARD THUESEN, A. Identifying social innovations in European local rural development initiatives. **Innovation: The European Journal of Social Science Research**, v. 29, n. 4, p. 442–461, 2016.

BRASIL. PRESIDÊNCIA DA REPÚBLICA. **Lei N°12,608, de 10 de abril de 2012**. Available from: <http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12608.htm>. Access on: 9 Oct. 2019.

BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS (IBGE). **São Luiz do Paraitinga**. Available from: <https://cidades.ibge.gov.br/brasil/sp/sao-luiz-do-paraitinga/panorama>.

BRIONES, F.; VACHON, R.; GLANTZ, M. Local responses to disasters: recent lessons from zero-order responders. **Disaster Prevention and Management: An International Journal**, v. 28, n. 1, p. 119–125, 2019.

BULLARD, R. D.; BEVERLY, W. **Race, place, and environmental justice after Hurricane Katrina**: struggles to reclaim, rebuild, and revitalize New Orleans and the Gulf Coast. 4.ed. [S.l.]: Environmental Justice 2, 2009. 216 p.

BURNSIDE-LAWRY, J.; CARVALHO, L. Building local level engagement in disaster risk reduction: a Portuguese case study. **Disaster Prevention and Management**, v. 24, n. 1, p. 80–99, 2015.

CADAG, J. R. D.; GAILLARD, J. Integrating knowledge and actions in disaster risk reduction: the contribution of participatory mapping. **Area**, v. 44, n. 1, p. 100–109, 2012.

CADAG, J. R. D.; PETAL, M.; LUNA, E.; GAILLARD, J. C.; PAMBID, L.; SANTOS, G. V. Hidden disasters: recurrent flooding impacts on educational continuity in the Philippines. **International Journal of Disaster Risk Reduction**, v. 25, p. 72–81, 2017.

CAJAIBA-SANTANA, G. Social innovation: moving the field forward: a conceptual framework. **Technological Forecasting and Social Change**, v. 82, n. 1, p. 42–51, 2014.

CAMPOS, J. T. **A imperial São Luiz do Paraitinga**: história, educação e cultura. Taubaté: Resolução Gráfica, 2011.

CARMIN, J.; TIERNEY, K.; CHU, E.; HUNTER, L. M.; ROBERTS, J. T.; SHI, L. Adaptation to climate change. In: DUNLAP, R. E.; BRULLE, R. J. (Ed.). **Climate**

change and society. [S.l]: Oxford, 2015. p. 164–198.

CASTREE, N.; ADAMS, W. M.; BARRY, J.; BROCKINGTON, D.; BÜSCHER, B.; CORBERA, E.; DEMERITT, D.; DUFFY, R.; FELT, U.; NEVES, K.; NEWELL, P. Changing the intellectual climate. **Nature climate change**, v. 4, n. 9, p. 763, 2014.

CENTRO UNIVERSITÁRIO DE ESTUDOS E PESQUISAS SOBRE DESASTRES. A**tlas brasileiro de desastres naturais**: 1991 a 2012. [S.l.]: Secretaria Nacional de Defesa Civil, 2013. 126p.

CHESBROUGH, H. **Open Innovation**: the new imperative for creating and profiting from technology. Cambridge, MA: Harvard Business School Press, 2003.

CHMUTINA, K.; VON MEDING, J.; SANDOVAL, V.; BOYLAND, M.; FORINO, G.; CHEEK, W.; WILLIAMS, D. A.; GONZALEZ-MUZZIO, C.; TOMASSI, I.; PÁEZ, H.; MARCHEZINI, V. What we measure matters: the case of the missing development data in Sendai framework for disaster risk reduction monitoring. **International Journal of Disaster Risk Science**, v. 12, n. 6, p. 779–789, 2021.

CHOI, B. C.; PAK, A. W. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. definitions, objectives, and evidence of effectiveness. **Clinical and Investigative Medicine**, v. 29, n. 6, p. 351, 2006.

CLARK, T. `We're over-researched here!'. **Sociology**, v. 42, n. 5, p. 953–970, 2008.

CLARK, T. On 'being researched': why do people engage with qualitative research? **Qualitative Research**, v. 10, n. 4, p. 399–419, 2010.

COMPANHIA ENERGÉTICA DE SÃO PAULO (CESP). **Usina hidrelétrica de Paraibuna**. Available from: <http://www.cesp.com.br/portalCesp/portal.nsf/V03.02/index_erroacesso?OpenDocument>. Access on: 17 Sept. 2019.

CORSI, A. C.; AZEVEDO, P. B. M.; GRAMANI, M. F. Damage valuation arising from flood in São Luiz Do Paraitinga (Sp). **Revista de Gestão Ambiental e Sustentabilidade**, v. 1, n. 2, p. 124–142, 2012.

CRISTINA, G.; FERNANDES, M.; BOEHS, A. E.; DENHAM, S. A.; MARTINI, J. G. Rural families ' interpretations of experiencing unexpected transition in the wake of a natural disaster. **Cadernos de Saúde Pública**, v. 33, n. 1, p. 1–11, 2017.

CUMISKEY, L.; HOANG, T.; SUZUKI, S.; PETTIGREW, C.; HERRGÅRD, M. M. Youth participation at the third UN World Conference on Disaster Risk Reduction. **International Journal of Disaster Risk Science**, v. 6, n. 2, p. 150–163, 2015.

CUTTER, S.; FINCH, C. Temporal and spatial changes in social vulnerability to natural hazards. **Proceedings of the National Academy of Sciences**, v. 105, n. 7, p. 2301–2306, 2008.

CUTTER, S. L.; ASH, K. D.; EMRICH, C. T. The geographies of community disaster resilience. **Global Environmental Change**, v. 29, p. 65–77, 2014.

DA SILVA ROSA, T.; BARRETO MENDOÇA, M.; GAVA MONTEIRO, T.; MATOS DE SOUZA, R.; LUCENA, R. A educação ambiental como estratégia para a redução de riscos socioambientais. **Ambiente & Sociedade**, v. 18, n. 3, p. 211–230, 2013.

DE FREITAS, L. E.; SATO, A. M.; SCHOTTZ, S.; NETTO, A. L. C.; LACERDA, N. Community, university and government interactions for disaster reduction in the mountainous region of Rio de Janeiro, southeast of Brazil. In: LEAL FILHO, W.; AZEITEIRO, U. M.; ALVES, F. (Ed.). **Climate change and health**. Berlin: Springer, 2016. p. 313–328.

