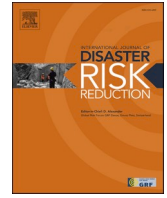




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Flood risk communication: Challenges and opportunities in Brazilian cities

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ABSTRACT

How flood risk is communicated is a key factor in disaster risk reduction. This is particularly true in the Global South countries, where several regions are susceptible to extreme weather events and have a significantly vulnerable population, deprived of urban services and facilities. Therefore, this research set out to assess the incorporation of flood risk communication into planning and public management in Brazilian cities. We analysed official documents and carried out semi-structured interviews with local officials linked to the disaster risk management to assess their practices and identify any gaps in flood risk communication. The results indicate that the limited perception of risk communication as purely an emergency measure is a significant barrier. A clear reliance on technological infrastructure was also noted, and this limits its effectiveness in areas with poor internet access. Customising messages for different audiences and adapting complex technical information were also identified as critical challenges. An informal assessment of risk communication strategies is a frequent practice. Hence, to improve risk communication, a multi-faceted approach is needed, including continuous education, personalisation of messages, use of multiple channels, training of professionals, and investment in technological infrastructure. Collaboration between sectors and the creation of formal assessment methods are crucial for strengthening the resilience of communities, improving management, and reducing the impacts of disasters. This study contributes to the existing literature by providing insights into the challenges faced by cities in implementing flood risk communication, offering recommendations to enhance the resilience of vulnerable communities and support evidence-based policy development.

1. Introduction

Floods are the most frequent natural hazard in the world and account for several impacts in the areas where they occur [1,2], particularly in developing countries in the Global South [3]. The damage caused there is enhanced by the expansion of urban settlement, infrastructure, and economic activities in floodplains [4,5], notably in South America, Africa, and Asia [6]. In Brazil specifically, Latin America's most populous country, 108 flood disasters were recorded between 2000 and 2024, affecting approximately 9.1 million people, with 2451 injured and 3347 deaths (EM-DAT, 2024). Data from the federal government's Integrated Disaster Information System (S2ID) shows that floods are the second leading cause of disasters in Brazil. Between 1991 and 2023,

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approximately 9407 floods were recorded, causing 49 % of deaths (1,872), 64 % of displaced and homeless people (6.17 million), 40.8 % of injuries (597.120 thousand) and 54.3 % of the losses in Brazil (US\$ 13,284,042,296.00) [7].

The impacts following these events can be reduced by implementing warning systems that involve risk communication strategies [8,9]. The process considers the period of normality prior to the occurrence of the adverse event, as per the UN 2030 Agenda and its Sustainable Development Goals (SDGs), the Paris Agreement, the Intergovernmental Panel on Climate Change (IPCC), and the Sendai Framework for Disaster Risk Reduction 2015–2030 plus the respective declaration (A/RES/77/289). Recently, and for the first time in the history, the United Nations Office for Disaster Risk Reduction (UNDRR) included a chapter on risk communication in its Global Assessment Report (GAR). Therefore, flood risk communication therefore plays a critical role in risk management [8,9] and is thus a process that enables the coordination of risk reduction, as well as the understanding and sharing of information and warnings/alerts to the public [10]. An effective communication process can also empower communities to take action to protect themselves and their assets [11].

However, several studies show that risk communication carried out by the State, which generally has authority over the subject, has several limitations [9,12–14]. In Brazil, where studies on this topic are few [15], the challenges in risk communication are intricately linked to the structural and operational constraints of civil defense agencies [15–22]. Risk communication is generally treated as an isolated action, without being integrated into the institutional function of the system [15] and without guidelines on how it should be carried out [21]. In the disaster that occurred on the North Coast of São Paulo in 2023, where more than 600 mm of rainfall in 24 h, for example, communication problems played a critical role. One contributing factor was the inability to send warnings to residents in informal settlements due to the absence of Postal Codes, which are a localization tool for the SMS-based alert system adopted in Brazil [23]. This limitation prevented the targeting of warnings to at-risk populations, a significant gap in the risk communication. This example illustrates how deficiencies in the coordination and capabilities of civil protection entities can exacerbate the challenges of risk communication, particularly in contexts where vulnerable populations reside in areas not formally integrated into existing systems.

Therefore, this research sets out to assess the incorporation of flood risk communication into planning and public management in 11 Brazilian cities: Curitiba and Morretes (Paraná), Rio de Janeiro and Petrópolis (Rio de Janeiro), Belo Horizonte (Minas Gerais), Recife (Pernambuco), Belém (Pará), Blumenau, Rio do Sul, Gaspar and Mafra (Santa Catarina). Our aim was to identify what kind of challenges and opportunities can be identified in (1) the internal communication (between institutional actors) and (2) the external communication (between institutions and the public). The research hypothesis is that although there is growing concern about the flood risk communication process, its incorporation into public management has shortcomings regarding the constraints on human, material and financial resources [9,21,24]. Therefore, this research advances the literature by addressing a critical gap in understanding how flood risk communication is realized and integrated into management practices in Brazil. It highlights the challenges and opportunities faced by cities in aligning risk communication with planning and decision-making. Furthermore, provides actionable insights and recommendations for enhancing communication strategies, fostering more effective disaster risk management.

2. Literature review

2.1. Risk communication

Risk communication has been the subject of understanding and evaluation in various disciplinary fields. The literature on the subject has been large since the 1970s, especially in the areas of health, technological and chemical risks [25]. Applied to flood risk, communication occupies a central position in risk management, interconnecting and helping information flows and dialogues between the different elements of its structure [26,27]. Therefore, it can be understood as a social process of exchanging information and clear and explanatory assessments focused on shared and locally based development among any entities in multiple spatial dimensions [27] on the level and meaning of flood risk [25], as well as actions to manage them. The ability to plan, develop, coordinate, and disseminate accurate, timely and reliable information, warnings before the event begins, is vital for risk reduction and event response.

Risk communication encompasses a wide range of activities that vary according to the phase of the disaster (prevention, preparedness, response, and recovery). The pre-event, which is the subject of this research, requires communication focused on raising public awareness, mainly through education, training and simulations; preparation of various organizations and agencies; emergency plans and procedures; and the provision of timely, accurate, simple and clear information about hazards, how to protect yourself, where to go and what to do [10,28]. Therefore, risk communication should increase public awareness about risks, so that different actors can recognise and understand risks, find their roles, and jointly engage in risk reduction [29].

Risk communication is carried out by a wide range of actors whose perspectives must be considered at different social and spatial levels [28]. Among the actors that make up the process, the following stand out: citizens, local governments, private and public organizations, the educational system, scientists and researchers, non-governmental organizations (NGOs) and mass media. However, it is imperative to highlight in the process who are the actors responsible for each stage of communication, since, in some cases, there may be some level of confusion about who is doing what, where and when [30]. It is worth noting that risk communication is not synonymous with disaster, crisis, and emergency communication.

