

Earthquakes and information emergencies. The case of February 17, 2025

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On Monday, February 17, 2025, two minor seismic events ($M < 3$) occurring in Italy were accompanied by inaccurate communications across the social media and web channels of the Earthquake Department of the National Institute of Geophysics and Volcanology (INGVterremoti), which are dedicated to real-time seismic monitoring. The simultaneous occurrence of two rare, yet not impossible, events on the same day renders February 17, 2025, a significant case study in the management of information emergencies.

Two communication incidents

At 08:11 AM (local time in Italy), the INGV automatic localization system briefly disseminated a significantly inaccurate provisional estimate (magnitude between 4.6 and 5.1) for a seismic event in the province of Latina. The error resulted from the incorrect association of seismic signals - originating from an actual magnitude M_d 3.2 earthquake in the Phlegraen area - with electronic interference. This information appeared for several minutes on the terremoti.ingv.it portal, the dedicated INGVterremoti App and the INGVterremoti Facebook and X (formerly Twitter) channels. Since 2018, the occurrence of such "incorrect localizations" has remained below 1%. While this is considered a scientifically acceptable margin of error, it represents a potential risk in terms of the impact of communication on the general public. Consequently, in accordance with established procedures within the INGV Earthquake Department, the erroneous information was rectified within minutes by removing it from database and social media channels. Furthermore, an in-depth article explaining the incident was published on the ingvterremoti.com blog-magazine and subsequently shared on X and Facebook.



Figure 1 – Post from the INGVterremoti Facebook page regarding the in-depth article on the false earthquake in the province of Latina, February 17, 2025.

At 6:54 PM (local time in Italy), the final localization of a seismic event in the Phlegraen area was automatically published on the websites terremoti.ingv.it and terremoti.ov.ingv.it/gossip/, as well as on the INGVterremoti social media channels X, Facebook and Instagram. Due to a human error by the personnel on duty at the Monitoring Room of the Vesuvius Observatory in Naples, the magnitude published across the aforementioned platforms was erroneously listed as 9.0 instead of 0.9. The error was promptly addressed: the INGVterremoti team removed and corrected the posts on its social media channels and the Press Office issued a clarifying note to the media.

Communication strategies and impact

While social media platforms bridge the gap with citizens and amplify messages, they also facilitate the rapid spread of misinformation, significantly complicating the management of emergency situations (Gürer et al., 2023). Consequently, the INGVterremoti team applied the principles of timeliness, transparency and proactivity to manage the emergency (Columello, 2014) through prompt corrections and explanatory communications. The same level of attention dedicated to external communication was also reserved for internal communication.

For the first time ever, a real-time social media monitoring dashboard was utilised to analyze the impact of communication incidents. The analysis of the INGVterremoti channels covered 1,600 results and revealed a sentiment distribution as follows: 75,3% neutral, 16.9% negative and 7.7%

positive.

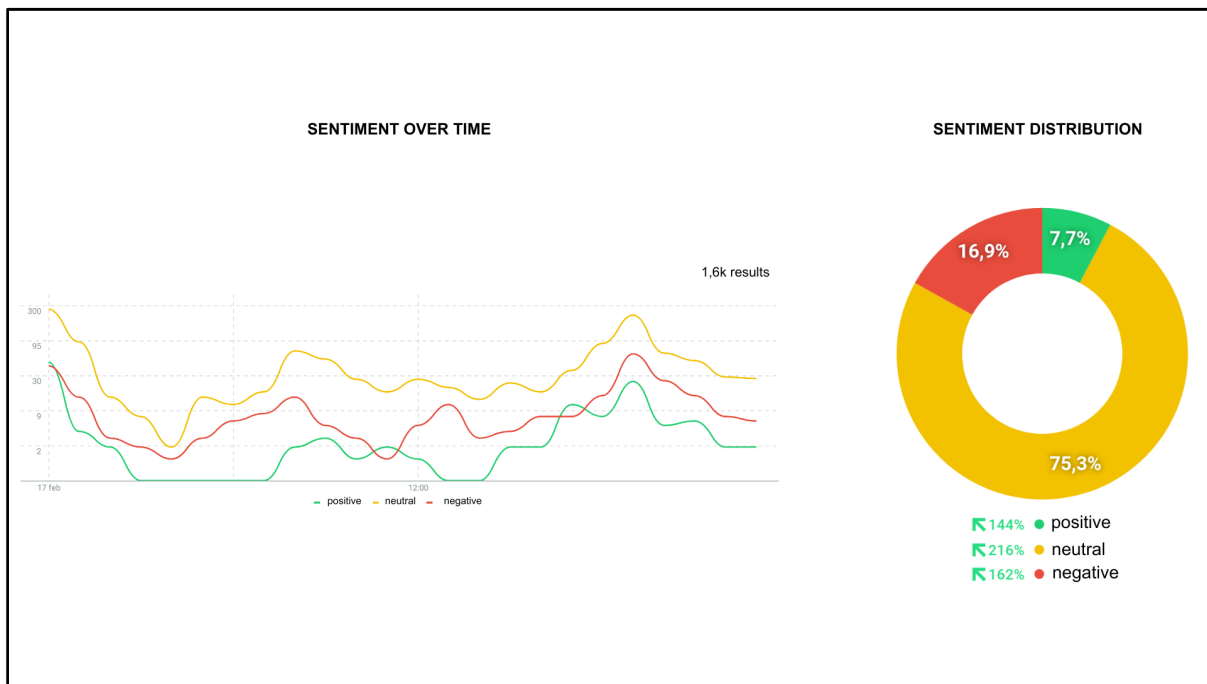


Figure 2 - Charts illustrating the trend and distribution of sentiment across INGVterremoti channels on February 17, 2025 (data processing: Talkwalker).

The online press review gathered 30 articles, revealing a predominantly neutral sentiment regarding the event in the province of Latina and a negative sentiment concerning the Phlegraen area event. The latter was driven by widespread public concern regarding bradyseism and the ongoing seismic crisis affecting the area. The ex-post analysis, conducted using manual editorial methods rather than automated processes, examined a sample of 1,412 results with a specific focus on Facebook. This analysis confirmed a higher negative sentiment for the Phlegraen area case (50.18% negative) compared to the Latina event (37.10% negative). Finally, the strong community reaction to the magnitude 9.0 error prompted INGVterremoti to produce a brief explanatory video on Instagram to clarify the impossibility of earthquakes in Italy with a magnitude equal or greater than 9.0. This reel emerged as one of the channel's top-performing content, demonstrating significant public interest in the subject (Pignone et al., 2025).

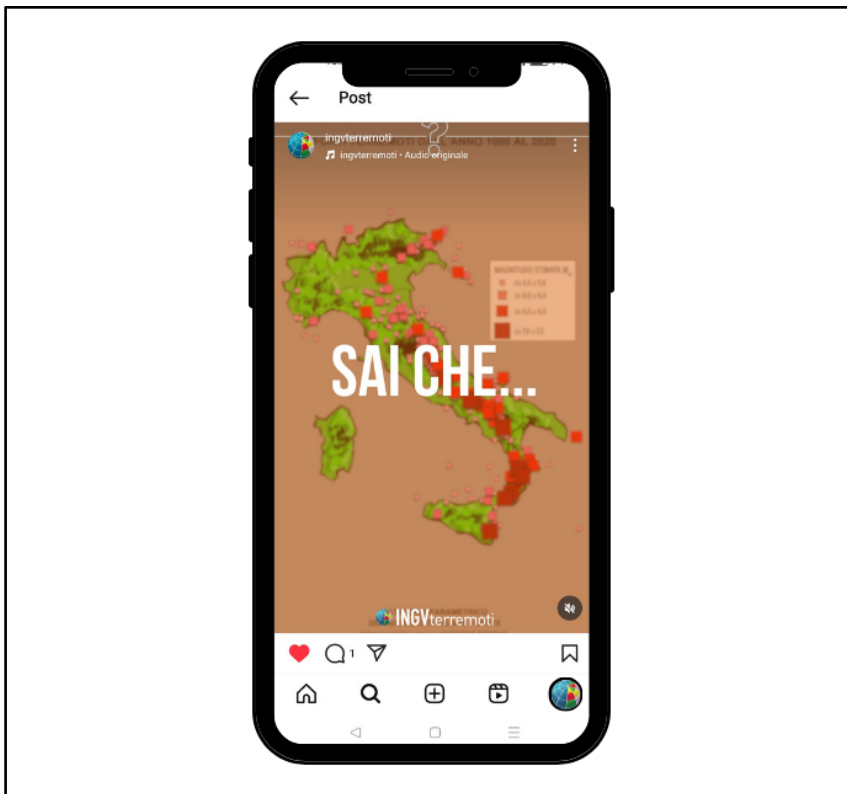


Figure 3 - Reel from the INGVterremoti Instagram profile regarding the in-depth reel published on February 21, 2025, following the communication error of February 17, 2025.

Future scenarios

The communication strategies adopted averted a reputational crisis and guided citizens toward a better understanding of the events. Looking ahead, the adoption of more comprehensive automated tools for a social sentiment analysis is highly recommended.

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Preventive Governance of Natural Risks: Social Vulnerability and Legal Tools in Territorial Contexts

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Natural hazards increasingly expose territorial inequalities, revealing how social vulnerability shapes risk distribution and impact severity. This contribution analyses preventive governance as a legal and social framework aimed at reducing exposure before disasters occur. Particular attention is paid to the role of public spending and contractual instruments in risk mitigation policies, highlighting how procurement choices influence territorial resilience. The paper examines how preventive investments, when guided by vulnerability assessments, can align legal compliance with social effectiveness. By integrating social sciences and public law perspectives, the study argues that prevention-oriented governance enhances accountability, reduces emergency-driven expenditures, and promotes more equitable protection of communities at risk.

In this perspective, preventive governance is not limited to a technical anticipation of hazardous events but operates as a redistributive mechanism capable of correcting structural imbalances among territories. Risk prevention policies, when embedded in ordinary administrative action, become a means to address long-standing disparities in infrastructure quality, access to essential services, and institutional capacity. The paper therefore conceptualizes prevention as a form of anticipatory justice, whereby public authorities are called to intervene before harm materializes, particularly in areas characterized by socio-economic fragility and limited adaptive resources.

From a legal standpoint, the analysis highlights how preventive governance reshapes traditional categories of administrative law. The shift from emergency response to ex ante risk management challenges the exceptional logic that often governs disaster-related interventions and calls for a reconfiguration of planning, budgeting, and procurement procedures. In this framework, public contracts emerge as a strategic lever through which prevention policies are operationalized. The choice of contractual models, award criteria, and performance clauses directly affects the capacity of public investment to generate durable resilience rather than short-term compliance. Emphasis is placed on the use of life-cycle costing, sustainability requirements, and outcome-oriented specifications as tools to integrate risk reduction objectives into procurement practices.

The contribution further examines the financial dimension of prevention, arguing that preventive spending should be understood not merely as a cost, but as a form of investment with measurable social returns. Vulnerability-based allocation of resources allows public authorities to prioritize interventions where marginal benefits are highest in terms of risk reduction and social protection. This approach also supports fiscal sustainability by limiting the escalation of emergency expenditures, which are often characterized by opacity, derogations from ordinary rules, and reduced accountability. By contrast, prevention-oriented investments strengthen transparency and

traceability, reinforcing the link between public spending, legal responsibility, and collective outcomes.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance (IFRC / Disaster Law Database)

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Integrating Social Sciences and Law in Preventive Natural Risk Policies

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Effective prevention of natural risks requires an interdisciplinary approach that combines social sciences, legal analysis, and public governance tools. This contribution explores how social vulnerability assessments—understood as analytical instruments capable of identifying differential exposure, sensitivity, and adaptive capacity of communities—can inform and reshape legal frameworks governing public spending, administrative action, and public contracts. By focusing on territorial case dynamics, the paper demonstrates how preventive policies are strengthened when social knowledge is systematically integrated into legal decision-making processes, particularly in the allocation of resources and the design of contractual instruments for risk mitigation.

The analysis highlights the role of law not merely as a reactive system responding to emergencies, but as a proactive mechanism capable of translating social insights into binding preventive actions. Special attention is devoted to the principles of precaution, proportionality, and sound financial management, showing how they can be operationalized through procurement strategies, planning instruments, and budgetary choices that prioritize vulnerable territories and populations. From this perspective, social vulnerability assessments function as a bridge between empirical knowledge and normative choices, enhancing the legitimacy and effectiveness of preventive interventions.