DE LEON, E. G.; PITTOCK, J. Integrating climate change adaptation and climate-related disaster risk-reduction policy in developing countries: a case study in the Philippines. **Climate and Development**, v. 9, n. 5, p. 471–478, 2017.

DEYOUNG, S. E.; FARMER, A. K.; CALLARO, Z.; NAAR, S. Disaster preparedness among service dog puppy- raisers (human subject sample). **Animals**, v. 10, n. 2, p. 246, 2020.

DODMAN, D.; MITLIN, D. Challenges for community-based adaptation: discovering the potential of transformation. **Journal of International Development**, v. 25, n. 5, p. 640–659, 2011.

DOS SANTOS, D. M. **Os sentidos da patrimonialização no processo de reconstrução de São Luiz do Paraitinga**. 2016. 173p. Dissertação (Mestrado em Desenvolvimento Humano) - Universidade de Taubaté, Taubaté, 2016.

DUNLAP, R. E.; BRULLE, R. J. **Climate change and society**. [S.l.]: Oxford University Press, 2015. 460 p. ISBN 9780199356102.

DYBALL, R.; BROWN, V. A.; KEEN, M. **Social learning towards a sustainable world**. The Netherlands: Wageningen Academic Publishers, 2007. 181–194 p. ISBN 978-90-8686-031-9.

FARRELL, A. **Ethical research with children**. [S.l.]: McGraw-Hill Education (UK), 2005. 188 p. ISBN 9780335224982.

FERNANDES, G. C. M.; BOEHS, A. E.; HEIDEMANN, I. T. S. B. O suporte social durante a transição familiar no pós-desastre natural. **Texto & Contexto - Enfermagem**, v. 22, n. 4, p. 1098–1105, 2013.

FERNANDEZ, G.; SHAW, R. Youth Council participation in disaster risk reduction in Infanta and Makati, Philippines: a policy review. **International**

Journal of Disaster Risk Science, v. 4, n. 3, p. 126–136, 2013.

FLEMING, K.; ABAD, J.; BOOTH, L.; SCHUELLER, L.; BAILLS, A.; SCOLOBIG, A.; PETROVIC, B.; ZUCCARO, G.; LEONE, M. F. The use of serious games in engaging stakeholders for disaster risk reduction, management and climate change adaption information elicitation. **International Journal of Disaster Risk Reduction**, v. 49, e101669, 2020.

FOLHES, R. T.; AGUIAR, A. P. D. DE; STOLL, E.; DALLA-NORA, E. L.; ARAÚJO, R.; COELHO, A.; CANTO, O. DO. Multi-scale participatory scenario methods and territorial planning in the Brazilian Amazon. **Futures**, v. 73, p. 86–99, 2015.

FREIRE, P. **Pedagogy of autonomy**: knowledge necessary for educational practice. São Paulo: Peace and Earth, 1996.

GAILLARD, J. C.; MONTEIL, C.; PERRILLAT-COLLOMB, A.; CHAUDHARY, S.; CHAUDHARY, M.; CHAUDHARY, O.; GIAZZI, F.; CADAG, J. R. D. Participatory 3-dimension mapping: a tool for encouraging multi-caste collaboration to climate change adaptation and disaster risk reduction. **Applied Geography**, v. 45, p. 158–166, 2013.

GAILLARD, J.; PEEK, L. Disaster-zone research needs a code of conduct. **Nature**, v. 575, p. 440–442, 2019.

GEORGE, J. B. **Nursing theories**: the base for professional nursing practice. 5.ed. NJ: Prentice Hall: Upper Saddle River, 2005.

GIBSON, T.; WISNER, B. “Lets talk about you …”: opening space for local experience, action and learning in disaster risk reduction. **Disaster Prevention and Management**, v. 25, n. 5, p. 664–684, 2016.

GILBERT, C. Studying disaster: changes in the main conceptual tools. In: QUARANTELLI, E. L. (Ed.). **What is a disaster?** perspectives on the question. London: Routledge, 1998. p. 11–18.

GIRALDO, H. G. Producción social, proceso participativo e intervención sostenible en el espacio público de los centros históricos. El caso de Pamplona, Colombia. **Territorios**, v. 17, n. 33, p. 33–61, 2015.

GRAMANI, M. F.; GOMES, L. A. São Luiz do Paraitinga, São Paulo (Brasil): severidade das inundações e ocorrência de escorregamentos. In: CONGRESSO BRASILEIRO DE GEOLOGIA DE ENGENHARIA,13., 2011, São Paulo. **Anais...** 2011.

GUILLEMETTE, M.; POTVIN, C.; MARTINEZ, L.; PACHECO, B.; CAÑO, D.; PÉREZ, I. Building a common description of land cover in a tropical watershed plagued with intercultural conflicts: the value of participatory 3D modelling. **FACETS**, v. 2, n. 1, p. 195–211, 2017.

GUZZETTI, F.; REICHENBACH, P.; CARDINALI, M.; GALLI, M.; ARDIZZONE,

F. Probabilistic landslide hazard assessment at the basin scale. **Geomorphology**, v. 72, n. 1–4, p. 272–299, 2005.

HAQUE, C. E.; ETKIN, D. People and community as constituent parts of hazards: the significance of societal dimensions in hazards analysis. **Natural Hazards**, v. 41, n. 2, p. 271–282, 2007.

HARDOY, J.; PANDIELLA, G.; BARRERO, L. S. V. Local disaster risk reduction in Latin American urban areas. **Environment and Urbanization**, v. 23, n. 2, p. 401–413, 2011.

HARTLEY, J. Innovation in governance and public services. **Past and Present, Public Money &Management**, v. 25, n. 1, p. 27–34, 2005.

HAYNES, K.; BIRD, D. K.; WHITTAKER, J. Working outside 'the rules': opportunities and challenges of community participation in risk reduction. **International Journal of Disaster Risk Reduction**, v. 44, e101396, 2020.

HUTTON, D. Vulnerability of children: more than a question of age. **Radiation Protection Dosimetry**, v. 142, n. 1, p. 54–57, 2010.

JACOBI, P. R.; MOMM-SCHULT, S. I.; BOHN, N. Ação e reação: intervenções urbanas e a atuação das instituições no pós-desastre em Blumenau (Brasil). **EURE (Santiago)**, v. 39, n. 116, p. 243–261, 2013.

KASPERSON, R. E.; KASPERSON, J. X. **Climate change, vulnerability and social justice**. 2001. Available from: <http://stc.umsl.edu/essj/unit4/climate change risk.pdf>.