2.2. Public risk communication

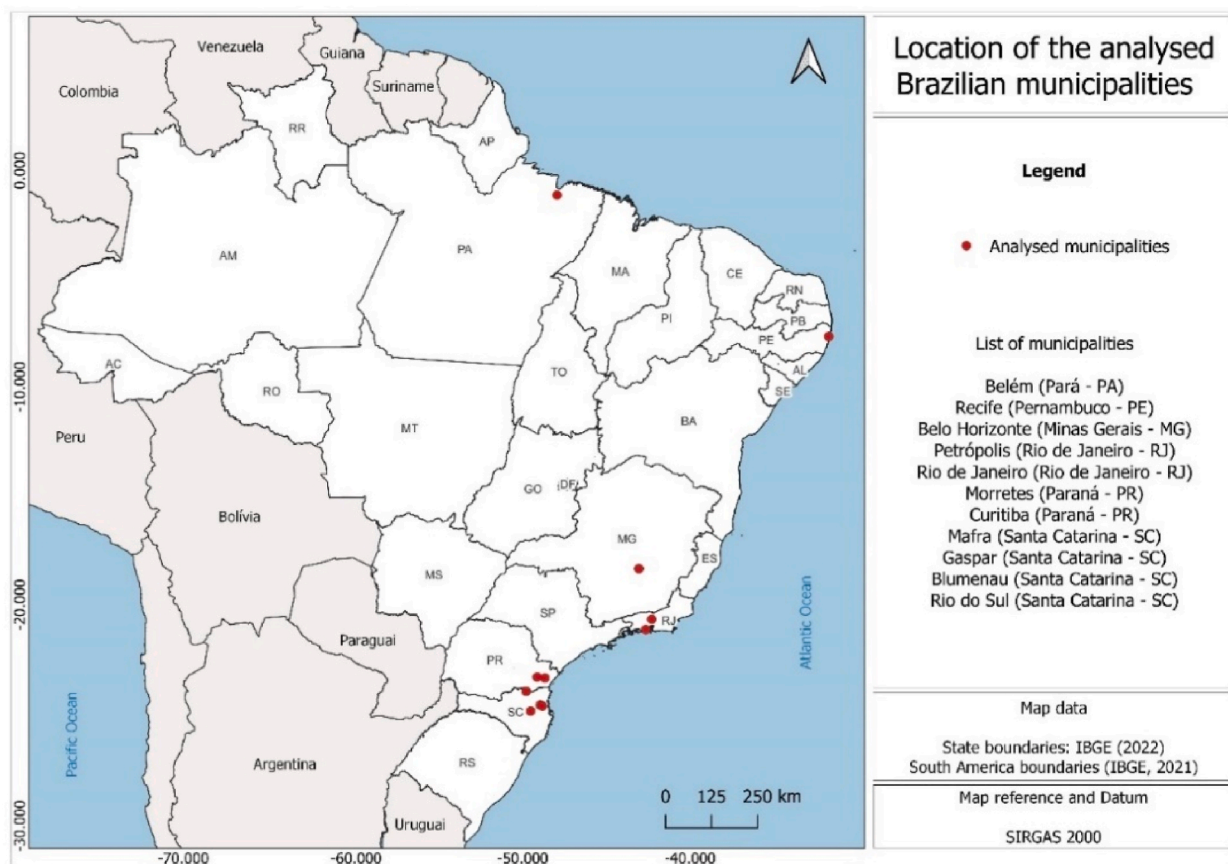
The way in which public authorities communicate flood risk has varied over time. There has been a shift from simple communication models to more complex approaches that consider the complexity of risks and society. Initially, it was conceived as a

unidirectional approach between communicators and citizens. In this model, communicators seek to scientifically “educate” citizens and improve understanding among those who were considered to need it most [31]. But this model has been classified as producing an “information deficit” [12,27,32]. Those at risk are framed as needy and dependent on experts to dictate what information is important and why. Despite that, this form of communicating risk remains the most widely used form in management. The choice of this strategy can be due in four factors: (a) low assessment of public interest in communication; (b) fear of generating a negative reaction; (c) perceived lack of necessary resources, such as skills and experience; and (d) lack of pressure from the state and support, such as good practices or training [9].

To be more effective in reducing risk, since the early 1990s there has been a more reflective approach, where the focus is less on what the public does not know and more on what they do know and their subsequent questions and concerns. That is, dialogue and the construction of social connections are presented as an alternative to the dissemination of information [33]. Because people are not only passive, but they are also active recipients of information. Risk perception, previous experience with the phenomenon, attitudes, personal responsibility in reducing risk, financial incentives and limitations, and sociodemographic characteristics are among the list of factors that influence individual decision-making in relation to floods [34]. In this two-way approach, public dialogues are seen as opportunities to bring science closer to society [35]. It is important to emphasise that a homogeneous “general public” does not exist and that different population groups may require different communication strategies. Communities are composed of individuals with different sociodemographic profiles, and these differences are reflected in the multidimensional nature of communication. Therefore, communication must be tailored to people’s needs, so that they can assess their situation and receive the means to make appropriate decisions.

3. Materials and methods

This research adopts a qualitative approach, which is particularly well-suited for exploring complex social phenomena such as disaster risk perception and communication. Qualitative methods prioritize depth over breadth, allowing researchers to uncover



Source: the authors (2024)

Fig. 1. Location of the analysed Brazilian cities.
Source: the authors (2024)

nuanced insights through open-ended inquiries and contextual analysis [36]. By focusing on the perspectives of civil defense officials, this approach facilitates a detailed understanding of localized practices in disaster management.

3.1. Research scenario and case studies

A qualitative approach was adopted, based on documental analysis and semi-structured interviews with officials from the municipal civil defense institutions responsible for disaster risk management in Brazil. The cities of Curitiba and Morretes (Paraná), Rio de Janeiro and Petrópolis (Rio de Janeiro), Belo Horizonte (Minas Gerais), Recife (Pernambuco), Belém (Pará), Blumenau, Rio do Sul, Gaspar and Mafra (Santa Catarina) were chosen [37] (Fig. 1).

The cities were selected based on the history of flooding and the areas and people at risk [37,38], as shown in Table 1.

We selected cities with recurring flooding events because these phenomena offer windows of opportunity for finding new perspectives about the practice and strategies of risk communication.

3.2. Data collection and analysis

3.2.1. Semi-structured interviews and document analysis

The development of the data collection instruments was guided by a conceptual and theoretical framework based in the literature on disaster risk. Key studies and frameworks informed the design of the questionnaire, ensuring that the questions were aligned with the current understanding of the role and challenges of communication in flood risk management [24,34,39–41]. The semi-structured questionnaire was designed to balance structure and flexibility, allowing for the collection of standardized information while also accommodating local contexts and insights from the interviewees. The interviews were conducted between September and December 2023 in an online format, through Microsoft Teams. There were fifteen open questions divided into seven sections or main topics, each addressing a key aspect of risk communication in local disaster management: (a) the role of communication in disaster risk reduction (DRR), (b) the existence of a guiding communication protocol in local management, (c) methods of sharing risk information, (d) geographical and social segmentation of risk information, (e) assessment of messages sent and received from other actors, (f) the presence of evaluation mechanisms for communication strategies, and (g) institutional and social challenges faced by local agencies.