Ultimately, the paper argues that interdisciplinary governance is essential for sustainable and socially just risk prevention. Integrating social science methodologies into legal and administrative frameworks allows public authorities to move beyond sectoral approaches, fostering a preventive culture grounded in territorial realities, equity considerations, and long-term resilience. Such an approach contributes to redefining public interest in risk governance, aligning legal obligations with social needs and reinforcing the capacity of public law to address complex environmental challenges.

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“It’s pretty cool, honestly. But it’s also scary.”

Debating generative artificial intelligence in risk communication: frames, sources, ethics

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Introduction and research questions

This contribution presents the results of a research action conducted within a broader project (Anonymized for review). Specifically, it explores the opportunity to apply generative artificial intelligence (hereafter, gen-AI) to the production of risk communication content. This empirical qualitative action is conceived as a preliminary step to a survey currently being administered to a representative sample of the Italian population.

The analysis is structured around two interrelated research areas. The first concerns how recipients understand and assess the acceptability of specific communicative frames in risk communication (RQ1). In particular, the study focuses on gain/loss frames, which have been increasingly problematised in analyses of climate change narratives and their effects (Marti et al., 2018; Ngo et al., 2022; Freihardt & Buchs, 2024). Within this same area, the study also reflects on the role of the source and on the acceptability of specific institutional actors in risk communication (RQ2).

The second, more transversal, research area addresses the use of gen-AI in the communicative practices of public institutions. Although this topic has attracted growing interest, it remains largely underexplored in the literature. Risk communication constitutes a particularly effective site for examining AI’s role as a producer of meaning, as both the production and reception of such content involve intangible dimensions such as credibility and trust. By administering AI-generated risk communication messages, the study therefore analyses how the presence of gen-AI is perceived as acceptable or intrusive depending on the type of content proposed (RQ3).

The research questions are explored through a sample of young university students belonging to so-called Generation Z, considered a particularly relevant cohort for identifying emerging communicative trends, especially in digital contexts (We Are Social, 2025). Moreover, this generation has received increasing attention in the literature with regard to climate consciousness (Barrón et al., 2022; Belotti et al., 2022; Belotti & Bussoletti, 2022) and reactions of eco-anxiety (Gunasiri et al., 2022; Brophy et al., 2023).

Prompt design

The materials shown to participants were generated with ChatGPT and guided by detailed yet flexible prompts. The inputs included official texts on seismic and hydrogeological risk prevention drawn from the Italian Civil Protection “Io non rischio” campaign. ChatGPT was instructed to

simulate Facebook posts from two alternative sources: a mayor communicating with citizens in a hydrogeological risk area, and the Municipal Civil Protection addressing seismic risk. For each source, two types of messages were generated, based on gain (benefits from adopting preventive behaviours) and loss (negative consequences of inaction) framing. Each message included a visual card. The selected posts were chosen based on three main criteria: (1) clarity; (2) accuracy of the image; (3) representativeness of the information provided.

The messages were formatted as simulated Facebook posts, labelled either “Mario Verdi Sindaco – Comune di Monterosso” or “Protezione Civile – Comune di Monterosso.” The choice of a fictitious but plausible municipality enabled researchers to evoke a local dimension without directly referencing the data-collection context. Some “imperfect” design elements (e.g., slightly long captions or uneven alignment) were intentionally preserved to stimulate critical feedback and encourage participants’ suggestions for improvement.

Sample and interview procedure

The sample included 32 university students (19 F, 13 M) aged 21–28, studying communication or related disciplines, or working as collaborators or interns in university communication offices at Sapienza University of Rome.

Interviews were conducted online or in person between July and October 2025. Each participant was presented with two products (one gain-framed and one loss-framed), following both mixed and mirrored sequences to minimise conversational effects linked to the order of exposure. After viewing the materials, participants were asked to summarise the main messages following a plus/minus approach. The subsequent discussion focused on their evaluation of AI use in risk communication and the perceived relevance of environmental and natural hazard information in their media routines. All interviews were recorded, fully transcribed, and analysed through thematic analysis (Braun & Clarke, 2021).

Main results

When discussing frames (RQ1), opinions tended to polarise. Specifically, the loss tone was appreciated for its functionality, in line with expectations for risk communication (i.e., direct, urgent, and action-oriented). The gain tone, on the other hand, was valued for its expressive and emotional dimension: respondents frequently noted that risk communication “should make people feel.” Indeed, students perceived loss-framed messages as conveying a stronger sense of urgency, often due to associated visual codes (red colouring, warning emojis, bold fonts). Overall, students perceived the alerting and urgent dimension conveyed by loss-framed messages as particularly effective in making the possible consequences of non-compliance immediately clear.

“Phrases like ‘if you ignore the rules, you can lose everything, danger of death’ — they make the situation more immediate (...) It says, ‘The danger is now.’ If you don’t do this, you risk that. It puts it on a practical level: if – consequence.” (M_08_LT_S_RM)

However, a smaller number of testimonies tended to reject this kind of content, finding it overly anxiety-inducing or guilt-driven, overlooking the unpredictable nature of natural hazards.

[I don't like] the reference to 'it could cost you dearly', because many times it doesn't depend on the individual: if a house was built in an area where it shouldn't have been, the fault isn't with the person living there. So, blaming them isn't right. (F_02_LM_M_RM)

As for gain-framed messages, interviewees were most impressed by a stronger perception of empathy and emotional involvement. Respondents appreciated references to community, as well as the reassuring sense that institutions were actively addressing risks.

Let's act together: I like that message. It gives a sense of solidarity, of a community that can protect itself together. (...) This idea of solidarity appeals to me because a mayor is usually a leader, a mediator, and I like to think that someone sending this kind of message would also try to calm people down in such a situation. (F_04_LM_S_RM)

However, despite these empathetic reactions, these messages were generally considered less effective in practice. Many respondents felt that they conveyed less urgency, partly because of their softer, more reassuring visual codes, such as pastel yellow or institutional blue as primary colours.

Paradoxically, even the use of blue emojis doesn't give me the feeling that it's something I need to read to stay safe, something urgent or important to read right now. Maybe it could just be a general piece of information, though... (F_17_LM_S_RM)

Among the young interviewees, the approach to sources appeared ambivalent (RQ2). On the one hand, participants rarely mentioned the sender as a relevant factor when discussing the message. On the other hand, their statements revealed considerable attention to source credibility, especially when it came to traditional and locally grounded figures. The mayor emerged as the most trustworthy source, due both to territorial proximity and to a tone perceived as direct and recognisable.

Maybe a direct message from the mayor, especially if I had voted for them, would work better for me. I mean, I have the utmost respect for Civil Protection, but a direct message from the mayor has a stronger impact. (M_03_LM_M_RM)

Civil Protection was generally perceived as an authoritative and competent source, seen as a legitimate actor for disseminating messages related to risk prevention and public safety. Some participants even considered it more trustworthy than the mayor, as a more generalisable and less personalistic source.

I imagine that certain messages come from Civil Protection or other kinds of organisations. Usually, a mayor (at least the mayors of big cities that I follow on social media) doesn't post this kind of message. (M_24_LM_S_RM)

In contrast, figures associated with digital imaginaries, such as influencers and content creators, were not considered particularly credible, especially when perceived as “generalist” content producers, such as lifestyle influencers.

Another key point concerned the disclosure and discussion of AI (RQ3). When participants spontaneously pointed out that the materials seemed AI-generated, they usually did so to criticise their tone or quality (e.g., lack of personalisation, simplistic tone):

Basically it seems like a message that could easily be given by AI. I mean, if I asked ChatGPT, for example, ‘how can I prevent this?’, it seems like the text it would give me.
(F_17_LM_S_RM)

As for whether AI use should be disclosed when a message has been generated or revised by it, participants’ views clustered around two opposing poles. On one side were those who preferred that AI use be clearly stated, mainly for ethical and transparency reasons. On the other side were those who preferred not to include any such indication. The latter group was quite heterogeneous: it included those who did not consider disclosure necessary because they saw AI as a mere technical support, and those who believed that disclosure could harm credibility and trust, especially among people unfamiliar with such tools.

It makes me think that whoever sees that little line saying ‘created with AI’ would just skip the post altogether, given the reputation AI has, the way it’s currently seen.
(F_13_LM_S_RM)

Overall, the use of AI in risk communication evoked mixed feelings. Participants expressed a wide variety of attitudes. Some were curious about AI’s potential as an innovation and a way to improve readability and clarity, especially when compared with what they perceived as the often cumbersome communication style of institutions. Others expressed distrust, mainly related to fears of human job loss (particularly salient given that almost all participants were communication students) or to the perceived loss of control and intentionality in the messages. Several interviewees remarked that locally relevant or emotionally resonant content was expected to carry a more human tone.

If it had been a real person creating content on these issues, it would have been more effective. (F_16_LM_S_RM)

The acceptability of AI use also depended on the source. Some participants stated that supervision by scientific bodies or institutional experts would be both a necessary and sufficient condition for trusting AI-generated content.

If it’s content made by AI, but at the same time experts have agreed and checked the accuracy of the information, I’d be totally fine with that. (F_19_LM_M_RM)

Some participants viewed the integration of AI as already underway and therefore inevitable. For them, ethical questions seemed marginal or redundant, given that such practices were already perceived as widespread. Others, by contrast, considered AI use ethically questionable or unnecessary for communication tasks that could be adequately handled by humans. Distrust toward AI was often linked to a perceived loss of human commitment and relational investment.

Thinking as an average citizen, it would kind of piss me off that they didn't even bother to write a message themselves. (...) On the other hand, and this is a terrible thing to say, maybe I'd trust AI more than the institutions. (M_11_LM_M_RM)

The main findings show that different frames are perceived as functional for achieving different outcomes, action in the case of loss frames and community building in the case of gain frames, while institutional sources remain the primary actors from whom people expect to receive information. In this sense, AI functions as a stress test for dimensions of trust, authority, and responsibility. Regarding possible future developments, AI was generally viewed as helpful in automating message production. Yet reservations remained about replacing human labour. The human factor was consistently perceived as essential, reflecting the substantial emotional and fiduciary investment that characterises risk communication.

Acknowledgements

This study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-GenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005).

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Extreme Meteorological Risk and the Governance of Port Areas: Resilience, Planning, and Public Responsibility

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Port areas represent strategic nodes of the global economy and critical infrastructures for national and regional development. Their physical exposure to coastal dynamics, combined with increasing urbanization and logistical concentration, makes them particularly vulnerable to extreme meteorological events. Climate change has intensified the frequency and severity of phenomena such as storm surges, extreme precipitation, sea level rise, heatwaves, and strong winds, significantly amplifying the risk profile of ports and coastal logistics hubs. These risks are no longer episodic but structural, requiring a rethinking of port governance, spatial planning, and public risk management strategies.

This paper examines extreme meteorological risk in port areas through an integrated perspective that combines environmental risk analysis, infrastructure resilience, and public governance. It argues that ports should be considered not only as economic assets but also as complex socio-technical systems whose disruption can generate cascading effects on supply chains, urban safety, energy security, and public finances. Damage to port infrastructure, temporary closure of terminals, and interruptions to maritime connectivity can have immediate economic costs and long-term consequences for territorial competitiveness.

The first part of the paper outlines the main categories of extreme meteorological risks affecting port areas, distinguishing between acute events (such as storms and flooding) and chronic processes (such as sea level rise and coastal erosion). Particular attention is devoted to the interaction between natural hazards and anthropogenic factors, including land reclamation, rigid coastal defenses, and the concentration of hazardous activities within port perimeters. These elements often increase systemic vulnerability and reduce adaptive capacity.

The second part focuses on governance and planning instruments for managing meteorological risk in ports. It analyzes the role of port authorities, local governments, and national regulators in integrating climate risk into port master plans, coastal zoning, and infrastructure investment decisions. The paper highlights the importance of preventive planning, adaptive design standards, and scenario-based risk assessment, moving beyond emergency-driven approaches. In this context, resilience is understood not only as the capacity to withstand shocks, but also as the ability to ensure rapid recovery and functional continuity.

The final section discusses the implications for public responsibility and financial sustainability. Extreme meteorological events increasingly generate significant public costs related to emergency response, infrastructure repair, and compensation mechanisms. The paper argues that proactive risk management and climate adaptation in port areas should be framed as a matter of public interest, justifying coordinated investment, regulatory oversight, and accountability mechanisms. Strengthening the resilience of port areas is therefore not only an environmental or technical

challenge, but also a legal and institutional one, requiring integrated policies that align economic efficiency, environmental protection, and public safety.