KIENBERGER, S. Participatory mapping of flood hazard risk in Munamicua, District of Búzi, Mozambique. **Journal of Maps**, v. 10, n. 2, p. 269–275, 2014.

KLEIN, R. J.; NICHOLLS, R. J.; THOMALLA, F. Resilience to natural hazards: how useful is this concept? **Global environmental change part B: environmental hazards**, v. 5, n. 1, p. 35–45, 2003.

KRUSE, D. J.; GOELDNER, M.; ELING, K.; HERSTATT, C. Looking for a needle in a haystack: how to search for bottom-up social innovations that solve complex humanitarian problems. **Journal of Product Innovation Management**, v. 36, n. 6, p. 671–694, 2019.

KVOČKA, D.; FALCONER, R. A.; BRAY, M. Flood hazard assessment for extreme flood events. **Natural Hazards**, v. 84, n. 3, p. 1569–1599, 2016.

LAHSEN, M.; RIBOT, J. Politics of attributing extreme events and disasters to climate change. **WIREs Climate Change**, v. 13, n. 1, 2022.

LAVELL, A.; MANSILLA, E.; MASKREY, A.; RAMIREZ, F. **The social construction of the COVID-19 pandemic**: disaster, risk accumulation and public policy. [S.l.]: LA RED, 2020.

LÉVESQUE, B. **Social innovation in governance and public management**

systems: toward a new paradigm. [S.l.: s.n.], 2013.

LEWIS, J. The susceptibility of the vulnerable: some realities reassessed. **Disaster Prevention and Management**, v. 23, n. 1, p. 2–11, 2014.

LONG, N. From paradigm lost to paradigm regained: the case for an actor-oriented sociology of development. **Revista Europea de Estudios Latinoamericanos y del Caribe**, p. 3–24, 1990.

LÓPEZ MARRERO, T.; HEARTSILL SCALLEY, T. ¿Cómo, por quién y para qué? Investigación y labor creativa en el estudio de desastres en Puerto Rico. **Revista de Estudios Latinoamericanos sobre Reducción del Riesgo de Desastres REDER**, v. 5, n. 2, p. 107–124, 2021.

LOPEZ, Y.; HAYDEN, J.; COLOGON, K.; HADLEY, F. Child participation and disaster risk reduction. **International Journal of Early Years Education**, v. 20, n. 3, p. 300–308, 2012.

LOSEKANN, C. “It was no accident” the place of emotions in the mobilization of people affected by the collapse of Samarco’s tailings dam in Brazil Cristiana. **Vibrant: Virtual Brazilian Anthropology**, v. 14, n. 2, p. 1–25, 2017.

LUND, B. The questionnaire method in systems research: an overview of sample sizes, response rates and statistical approaches utilized in studies. **VINE Journal of Information and Knowledge Management Systems**, ahead-of-print, 14 jan. 2021.

MARCHEZINI, V. La producción silenciada de los “desastres naturales” en catástrofes sociales. **Revista Mexicana de Sociologia**, v. 76, n. 2, p. 253–285, 2014.

MARCHEZINI, V. The biopolitics of disaster: power, discourses, and practices. **Human Organization**, v. 74, n. 4, 2015.

MARCHEZINI, V. As ciências sociais nos desastres: um campo de pesquisa em construção. **Revista Brasileira de Informação Bibliográfica em Ciências Sociais - BIB**, v. 83, p. 43–72, 2018.

MARCHEZINI, V. The power of localism during the long-term disaster recovery process. **Disaster Prevention and Management: An International Journal**, v. 28, n. 1, p. 143–152, 2019.

MARCHEZINI, V.; AOKI HORITA, F. E.; MIE MATSUO, P.; TRAJBER, R.; TREJO-RANGEL, M. A.; OLIVATO, D. A review of studies on Participatory Early Warning Systems (P-EWS): pathways to support citizen science initiatives. **Frontiers in Earth Science**, v. 6, 2018.

MARCHEZINI, V.; DE RESENDE LONDE, L.; BERNARDES, T.; SILVA DA CONCEIÇÃO, R.; DOS SANTOS, E. V.; SAITO, S. M.; SOLER, L.; PEREIRA DA SILVA, A. E.; BORTOLETTO, K. C.; MEDEIROS, M. D. S.; GONÇALVES, D. A. Sistema de alerta de risco de desastres no Brasil: desafios à redução da

vuldade institucional. In: MARCHEZINI, V.; WISNER, B.; LONDE, L. R.; SAITO, S. M. (Org.). **Reduction of vulnerability to disasters: from knowledge to action**. [S.l.]: Rima, 2017a. p. 287–310.

MARCHEZINI, V.; IWAMA, A. Y.; MAGALHÃES, M. R.; TRAJBER, R.; ROCHA, I.; OLIVATO, D. Geotecnologias para prevenção de riscos de desastres : usos e potencialidades dos mapeamentos participativos. **Revista Brasileira de Cartografia**, v.69, n.1, p. 107–128, 2017b.

MARCHEZINI, V.; SARTORI, J.; GONÇALVES, J. C. Desenvolvimento, desastres e reconstrução: o caso de são luiz do Paraitinga/Sp, Brasil. **Revista Brasileira de Gestão e Desenvolvimento Regional**, v. 13, n. 2, p. 202–226, 2017.

MARCHEZINI, V.; TRAJBER, R.; OLIVATO, D.; MUÑOZ, V. A.; DE OLIVEIRA PEREIRA, F.; OLIVEIRA LUZ, A. E. Participatory early warning systems: youth, citizen science, and intergenerational dialogues on disaster risk reduction in Brazil. **International Journal of Disaster Risk Science**, v. 8, n. 4, p. 390–401, 2017c.

MARENGO, J. A.; ALVES, L. M. Tendências hidrológicas da Bacia do Rio Paraíba do Sul. **Revista Brasileira de Meteorologia**, v. 20, n. 2, p. 215–226, 2005.

MARFAI, M. A.; SEKARANOM, A. B.; WARD, P. Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia. **Natural Hazards**, v. 75, n. 2, p. 1127–1144, 2015.

MASSON-DELMOTTE, V.; ZHAI, P.; PÖRTNER, H. O.; ROBERTS, D., SKEA, J.; SHUKLA, P. R.; PIRANI, A.; MOUFOUMA-OKIA, W.; PÉAN, C.; PIDCOCK, R.; CONNORS, S. **Summary for policymakers:** global warming of, 1.5°C. 2018. Available from: <https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf>.