The selection of interviewees in each city was guided by their official role as representatives of local civil defense agencies, ensuring that the perspectives gathered were directly linked to disaster risk management practices [42]. The choice to interview a single representative per city was due to the hierarchical nature of these agencies, where one official typically holds the responsibility for decision-making and communication. Additionally, logistical constraints, including limited responses to our contact attempts via email, social media, and telephone, further shaped the final sample of eleven municipalities (Table 2). The employee status refers to the type of employment status of the interviewees within their respective institutions in Brazil. There are two main categories: Permanent, which applies the employees who are public servants. They enter the institution after approval in a formal public contest. After three years of service, they may achieve tenure, meaning they can only be dismissed under serious allegations. The other category is named Service Commission, which applies to employees appointed by a competent authority (e.g. the mayor). They can also be under a temporary contract. These employees do not have tenure and may be deposed or dismissed at any time. To ensure the anonymity of the interviewees, they are described by a randomly assigned letter of the alphabet.

For each selected city, key documents were analysed, including the Municipal Civil Defense and Contingency Plans (PlamCon), the Basic Sanitation Plan (PSB), the Climate Action Plan (PAC, acronym in Portuguese Language), and the local disaster risk management legislation (Table 3). These documents were selected as they are the primary policy instruments for disaster risk management both in the Federal and local level in Brazil, particularly for water-related hazards such as floods. The Basic Sanitation Plan (PSB), mandated by Federal Law 14.026/2020, addresses water supply, sewage and waste management, as well as urban stormwater drainage and management, a crucial aspect of flood mitigation [43]. The Contingency Plan (PlamCon), as defined by Federal Law 14.750/2023, establishes procedures for disaster prevention, preparedness, response, and recovery on the municipal level [44]. The PAC integrates multisectoral strategies to reduce greenhouse gas emissions (mitigation) and enhance urban resilience to climate risks. The content

Table 1
Population in risk areas.

City	State	Population	Population under risk	%
Rio de Janeiro	Rio de Janeiro (RJ)	6,211,423	444,893	7,2
Belo Horizonte	Minas Gerais (MG)	2,315,560	389,218	16,8
Curitiba	Paraná (PR)	1,773,733	1288	0,07
Recife	Pernambuco (PE)	1,488,920	206,761	13,9
Belém	Pará (PA)	1,303,389	8303	0,63
Blumenau	Santa Catarina (SC)	361,261	78,371	21,7
Petrópolis	Rio de Janeiro (RJ)	278,881	72,070	25,8
Rio do Sul	Santa Catarina (SC)	72,587	1130	1,55
Gaspar	Santa Catarina (SC)	72,570	13,566	18,69
Mafra	Santa Catarina (SC)	55,286	3932	7,11
Morretes	Paraná (PR)	18,309	5232	28,57

Source [37].

Table 2
Characterisation of the interviewees.

City	Interviewee	Education	Employee status	No. of Years	Interview duration
Belém	E	Administration	Permanent	12 years	58m23s
Belo Horizonte	B	Military Firefighter	Permanent	14 years	01 h53m35s
Blumenau	F	Meteorology	Permanent	6 years	01 h44m38s
Curitiba	C	Municipal Guard	Permanent	25 years	01 h33m01s
Gaspar	J	Social Care	Service Commission	3 years	01 h05m50s
Mafra	K	Systems Analysis	Service Commission	3 years	01 h18m10s
Morretes	H	Administration	Service Commission	3 years	42m
Petrópolis	G	Geography	Permanent	2 years	43m12s
Recife	D	Social Care	Permanent	16 years	02 h00m50s
Rio de Janeiro	A	Systems Analysis	Permanent	10 years	02 h08m48s
Rio do Sul	I	Military Police	Service Commission	3 years	01 h11m05s

Table 3
Documents analysed.

City	PlamCon	PSB	PAC	Legislation
Belém	None	2020	None	Law no. 7269 of 13 December 1984
Belo Horizonte	2023	2020	2020	Law no. 3135 of 23 November, 1979
Blumenau	2021	2016	None	Law no. 1234 of 06 June 2019
Curitiba	2024	2017	2020	Law no. 11,645 of 22 December 2005
Gaspar	2023	2017	None	Law no. 169 of 16 June 2023
Mafra	2021	2017	None	Law no. 4,543, of 11 August 2021
Morretes	2024	2014	None	Law no. 20, of 16 October 1997
Petrópolis	2023	2014	None	Law no. 7056 of 15 April 2013
Recife	2023	2015	2020	Law no. 19,042 of 18 April 18 2023
Rio de Janeiro	2021	2015	2021	Decree no. 31,888, of 05 May 2010
Rio do Sul	2022	2012	None	Law no. 5,394, of 22 August 2013

analysis of these documents was conducted using the same categories applied in the interviews, ensuring consistency in the evaluation framework.

After being transcribed, the interviews and documents were transferred to NVivo software for thematic analysis, which is a qualitative data analysis approach that consists of looking for themes that stand out as relevant for the nature of the research phenomenon [45]. Furthermore, to allow for new observations the coding proceeded using a “hybrid” approach whereby deductive (literature-based) and inductive coding methods were employed - from the interview [46]. The codes were grouped into categories based on the research objective. In the analysis, quotations were selected based on their relevance to the themes identified during the coding (Table 4). Priority was given to quotations that exemplified the most frequently recurring themes, as these provided a representative overview of the challenges and opportunities identified in risk communication. However, in cases where comments provided unique insights, these were also included in analysis. This approach aimed to balance the representation of dominant narratives with the inclusion of other perspectives.

To ensure rigor and credibility, the study followed qualitative research criteria: credibility, confirmability, dependability, and transferability [47]. Credibility was achieved through triangulation of data from interviews and document analysis, cross-referencing findings with local plans, and using NVivo software for thematic analysis. Participant validation allowed interviewees to verify statements, enhancing reliability. Confirmability was ensured by documenting all research steps, maintaining an audit trail, and employing a hybrid coding framework combining deductive (literature-based) and inductive (data-driven) approaches. Dependability was supported by a consistent methodology, detailed descriptions of data collection instruments, and peer debriefing with co-authors and experts. Transferability was addressed by providing descriptions of the demographic, geographic, and institutional contexts of the 11 Brazilian cities studied. While focused on Brazil, the findings offer insights for risk communication in similar socio-political and environmental contexts, particularly in developing countries. Grounding the study in theoretical frameworks ensures broader applicability to disaster risk management practices.

Table 4
Categorization of codes and quotations.

Theme	Sub-Theme	Citation
Risk Communication Protocol	Communication Protocol and Procedures	"It would be in the contingency plan, which provides a step-by-step guide for all actions, whether prevention, mitigation, preparation, or response and recovery"
Information Sharing	Use of Technology for Communication	"We have several WhatsApp groups, assigned to the municipality and communities, where we post daily information about weather conditions and possible risks."
Geographic and Social Segmentation	Targeting Specific Regions and Groups	"COR.Rio has an option that allows the Operations Center to select specific regions to send alerts, using georeferencing technology"

The research was approved by the Research Ethics Committee of the Pontifical Catholic University of Paraná, according to process number: 6.001.120.