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Ex-ante assessment of information needs on marine hazards in municipalities participating in the Tsunami Ready programme

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Increasing urbanisation of Mediterranean coastal areas, combined with the development of tourist infrastructure and high-impact industrial facilities, determines an increase in the risks faced by coastal communities from marine hazards such as tsunamis, storm surges and sea level rise. These risks need to be addressed by rapidly strengthening early warning systems and preparedness and resilience strategies at the local level. In this context, the Tsunami Ready programme, promoted by UNESCO, aims to improve the resilience of coastal communities in the Mediterranean by achieving twelve indicators. This study proposes an ex-ante assessment of the information needs on marine risks in Italian coastal areas adjacent to the municipalities involved in the implementation of the Tsunami Ready programme, with a focus on the target municipalities. The objective is to analyse the level of awareness, risk perception and preparedness of the population regarding the main hazards related to sea level. To assess these aspects, a structured questionnaire, implemented as part of the CoastWAVE project promoted by UNESCO-IOC and funded by European DG-ECHO funds, was used. The questionnaire was administered to a sample of residents stratified by age, gender and level of education representative of coastal communities, in order to make the survey statistically robust. A total of 303 interviews were collected in coastal municipalities involved in the development of the Tsunami Ready programme, considering two coastal municipalities to the north and two coastal municipalities to the south of the target municipality.

The objectives of the study include an in-depth analysis of aspects related to knowledge of marine hazards, trust in warning systems, information sources used, the degree of preparedness in response to a potential warning and expectations of the institutions responsible for risk management.

The expected results will make it possible to identify information gaps and communication issues, providing operational recommendations for the development of more effective, contextualised risk communication strategies aimed at implementing the Tsunami Ready programme and marine risk reduction measures. Finally, the study offers useful insights for refining the communication conveyed through marine risk warning and mitigation systems in the target municipalities. The study is relevant at European level from a UNESCO perspective, both in terms of its specific type and the shared survey tool.

Social Inequalities in Earthquake Prevention: A Comparative Assessment of Seismic Governance in 12 High-Risk Countries

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Earthquake disasters are not solely determined by the physical characteristics of ground shaking but emerge from a complex interaction between hazard, exposure, structural vulnerability, institutional capacity and societal behaviour [Wisner et al., 2004; UNDRR, 2019]. Countries experiencing comparable magnitudes and intensity levels routinely exhibit losses that differ by one or even two orders of magnitude, underscoring profound inequalities in seismic governance, preparedness, and risk communication [Tierney, 2014; Cutter et al., 2003]. Despite the central role of prevention in shaping disaster outcomes, a unified and globally comparable metric that captures the multidimensional nature of seismic prevention has been lacking.

To fill this gap, we introduce the Global Seismic Prevention Index (GSPI)—a composite indicator designed to quantify national-level prevention capacity along structural, institutional and social dimensions. The GSPI integrates seven domains widely recognized in disaster risk reduction frameworks: (i) building code enforcement; (ii) earthquake early warning systems (EWS); (iii) risk-informed urban planning and land-use regulation; (iv) institutional capacity and governance; (v) public preparedness and education; (vi) retrofitting and safety of critical infrastructure; and (vii) exposure–vulnerability profiles informed by global seismic risk models. These components, grounded in engineering resilience [Bruneau et al., 2003], early warning science [Allen & Melgar, 2019], and socio-institutional risk frameworks [UNISDR, 2015], are normalized and combined into a reproducible 0–100 index. Their conceptual arrangement is shown in Fig. 1, which highlights how the GSPI captures the systemic nature of prevention, spanning policies, infrastructure, institutions and collective behaviours.

The index is applied to twelve high-risk countries and regions—Japan, California (USA), New Zealand, Chile, Italy, Greece, Mexico, the Philippines, Indonesia, India, Türkiye and Iran—selected for their diverse tectonic regimes, socio-economic profiles and risk governance traditions. To examine whether prevention capacity modulates observed earthquake consequences, the GSPI is compared with a harmonized catalogue of 552 significant seismic events (1970–2024) integrating EM-DAT losses [CRED, 2023], USGS source parameters [USGS, 2024], and population and GDP baselines from the World Bank [World Bank, 2024]. From these data, we compute three normalized

impact indicators: Fatality Rate (FR), expressing deaths per million inhabitants; Casualty Efficiency (CE), relating fatalities to the energy released by each earthquake; and Damage-to-GDP ratio (DG), quantifying the economic burden of events relative to national economic output.

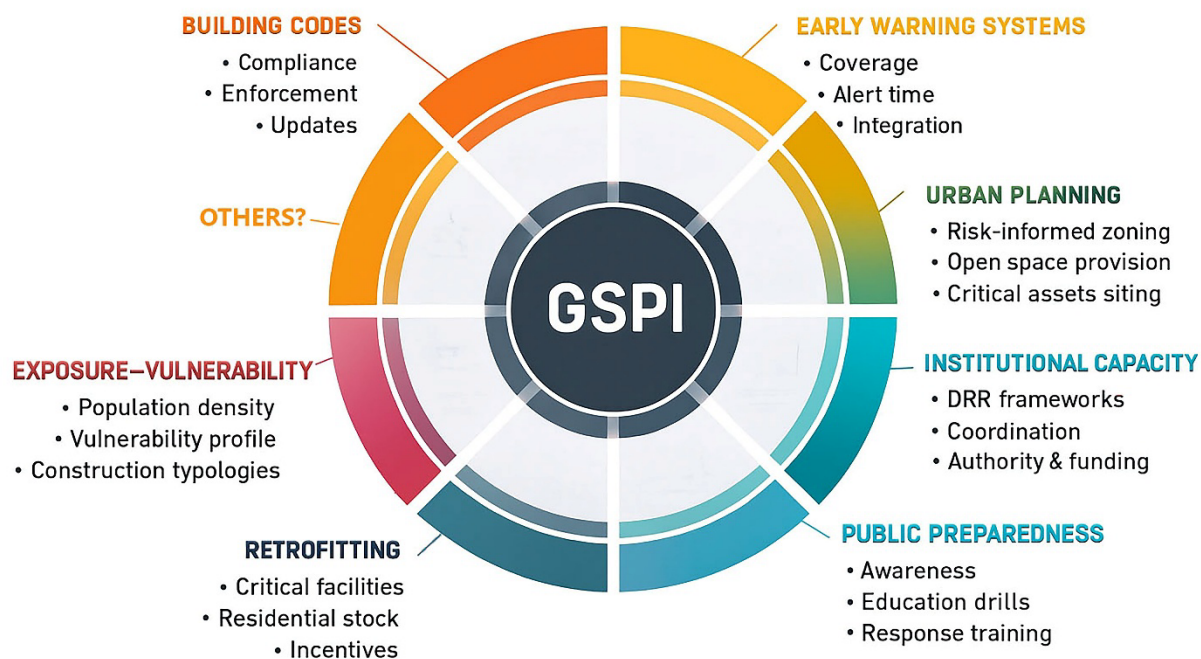


Fig. 1 – Structure of the Global Seismic Prevention Index (GSPI), integrating seven prevention domains: building code enforcement, early warning systems, urban planning, institutional governance, public preparedness, retrofitting of critical infrastructure, and exposure–vulnerability profiles.

The GSPI ranking (Fig. 2) reveals three distinct prevention clusters. Japan, California, New Zealand and Chile form a high-prevention group, characterized by stringent building regulations, mature EWS, extensive retrofitting of critical facilities and coherent multi-level governance structures. These countries have consolidated prevention architectures through decades of policy evolution following major seismic crises. Italy, Greece, Mexico, the Philippines and Indonesia constitute an intermediate group where modern codes coexist with legacy building stock, heterogeneous enforcement, incomplete retrofitting programmes and uneven institutional coordination. India, Türkiye and Iran form a low-prevention cluster marked by chronic structural vulnerabilities, limited institutional capacity, lower EWS penetration, and slower adoption of risk-informed urban planning. A Principal Component Analysis confirms that the seven domains covary strongly, demonstrating that prevention capacity behaves as a systemic socio-technical construct rather than a collection of independent components.

Despite the clear prevention clusters, comparisons between GSPI and aggregated impacts (FR, CE, DG) reveal no statistically significant monotonic relationships across the 12 countries. High-GSPI countries tend to exhibit lower impact severity on average, while low-GSPI countries cluster toward higher FR and CE values; however, variability is large due to profound differences in hazard regimes, exposure patterns and the influence of rare catastrophic events. This behaviour is consistent with findings in global disaster research, which highlight how long-term loss statistics at national scale

can be dominated by a small number of extreme earthquakes [Wisner et al., 2004], masking the protective effects of prevention. Moreover, population density, spatial distribution of assets, building age, and socio-economic fragility contribute substantially to impact variability and cannot be captured by prevention capacity alone.

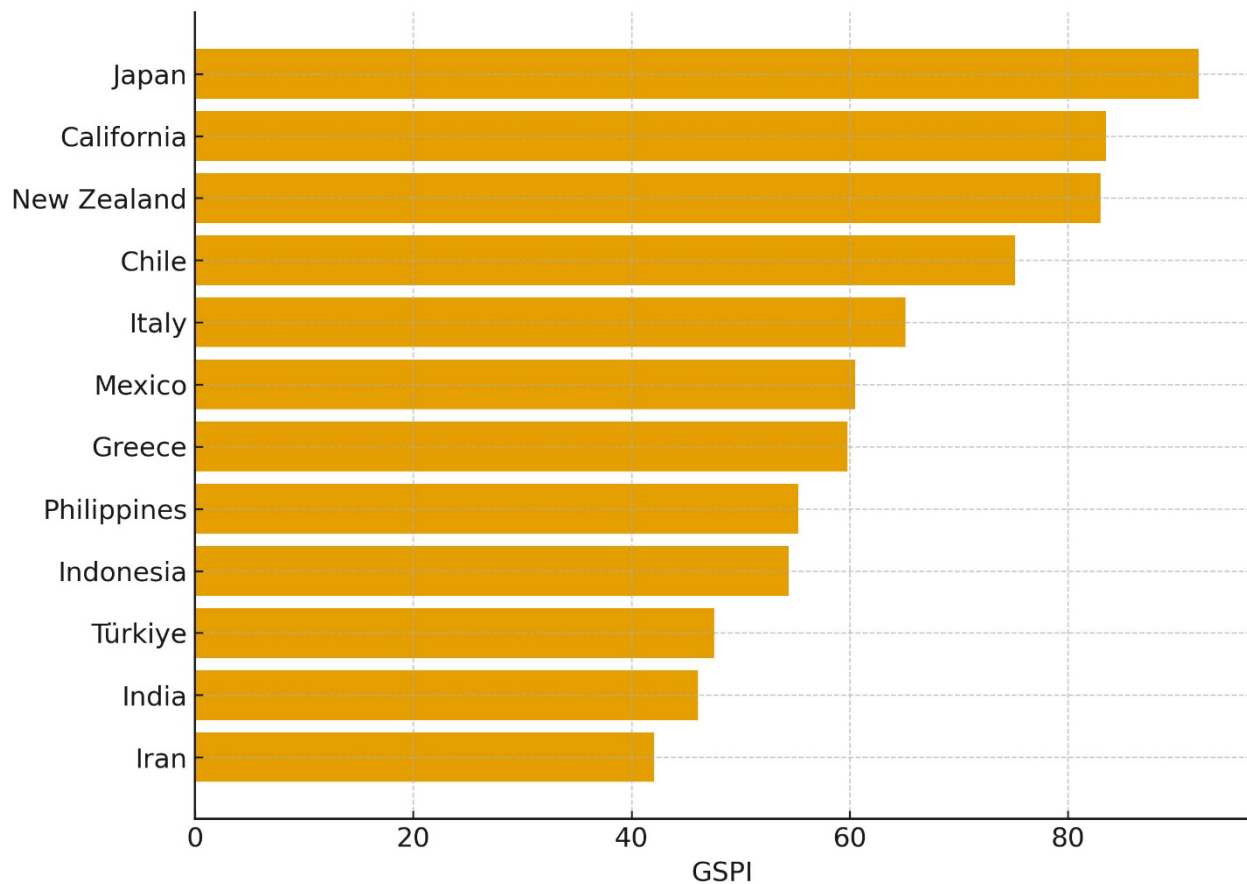


Fig. 2 – GSPI ranking for the twelve high-risk countries analyzed. Three clusters emerge: high-, intermediate-, and low-prevention systems, reflecting disparities in governance, enforcement, preparedness, and infrastructural resilience.