MCCLINTOCK, N.; MAHMOUDI, D.; SIMPSON, M.; SANTOS, J. P. Socio-spatial differentiation in the sustainable city: a mixed-methods assessment of residential gardens in metropolitan Portland, Oregon, USA. **Landscape and Urban Planning**, v. 148, p. 1–16, 2016.

MÉJEAN, A.; POTTIER, A.; FLEURBAEY, M.; ZUBER, S. Catastrophic climate change, population ethics and intergenerational equity. **Climatic Change**, v. 163, p. 873–890, 2020.

MERCER, J.; KELMAN, I.; TARANIS, L.; SUCHET-PEARSON, S. Framework for integrating indigenous and scientific knowledge for disaster risk reduction. **Disasters**, v. 34, n. 1, p. 214–239, 2010.

MORADEI, N. D. S. **A grande enchente de São Luiz do Paraitinga**. 2016. 222 p. Dissertação (Mestrado em Arquitetura e Urbanismo) - Universidade de São Paulo, São Paulo, 2016.

MULGAN, G. The process of social innovation. **Innovations: Technology, Governance, Globalization**, v. 1, n. 2, p. 145–162, 2006.

NAM, W.-H.; HAYES, M. J.; SVOBODA, M. D.; TADESSE, T.; WILHITE, D. A. Drought hazard assessment in the context of climate change for South Korea. **Agricultural Water Management**, v. 160, p. 106–117, 2015.

NEUMAN, W. L. **Social research methods**: qualitative and quantitative approaches. 7.ed. Edinburgh: Pearson, 2014. 594 p. ISBN 1-292-02023-7.

NEWMAN, L.; DALE, A. Network structure, diversity, and proactive resilience building: a response to Tompkins and Adger. **Ecology and Society**, v. 10, n. 1, 2005.

NEWNHAM, E. A.; TEARNE, J.; GAO, X.; GURAGAIN, B.; JIAO, F.; GHIMIRE, L.; BALSARI, S.; CHAN, E.; LEANING, J. Tailoring disaster risk reduction for adolescents: qualitative perspectives from China and Nepal. **International Journal of Disaster Risk Reduction**, v. 34, p. 337–345, 2019.

NORSTRÖM, A. V.; CVITANOVIC, C.; LÖF, M. F.; WEST, S.; WYBORN, C.; BALVANERA, P.; BEDNAREK, A. T.; BENNETT, E. M.; BIGGS, R.; DE BREMOND, A.; CAMPBELL, B. M.; CANADELL, J. G.; CARPENTER, S. R.; FOLKE, C.; FULTON, E. A.; GAFFNEY, O.; GELCICH, S.; JOUFFRAY, J. B.; LEACH, M.; LE TISSIER, M.; MARTÍN-LÓPEZ, B.; LOUDER, E.; LOUTRE, M. F.; MEADOW, A. M.; NAGENDRA, H.; PAYNE, D.; PETERSON, G. D.; REYERS, B.; SCHOLES, R.; SPERANZA, C. I.; SPIERENBURG, M.; STAFFORD-SMITH, M.; TENGÖ, M.; VAN DER HEL, S.; VAN PUTTEN, I.; ÖSTERBLOM, H. Principles for knowledge co-production in sustainability research. **Nature Sustainability**, v. 3, n. 3, p. 182–190, 2020.

O'KEEFE, P.; WESTGATE, K.; WISNER, B. Taking the naturalness out of natural disasters. **Nature**, v. 260, n. 5552, p. 566–567, 1976.

OLIVATO, D.; GALLO JUNIOR, H. Evolução da participação social na legislação brasileira sobre gestão de riscos ambientais. **Territorium**, v. 27, n. 1, p. 155–166, 2020.

OLIVEIRA, R.; ZUCARELLI, M.; VASCONCELOS, M. The Rio Doce mining disaster in Brazil. **Virtual Brazilian Anthropology**, v. 14, n. 2, p. 1–21, 2017.

OLIVEIRA, S. S.; PORTELLA, S. L. D.; SIQUEIRA, A.; FREITAS, M. Desnaturalização dos desastres e mobilização comunitária: redes e rodas. **Ciência & Trópico**, v. 40, n. 1, p. 13–26, 2016.

OSBORNE, S.; BROWN, L. Innovation in public services: engaging with risk. **Public Money & Management**, v. 31, n. 1, p. 4–6, 2011.

PACHAURI, R. K.; ALLEN, M. R.; BARROS, V. R.; BROOME, J.; CRAMER, W.; CHRIST, R.; CHURCH, J. A.; CLARKE, L.; DAHE, Q.; DASGUPTA, P.; DUBASH, N. K. **Climate change 2014**: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the

Intergovernmental Panel on Climate Change. [S.l.]: IPCC, 2014.

PAIVA ARGUELLO, F. V. **Simulação hidrológica da bacia do Rio Paraitinga para análise das potenciais causas do evento extremo de cheia e desastre ocorrido na passagem de ano de 2009/2010**. 2017. 106 p. Tese (Doutorado em Ciência do Sistema Terrestre) - Instituto Nacional de Pesquisas Espaciais, São José dos Campos, 2017. Available from: <http://mtc-m21b.sid.inpe.br/col/sid.inpe.br/mtc-m21b/2016/10.19.19.03/doc/publicacao.pdf>.

PASSOS, F. L.; COELHO, P.; DIAS, A. (Des)territórios da mineração: planejamento territorial a partir do rompimento em Mariana, MG. **Cadernos Metrópole**, v. 19, n. 38, p. 269–297, 2017.

PATON, D. Disaster preparedness: a social-cognitive perspective. **Disaster Prevention and Management: An International Journal**, v. 12, n. 3, p. 210–216, 2003.

PEEK, L. Children and disasters: understanding vulnerability, developing capacities, and promoting resilience: an Introduction. **Children, Youth and Environments**, v. 18, n. 1, p. 29, 2008.

PETAL, M.; RONAN, K.; OVINGTON, G.; TOFA, M. Child-centred risk reduction and school safety: an evidence-based practice framework and roadmap. **International Journal of Disaster Risk Reduction**, v. 49, e101633, 2020.

PFEFFERBAUM, B.; PFEFFERBAUM, R. L.; VAN HORN, R. L. Involving children in disaster risk reduction: the importance of participation. **European Journal of Psychotraumatology**, v. 9, Sup. 2, e1425577, 2018.

RAMBALDI, G.; CALLOSA-TARR, J. **Participatory 3-dimensional modelling**: guiding principles and applications. [S.l.]: ARCBC, 2002.