4. Results

4.1. Documental analysis

While analysing the documents related to disaster risk management in the various cities, it became clear that risk communication is addressed with greater emphasis when issuing meteorological warnings. In cities such as Belo Horizonte, Petrópolis, Recife and Rio de Janeiro, risk communication is not limited to times of crisis. In fact, it is an ongoing activity that is part of the routine of local officials. In both cases, the Civil Defense Contingency Plan emphasises that risk communication is one of the pillars to ensure risk reduction and preparedness when facing adverse events, by implementing educational campaigns, training, and drills [48–51]. In Belo Horizonte, Recife and Curitiba, the Climate Action Plans stress the importance of communication before and during an adverse event. This reveals an effort to integrate risk communication as a strategy for prevention and training.

In cities such as Blumenau, Gaspar Mafra, Morretes, and Rio do Sul, however, the documents analysed focus mostly on the warning and monitoring systems, with less emphasis on details about risk communication activities during normal times. In the case of Mafra, for example, the plan only mentions “communication means, radios, newspapers, television, the Internet, Civil Protection and Defence emergency telephone” [52], without detailing ongoing preventive or educational measures. This reveals a shortcoming in the approach to risk communication during normal times, which highlights the need to incorporate and strongly integrate preventive measures, educational and ongoing training of the population on risk management and communication strategies (Fig. 2).

While some cities, such as Rio de Janeiro and Belo Horizonte, have a robust and integrated approach to risk communication in normal times and prevention periods others, such as Mafra, Gaspar, Rio do Sul and Morretes, which are smaller in terms of population and management structure, still need to consolidate these practices in their risk management strategies. This asserts the need for a more uniform and comprehensive approach to strengthening risk communication in all stages of disaster management. In the next section we will analyse the results of the interviews, which will be complemented with data gathered during the document analysis.

4.2. Interviews

4.2.1. The role of communication in DRR

The interview analysis reveals an intricate web of challenges in the process of communicating flood risk. The process of disseminating information and promoting and raising public awareness are practices provided for in all the plans analysed. However, from the documents, risk communication is often perceived as an activity limited to issuing warnings and alerts when adverse events are imminent. This narrow perspective often overlooks the importance of communication in normality situations, when preparing and raising awareness within the community are fundamental steps to DRR. Nonetheless, throughout the interviews, participants point out a series of activities which, although not explicitly identified as risk communication, play a crucial role in raising awareness. Of these activities, education and training emerge as essential factors as they empower the residents and enable them to understand the risks associated with flooding and thus adopt appropriate preventive measures.

4.2.2. The existence of a guiding communication protocol in local management

The analysis of the documents reveals a series of crucial aspects related to risk communication and its corresponding protocols. The

City	Normal times	Early warning system	Communication protocol	Channels	Segmentation	Assessment
Belém						
Belo Horizonte						
Blumenau						
Curitiba						
Gaspar						
Mafra						
Morretes						
Petrópolis						
Recife						
Rio de Janeiro						
Rio do Sul						

Fig. 2. Summary table of document evaluation.
Caption: Red: no mention; Green: mentioned.

interviewees highlight the existence of a Municipal Contingency Plan for Civil Protection and Defence (PlamCon), although it is not explicitly referred to as a communication protocol. From the answers provided, it is apparent that there is a structure that covers everything from prevention to recovery, as one of the participants mentioned: "It would be in the contingency plan, which provides a step-by-step plan for all the actions, whether prevention, mitigation and preparation, or response and recovery" (INTERVIEWEE B). Another interviewee states that the Contingency Plan "has exactly the protocols that will direct all these alerts, all these attitudes that Civil Defence needs to undertake in a moment of risk, including how monitoring and response work" (INTERVIEWEE A). Despite this, there is no chapter on the subject, nor is there a clear definition of objectives, target groups and messages, which are all relevant for an effective risk communication protocol. Usually, only the communication channels used and the responsibilities of each of the bodies during the outbreak of an adverse event are mentioned.

Although the text emphasises the existence of a contingency plan, it is important to note that some interviewees pointed out the absence of specific protocols aimed exclusively at-risk communication. As one of them states: "I am not aware of any official document saying that it must be in a certain way, I have no knowledge of it" (INTERVIEWEE C). Another participant noted that "currently there is no specific work to make such communication during normal times" (INTERVIEWEE J). One of the interviewees highlights: "There is no formal protocol. We do it empirically, right?" (INTERVIEWEE I). Another interviewee also highlights: "We already have many documents, such as the management plan, the annual work management plan, but we don't have a specific one just to work on communication" (INTERVIEWEE D). This situation denotes a gap in the clear definition of the procedures to be followed during risk situations, especially regarding communication with the public. Therefore, it presents an opportunity to draft more detailed and comprehensive guidelines.

One of the main findings is the importance of the Civil Defence body, which plays a leading role, according to one of the interviewees: "One of the responsibilities of Civil Defence is risk communication" (INTERVIEWEE K). However, this responsibility is not restricted to this body; responsibility is shared between different sectors of the local administration: "Well it's not just the civil defence that's responsible" (INTERVIEWEE I). Another interviewee states that Civil Defence "issues these alerts and relies on other public bodies to amplify the information that we want to pass on to the population" (INTERVIEWEE A). For example, "a communications person within the civil defence and the communications advisory department at the city hall, these are the two responsible agents" (INTERVIEWEE G). But the way in which such responsibilities are fulfilled varies from one city to another. Therefore, there is no clear assignment of responsibilities and roles in public risk communication, which can lead to lack of coordination and consistency in the messages.

Under the threat of an event, the monitoring and warning system for adverse events is a shared competence among the three federal entities [42]. Internally, with the communications department, as borne out by the following excerpt: "we pass it on to the communications department, which is in charge, and they authorise us to launch it" (INTERVIEWEE E). In this case, PlamCom has a description of the communication process, of the responsibility roles of those involved and the channels used. However, only in a few cities is there a communications team or person on the Civil Defence staff. The documents from civil protection managers also denote a significant problem: the lack of formal training in risk communication. In several of the interviews, it was stated that teams rely mostly on empirical experience and informal in-house training to deal with risk communication. For example: "No, there is no training. But it is empirical. I use my communication skills, right? All my life in the Military Police, talking to the troops, talking to people" (INTERVIEWEE I). Another interviewee highlights that "So it's up to me. I do not know if it is right or wrong" (INTERVIEWEE C). In other words, the directives regarding when and how to communicate alert/warning messages are based on the experience of a single manager, who makes decisions without any established protocol, which underlines the lack of training.

Several interviewees, such as those from Gaspar and Recife, maintained that although there are general training courses and seminars, these rarely focus specifically on risk communication. In Recife, for example, it was mentioned that risk communication and conflict mediation have recently been identified as areas needing greater attention, but there is still a lack of structured formal training for this purpose. This lack of training can contribute to ineffective communication, where critical information might be misinterpreted or not understood by the public, thus enhancing the vulnerability of the communities at risk. Although the interviewees point to the existence of a contingency plan and protocols for risk situations, in the normality, in particular, there is a lack of clarity and detail regarding the objectives, messages, communication channels, responsibilities and evaluation metrics associated with communication. This gap can jeopardise the effectiveness of the communication strategies adopted and the ability to assess their impact on the population.