To interpret these findings, we conceptualize the Earthquake Impact Pathway (shown in Fig. 3). This framework illustrates how earthquake consequences emerge from the sequential and interacting influences of hazard, exposure, vulnerability and prevention. Prevention capacity affects multiple layers of this pathway:

- Pre-event stage: land-use planning shapes exposure patterns; building codes and retrofitting reduce vulnerability; preparedness enhances behavioural readiness;
- Event stage: early warning enables protective actions, and institutional coordination accelerates emergency responses;
- Post-event stage: governance structures influence response efficacy, continuity of services and long-term recovery.

Earthquake Impact Pathway

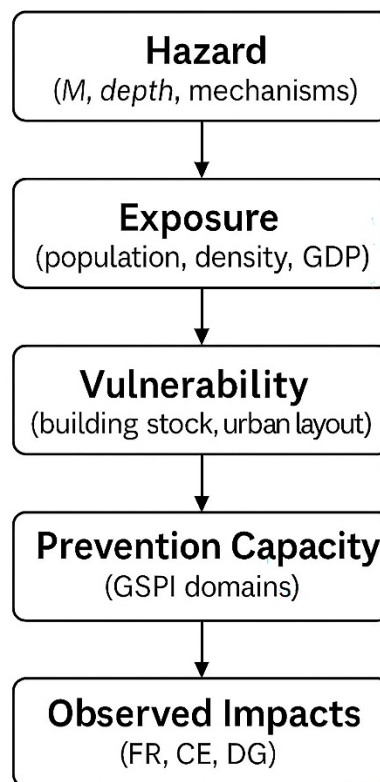


Fig. 3 – Earthquake Impact Pathway illustrating how hazard, exposure, vulnerability, and prevention capacity jointly shape human and economic losses. Prevention influences multiple stages of the pathway, explaining why impacts cannot be predicted from hazard alone.

This layered conceptualization clarifies why prevention alone does not fully explain national-scale impacts when considered across multi-decadal timelines. Instead, prevention interacts with socio-economic conditions, spatial development patterns, and hazard variability to determine the probability distribution of losses. Therefore, the absence of strong correlations between GSPI and aggregated national losses reflects the complexity of seismic risk as an emergent property of intertwined physical and social dimensions.

From a policy perspective, this work offers three contributions. First, the GSPI provides a diagnostic tool for comparing national prevention architectures and identifying priority gaps—such as enforcement deficits, retrofitting needs, or weaknesses in governance and preparedness. Second, the results demonstrate the limits of country-scale, long-term impact indicators and emphasize the need for finer spatial granularity (regional or urban scales) and event-level analyses that link prevention measures to shaking intensity, damage patterns and response performance. Third, by integrating social, institutional and infrastructural dimensions, the GSPI and Earthquake Impact Pathway contribute to bridging disciplinary boundaries between geophysics and social disaster science, strengthening the evidence base for integrated Disaster Risk Reduction strategies aligned with the Sendai Framework.

Overall, this study highlights substantial global inequalities in seismic prevention and demonstrates that risk is deeply rooted in social structures, governance systems and collective behaviours. While prevention capacity does not predict national-scale losses in a simple monotonic way, it establishes the conditions under which earthquakes become disasters. Extending the GSPI to include temporal evolution, sub-national indicators, and links to ground-motion and vulnerability models represents a key direction for future research. Such advances will improve our ability to quantify how prevention investments translate into lives saved and economic resilience strengthened, thereby supporting more equitable and evidence-based seismic risk governance worldwide.

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Legal Instruments for Reducing Territorial Vulnerability to Natural Hazards

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Reducing territorial vulnerability requires legal instruments capable of addressing social, economic, and institutional factors. This abstract explores the preventive potential of regulatory frameworks governing public spending and contractual arrangements. The analysis focuses on how laws and administrative practices can anticipate risks by directing resources toward vulnerable populations and areas. By examining the interaction between legal obligations and social needs, the paper highlights the role of preventive law in fostering resilience. The contribution stresses that vulnerability reduction is not only a technical task but a legal and social responsibility.

In this perspective, public law is examined not merely as a reactive system responding to emergencies, but as a proactive framework capable of shaping policy choices before critical situations materialize. Budgetary rules, procurement procedures, and accountability mechanisms are assessed as tools that can embed prevention into ordinary administrative action. Particular attention is paid to how discretionary powers are structured and constrained in order to ensure that public resources are allocated in a manner consistent with principles of equity, sustainability, and social cohesion.

The paper also considers the role of institutional coordination and multilevel governance in mitigating territorial disparities. Legal obligations imposed on public authorities, when combined with data-driven risk assessment and social impact evaluation, can transform public spending into a strategic instrument for reducing exposure to systemic risks. Contractual mechanisms, including performance clauses and social criteria in public procurement, are analyzed as means to align economic efficiency with broader public interests.

Ultimately, the abstract argues that preventive legal frameworks contribute to redefining vulnerability as a collective concern, requiring long-term planning and normative coherence. By integrating social protection objectives into financial and administrative law, preventive regulation can enhance the resilience of territories and communities, reinforcing trust in public institutions and strengthening the legitimacy of public intervention.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance
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Territorial vulnerability and Contractual Choices in Risk Prevention Policies

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Territorial vulnerability is not only a physical condition but also the result of legal and administrative decisions. This abstract examines how public contracts and procurement procedures shape preventive risk policies at the local level. By analysing the social implications of awarding works and services related to natural risk mitigation, the paper highlights the importance of integrating vulnerability indicators into contractual design. Legal tools are presented as key instruments for steering preventive action, ensuring that public spending addresses social fragilities and territorial disparities. The study underscores the need for a preventive legal culture capable of transforming contracts into tools of social protection.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance (IFRC / Disaster Law Database)

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Echoes of the earthquake: Evidence-based suggestions for the management of psychological consequences of earthquakes

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Experiencing an earthquake can be a traumatic event, sometimes followed by another negative experience represented by post-earthquake temporary displacement. Both can have serious and lasting consequences on people's wellbeing, quality of life, and life satisfaction even years after the traumatic event. These consequences can hinder the recovery of individuals and communities affected by an earthquake. After summarizing our previous investigations of psychological consequences in individuals who faced different experiences in terms of temporary displacement from their home after an earthquake, we provide a new empirical contribution on the predictors and correlates of autobiographical memory of post-traumatic stress disorder (PTSD) symptoms in individuals who had or had not been displaced from their homes after three Italian earthquakes ($n = 340$). We also examined the association between the PTSD memory measure and measures of wellbeing, quality of life, life satisfaction, and event-related health impairment. Being female, having lower individual resilience and stronger place attachment, having been or still being displaced from home, and having higher current risk awareness were associated with higher scores on the PTSD memory measure. Higher scores were also associated with lower current wellbeing, lower current and expected quality of life, lower life satisfaction during displacement, and more severe perceived health consequences. The results suggest that experiencing an earthquake followed by prolonged displacement hinders recovery from the negative psychological effects of the disaster. Overall, the reviewed research suggests the need for tailored interventions at the individual, social, and management levels to prevent and manage the negative psychological consequences of earthquakes at different stages of the disaster risk management cycle.

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From Emergency to Prevention: Rethinking Legal Frameworks for Natural Risk Governance

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Emergency-driven governance remains a dominant approach to natural risks, often privileging reactive measures over long-term prevention and structural mitigation. This contribution critically examines the legal and social limits of emergency-based models, highlighting how reliance on extraordinary powers, derogatory procedures, and post-event financing tends to weaken planning capacity, reduce transparency, and reproduce territorial inequalities. Against this backdrop, the paper proposes a shift toward preventive frameworks rooted in territorial analysis and informed by social vulnerability assessments.

The analysis focuses in particular on the regulation of public works and service contracts, showing how preventive planning can be embedded into ordinary legal procedures governing procurement, infrastructure development, and public service delivery. By examining the legal design of planning instruments, ex ante evaluations, and contractual clauses, the paper demonstrates how prevention can be institutionalized within administrative action, rather than confined to exceptional or emergency contexts. Preventive governance is thus framed as a legal strategy that integrates risk knowledge, territorial specificity, and financial programming into binding decision-making processes.

By emphasizing vulnerability reduction and anticipatory public spending, the study shows how prevention-oriented governance contributes to improving legal certainty, social equity, and territorial sustainability. Allocating resources on the basis of differentiated risk and vulnerability profiles allows public authorities to prioritize interventions where social exposure is highest, aligning public expenditure with constitutional principles of equality, solidarity, and protection of fundamental rights. In this sense, prevention operates not only as a technical objective but as a normative criterion guiding administrative discretion and public investment choices.

The contribution ultimately argues that prevention should be recognized as a structural principle of risk governance rather than an exceptional policy choice triggered by crises. Moving beyond emergency-driven approaches requires a reconfiguration of legal frameworks governing public contracts and spending, capable of embedding anticipatory logic, accountability, and long-term resilience into ordinary administrative practice. Such a shift enhances the capacity of public law to address complex environmental risks while fostering more just, sustainable, and territorially sensitive governance models.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance (IFRC / Disaster Law Database)

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Preventive Public Action and Trust: Legal Transparency in Risk-Related Expenditures

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Trust between public institutions and communities is essential for effective natural risk prevention, particularly in contexts marked by high exposure to environmental hazards and increasing social sensitivity to public decision-making. This paper analyses how transparency in public spending and public contracting contributes to the social acceptance and long-term sustainability of preventive measures. Focusing on territorial risk management, the study examines the legal and administrative frameworks that govern openness, traceability, and accountability in procurement processes related to prevention, mitigation, and adaptation policies.

Through a legal and institutional analysis, the paper highlights how transparency obligations—such as access to information, justification of choices, and clear allocation of financial resources—play a crucial role in shaping public trust. Particular attention is paid to the preventive phase, where investments often produce benefits that are indirect, delayed, or not immediately visible to affected communities. In this context, the absence of transparency can foster mistrust, resistance, and social conflict, undermining the effectiveness of risk prevention strategies.

The analysis shows that preventive investments, when clearly justified, proportionate, and legally sound, strengthen institutional credibility and enhance cooperative relationships between public authorities and local communities. Transparent procurement procedures not only reduce the risk of corruption and mismanagement but also function as instruments of communication, making public action intelligible and socially legitimate.

The contribution ultimately frames transparency as a preventive tool in itself, capable of reinforcing both social cohesion and legal compliance. By integrating legal guarantees with participatory and informative practices, transparency supports a model of risk governance in which prevention is understood not only as a technical or financial issue, but also as a relational and institutional process grounded in trust.

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Voices of Resilience: Exploring Citizens' Risk Perceptions, Communicative Practices and Insular Response Strategies

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The sociology of risk (Beck, 1992; Giddens, 1999) highlights that modernity is characterized by a progressive shift from natural danger to reflexive risk - that is, a form of risk generated or amplified by the very social and technological practices designed to control it. Alongside the several dimensions that characterize the concept of risk, communication is being considered as one of the most crucial ones (Heath & O'Hair, 2009). Indeed, the increasing frequency and intensity of natural disasters, exacerbated by climate crises, have made risk communication a crucial dimension of contemporary society, for understanding persistent and emerging problems that occur in different part of the world (Diers-Lawson & Meißner, 2021; Massa & Comunello, 2024). The impacts of climate change, which are distributed unequally across the world, have become clearly visible through floods, droughts, wildfires, heat waves and sea level rise (Reyes et al., 2021), and are strongly shaping how public sector organizations communicate with citizens and the media and their relationships (World Economic Forum, 2024).

The different forms of citizens' response are closely linked to risk and emergency communication management by government and public sector organizations (i.e., regions, municipalities, civil protections), whose legitimacy depends on trust in institutions (OECD, 2021). Public sector communication (Canel & Luoma-aho, 2019) is the leverage to transparently inform and actively engage multiple stakeholders in local territories also during uncertain situations and critical events that can harm different publics (Lovari, D'Ambrosi & Bowen, 2020). Indeed, in an era characterized by mega crises and mega risks (Sellnow-Richmond & Lukakovic, 2025), as well as by the proliferation of digital platforms, the challenge therefore lies not only in communicating risk, but in nurturing intangible assets, like trust, legitimacy and social capital around its management. Thus, when risks turn into disasters and emergencies, communicative effectiveness is influenced by the ability of institutions to maintain an ongoing dialogue with media and citizens (Ducci & Lovari, 2021), acknowledging the plurality of knowledge and the narrative dimension of collective safety, while integrating digital communication tools to foster civic engagement and enable digital volunteerism (Comunello, 2014; Smith et al. 2021).