RAMBALDI, G.; MUCHEMI, J.; CRAWHALL, N.; MONACI, L. Through the eyes of hunter-gatherers: participatory 3D modelling among Ogiek indigenous peoples in Kenya. **Information Development**, v. 23, n. 2–3, p. 113–128, 2007.

RAMIREZ-GOMEZ, S. O. I.; VERWEIJ, P.; BEST, L.; VAN KANTEN, R.; RAMBALDI, G.; ZAGT, R. Participatory 3D modelling as a socially engaging and user-useful approach in ecosystem service assessments among marginalized communities. **Applied Geography**, v. 83, p. 63–77, 2017.

REY, W.; MENDOZA, E. T.; SALLES, P.; ZHANG, K.; TENG, Y.-C.; TREJO-RANGEL, M. A.; FRANKLIN, G. L. Hurricane flood risk assessment for the Yucatan and Campeche State coastal area. **Natural Hazards**, v. 96, n. 3, p. 1041–1065, 2019.

ROBINSON, C. J.; MACLEAN, K.; HILL, R.; BOCK, E.; RIST, P. Participatory mapping to negotiate indigenous knowledge used to assess environmental risk. **Sustainability Science**, v. 11, n. 1, p. 115–126, 2016.

ROLLASON, E.; BRACKEN, L. J.; HARDY, R. J.; LARGE, A. R. G. Rethinking flood risk communication. **Natural Hazards**, v. 92, n. 3, p. 1665–1686, 2018.

ROLSTED, M.; RAJU, E. Addressing capacities of local communities in a changing context in Nepal. **Disaster Prevention and Management: An International Journal**, ahead-of-print, 10 jun. 2020.

RONAN, K.; HAYNES, K.; AMRI, A.; TOWERS, B.; ALISIC, E.; DAVIE, S.; IRELAND, N.; PETAL, M. Child-centred disaster risk reduction: can disaster resilience programs reduce risk and increase the resilience of children and households? **Australian Journal of Emergency Management**, v. 31, n. 3, p. 49–58, 2016.

ROWLEY, J. Designing and using research questionnaires. **Management Research Review**, v. 37, n. 3, p. 308–330, 2014.

RUÍZ, A. E. L.; COELHO NETTO, A. L.; DANTAS, M. E.; OLIVEIRA, R. R. DE. Cenários do passado no Vale do Rio Paraíba do Sul e a entrada do Antropoceno no Sudeste brasileiro. In: OLIVEIRA, R.; LAZOS, A. (Org.). **Geografia histórica do café no Vale do Rio Paraíba do Sul**. Rio de Janeiro: PUC-Rio, 2018. p. 61–81.

SAIA, L. Evolução urbana de São Luís de Paraitinga. **Risco: Revista de Pesquisa em Arquitetura e Urbanismo**, v. 10, p. 129–140, 2009.

SAKURAI, A.; SATO, T.; MURAYAMA, Y. Impact evaluation of a school-based disaster education program in a city affected by the 2011 great East Japan earthquake and tsunami disaster. **International Journal of Disaster Risk Reduction**, v. 47, e101632, 2020.

SALMAN, A. M.; LI, Y. Flood risk assessment, future trend modeling, and risk communication: a review of ongoing research. **Natural Hazards Review**, v. 19, n. 3, e04018011, 2018.

SÃO LUIZ DO PARAITINGA. PREFEITURA MUNICIPAL. **Igreja matriz**. Available from: <https://www.saoluizdoparaitinga.sp.gov.br/post/igreja-matriz$12621>. Access on: 1 May 2020.

SARTORI, J. **Como esquecer? memórias de um desastre vivenciado**. 2015. Dissertação (Mestrado em Engenharia Ambiental) - Universidade de São Paulo, São Paulo, 2015.

SCOLOBIG, A.; PRIOR, T.; SCHRÖTER, D.; JÖRIN, J.; PATT, A. Towards people-centred approaches for effective disaster risk management: balancing rhetoric with reality. **International Journal of Disaster Risk Reduction**, v. 12, p. 202–212, 2015.

SISTO, R.; LOPOLITO, A.; VAN VLIET, M. Stakeholder participation in planning rural development strategies: using backcasting to support Local Action Groups in complying with CLLD requirements. **Land Use Policy**, v. 70, p. 442–450, 2018.

SKRYABINA, E. A.; BETTS, N.; REEDY, G.; RILEY, P.; AMLÔT, R. The role of emergency preparedness exercises in the response to a mass casualty terrorist incident: a mixed methods study. **International Journal of Disaster Risk Reduction**, v. 46, e101503, 2020.

SMITH, V.; CARBONE, J.; POPE, J.; HALLSTROM, D.; DARDEN, M. Adjusting to natural disasters. **Journal of Risk and Uncertainty**, v. 33, n. 1, p. 37–54, 2006.

SOLINSKA-NOWAK, A.; MAGNUSZEWSKI, P.; CURL, M.; FRENCH, A.; KEATING, A.; MOCHIZUKI, J.; LIU, W.; MECHLER, R.; KULAKOWSKA, M.; JARZABEK, L. An overview of serious games for disaster risk management: prospects and limitations for informing actions to arrest increasing risk. **International Journal of Disaster Risk Reduction**, v. 31, p. 1013–1029, 2018.

SORENSEN, E.; TORFING, J. Enhancing collaborative innovation in the public sector. **Administration & Society**, v. 43, n. 8, p. 842–868, 2011.

SPIEKERMANN, R.; KIENBERGER, S.; NORTON, J.; BRIONES, F.; WEICHSELGARTNER, J. The disaster-knowledge matrix: reframing and evaluating the knowledge challenges in disaster risk reduction. **International Journal of Disaster Risk Reduction**, v. 13, p. 96–108, 2015.

SUKARIEH, M.; TANNOCK, S. On the problem of over-researched communities: the case of the Shatila Palestinian Refugee Camp in Lebanon. **Sociology**, v. 47, n. 3, p. 494–508, 2013.

SUN, D.; ZHANG, D.; CHENG, X. Framework of national non-structural measures for flash flood disaster prevention in China. **Water (Switzerland)**, v. 4, n. 1, p. 272–282, 2012.

TEXIER-TEIXEIRA, P.; CHOURAQUI, F.; LAVIGNE, F.; GRANCHER, D.; ROM CADAG, J.; GAILLARD, J. La Cartographie Participative en 3 Dimensions (CP3D) comme outil au service d'une gestion partagée des risques ? **Bulletin de l'Association de géographes français**, v. 91, n. 3, p. 309–324, 2014.