4.2.3. *Methods of sharing risk information*

Sharing information with citizens and organizations is essential to ensure the effectiveness of risk mitigation measures [53]. The number of communication channels used is worthy of note as they range from traditional media to digital platforms. The use of social networks is growing, permitting a wider dissemination of information [54]. As one of the interviewees pointed out: "We have several WhatsApp groups, assigned to the town hall and to the communities, where we post information on a daily basis about the weather conditions and the possible risks" (INTERVIEWEE C). Another stressed that "the WhatsApp group is the direct channel between the technical team and the general public" (INTERVIEWEE B). Other means such as websites and mobile apps are used to ensure that information reaches the population [55–57]. In Curitiba, for example, the local management publishes the flood depths in the yellow guide [58], a document that provides information about a property with parameters for the region where it is located, such as Permitted Uses and Construction Parameters. Another participant pointed out: "We have developed a specific civil defence app where citizens can receive notifications and updates on weather conditions and recommended safety measures" (INTERVIEWEE F). Another mentioned that "alerts are issued through the website, the app, warnings are always issued through the website" (INTERVIEWEE J).

Traditional media such as radio and television are also used to reach those who may not have access to technology. As one of the

respondents explained: "We broadcast regularly on radio programmes where we provide updates on the weather and share safety tips" (INTERVIEWEE B). Another respondent stated: "we try using the radio, right? People still listen to the radio a lot here" (INTERVIEWEE J). For another interviewee, information is shared "on television news in the morning, at lunchtime and at night, so we can reach the community" (INTERVIEWEE E). Sound warning systems too are seen as an important communication tool. In Belo Horizonte, Civil Defence works in partnership with residents and shopkeepers, considering the strategic importance of community participation in risk mitigation and the dissemination of preventive information through public address systems in local establishments. As one of the interviewees mentioned, "the sound emitted by the siren is very loud, precisely to reach the entire risk area" (INTERVIEWEE G). Another interviewee states that "we currently have 22 sirens and a whistle alert system in communities that do not have sirens" (INTERVIEWEE G). This type of alert is essential to reach even those with limited vision or without access to other means of communication.

However, it is important to recognise that communication has challenges, such as the need to adapt strategies to specific local realities and constraints in accessing technology. As one of the interviewees mentioned, "sirens have batteries, they have equipment that tries to give them a longer life" (INTERVIEWEE A). To overcome this gap, direct communication or "face-to-face" is emphasised as an essential practice. In Recife, risk communication measures are implemented from January to April, before the rainy season, to raise public awareness. The teams are reinforcing their "door-to-door" risk communication work, which consists of visiting every home within the risk areas in the most critical spots to advise residents about the risks, the rainfall warnings, the places where they can find shelter and other safety practices, to safeguard the lives of the population [59]. Another respondent notes that "the strategy focuses on contacting community leaders, volunteers and health workers" (INTERVIEWEE A). Another interviewee notes that "we have door-to-door work that is not only done by Civil Defense, but the Sanitation Department is also daily cleaning up the neighborhoods and taking information to the community" (INTERVIEWEE E).

Training sessions, community meetings, educational talks and simulations are other strategies reported by the respondents. As one of the interviewees highlighted: "We organize meetings on a regular basis in the most vulnerable neighbourhoods to discuss evacuation plans, security measures and how to prepare" (INTERVIEWEE D). In Rio de Janeiro, Civil Defence seeks to mobilise people to get to the meeting and support points with the help of officials and/or community leaders [56]. In Recife, the training is carried out in partnership with the University and other municipal departments [59]. In Petrópolis, the community is prepared in advance: a point of support is chosen, and escape routes are demarcated; they are given items such as raincoats, torches, and whistles [60]. Volunteers are taught basic notions of meteorology, warning systems, evacuation and first aid. Residents are trained to understand the alarm sounds and how to identify them. After the training, a simulation is carried out. In addition, bus companies and drivers are trained to identify risky situations and how to deal with the unexpected. However, some point out that awareness-raising campaigns are not widely adopted.

The features of the landscape must be considered, which are highlighted in only two cities. In Petrópolis, for example, the measures in place include closing the main roads that lead to the flood risk area with high drag power by means of automatic gates and "safety islands", that were implemented to serve as a point of support during critical moments "safety islands" [60]. Safety islands are formed by lines demarcated on streets, perpendicular to the closed roads, which provide information about the risks in the event of a threat, where the vulnerable population can divert their route and wait safely until the river returns to its normal course. Another interviewee highlights that "in areas considered to be at risk, support was provided, and signs were placed, indicating the support point, escape route, and emergency point. In such a situation, they already know where to run" (INTERVIEWEE H).

4.2.4. Geographical and social segmentation of risk information

The effectiveness of risk communication depends on the ability of public authorities to adapt their messages according to the target audience and the geographical context [61]. Geographical segmentation of warnings was only addressed in two cases. In Rio de Janeiro, the COR. Rio application features an option that enables the Operations Centre to select regions to send alerts [56]. Thus, alerts related to accidents, floods, landslides and other incidents, only reach users who are in the locations that may be affected by these events. In Blumenau, "when we have an isolated event, we only communicate to the area that is actually affected, but if it is a larger event, communication is for the entire municipality" (INTERVIEWEE G).

However, the difficulty in targeting messages to specific audiences is noticeable. According to one of the interviewees, "we still haven't managed to spread the message in an individualised way" (INTERVIEWEE C). One of the interviewees highlights that "we do not make any distinction regarding population categories, in this risk area, in this age group, or that one, whether it is a person with a disability or not. So, in communication, the message that is sent is the same for everyone, despite being defined by areas" (INTERVIEWEE F). Another interviewee states that "there is a lack of technical inputs to make this message more targeted" (INTERVIEWEE G). This suggests a gap in the personalisation of communications that can affect the effectiveness of the response. There is still a dichotomy between sending alerts to specific areas or citywide. While some advocate geographic segmentation to ensure greater precision, others emphasise the need to reach the greatest number of people. As explained, "the plan is to cover most of the population" (INTERVIEWEE A). While others stress the nature of the phenomenon: "the risk situation changes quickly" (INTERVIEWEE G), which may justify the preference for issuing broad warnings.

The use of the SMS alert system based on the registration of the Postal Code (CEP, in portuguese), an element of location of people who register, was highlighted only by interviewee H. According to him, "here in the city there is only one CEP, in fact, and it is very problematic, because many times we are here in the central region and people from Sagrado River contact us asking if they received an SMS saying of the possibility of a disaster". Using different communication channels is also mentioned as an important strategy. From social networks to SMS and WhatsApp groups, civil defence agencies use several platforms to disseminate safety information. This can also pose challenges in terms of coordination and consistency of the messages.

Finally, the complexity of the task needs a careful and adaptable approach to communication. This requires an effort of continuous consideration and improvement of strategies on the part of the civil defence bodies. As observed, “the most effective way of reaching this population would actually be to set up WhatsApp groups” (INTERVIEWEE C), indicating the need for innovation in the search for effective solutions. Another interviewee states that “the WhatsApp group is more effective in geographic segmentation, because, for example, we have the group for community X. So, the people in that group for community X are specifically the people who live in the risk area. So, in that group, the message is more targeted” (INTERVIEWEE G).