In contemporary contexts, risk communication plays a strategic role not only in disseminating information and warnings, but also in shaping perceptions, trust, resource mobilization, and communities' capacity to adapt and respond to disasters. This contribution presents the activities of Work Package 3 (WP3) of the research project PRIN PNRR INSULANDER (INvestigating the Strategic role of commUnication for resiLient islAnds copiNg DisastErs Risk management), which aims to support more participatory, inclusive, and informed public policies through an extensive survey on citizens' risk perception, communication practices, and response strategies. These

activities were carried out using a survey that focuses on the two major Italian islands, Sicily and Sardinia, where insularity constitutes a crucial dimension affecting vulnerability (Ivčević et al. 2021; La Rocca & Lovari 2024), access to resources, emergency management, and communicative resilience. By “capturing the voices of citizens,” the study explores how inhabitants perceive natural disaster risks, which information sources and channels they rely on during emergencies, the barriers they encounter in accessing information, and how individual and community resources are activated in natural disasters and critical situations. Adopting an integrated and multidisciplinary approach, the research conceptualizes resilience not merely as a technical capacity to return to normality, but as a social and cultural process rooted in trust, information sharing, institutional relationships, and active citizen participation in risk governance

Data collection was conducted between May and July 2025 using a mixed-method approach. Specifically, the survey combined CAWI (Computer Assisted Web Interviewing), administered through the Opinione.net panel, and CATI (Computer Assisted Telephone Interviewing), based on telephone interviews conducted on randomly generated numbers stratified by geographical area. A total of 3,022 interviews were completed, of which 2,245 (74.3%) were collected via CAWI and 777 (25.7%) via CATI. The CATI mode was primarily used to interview respondents aged over 65, who accounted for approximately 60% of the CATI sample, to enhance inclusivity and mitigate generational digital divides. The study adopted a probabilistic, multi-stage stratified sampling design structured around three main variables: territorial distribution, degree of urbanization, and age and gender. The territorial stratification covered the nine provinces of Sicily and the five provinces of Sardinia, further differentiated into metropolitan, urban, and rural areas. Within each stratum, quotas were defined according to four age groups (15–25, 26–45, 46–65, and over 65) and gender, reflecting the actual distribution of the resident population aged between 15 and 99 years. The same sampling logic was applied to a national comparison sample, stratified by the four ISTAT macro-regions (North-West, North-East, Centre, South) and subsequently by settlement type, age, and gender. The final sample consisted of 1,356 interviews in Sicily (44.8%), 443 in Sardinia (14.7%), and 1,223 in the national comparison sample (40.5%). This composition enables a robust comparative analysis between the two insular contexts and mainland Italy, while ensuring methodological consistency across territorial scales.

This abstract presents selected empirical findings on information sources, trust, and risk communication. Both direct experience of natural disasters and risk perception are strongly shaped by territorial context. At the national level, events such as heat and cold waves, storms, and strong winds are reported more frequently, whereas insular contexts display specific risk profiles, including a high perceived exposure to drought, wildfires (particularly in Sardinia), and earthquakes and volcanic eruptions (especially in Sicily). However, lived experience does not always correspond to perceived risk, suggesting the influence of additional cognitive, cultural, and social factors.

In terms of reliance and trust, family and friends emerge as the primary reference points for coping with disaster impacts, especially in the islands, where community cohesion appears stronger. Emergency services also enjoy high levels of trust, although with lower intensity in Sicily. A pronounced sense of self-reliance and individual responsibility characterizes insular populations: more than one quarter of respondents in Sardinia and Sicily believe that island residents must largely cope on their own in the event of a disaster, a proportion almost double that observed at the national level. Responsibility for disaster prevention, management, and recovery is mainly attributed to regional, municipal, and national institutions, while the role of the European Union is perceived as marginal. Attitudes toward citizen involvement are divided between support for more active civic participation and a preference for institutional management, with a non-negligible share of undecided respondents, particularly in Sicily. Regarding institutional trust, Fire Brigades and Civil Protection are consistently rated as the most reliable actors, whereas regional, national, and

European institutions receive lower evaluations, again more markedly in Sicily. Finally, only slightly more than half of respondents report awareness of the existence of a Municipal Civil Protection Plan, and this information is often acquired through informal or non-institutional channels. This highlights a persistent communication gap: risk awareness and knowledge of emergency plans are essential preconditions for effective prevention and response, and they require strengthened public communication strategies and more inclusive information channels, especially in insular contexts where digital and cultural divides remain significant.

A community's capacity to respond effectively to emergencies is closely linked to the quality of information, trust in institutional channels, and perceptions of adopted communication strategies. The empirical evidence shows that, across all the contexts considered (Italy, Sardinia, and Sicily), institutional channels and traditional media (television, newspapers, and official websites) are regarded as the most reliable sources of information before, during, and after emergencies. Emergency management actors, such as Civil Protection and law enforcement agencies, are consistently perceived as the most trustworthy institutions, with approval levels around 60% across all phases of the emergency cycle. Local and regional media play a particularly relevant role in insular contexts, especially in Sardinia, reflecting their importance in territorially embedded communication systems. By contrast, trust in social media and informal sources remains limited, although it is slightly higher in the islands, particularly in Sicily. A further critical issue concerns the low level of awareness of institutional risk communication campaigns, such as "Io non rischio" by Civil Protection, which is known by fewer than one in five respondents. Moreover, especially in Sardinia, respondents report difficulties in accessing timely and coherent information during emergencies. Overall, only a minority of the population considers itself adequately informed, while perceptions of the clarity, accessibility, and coherence of public sector communication remain at medium to moderately low levels. These findings aim at strengthening public risk communication by improving its clarity, timeliness, and territorial reach, particularly in insular settings.

The findings aim to contribute to a territorially grounded understanding of social resilience and the strategic role of communication in strengthening collective capacities to face and transform natural disasters and environmental crises. Territorial resilience does not rely solely on infrastructure and material preparedness, but is deeply intertwined with social, relational and psychological factors, which appear to be particularly salient in insular contexts. Investing in these dimensions—such as strengthening neighborhood networks, fostering shared values, and enhancing individual adaptive strategies—can play a crucial role in effective emergency management and in reinforcing social cohesion.

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Addressing Inequalities in Disaster Risk through Participatory Research: Evidence from REACT and PREPSHIELD

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Disasters do not affect all populations equally: older adults, migrants, women, and people with disabilities often experience disproportionate impacts due to heightened exposure and vulnerability, as well as structural barriers that limit access to preparedness resources and constrain their capacity to respond effectively. Addressing these differentiated impacts requires moving beyond technocratic models of disaster risk management toward a whole-of-society approach, as advocated by the World Health Organization (WHO, 2021). This approach recognises the interdependencies between diverse societal actors and emphasises the shared responsibility of governments, civil society organisations, businesses, and vulnerable communities in building preparedness and resilience. In this perspective, citizen engagement and participatory approaches are essential to effective risk governance, enabling the co-production of knowledge, the inclusion of marginalized voices, and the redistribution of preparedness capacities across all phases of the disaster risk cycle.

This contribution presents two multi-phase participatory research frameworks implemented in disaster research that operationalise these principles through inclusive, multi-actor co-production. Drawing on the work of CRIMEDIM – Università del Piemonte Orientale, this contribution examines how participatory approaches can enhance disaster risk governance, with a specific focus on vulnerable and non-compliant groups. The analysis is grounded in two transdisciplinary projects operating at different scales and addressing different hazards, REACT (Resilience Enhancement of Migrants through Active Community Participation and peer-Training) and PREPSHIELD (Preparedness for society in health crises and disasters), funded respectively by Fondazione Cariplo and the European Union.

REACT focuses on hydrometeorological hazards such as heatwaves and floods and empowers migrants as active agents of resilience through a community-based participatory research (CBPR) approach. Through the co-creation of a disaster risk reduction toolkit and the promotion of peer-to-peer training focused on extreme weather events in Milan, REACT demonstrates how CBPR can enhance preparedness and resilience among vulnerable populations. The methodology, illustrated in Fig. 1, unfolds across five phases: (0) mapping and trust-building through community engagement

and stakeholder identification; (1) exploration of disaster perceptions via in-depth interviews using an intersectional lens to capture diverse experiences and priorities; (2) co-creation of a disaster risk reduction toolkit through focus group discussions and joint sessions with disaster risk reduction experts, emphasising awareness-raising and locally grounded self-protection strategies; (3) peer-to-peer delivery and community dissemination of the toolkit to enhance legitimacy, trust, and collective capacity; and (4) participatory evaluation, treating co-creation itself as an intervention and assessing empowerment, engagement, and methodological effectiveness.

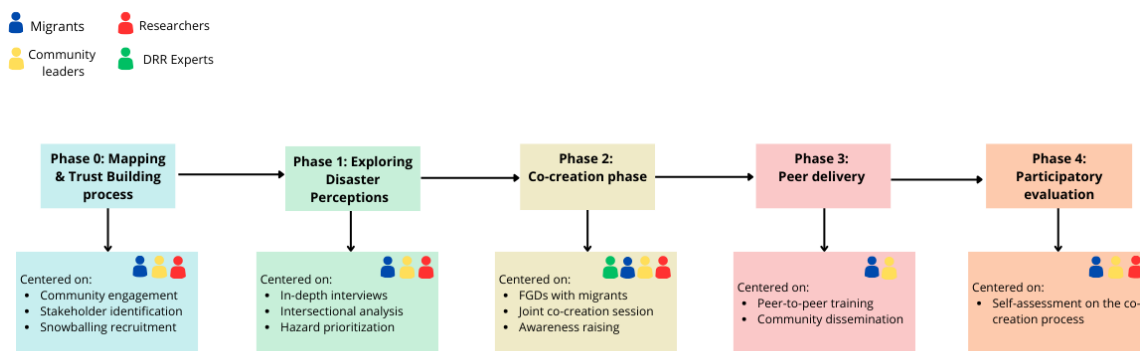


Fig. 1 – REACT Methodology

The Horizon Europe project PREPSHIELD focuses on social and societal preparedness to health crisis and disasters, adopting a multi-actor co-creation process that brings together healthcare institutions, policymakers, civil society organisations, and vulnerable or non-compliant citizens. These stakeholders are actively engaged through table-top exercises and online simulations, fostering the development of collaborative preparedness and targeted risk communication strategies. Project outcomes include a mobile app designed for citizens and a decision-support platform that incorporates agent-based modelling to better understand public responses to pandemic-related measures.

The methodology adopted by PREPSHIELD, illustrated in Fig. 2, adopts an iterative process that begins with a needs analysis integrating institutional priorities and the perspectives of vulnerable and non-compliant groups. These insights inform the co-development of best practices addressing crisis management challenges, healthcare governance, risk communication, and health literacy. Best practices are subsequently tested and refined through tabletop and online exercises, involving institutions, researchers, crisis management experts, and affected communities. Evaluation and iterative refinement underpin the process, culminating in policy-oriented recommendations aimed at strengthening inclusive communication, institutional learning, and knowledge transfer. This framework highlights how digital tools, training, and scenario-based exercises can reshape trust, decision-making, and preparedness under uncertainty.

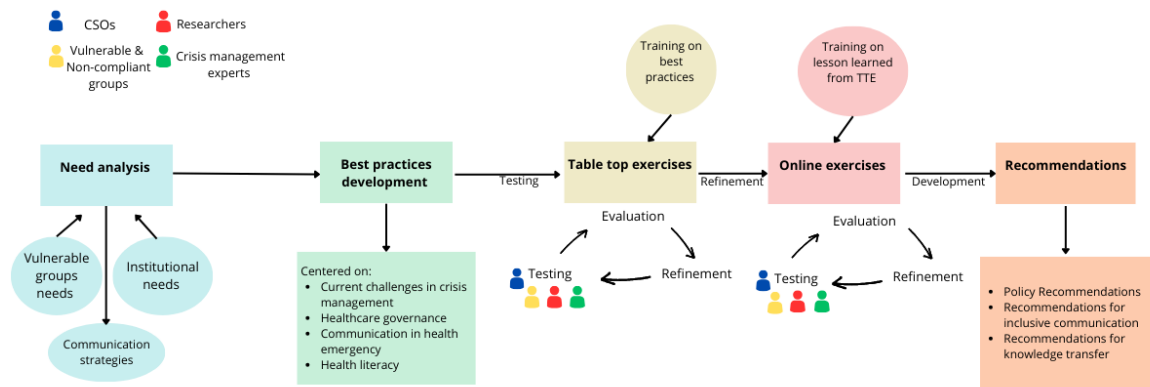


Fig. 2 – PREPSHIELD Methodology

Together, these two frameworks illustrate how risk perception, risk communication practices, governance structures, technologies, and social inequalities interact in shaping exposure, preparedness, and resilience. By combining scenario-based testing, digital platforms, and participatory co-production, REACT and PREPSHIELD projects demonstrate how inclusive engagement can transform risk management practices and contribute to more equitable and socially grounded disaster preparedness and response. Besides presenting the REACT and PREPSHIELD projects, this contribution will also highlight key barriers and facilitators to citizen engagement, drawing on evidence from both projects as well as from the existing literature.