TOMPKINS, E. L.; ADGER, W. N. Does adaptive management of natural resources enhance resilience to climate change? **Ecology and Society**, v. 9, n. 2, 2004.

TONG, T. M. T.; SHAW, R.; TAKEUCHI, Y. Climate disaster resilience of the education sector in Thua Thien Hue Province, Central Vietnam. **Natural Hazards**, v. 63, n. 2, p. 685–709, 2012.

TOWERS, B.; HAYNES, K.; SEWELL, F.; BAILIE, H.; CROSS, D. Child-centred disaster risk reduction in Australia: progress, gaps and opportunities. **Australian Journal of Emergency Management**, v. 29, n. 1, p. 31–38, 2014.

TRAJBER, R.; MOCHIZUKI, Y. Climate change education for sustainability in Brazil: a status report. **Journal of Education for Sustainable Development**, v. 9, n. 1, p. 44–61, 2015.

TRAJBER, R.; WALKER, C.; MARCHEZINI, V.; KRAFTL, P.; OLIVATO, D.; HADFIELD-HILL, S.; ZARA, C.; FERNANDES-MONTEIRO, S. Promoting climate change transformation with young people in Brazil: participatory action research through a looping approach. **Action Research**, v. 17, n. 1, p. 87–107, 2019.

TREJO-RANGEL, M. A.; MARCHEZINI, V.; RODRIGUEZ, D. A.; DA SILVA OLIVEIRA, M. Participatory 3D model to promote intergenerational engagement for disaster risk reduction in São Luiz do Paraitinga, Brazil. **Disaster Prevention and Management: An International Journal**, v. 30, n. 3, p. 308–326, 2021.

TREJO-RANGEL, M. A.; MOTA FERREIRA, A.; MARCHEZINI, V.; RODRIGUEZ, D. A.; OLIVEIRA, M. DA S.; MESSIAS DOS SANTOS, D. Giving voice to the voiceless: connecting graduate students with high school students by incubating DRR plans through participatory mapping. **Disaster Prevention and Management: An International Journal**, ahead-of-print, 7 Jan. 2022.

ULTRAMARI, C. Acidentes naturais : o paradoxo entre adversidades e potencialidades na gestão urbana Natural disasters : the paradox between adversities and potentialities in urban management. **Economía, Sociedad y Territorio**, v. 15, n. 47, p. 99–121, 2015.

UNITED NATIONS. **Convention on the rights of the child**. 1989. Available from: <https://www.ohchr.org/en/professionalinterest/pages/crc.aspx>.

UNITED NATIONS. **New urban agenda habitat III**. Quito. 2017. Available from: <https://habitat3.org/wp-content/uploads/NUA-English.pdf>.

UNITED NATIONS. **Hyogo Framework for Action (HFA) 2005-2015**: building the resilience of nations and communities to disasters. [S.l.]: UN, 2005.

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE. **What do adaptation to climate change and climate resilience mean?** Available from: <https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean>.

UNITED NATIONS GENERAL ASSEMBLY. **Transforming our world:** the 2030 Agenda for Sustainable Development. 2015. Available from: <https://sustainabledevelopment.un.org/content/documents/21252030 Agenda for Sustainable Development web.pdf>.

UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION. **Sendai Framework for Disaster Risk Reduction 2015-2030**. 2015. Available from: <https://sustainabledevelopment.un.org/content/documents/2157sendaiframeworkfordrren.pdf%0Ahttps://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf%0Ahttp://oxfordhandbooks.com/view/10.1093/oxfordhb/9780199560103.001.0001/oxfordhb-9780199560103-e-005>.

UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION. **UN 20-year review: earthquakes and tsunamis kill more people while climate change**

is driving up economic losses. Available from: <https://www.unisdr.org/archive/61121>.

UNITED NATIONS OFFICE FOR DISASTER RISK REDUCTION - UNDRR. **Terminology on disaster risk reduction**. Available from: <https://www.unisdr.org/we/inform/terminology>. Acesso em: 25 mar. 2020.

VALENCIO, N.; SIENA, M.; MARCHEZINI, V.; GONÇALVES, J. C. **Sociologia dos desastres:** construção, interfaces e perspectivas no Brasil. [S.l]: Rima, 2014. 280 p.

WACHTENDORF, T.; KENDRA, J. M.; DEYOUNG, S. E. Community innovation and disasters. In: RODRÍGUEZ, H.; DONNER, W.; TRAINOR, J. E. (Ed.). **Handbook of disaster research, handbooks of sociology and social research**. [S.l.]: Springer, 2018. p. 387–410.

WEAVER, C. P.; MOONEY, S.; ALLEN, D.; BELLER-SIMMS, N.; FISH, T.; GRAMBSCH, A. E.; HOHENSTEIN, W.; JACOBS, K.; KENNEY, M. A.; LANE, M. A.; LANGNER, L. From global change science to action with social sciences. **Nature Climate Change**, v. 4, n. 8, p. 656, 2014.

WEICHSELGARTNER, J.; PIGEON, P. The role of knowledge in disaster risk reduction. **International Journal of Disaster Risk Science**, v. 6, n. 2, p. 107–116, 2015.

WILSON, K.; COEN, S. E.; PIASKOSKI, A.; GILLILAND, J. A. Children's perspectives on neighbourhood barriers and enablers to active school travel: a participatory mapping study. **The Canadian Geographer**, v. 63, n. 1, p. 112–128, 2019.

WISNER, B.; GAILLARD, J. C.; KELMAN, I. Framing disaster: theories and stories seeking to understand hazards, vulnerability and risk. In: _____ (Ed.). **Handbook of hazards and disaster risk reduction**. [S.l.]: Routledge, 2012. p. 47–62.

WORLD METEOROLOGICAL ORGANIZATION. **Weather-related disasters increase over past 50 years, causing more damage but fewer deaths**. Available from: <https://public.wmo.int/en/media/press-release/weather-related-disasters-increase-over-past-50-years-causing-more-damage-fewer#:~:text=The number of disasters has,extreme weather and improved reporting.&text=From 1970 to 2019%2C weather,of all reported eco>. Access on: 22 Jan. 2022.

YAMORI, K. Action research on disaster reduction education: building a "Community of practice" through a gaming approach. **Journal of Natural Disaster Science**, v. 30, n. 2, p. 83–96, 2008.