4.2.5. *Assessment of messages sent and received from local management and other actors*

Assessing the accessibility and clarity of the messages received and transmitted by Civil Defence is crucial to ensuring that information is understood by the public and plays a role in decision-making. From the interviews, it can be concluded that the bodies responsible for Civil Defence face challenges to improve of risk communication. One of the issues raised is the clarity and accessibility of the messages received from government bodies higher up in the chain of command. As Interviewee F noted, the weather forecast needs to be adapted to the local context, since the federal government’s alerts often cover a wide area, which can result in inaccurate forecasts for a city. Another interviewee states: “we receive alerts from the federal government for practically the entire state of Rio de Janeiro, so if I didn’t have my meteorologist monitoring, I wouldn’t have an accurate forecast for the municipality depending on other agencies” (INTERVIEWEE G). However, he emphasised that the information received is clear, which does permit an acceptable transmission to the population: “This information reaches the population in a clear manner, because it comes in various ways for understanding” (INTERVIEWEE E).

When messages are transmitted by the Civil Defence, clarity is a priority, as another interviewee pointed out: “We always try to do our work as clearly and succinctly as possible” (INTERVIEWEE B). However, one of the interviewees highlights that no work is done to ensure that people understand and use the information disclosed: “There is no work to say, did the person understand, right?” (INTERVIEWEE C). Furthermore, the excessive amount of information available and the character limitation on platforms such as SMS can make it hard to filter out what is relevant for each local reality. The challenge lies in determining what information is relevant and adapting it to each local reality: “It’s very difficult to discern within a large volume of information what is tangible for our reality and what isn’t” (INTERVIEWEE F), or “excess of simultaneous information” (INTERVIEWEE K) can generate distrust.

Another critical aspect concerns the interpretation and dissemination of information received by civil defence bodies. It is essential that messages are objective, clear and tailored to the target audience, to facilitate their understanding and the adoption of preventive measures. The training of professionals involved in risk communication was also mentioned as a requirement, including the development of skills in interpreting satellite images and producing more accurate and effective warnings. Only in the city of Petrópolis was anyone from the communications field a member of the Civil Defence technical team. One of that person’s tasks is to define the techniques and media to achieve the desired results and evaluate the results of awareness-raising campaigns, in relation to the objectives, during and after their implementation, by parameterising their data [60].

Moreover, interaction between the authorities and the community plays a crucial role in risk management. Setting up communication channels and establishing strategic partnerships can significantly help to improve the dissemination of information and response to emergencies. As mentioned by one of the interviewees, public participation in risk management is essential to ensure that messages are relevant and understandable to those who will be affected by adverse events. However, there are still a few challenges to overcome, including the need for greater clarity regarding civil defense measures and the importance of ensuring that the messages conveyed are dependable and based on scientific evidence. As one of the interviewees pointed out, the lack of legal backing can make decision-making difficult and lead to legal conflicts, especially in cases where preventive measures are contested.

4.2.6. *The existence of evaluation mechanisms for communication strategies*

Assessing the effectiveness of risk communication and the degree of public engagement is essential to ensure the safety and well-being of communities. Not all the bodies have formal, official systems for collecting and analysing feedback from the public. Many of the documents emphasise that the effectiveness of communication is assessed informally, based on experience or resulting from contact with the community, as Interviewee C pointed out: “it’s an informal way of measuring the effectiveness of the work” and “the assessment normally takes place during training periods and also through social media” (INTERVIEWEE E). Another interviewee emphasises: “We try to interact with people on social media, so that they never go without a response. But, as I said, it is an informal way of measuring the effectiveness of the work” (INTERVIEWEE G). In other situations, the community’s contact with the officials is emphasised: “I saw you talking the other day about (...) sometimes in the street, or in the community where he goes to talk. So, I believe that in this way I caught their attention in some way” (INTERVIEWEE I).

Only two interviewees mentioned institutionalised monitoring, which includes the analysis of social networks, telephone numbers and quantitative metrics such as the volume of accesses to the site and the number of content downloads. Measuring the effectiveness of communication must go beyond monitoring quantitative metrics. It is essential to assess whether the messages are being understood and whether they lead the public to take appropriate action. As one interviewee remarked, “you have to know if people are receiving it properly” (INTERVIEWEE C). One of the interviewees highlights that “the website provides an email address for communication with the population and the team. So, we receive several emails questioning the information that is made available to the population, making criticisms, and providing positive, positive, and negative feedback” (INTERVIEWEE F). This highlights the importance of a comprehensive approach that contemplates the reach of messages and whether they are understood, as well as their impact on community decision-making.

While this approach provides valuable insights, it is necessary to formalise and systematise more robust, evidence-based methods for assessing the impact of risk communication. For example, “we don’t have this data measured” (INTERVIEWEE D) and “we don’t

have a database as soon as its done" (INTERVIEWEE H). This acknowledgment opens opportunities for research and collaboration between the responsible bodies and academic institutions, with the aim of developing robust, evidence-based approaches to assessing the risk communication.

4.2.7. Challenges faced by local agencies in risk communication

4.2.7.1. Institutional. Risk communication carried out by various cities presents a series of multifaceted challenges, ranging from financial and technological issues to social and knowledge barriers. The considerations raised by local managers reveal a complex reality, where distinct factors interact and have an impact on communication efforts. One aspect is the need for financial resources to communication initiatives. The lack of investment hinders the capacity of civil defence bodies to develop risk reduction measures and implement communication strategies. As one interviewee mentioned, "There is always a more up-to-date tool [...] so we move forward the best way we can, because resources are always scarce within civil protection" (INTERVIEWEE J).

In addition to financial constraints, technological limitations are also reported as a significant barrier. The lack of adequate technological infrastructure hinders the effective risk communication. One interviewee highlights that limitations in telecommunications and internet access cause several limitations in risk communication, which generates complaints from residents. For example, "There are many places where there is no connection, much less internet, so people complain about the delay in sending messages" (INTERVIEWEE H). As one of the interviewees mentioned, "We have to make more progress with technology so that we can reach as many people as possible" (INTERVIEWEE F). For another interviewee, bureaucracy mainly causes such difficulties: "we send reports, we explain our needs and we encounter this difficulty, things are very bureaucratic" (INTERVIEWEE E).

Institutional problems are also mentioned, including the lack of coordination between different bodies and the need for integrated information management systems. The fact that there is no single harmonised system for collecting and analysing data is seen as a factor that makes it difficult to plan and respond effectively to risk situations. Another issue is the lack of trained human resources. The shortage of qualified personnel affects the civil defence ability to carry out risk communication in an efficient manner. One of the interviewees highlights that "we don't have an outside communications specialist to do this training, it's based on the knowledge I've acquired over the years and I'm passing on this knowledge and my experience to the new team members" (INTERVIEWEE F). "That really is the challenge," said Interviewee G, pointing out the need to find more people to deal with the current demands.

Therefore, the challenges in communicating flood risks with municipal residents comprise a complex combination of factors, ranging from financial and technological constraints to social and knowledge issues. Overcoming these barriers requires a comprehensive and coordinated approach, which involves appropriate investment, staff training, raising public awareness, and improving the technological and institutional infrastructure. As one of the interviewees remarked, "I think we need to train our professionals more, we need to train the population" (INTERVIEWEE C).