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PREPSHIELD is a project funded through the European Union's Horizon Europe research and innovation programme under grant agreement no 101168124. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them. The REACT project is funded by Fondazione Cariplo under grant no. 2025-1798.

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Public Spending and Prevention: Legal Accountability in Natural Risk Management

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Preventive action in natural risk management is strongly conditioned by public spending decisions and their legal frameworks. This paper explores how budgetary choices reflect priorities between emergency response and long-term prevention, with significant social consequences for vulnerable territories. In many legal systems, public expenditure continues to be predominantly oriented toward post-disaster intervention, often justified by urgency and political visibility, while preventive investments remain structurally underfinanced and legally fragmented.

The analysis situates preventive policies within the broader context of public finance law, administrative discretion, and procurement regulation, emphasizing how legal constraints and accounting rules shape the capacity of public authorities to plan anticipatory actions. Particular attention is paid to the role of public contracts and service procurement as strategic tools for risk mitigation, infrastructure maintenance, and territorial resilience. Through this lens, prevention is not merely a technical or scientific issue, but a legally mediated choice that reflects institutional priorities and interpretations of the public interest.

The paper highlights the legal obligations of public authorities to ensure efficiency, transparency, and social utility in spending decisions, arguing that these principles acquire specific relevance in the field of natural risk management. Preventive expenditure, when properly framed within procurement law and budgetary discipline, can reconcile cost-effectiveness with long-term social benefits. Conversely, the systematic preference for emergency spending tends to produce distortive effects, including higher overall costs, reduced accountability, and unequal protection for peripheral or economically fragile areas.

The study further examines how preventive policies contribute to social cohesion and institutional trust. Investments in risk reduction, early warning systems, and territorial planning signal a commitment to safeguarding communities before disasters occur, thereby strengthening the relationship between public institutions and local populations. From this perspective, prevention functions as a form of social investment, capable of mitigating not only physical damage but also social vulnerability and administrative conflict.

The contribution ultimately emphasizes the need for legal mechanisms and budgetary instruments that support anticipatory investments rather than reactive spending. This includes multi-year financial planning, adaptive procurement models, and regulatory frameworks that integrate scientific risk assessment into administrative decision-making. By rebalancing public spending priorities in favor of prevention, the paper argues, legal systems can enhance resilience, reduce long-term public expenditure, and promote a more equitable and sustainable approach to natural risk governance.

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Plausible scenario-based multi-risk storylines: development and testing for selected coastal areas in the Northeastern Adriatic

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Physical modelling of earthquakes and cascading hazards (e.g. earthquake induced tsunamis or landslides), as well as concurrent hazards (e.g. a storm surge followed by a tsunami), provides the basis for defining plausible (yet unobserved) multi-hazard and risk scenarios. The developed scenarios supply a systematic method for exploring how the complex interplay between hazards and urban systems may impact society, and can be applied to support and rationalise decision making and inform preparedness for multi-risk management and mitigation (e.g. Strong, Carpenter and Ralph, 2020).

Significant earthquake-induced tsunamis in the Northern Adriatic are rare events. Since most of these events occurred in historical times and at large distances, awareness and understanding of their potential impacts in the region remain limited. To address this issue, we develop a wide set of hazard scenarios for tsunamis generated by offshore earthquakes, for selected urban areas (e.g. Lignano and Trieste) along the coast of North-eastern Adriatic (Peresan & Hassan, MEGR 2024). Tsunami modelling is carried out by NAMI DANCE code (Yalciner et al., 2019), which incorporates seismic source parameters, bathymetry, topography, and non-linear effects in wave propagation. Potential earthquake-induced tsunamis, with sources defined from historical catalogues and active fault databases, are modelled to provide various hazard parameters, such as arrival times and inundation maps. Existing bathymetry and topography datasets are revised considering available high-resolution information to better capture small-scale coastal features that may influence tsunami inundation patterns (Hassan & Peresan, EGU 2025). The modelling yields a set of tsunami hazard-related parameters, such as arrival times and inundation maps, which are critical for planning emergency and mitigation actions in these areas. For the definition of possible impacts, high-resolution exposure models and descriptions of the social context are also needed at the local scale, especially for hazards which exhibit high spatial variability. In this study the methodology by

Badreldin et al., (2025) is considered, which allows us to develop high-resolution exposure models for population and residential buildings.

This study explores the possibility of adopting a scenario based approach, which relies on the physical modelling of plausible hazardous events, to develop realistic site specific multi-risk storylines for urban contexts of different typologies (Marciano et al., 2024). Properly defining the urban context of interest is essential for the development of risk storylines, as it enables the identification of relevant hazards, exposure and local vulnerabilities affecting the urban system. The socio-economic characteristics and possible social vulnerabilities are also important factors that may influence impacts and the effectiveness of response and mitigation strategies. The experimental testing of the multi-risk storyline methodology was carried out for two selected coastal areas along the Northern Adriatic, considering both frequent (storm surge) and rare (tsunami) events. The proposed approach can be easily replicated in other urban areas with similar features, e.g. those located along the coasts of Western Adriatic. The first phase of this experimentation aimed to identify the potential impacts of the proposed scenarios on the different components of the urban ecosystem, while the second phase explored the possible interventions and mitigation strategies, in order to highlight relevant complexities and interactions. Through a participatory process, the multi-risk storylines engaged institutional actors, technical experts, and local communities, transforming data, experiences, and perceptions into dynamic and shared risk scenarios. The resulting narratives do not intend to merely describe past events, but rather to anticipate plausible future scenarios and viable response, recovery and mitigation actions, contributing towards integrated multi-risk management strategies.

The study shows that the developed scenarios provide a systematic methodology for exploring how the complex interplay between hazards and urban systems may impact a society, and can be applied to support and rationalise decision making and inform preparedness for multi-risk management and mitigation.

Acknowledgements

This research is a contribution to the RETURN Extended Partnership (European Union Next-Generation EU—National Recovery and Resilience Plan—NRRP, Mission 4, Component 2, Investment 1.3—D.D. 1243 2/8/2022, PE0000005).

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“Your Choice”: a story, a game, and a test of your relationship with Risk

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The 2024 edition of the "Futuro Remoto" Science Festival, held in Pozzuoli, Italy, was centered on the theme "CO-SCIENZE" (CO-SCIENCES). The event aimed to place natural and human sciences at the heart of our ability to discern, evaluate, and act within a multifaceted and interconnected world. In this context, we developed an interactive exhibit designed to investigate the relationship between citizens and natural risk. Our approach was rooted in the conviction that risk education must consider people's lived experiences, imagination, and conscience.

Visitors, including both students and adults, were engaged in a storytelling and role-playing activity structured into four sequential episodes (Fig. 1):

1. Choosing a travel destination
2. Selecting accommodation
3. Reacting to an unexpected event
4. Engaging in a final action



Fig. 1 – Setting up the story: the first panel briefly describes the purpose of the activity, followed by 4 panels representing the 4 scenes that make up the story, and finally a panel explaining the meaning of the risk profiles.

For each narrated and illustrated scene, which deal with risk, participants were faced with three behavioural alternatives and after making a choice, they randomly drew a corresponding card to reveal the outcome of their action. The participants' choices lead to a deeper discussion of behaviours: these outcomes emphasized the potential consequences of their choices not only for the individual but also for the community and "the world" at large.

Data from these interactions were synthesized to identify six discrete risk profiles, aimed at quantifying individual risk propensity in daily life. The profile pairs are: Prudent / Temerarious, Collettivist / Individualist, Organized / Disorganized.

While these profiles were intentionally exaggerated to spark reflection and debate, they do not imply any moral judgment: there is no "right" or "wrong" profile. Instead, the exercise suggests that only the extremes of any attitude may become problematic for oneself or others.

This comparison encourages participants to confront complex questions. Should we remain cautious even when facing a risk might serve a greater good? Is it right to prioritize the well-being of others to the point of overlooking our own needs? Does absolute organization border on a mania for control, and are risks ever truly controllable? Is it perhaps more useful to learn to live with certain aspects of uncertainty?

The proposed activity held significant relevance for the local audience in Pozzuoli, a population that had been experiencing the effects of a bradyseismic crisis and repeated seismic swarms for nearly a year.

However, the modular nature of the exhibit allows it to be adapted and repeated in any context.

Ultimately, the central objective of this activity is to determine whether individuals translate their knowledge of risk into concrete preventative actions. Exploring the discrepancy between perception and action is crucial to enhancing the efficacy of risk communication directed toward the general public.

Acknowledgments

The proposed activity is the citizen-adapted version of a teacher training module designed within the "A Scuola di Protezione Civile" 2024-27 project, funded by the Civil Protection Department of the Calabria Region.

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When the Storm Hits: An Analysis of Institutional Public Communication after the Mortegliano Hailstorm

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Institutional public communication (Lovari & Ducci, 2022) plays a crucial role in post-event emergency management, integrating functions of alerting, operational coordination, and the construction of public legitimacy, with significant implications for access to information and the response capacities of people in conditions of vulnerability. Drawing on a theoretical framework that combines Crisis and Emergency Risk Communication (CERC) (Reynolds & Seeger, 2005) with scholarship on the social construction of vulnerability (Cutter et al., 2003), this study examines how two key actors—the Friuli Venezia Giulia Regional Government and the Regional Civil Protection Agency—communicated the emergency on their Facebook and Instagram pages during the thirty days following the severe hailstorm that struck Mortegliano (Udine) in July 2023. Particular attention is also paid to the forms of reaction and interaction emerging from users' comments in response to this content.

Using a mixed-methods approach based on topic modelling of posts (N = 195) and comments (N = 1,499) from the aforementioned platforms, complemented by a qualitative thematic analysis of selected Facebook posts relevant to the analytical dimensions, the study investigates communicative strategies, linguistic choices, and representations of vulnerability.

The findings reveal a marked communicative asymmetry. Despite some predictable differences in communicative registers, the social media communication of both the Regional Government and the Civil Protection Agency portrays people in conditions of vulnerability as passive actors, primarily defined by physical exposure and material damage, and framed exclusively as recipients of assistance. Vulnerability is thus constructed in narrowly physical and economic terms, neglecting relational, psychological, and informational-access dimensions. By contrast, the analysis of comments uncovers a counter-narrative structured along three main thematic axes: expressions of solidarity with affected communities and appreciation for first responders; contextualization of the event within the broader debate on climate change, accompanied by demands for preventive policies; and criticism of institutional action. This reveals an unresolved tension between the institutional representation of the emergency as an exceptional event to be managed through technical means and the public perception of a systemic emergency requiring transformations in territorial and policy approaches.

Overall, the study highlights how the observed emergency communication remains strongly anchored in top-down, reactive logics and is only marginally inclusive, lacking a strategy to systematically incorporate the broad spectrum of vulnerabilities and to establish a constructive dialogue with the affected community. The absence of a communication strategy oriented toward dialogue and interaction ultimately turns social media from potential spaces for the co-construction of resilience into arenas of conflict between institutional logics and civic expectations.

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How unequal? Why vulnerable? Clearly differentiated

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Natural hazards such as earthquakes, eruptions, floods, and heat waves can severely affect society. In principle, they are natural phenomena by which nature expresses itself, but they may transform into disasters if proper measures are not taken.

Traditionally, scientific institutions conduct outreach, communication, and public engagement activities to explain these phenomena, as better knowledge and awareness can mitigate the effects of such natural hazardous events. Preparedness is crucial.

Both education and communication are very challenging. Digital communication has disrupted the traditional communication channels. The deficit model is still used, but dialogues have been started to listen to the voices of citizens and non-expert stakeholders, to better understand both the context and the public's concerns. Scientists study complex phenomena and are skilled at providing simple explanations, primarily from a scientific perspective. However, in vulnerable or at-risk areas, what do citizens want to know? On the one hand, when a phenomenon occurs and the crisis is ongoing, there is a demand for information that can disrupt scientists' routines, requiring them to adjust and adapt their contributions. On the other hand, pressures from citizens and other stakeholders are significant (Fig. 1).