APPENDIX A

A.1 Semi-structured interview questions used during the Participatory 3D model implemented in São Luiz do Paraitinga in July 2019

1. Where does the Lord live?
2. Were you here when the 2010 flood happened?
3. How long did it take to lower the water level?
4. What was the most striking scene?
5. Did you find out by news? How did you find out about the flood?
6. Do you think it could happen again?
7. Do you think that something could be done to prevent it, or something they could have done differently in any of the processes (before, during and after the flood)?
8. Do you think there is any way for the community to organize itself to prevent itself?

A.2 Survey questions asked in 2021 (Portuguese version)

Questionário de pesquisa

Olá! Você é convidado(a) a participar de uma pesquisa desenvolvida por profissionais da **E.E. Monsenhor Ignácio Gióia, INPE e CEMADEN**, que tem por objetivo identificar ações sociais (inovações sociais) para a prevenção de riscos de desastres em São Luiz do Paraitinga, Brasil. O preenchimento deste questionário é voluntário e não gera pagamento financeiro para as partes envolvidas (entrevistados e pesquisadores). O preenchimento significa concordância em participar da pesquisa, sem divulgação de dados pessoais.

Para responder todo o questionário, é estimado um tempo de aproximadamente 15 minutos.

Contato:

Miguel Angel Trejo-Rangel (E-mail: miguel.rangel@inpe.br)

Grupo de Pesquisa em Desastres (IG: @grupodesastres)

*Perguntas obrigatorias

Desde já, agradecemos sua participação!

(Você também pode escanear o QR para responder à pesquisa online).

PARCEIROS

INPE
UNIDADE DE PESQUISA DO MCTIC

GRUPO DE PESQUISAS EM
DESASTRES

Cemaden
Centro Nacional de Monitoramento e Alertas de Desastres Naturais

E.E. MONS. IGNÁCIO GIÓIA
MIG
SÃO LUIS DO PARAITINGA

1

Informações demográficas

1. Nome *

   _____

2. Gênero *

   [Marque com um "X" apenas **UMA** opção]

   - Feminino
   - Masculino
   - Prefiro não dizer
   - Other: _____

3. Idade *

   [Marque com um "X" apenas **UMA** opção]

   - 14 anos ou menos
   - Entre 15 e 24 anos
   - Entre 25 e 34 anos
   - Entre 35 e 44 anos
   - Entre 45 e 54 anos
   - Entre 55 e 64 anos
   - 65 anos ou mais

4. Você mora no município de São Luiz do Paraitinga? *

   [Marque com um "X" apenas **UMA** opção]

   - Sim
   - Não

5. Se você mora em São Luiz do Paraitinga, qual é seu bairro?

[Marque com um "X" apenas **UMA** opção]

- Alto Do Cruzeiro
- Benfica
- Centro
- Chácara Coelho
- Conjunto Mons. Tarcíso C. Moura
- Conjuntos Populares
- Distrito de Catuçaba
- Jovem
- Lemos Ribeiro
- Orris
- Ovíedo
- Pimentas
- Santa Terezinha (Nhá Leocadia, Vila União)
- São Benedito
- Várzea Dos Passarinhos
- Verde Perto
- Vigor – Morro Do Juiz
- Vitorio
- Outro

6. Caso você tenha selecionado a opção "Outro", qual é o nome do bairro onde você mora?

_____

7. Número de pessoas com até 14 anos que moram com você: *

[Apenas números]

_____

8. Número de pessoas com mais de 65 anos que moram com você: *

[Apenas números]

_____

Percepção de riscos de desastres

9. Qual é o principal perigo ambiental que pode acontecer em São Luiz do Paraitinga? *

[Marque com um "X" apenas **UMA** opção]

- Enchentes
- Deslizamentos
- Vendaval
- Incêndios
- Secas
- Ondas de calor
- Ondas de frio
- Outro

10. Caso você tenha selecionado a opção "Outro", qual?

_____

11. Você já sofreu danos do perigo ambiental que você selecionou? *

[Marque com um "X" apenas **UMA** opção]

- Sim
- Não

12. Se sim, em qual ano ocorreu?

[Apenas números]

_____

13. Sua moradia foi impactada durante a ocorrência?

[Marque com um "X" apenas **UMA** opção]

- Sim
- Não

14. No caso específico das inundações, você concorda com as seguintes afirmações? *

[Marque com um "X" apenas **UMA** opção por afirmação]

Afirmações	Concordo plenamente	Concordo parcialmente	Não concordo, nem discordo	Discordo parcialmente	Discordo plenamente
Eu moro em área exposta a inundações					
Eu sei o que fazer caso ocorra alguma inundação					
Eu e os membros da minha família estamos seguros					
O local onde eu moro é seguro					
Eu tenho um local seguro para onde ir caso isso seja necessário					
Eu tenho os recursos econômicos para fazer reformas na minha moradia caso seja impactada					
Eu conto com o apoio dos vizinhos caso precise					
Meus vizinhos estão prontos caso ocorra uma inundação					
Nós, na cidade, sabemos como agir caso ocorra uma inundação					
As escolas locais têm a capacidade de agir e providenciar as instruções necessárias					
Organizações da sociedade civil têm a capacidade de agir e providenciar as instruções necessárias					
A defesa civil local tem a capacidade de agir e providenciar as instruções necessárias					
A prefeitura tem a capacidade de agir e providenciar as instruções necessárias					
As autoridades estaduais têm a capacidade de agir e de providenciar as instruções necessárias					
As autoridades federais têm a capacidade de agir e de providenciar as instruções necessárias					

15. Na sua opinião, qual setor é o principal responsável pela prevenção de enchentes nacidade de São Luiz do Paraitinga? *

[Marque com um "X" **TODAS** as opções aplicáveis]

Governo municipal (Ex. prefeitura, defesa civil local)
Governo estadual (Ex. autoridades do Estado de São Paulo)
Governo federal (Ex. autoridades federais, CEMADEN)
Acadêmico (Ex. universidades, instituições de pesquisa)
Educacional (Ex. escolas municipais e estaduais)
Religioso (Ex. Igrejas, templos, etc.)
Não governamental (Ex. ONGs, associações civis)
Privado (Ex. turismo, restaurantes, comercio)
Social (Ex. população)
Other: _____

Aşões sociais de prevenşão de enchentes

16. Das seguintes opções, em quais ações preventivas você tem interesse de participar? *

[Marque com um "X" apenas **UMA** opção por ação]