4.2.7.2. Social. Social barriers, such as the lack of public engagement during training and drills, are pointed out by the interviewees as a challenge to the success of risk reduction. Reduced community participation in these activities jeopardises the effectiveness of disaster preparedness and response efforts. Social barriers like people's low perception of risk are also noteworthy, according to one of the interviewees: "it is more about lack of knowledge; you know? People do not know, because when we get there and talk to them and they understand, their perception starts to change, their behavior starts to change" (INTERVIEWEE C). Another barrier highlighted by the interviewees is the dissemination of false or distorted information, known as "fake news." As Interviewee E mentioned, "it's rare to be faced with fake news, that is, with false information," but when it does happen, it can cause confusion and panic in the population, undermining confidence in the authorities and the warning systems.

Another interviewee states that "I think that distrust in the issuance of the alert and the alarm itself is low here in Petrópolis" (INTERVIEWEE G). The excess of information that people have access to daily is considered by two interviewees as one of the major barriers to risk communication. For example, "there are so many simultaneous messages, one after the other, that people no longer see or give importance to that warning message" (INTERVIEWEE I) and "there is a lot of information disseminated, and the biggest difficulty is discerning within this large volume of information what is tangible for our reality or not" (INTERVIEWEE F). Another interviewee highlights the importance of people's behavior, especially those who throw garbage in the river, build on the riverbank, areas at risk of flooding" (INTERVIEWEE I). One of the interviewees highlights that "our biggest barrier to communicating the risk is raising awareness among the population. Culturally, Brazil is a reactionary and non-preventive country. So, people often receive warnings, hear warnings, but do not internalize" (INTERVIEWEE F). In addition, resistance by some residents to changing behaviours can make it difficult to adopt preventive measures and respond appropriately to emergencies. Even when information is made available, not all residents are willing or able to follow the provided guidelines.

5. Discussion

5.1. The need for structured protocols and professional training

Institutional mechanisms and protocols with appropriate guidelines for communicating risk are essential for a coordinated and effective risk reduction [62]. This influences how risk information is applied and is represented in the content of communication and how it takes place, including which channels, by whom and to whom [63]. In Brazil, there are some documents on Civil Defense that, directly or indirectly, concern communication [15]. Law 12.608/2012, which establishes the National Policy for Civil Defense and

Protection, for example, does not explicitly mention communication aspects. To apply its guidelines, communication initiatives need to encourage plans to prioritize preventive actions. However, the results show that there is a lack of structure regarding risk communication in the cities analysed. The lack of a dedicated document and/or chapters, objectives and geographic and target group segmentation compromises the effectiveness of these protocols. Between the interview and the writing of this paper, one city had included a topic on risk communication in its contingency plan. This is an improvement, although it takes time to develop a risk communication plan and requires expertise in communication.

Furthermore, developing effective risk communication materials for laypeople is no simple task. Adapting a technical message for a non-technical audience with the appropriate level of detail is a challenge often undervalued. However, the results indicate that this practice occurs based on the experience of those responsible for the civil defense agency, who normally do not have education and/or training in communication, result found in another research [15,64]. The language used can be a problem if an adequate interpretation is not achieved. In the disaster that occurred in Rio Grande do Sul at the end of April and beginning of 2024, for example, the warning messages presented several gaps, mainly an insufficient description of the potential impacts and a lack of geographic and temporal precision in the occurrence of the disaster [65]. This may result in people ignoring future messages or not taking the recommended action [66]. For successful communication, it is essential to include communication professionals in the technical teams of civil defense agencies and to organize communication training for other staff members [12,67]. The splitting up of responsibilities between different sectors of a management can lead to inconsistency in the messages transmitted, which is a challenge recognised in several countries [28].

Moreover, evaluating the clarity and accessibility of the messages sent and received, as well as the existence of mechanisms for assessing the activities carried out, are key matters when discussing the effectiveness of risk communication [68]. However, the results indicate that this practice occurs informally and does not necessarily mean that it is integrated into planning. For this reason, it is essential to formalise evidence-based evaluation methods, including the use of quantitative and qualitative metrics, for a robust analysis and for the continuous improvement of communication strategies and a change in behaviour [64]. Continuous training of the professionals involved in the risk communication process is fundamental for the accurate interpretation of data and the effective transmission of information [10]. Therefore, collaboration between different levels of government, educational institutions, non-governmental organizations and the private sector can help translate technical information into clear, complete, useful and understandable messages for the public, increasing the preparedness and effectiveness of risk communication [68].

5.2. Integrating digital and traditional channels for diverse audiences

Sharing information with citizens and other bodies through various channels is a positive aspect identified in the interviews. Digital technologies such as social networks, mobile applications and WhatsApp groups are those most used by managers to disseminate information, corroborating several surveys [15,17]. However, relying on these technologies does present challenges, particularly in regions with limited access to the internet or mobile devices, and constraints regarding adequate preparation [13] of different groups, such as the elderly [28] illiterate people and people with disabilities. The warning system based on voluntary postcode registration increases the risk of disaster in informal settlements, since in these areas there is usually no address, and therefore there is no postcode [23]. To reach a wide, diverse audience the integration of traditional methods with digital technologies is essential. The literature supports this approach, emphasising that the diversity of channels increases the likelihood of messages reaching all segments of the population [23].

The difficulty in adapting or segmenting risk communication messages to the socio-spatial context is another aspect highlighted in the interviews. Messages sent to the public that do not consider socio-spatial differences can represent a significant gap e being less effective [69], especially at times of evacuation [70]. On the other hand, studies show that the socio-spatial customization of risk communication can improve the population's understanding, preparedness, and response to warnings [23,28,71,72] and ensure that limited resources and budgets are allocated efficiently [73]. For example, digital media present a source of information among young people [74]. Older people, on the other hand, tend to use traditional means of communication such as newspapers, television, radio, and face-to-face [75]. People with disabilities, and with reading and writing difficulties may not be able to interpret and react to an alert message received on a mobile phone [76]. For this reason, verbal communication gives the receiver the chance to seek clarification and ask the person involved questions, which could help them to understand the information better [77]. No single approach works for all populations nor all risk situations. Therefore, understanding the local perception and needs of different population groups can make risk management and communication strategies more target-group oriented and effective.

5.3. Enhancing risk communication through community engagement: moving beyond top-down approaches

Including the community in the communication process, along with their feedback, are other practices that are carried out and recommended to increase the effectiveness of risk communication [12,33]. Successful community engagement in normal times is correlated with the effectiveness of risk reduction strategies [9,10,24], to enable better preparedness and response. However, the results show that the top-down approach is the one most adopted by the interviewees and that risk communication is understood as a process that deals only with the issuance of warnings and alerts. Studies indicate that in the top-down approach, communicators seek to 'educate' citizens [78]. But that model has been labelled as producing an 'information deficit' and vulnerability [27], by marginalising the local information and communication networks. The cultural characteristics of communities are often ignored when analysing flood risk communication strategies [33]. Those at risk are commonly viewed as needy and dependent on experts to state which risk information is important and why [79]. Therefore, users are excluded from communication creation processes.

In recent years, the increase in public participation has generated an enormous range of interactions between science and society in which the lay public are active participants. The aim is to motivate a social dialogue around science [33], not only between the public and scientists, but also between the public in various social milieus [80,81]. It is an approach based on a deeper level of community participation related to broader notions of participatory democracy, social learning, and co-production [12]. In other words, communication becomes part of a collective and continuous process of knowledge production, rather than the final act of knowledge transfer, it can therefore be classified as a three-way communication process.