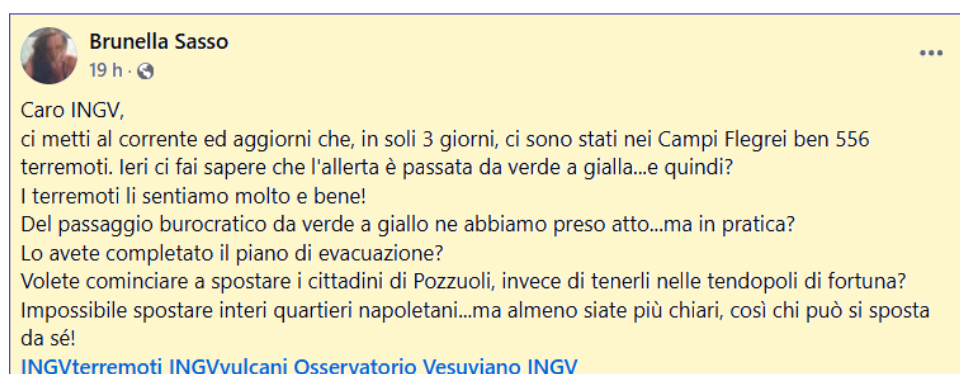


Fig. 1 – INGV Facebook follower's comment asking for an evacuation plan (for which INGV is not responsible).¹

¹ "Dear INGV, you informed us and update that, in just 3 days, there have been 556 earthquakes in the Campi Flegrei. Yesterday you let us know that the alert went from green to yellow... so what? We feel earthquakes a lot and well! We have taken note of the bureaucratic transition from green to yellow... but in practice? Have you completed the evacuation plan? Do you want to start moving the citizens of Pozzuoli, instead of keeping them in makeshift tent cities? It's impossible to move entire Neapolitan neighborhoods... but at least please be clearer, so."

Comments on social channels, such as "Yes, you are explaining the magnitude to us, but so what? What about an evacuation plan?" illustrate the unavoidable issue "who is asking what from whom", a dimension still crucial in current scientific communication debates (Bucchi & Schäfer, 2025).

Moreover, natural hazards affect men and women, boys and girls in different ways, due to biological, cultural, and social characteristics. Communication should consider these factors to be effective and new tools are needed for intersectional analysis of social media communication.



Fig. 2 – Gendered analysis of social media interaction in May 2024. From Rubbia et al, 2025.

The importance of adopting gender-sensitive and intersectional approaches in disaster risk reduction (DRR) is well documented in the literature, with room for implementation (Erman et al. 2021). The Midterm Review of the Sendai Framework for Disaster Risk Reduction (UNDRR 2022) clearly stated that disaster risk is gendered, noting that higher death rates among women and girls in many recent disasters are attributable to existing gender inequalities, and called for actions to close gender gaps in disaster risk prevention, mitigation, preparedness, and recovery. Beyond gendered impacts in countries prone to extreme phenomena, various studies highlight that gender should not be polarised between men and women, but should also include gender minorities (Sharan & Gaillard, 2025). Some studies also highlight that violence and gender-based violence tend to increase during crises (Muñoz-Nieves et al., 2025). Some others begin with the concept of women's vulnerability during an event, and move on to that of resilience, reconsidering the event as an opportunity for women to be not just victims, but agents of change, with the consequent improvement of conditions for both women and men (Luna & Hilhorst, 2022).

If we look at the narratives of the Genoa flood of 4 November 2011, Italy, (Fig. 3) which resulted in six fatalities, all of whom were women or girls, we understand that disaster risk-reduction frameworks must acknowledge caregiving, more often up to women, as a determinant of vulnerability. That event stands as a reminder that disasters are never purely natural.

Meteorological extremity interacted with urbanisation and with deeply ingrained social roles. Evacuation planning, transport logistics, and communication strategies should take into account people's social roles and attitudes and focus primarily on those most at risk.



Fig. 3 – The Bisagno River overflowed during the severe flooding in Genoa on November 4, 2011. *Source:* ARPAL Liguria, *Quaderno ARPAL – Genova, Settembre* (2011), available at: *QuadernoArpalGenovaSettembre_WEB.pdf*

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Communicating flood risk in the context of climate change

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Weather events are environmental hazards that can occur daily (IPCC, 2022). Among these types of risks, river floods represent the one with the greatest economic impact in Europe (Paprotny et al., 2018) and are expected to increase further in the near future (Jongman, 2018). Effective risk communication is therefore essential to link expert knowledge and management practices with the development of resilience in local communities at risk (Butler & Pidgeon, 2011). However, current risk communication often fails to meet the information needs of citizens (Rollason et al., 2018) and is often accompanied by a high level of mistrust in the organisations responsible for communication and management (O'Sullivan et al., 2012).

Numerous studies have shown that understanding the factors that influence the perception of flood risk at the local level is essential for effective risk communication (Burns & Slovic, 2012) and for improving the resilience of local communities to natural hazards (Bradford et al., 2012). However, risk communication in Italy seems to focus mainly on the emergency phase, i.e. the disaster management phase. We believe, in line with international literature, that risk communication should also serve to increase trust between citizens and institutions, and that this could be achieved through transparent and participatory dialogue.

In line with these premises, our contribution will present the results of two sample surveys and a public consultation event conducted as part of the PRIN-PNRR project “Risk Communication and Engagement for Societal Resilience”, funded by the Ministry of University and Research. The two surveys, which involved a sample of 2,500 respondents proportionally representative of the Italian adult population by gender, age, level of education and area of residence, investigated Italians' perception of the risk of natural disasters from various perspectives, with a particular focus on climate change and the perception of flood risk. The results were then used to inform a public consultation event held in April 2025 in Bologna (Emilia-Romagna). Conceived as a multi-stakeholder initiative, the event brought together 100 Italian citizens and experts in risk management and communication.

Using a mixed methodological approach, the project aimed to identify gaps in flood risk communication strategies in Italy and develop tailored guidelines that better respond to citizens' needs.

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The contentious social construction of hydraulic risk: a critical thematic analysis of the controversial flood risk management of the Piave river

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This paper is based on data collected during my PhD project, which examined two environmental controversies concerning hydraulic infrastructures designed to reduce flood risk in the rural context of the Veneto region. The two case studies focus, on the one hand, on the conversion of the Padua–Venice waterway into a flood diversion channel and, on the other, on the planning and construction of a flood retention basin in the Grave di Ciano area. Both cases lie at the intersection of flood risk governance, territorial transformation, and socio-environmental conflict, offering a privileged analytical vantage point from which to investigate the role of discourse in the construction of legitimacy around infrastructural choices.

This contribution focuses on the Piave River case study, where since 2018 a conflict has emerged between the Veneto regional authorities and a coalition of local actors associated with the Municipality of Crocetta del Montello. Despite the complexity of the interests at stake and the plurality of actors involved, the conflict has progressively polarized into two opposing discursive positions: one in favor of the flood retention basin and one against it. Proponents frame the infrastructure as the only technically effective solution to the flood risk of the Piave River, thereby justifying its ecological and territorial impact in the name of safety and the protection of human life. Opponents, by contrast, challenge this framing by advocating alternative models of flood risk management and questioning both the necessity of the project and the epistemic assumptions on which it is based.

The aim of the paper is to show how the different components of flood risk are symbolically constructed and rhetorically mobilized within the controversy, contributing to the legitimation of conflicting positions. The analysis is situated within critical scholarship on risk and infrastructure, and adopts the premise that risk should not be understood as a purely technical object, but rather as a discursive and political one.

The methodology draws on the qualitative research tradition and is based on a critical thematic mapping of the conflicting discourses produced by the actors involved. More specifically, the analysis combines Braun and Clarke's thematic discourse analysis with Critical Discourse Analysis as developed by Fairclough and Wodak, allowing for an integrated examination of textual features, discursive practices, and broader social practices.

The findings show how these dimensions are closely intertwined with the main thematic tropes structuring the conflict, highlighting their rhetorical and ideological functions within the controversy. In particular, three core discursive nuclei emerge through which flood risk is contested in the debate over the retention basin: the ontology of the basin itself, oscillating between technical necessity and environmental threat; the protection of life, mobilized as a moral and iperpolitical argument; and the esoteric character of hydraulic expertise, which contributes to reinforcing power asymmetries between experts, institutions, and local communities.

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Social Dimensions of Public Procurement in Natural Risk Prevention

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Public procurement plays a central role in shaping preventive strategies for natural risks. This paper investigates how procurement rules can incorporate social vulnerability considerations into the allocation of public resources. Focusing on territorial contexts, the study analyses contracts for infrastructure, monitoring, and maintenance services, assessing their impact on community resilience. The legal dimension of procurement is examined as a tool for guiding preventive investments toward socially sensitive outcomes. The contribution argues that socially informed procurement enhances both legal legitimacy and preventive effectiveness, reinforcing the link between public spending and collective safety.

Building on this premise, the paper situates public procurement within the broader framework of risk governance, where prevention is no longer conceived as a purely technical activity but as a multidimensional policy integrating social, environmental, and institutional factors. In this perspective, procurement procedures become a strategic lever for anticipating risks, reducing exposure, and mitigating the differentiated effects of natural hazards on vulnerable populations. The analysis highlights how award criteria, contract design, and performance requirements can be calibrated to reflect territorial fragilities, demographic conditions, and socio-economic inequalities. Special attention is devoted to the interaction between procurement law and principles such as proportionality, non-discrimination, and equal treatment, assessing their compatibility with vulnerability-sensitive approaches. The paper argues that the inclusion of social vulnerability indicators does not undermine competition or transparency, but rather redefines value for money in light of preventive objectives and long-term public interest.

Through a legal and functional analysis, the study demonstrates that preventive procurement contributes to strengthening institutional accountability and to aligning public spending with constitutional and administrative principles related to safety, solidarity, and sustainable development. Ultimately, the paper suggests that procurement law can operate as a normative bridge between disaster prevention policies and social protection goals, fostering resilient territories and more inclusive forms of public action.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance
(IFRC / Disaster Law Database)

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Extreme Meteorological Risk and the Governance of Port Areas: Resilience, Planning, and Public Responsibility

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Port areas represent strategic nodes of the global economy and critical infrastructures for national and regional development. Their physical exposure to coastal dynamics, combined with increasing urbanization and logistical concentration, makes them particularly vulnerable to extreme meteorological events. Climate change has intensified the frequency and severity of phenomena such as storm surges, extreme precipitation, sea level rise, heatwaves, and strong winds, significantly amplifying the risk profile of ports and coastal logistics hubs. These risks are no longer episodic but structural, requiring a rethinking of port governance, spatial planning, and public risk management strategies.

This paper examines extreme meteorological risk in port areas through an integrated perspective that combines environmental risk analysis, infrastructure resilience, and public governance. It argues that ports should be considered not only as economic assets but also as complex socio-technical systems whose disruption can generate cascading effects on supply chains, urban safety, energy security, and public finances. Damage to port infrastructure, temporary closure of terminals, and interruptions to maritime connectivity can have immediate economic costs and long-term consequences for territorial competitiveness.

The first part of the paper outlines the main categories of extreme meteorological risks affecting port areas, distinguishing between acute events (such as storms and flooding) and chronic processes (such as sea level rise and coastal erosion). Particular attention is devoted to the interaction between natural hazards and anthropogenic factors, including land reclamation, rigid coastal defenses, and the concentration of hazardous activities within port perimeters. These elements often increase systemic vulnerability and reduce adaptive capacity.

The second part focuses on governance and planning instruments for managing meteorological risk in ports. It analyzes the role of port authorities, local governments, and national regulators in integrating climate risk into port master plans, coastal zoning, and infrastructure investment decisions. The paper highlights the importance of preventive planning, adaptive design standards, and scenario-based risk assessment, moving beyond emergency-driven approaches. In this context, resilience is understood not only as the capacity to withstand shocks, but also as the ability to ensure rapid recovery and functional continuity.

The final section discusses the implications for public responsibility and financial sustainability. Extreme meteorological events increasingly generate significant public costs related to emergency response, infrastructure repair, and compensation mechanisms. The paper argues that proactive risk management and climate adaptation in port areas should be framed as a matter of public interest, justifying coordinated investment, regulatory oversight, and accountability mechanisms. Strengthening the resilience of port areas is therefore not only an environmental or technical

challenge, but also a legal and institutional one, requiring integrated policies that align economic efficiency, environmental protection, and public safety.