	Interessado completamente	Interessado parcialmente	Não interessado, nem desinteressado,	Desinteressado parcialmente	Desinteressado completamente
Atividades artísticas de conscientização					
Aplicativo de redução de riscos de desastres					
Campanhas de sensibilização					
Comitês de comunicação entre municípios da Bacia do Paraitinga					
Comitê municipal comunitário de redução de riscos de desastres					
Conservação e restauração de ecossistemas					
Elaboração de plataformas de informações de pesquisas locais					
Engajamento de crianças e jovens					
Engajamento de parceiros locais para fortalecer capacidades de respostas					
Estratégias de comunicação de medidas preventivas					
Mapeamento das áreas de vulnerabilidade					
Monitoramento comunitário de chuvas					
Monitoramento comunitário do Rio Paraitinga					
Passeios de reconhecimento das áreas de risco					
Planejamento territorial e de uso do solo					
Planos de evacuação					
Planos de prevenção					

17. Escreva outras ações preventivas que não foram mencionadas

6

Setores envolvidos na implementação de ações

18. Dos seguintes setores, você concorda em eles serem envolvidos na prevenção de enchentes na cidade? *

[Marque com um "X" apenas **UMA** opção por setor]

	Concordo plenamente	Concordo parcialmente	Não concordo, nem discordo	Discordo parcialmente	Discordo plenamente
Governo municipal (Ex. Prefeitura, defesa civil)					
Governo estadual (Ex. Estado de São Paulo)					
Governo federal (Ex. CEMADEN)					
Acadêmico (Ex. universidades, instituições de pesquisa)					
Educacional (Ex. escolas municipais e estaduais)					
Religioso (Ex. Igrejas, templos, etc.)					
Não governamental (Ex. ONGs, associações civis)					
Privado (Ex. turismo, restaurantes, comércio)					
Social (Ex. população)					

19. Escreva outros setores que não foram mencionados

Recursos e incentivos

20. Qual é a importância dos seguintes recursos para implementar ações de prevenção de enchentes? *

[Marque com um "X" apenas **UMA** opção por recurso]

	Importante plenamente	Importante parcialmente	Não importante, nem desimportante	Desimportante parcialmente	Desimportante plenamente
Humanos (Ex. Pessoal capacitado,)					
Técnicos (Ex. treinamentos, conhecimento)					
Financeiros (Ex. Dinheiro)					

21. Escreva outros recursos que não foram mencionados e que são necessários

22. Qual é a importância dos seguintes incentivos para engajar a população nas ações de prevenção de enchentes? *
[Marque com um "X" apenas **UMA** opção por incentivo]

	Importante plenamente	Importante parcialmente	Não importante, nem desimportante	Desimportante parcialmente	Desimportante plenamente
Reconhecimento social					
Apoio institucional					
Treinamentos					
Espaços de conversas					
Continuidade de propostas					

23. Escreva outros incentivos importantes a ser considerados

Perguntas finais

24. Utilize esse espaço, caso queira compartilhar algo que não foi perguntado

25. Qual é a sua avaliação sobre este questionário? *
[Marque com um "X" apenas **UMA** opção]

	1	2	3	4	5	
Não gostei						Gostei muito

26. Escreva seu contato de WhatsApp e/ou e-mail caso você queira receber os resultados destapesquisa e/ou participar de um evento virtual sobre prevenção de desastres para São Luiz do Paraitinga.

Obrigado pela sua participação!

A.3 Conducting questions to facilitate the dialogue with locals and to assess the research impact of this project, which were asked during the final webinar on March 4, 2022

1. Why is it important to involve local people in disaster risk reduction?
2. Do you consider that the research activities (workshops, interactive model, participatory mapping) carried out at the school have contributed to disaster risk management? and why?
3. How has been the process of participating in research activities to reduce disaster risks in the city?
4. Why is it important to involve young people in disaster risk reduction?
5. What is the school's role in disaster risk management?
6. Do you think that young people are heard and considered in disaster risk management?
7. As a teacher, what would be one of the main challenges in engaging and promoting children participation in disaster risk management?
8. How would you like young people to be involved in the city's disaster risk management?
9. What would you recommend to other teachers who would like to involve young people in disaster risk management?
10. What would you say to adults who have not yet engaged children in disaster risk management, and to children who are interested?

A. 4. FAPESP Na Mídia[9]

Partial findings of this research were shared on the Agência FAPESP and reproduced in different websites that were compiled in the FAPESP Na Mídia.

Figure A.4 - Compilation of website links on the FAPESP Na Mídia website.

Source: FAPESP Na Mídia (2022).

[9]FAPESP Na Mídia: https://bit.ly/3Cj4byO

A.5 Policy brief for enhancing flood resilience in São Luiz do Paraitinga, São Paulo, Brazil[10]

The policy brief was written in Portuguese and includes the main research findings and general recommendations that can be adopted by local decision makers to enhance flood resilience and mitigate risk disasters in São Luiz do Paraitinga.

Figure A.4 - Policy brief.

Source: Trejo-Rangel et al. (2022).

[10]Policy Brief document: https://bit.ly/35x9VZU

PUBLICAÇÕES TÉCNICO-CIENTÍFICAS EDITADAS PELO INPE

Teses e Dissertações (TDI)

Teses e Dissertações apresentadas nos Cursos de Pós-Graduação do INPE.

Manuais Técnicos (MAN)

São publicações de caráter técnico que incluem normas, procedimentos, instruções e orientações.

Notas Técnico-Científicas (NTC)

Incluem resultados preliminares de pesquisa, descrição de equipamentos, descrição e ou documentação de programa de computador, descrição de sistemas e experimentos, apresentação de testes, dados, atlas, e documentação de projetos de engenharia.

Relatórios de Pesquisa (RPQ)

Reportam resultados ou progressos de pesquisas tanto de natureza técnica quanto científica, cujo nível seja compatível com o de uma publicação em periódico nacional ou internacional.

Propostas e Relatórios de Projetos (PRP)

São propostas de projetos técnico-científicos e relatórios de acompanhamento de projetos, atividades e convênios.

Publicações Didáticas (PUD)

Incluem apostilas, notas de aula e manuais didáticos.

Publicações Seriadas

São os seriados técnico-científicos: boletins, periódicos, anuários e anais de eventos (simpósios e congressos). Constam destas publicações o Internacional Standard Serial Number (ISSN), que é um código único e definitivo para identificação de títulos de seriados.

Programas de Computador (PDC)

São as sequências de instruções ou códigos, expressos em uma linguagem de programação compilada ou interpretada, a ser executada por um computador para alcançar um determinado objetivo. São aceitos tanto programas fonte quanto executáveis.

Pré-publicações (PRE)

Todos os artigos publicados em periódicos, anais e como capítulos de livros.