5.4. Strategies to overcome institutional and social barriers

The availability of material, human, technological and financial resources are essential for the DRR [16,17,19,21]. However, the results show that these were the main challenges identified by the interviewees, mainly in small and medium-sized cities, which limits the implementation of risk communication strategies. This situation is not exclusive to the cities analysed, but is also recurrent in several locations in Brazil, where civil defense agencies often operate with reduced technical teams and with multiple responsibilities assigned to professionals [82,83]. In addition, there is a turnover of local managers and technical staff, since these positions are assumed, normally, by the appointment of new managers. The exclusivity of the position is necessary due to the need for constant monitoring of events that require this professional to work long hours. At all levels of action, there is a need for a higher level of technical and professional training for the actors involved, which cannot be achieved without the structured and well-defined career plan in terms of its objectives [82]. In addition, the creation of clear governance structures and the definition of responsibilities are essential to improve coordination and effective communication [10,61]. The implementation of integrated risk management platforms can facilitate coordination and information exchange between different organizations [10].

Furthermore, social barriers pose significant challenges to the effectiveness of the risk communication. The level of awareness among the population, the limited participation in prevention and preparedness activities and resistance to changing behaviour are all factors that can compromise the effectiveness of communication [34,41,84]. The literature suggests that promoting a culture of prevention and ongoing education are essential to overcoming those social barriers [85]. Awareness campaigns and educational programmes can increase community engagement and reduce resistance to adopting preventive measures. Another factor that should be noted is the spread of fake news. The fight against the spread of fake news is crucial to maintaining the credibility of official information and ensuring that the public makes informed decisions [86,87]. Communication strategies must include mechanisms to monitor and debunk false information quickly. Studies show that transparency and initiative-taking communication by the authorities can help build trust and minimise the impact of fake news [86,87]. Partnerships with media enterprises and local influencers can be effective in disseminating the right messages and fighting misinformation.

Therefore, the challenges in flood risk communication comprise a complex combination of factors. Overcoming these barriers requires a comprehensive and coordinated approach, involving proper investment, staff training, constant efforts to raise public awareness and improved technological and institutional infrastructure. Risk communication requires an integrated approach that considers the complex interactions between institutional, technological, and social factors [12]. Adopting evidence-based practices, formalising assessment methods and promoting a culture of prevention are essential steps towards improving the resilience of communities faced with disasters. Collaboration between different sectors, investment in technology and ongoing education of the population are key components in overcoming the barriers identified and strengthening risk communication at local and national level.

6. Conclusion

Analysis of the challenges posed to effective risk communication in local management revealed a series of complex and interconnected challenges in Brazilian municipalities with specific characteristics and magnitude. Internally, the narrow perception of risk communication as purely an emergency activity jeopardises its effectiveness. The lack of specificity in the existing protocols and the absence of chapters dedicated to risk communication in the analysed documents are shortcomings detected in risk management. Communication strategies are assessed informally and, although this is common, there is a lack of formalised methods and robust metrics. Externally, the use of diverse communication channels, including social networks and SMS, is a positive aspect, although it depends on the technological infrastructure available and becomes increasingly important in the build up to the event. The difficulty of personalising messages for different publics and the need to simplify complex information for local contexts were identified as obstacles.

The results show that institutions use a variety of channels to communicate risk. But the effectiveness of the communication is often limited by issues such as the degree of clarity of messages, overloading the public with information, and the need to adapt weather forecasts to the local reality. Financial and technological barriers, along with the need for increased training of professionals, were highlighted as challenges. Communication with the community, by making door-to-door and organising training sessions, has proved to be an essential practice but it faces difficulties regarding engagement. However, it is important to recognise the constraints of this study. The research was based on a limited number of interviews and documents from eleven Brazilian cities which, though providing valuable insights, might fail to capture the nuances and diversity of communication practices in various places. The lack of quantitative data limits the ability to draw generalisations from the results.

Therefore, the results of this article contribute to understanding the challenges faced in risk communication and provide insights for improving current practices, whether in small, medium, or large cities. In theory, the results highlight the importance of clarity and accessibility in risk communication messages by corroborating previous studies that emphasise the need for effective communication in normal times and emergency situations. That is to say, the results suggest the need for investment in technological infrastructure and

professional training so that risk communication can be improved. To overcome the barriers identified it is recommended that integrated information management systems should be created and methods for evaluating the effectiveness of communications formalised. In addition, the community should be encouraged to actively participate in risk management to ensure that messages are relevant and understandable.

In conclusion, the research highlights the complexity and the challenges of flood risk communication in Brazilian cities. Although significant efforts to improve the dissemination of information and involve the community have been identified, the lack of resources and poor coordination between institutions hinder the effectiveness of these initiatives. Overcoming these barriers requires an integrated, multi-faceted approach that combines investment in technology, ongoing training of the professionals and the population, and the implementation of robust assessment systems. Collaboration between different sectors and the formalisation of assessment methods are identified as crucial steps towards building more effective and resilient risk communication. Community participation and the adaptation of messages to the local context are essential to ensuring that risk information is understood and leads to appropriate action by the public. Adopting these recommendations could help to improve disaster management and protect communities from natural hazards.

CRedit authorship contribution statement

Murilo Noli da Fonseca: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Luciene Pimentel da Silva:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Conceptualization. **Fantina Maria Santos Tedim:** Writing – review & editing, Writing – original draft, Validation, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2025.105292>.

Data availability

No data was used for the research described in the article.

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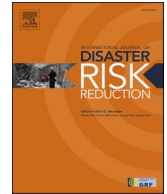
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Corrigendum to “Flood risk communication: Challenges and opportunities in Brazilian cities” [Int. J. Disaster Risk Reduct., Volume 119 (2025) 105292]

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The authors regret < I would like to request the inclusion of additional funding information in the article "Flood Risk Communication: Challenges and Opportunities in Brazilian Cities" (<https://www.sciencedirect.com/science/article/abs/pii/S2212420925001165>) published in International Journal of Disaster Risk Reduction.

Following a request from the Centre for Studies in Geography and Spatial Planning (CEGOT), and in compliance with a requirement from the Foundation for Science and Technology (FCT) of Portugal, I kindly request the following amendment in the manuscript:

1. Funding Information: Please include the following sentence in the funding section of the article, rather than in the acknowledgments:

a. "This research received dissemination support from the Centre for Studies in Geography and Spatial Planning (CEGOT), funded by national funds through the Foundation for Science and Technology (FCT) under reference UIDB/04084/2020."

2. Author Affiliation Update:

a. Additionally, I would like to request a correction to the institutional affiliation of Professor Fantina Tedim. Kindly replace:
i. "Fantina Maria Santos Tedim, Universidade do Porto, Via Panorâmica, s/n, Porto, 4150-564, Portugal" with: "Fantina Tedim (Research Centre in Geography and Spatial Planning, CEGOT, Geography Department, Faculty of Arts and Humanities, University of Porto, Via Panorâmica, s/n, 4150-564 Porto, Portugal)."

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