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Ex-ante assessment of information needs on marine hazards in municipalities participating in the Tsunami Ready programme

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Increasing urbanisation of Mediterranean coastal areas, combined with the development of tourist infrastructure and high-impact industrial facilities, determines an increase in the risks faced by coastal communities from marine hazards such as tsunamis, storm surges and sea level rise. These risks need to be addressed by rapidly strengthening early warning systems and preparedness and resilience strategies at the local level. In this context, the Tsunami Ready programme, promoted by UNESCO, aims to improve the resilience of coastal communities in the Mediterranean by achieving twelve indicators. This study proposes an ex-ante assessment of the information needs on marine risks in Italian coastal areas adjacent to the municipalities involved in the implementation of the Tsunami Ready programme, with a focus on the target municipalities. The objective is to analyse the level of awareness, risk perception and preparedness of the population regarding the main hazards related to sea level. To assess these aspects, a structured questionnaire, implemented as part of the CoastWAVE project promoted by UNESCO-IOC and funded by European DG-ECHO funds, was used. The questionnaire was administered to a sample of residents stratified by age, gender and level of education representative of coastal communities, in order to make the survey statistically robust. A total of 303 interviews were collected in coastal municipalities involved in the development of the Tsunami Ready programme, considering two coastal municipalities to the north and two coastal municipalities to the south of the target municipality.

The objectives of the study include an in-depth analysis of aspects related to knowledge of marine hazards, trust in warning systems, information sources used, the degree of preparedness in response to a potential warning and expectations of the institutions responsible for risk management.

The expected results will make it possible to identify information gaps and communication issues, providing operational recommendations for the development of more effective, contextualised risk communication strategies aimed at implementing the Tsunami Ready programme and marine risk reduction measures. Finally, the study offers useful insights for refining the communication conveyed through marine risk warning and mitigation systems in the target municipalities. The study is relevant at European level from a UNESCO perspective, both in terms of its specific type and the shared survey tool.

Social Inequalities in Earthquake Prevention: A Comparative Assessment of Seismic Governance in 12 High-Risk Countries

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Earthquake disasters are not solely determined by the physical characteristics of ground shaking but emerge from a complex interaction between hazard, exposure, structural vulnerability, institutional capacity and societal behaviour [Wisner et al., 2004; UNDRR, 2019]. Countries experiencing comparable magnitudes and intensity levels routinely exhibit losses that differ by one or even two orders of magnitude, underscoring profound inequalities in seismic governance, preparedness, and risk communication [Tierney, 2014; Cutter et al., 2003]. Despite the central role of prevention in shaping disaster outcomes, a unified and globally comparable metric that captures the multidimensional nature of seismic prevention has been lacking.

To fill this gap, we introduce the Global Seismic Prevention Index (GSPI)—a composite indicator designed to quantify national-level prevention capacity along structural, institutional and social dimensions. The GSPI integrates seven domains widely recognized in disaster risk reduction frameworks: (i) building code enforcement; (ii) earthquake early warning systems (EWS); (iii) risk-informed urban planning and land-use regulation; (iv) institutional capacity and governance; (v) public preparedness and education; (vi) retrofitting and safety of critical infrastructure; and (vii) exposure–vulnerability profiles informed by global seismic risk models. These components, grounded in engineering resilience [Bruneau et al., 2003], early warning science [Allen & Melgar, 2019], and socio-institutional risk frameworks [UNISDR, 2015], are normalized and combined into a reproducible 0–100 index. Their conceptual arrangement is shown in Fig. 1, which highlights how the GSPI captures the systemic nature of prevention, spanning policies, infrastructure, institutions and collective behaviours.

The index is applied to twelve high-risk countries and regions—Japan, California (USA), New Zealand, Chile, Italy, Greece, Mexico, the Philippines, Indonesia, India, Türkiye and Iran—selected for their diverse tectonic regimes, socio-economic profiles and risk governance traditions. To examine whether prevention capacity modulates observed earthquake consequences, the GSPI is compared with a harmonized catalogue of 552 significant seismic events (1970–2024) integrating EM-DAT losses [CRED, 2023], USGS source parameters [USGS, 2024], and population and GDP baselines from the World Bank [World Bank, 2024]. From these data, we compute three normalized

impact indicators: Fatality Rate (FR), expressing deaths per million inhabitants; Casualty Efficiency (CE), relating fatalities to the energy released by each earthquake; and Damage-to-GDP ratio (DG), quantifying the economic burden of events relative to national economic output.

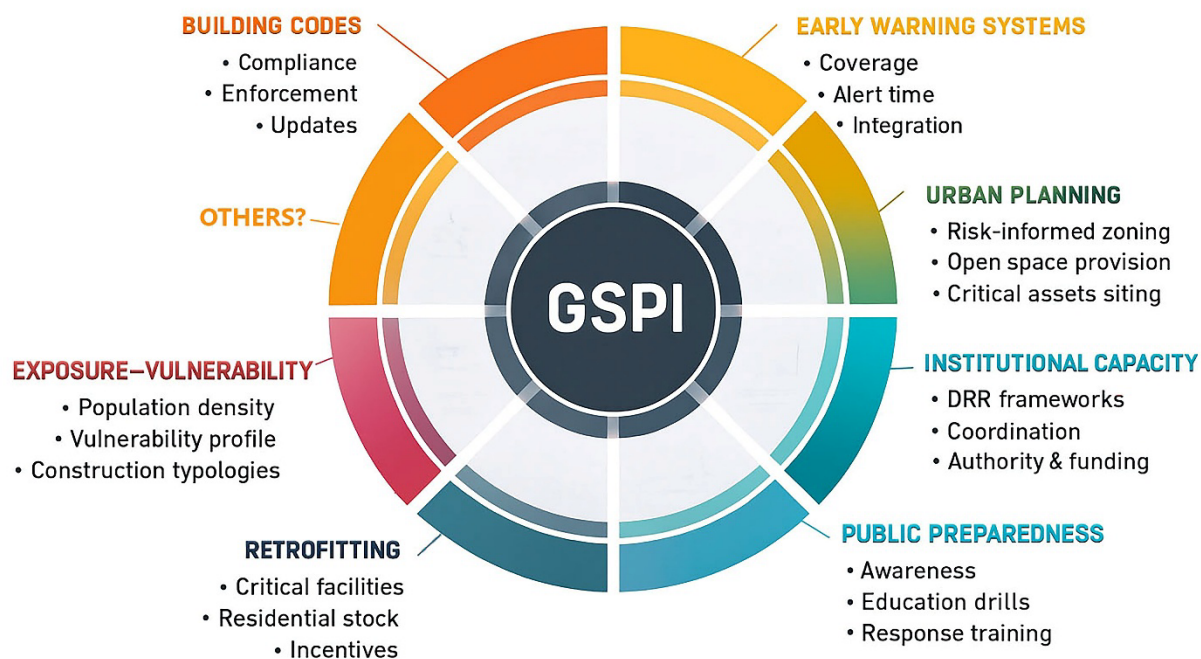


Fig. 1 – Structure of the Global Seismic Prevention Index (GSPI), integrating seven prevention domains: building code enforcement, early warning systems, urban planning, institutional governance, public preparedness, retrofitting of critical infrastructure, and exposure–vulnerability profiles.

The GSPI ranking (Fig. 2) reveals three distinct prevention clusters. Japan, California, New Zealand and Chile form a high-prevention group, characterized by stringent building regulations, mature EWS, extensive retrofitting of critical facilities and coherent multi-level governance structures. These countries have consolidated prevention architectures through decades of policy evolution following major seismic crises. Italy, Greece, Mexico, the Philippines and Indonesia constitute an intermediate group where modern codes coexist with legacy building stock, heterogeneous enforcement, incomplete retrofitting programmes and uneven institutional coordination. India, Türkiye and Iran form a low-prevention cluster marked by chronic structural vulnerabilities, limited institutional capacity, lower EWS penetration, and slower adoption of risk-informed urban planning. A Principal Component Analysis confirms that the seven domains covary strongly, demonstrating that prevention capacity behaves as a systemic socio-technical construct rather than a collection of independent components.

Despite the clear prevention clusters, comparisons between GSPI and aggregated impacts (FR, CE, DG) reveal no statistically significant monotonic relationships across the 12 countries. High-GSPI countries tend to exhibit lower impact severity on average, while low-GSPI countries cluster toward higher FR and CE values; however, variability is large due to profound differences in hazard regimes, exposure patterns and the influence of rare catastrophic events. This behaviour is consistent with findings in global disaster research, which highlight how long-term loss statistics at national scale

can be dominated by a small number of extreme earthquakes [Wisner et al., 2004], masking the protective effects of prevention. Moreover, population density, spatial distribution of assets, building age, and socio-economic fragility contribute substantially to impact variability and cannot be captured by prevention capacity alone.

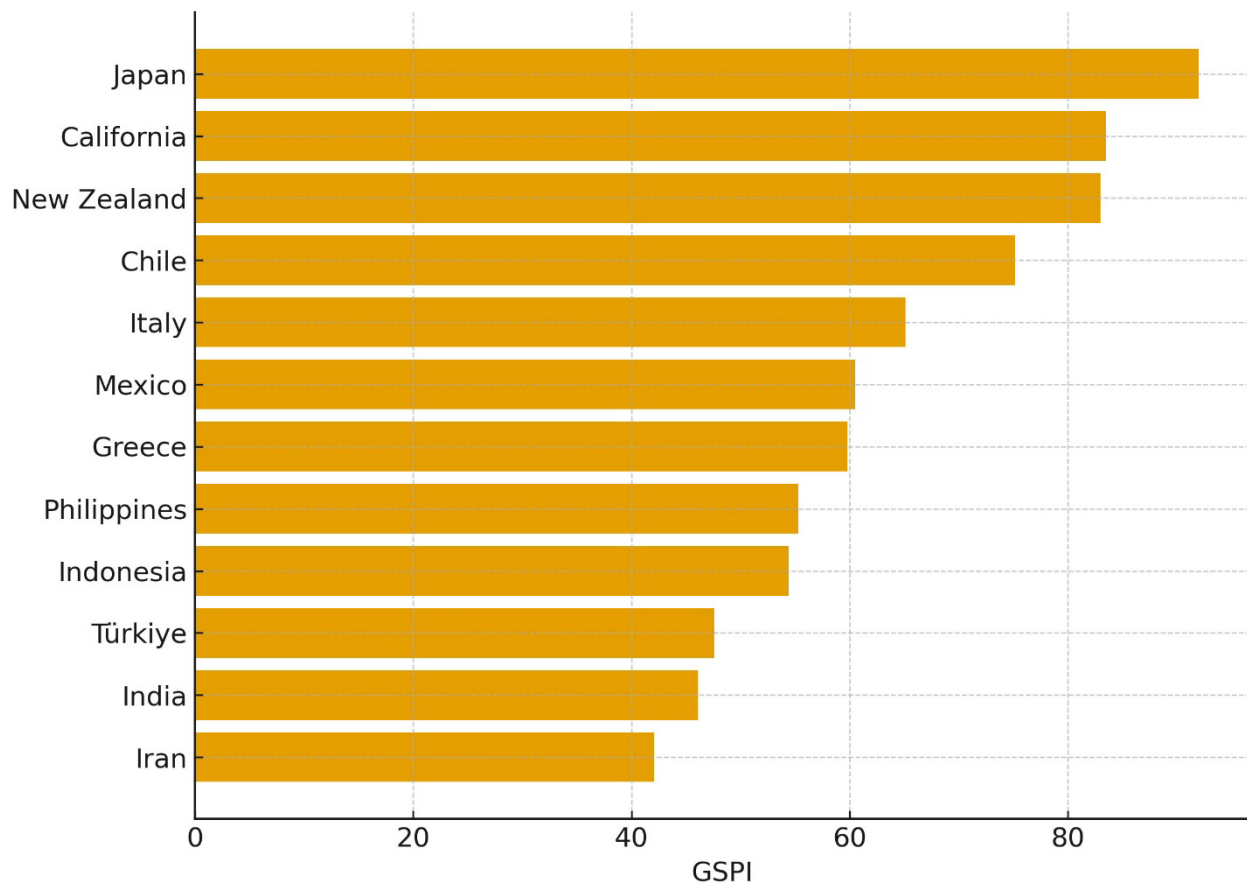


Fig. 2 – GSPI ranking for the twelve high-risk countries analyzed. Three clusters emerge: high-, intermediate-, and low-prevention systems, reflecting disparities in governance, enforcement, preparedness, and infrastructural resilience.

To interpret these findings, we conceptualize the Earthquake Impact Pathway (shown in Fig. 3). This framework illustrates how earthquake consequences emerge from the sequential and interacting influences of hazard, exposure, vulnerability and prevention. Prevention capacity affects multiple layers of this pathway:

- Pre-event stage: land-use planning shapes exposure patterns; building codes and retrofitting reduce vulnerability; preparedness enhances behavioural readiness;
- Event stage: early warning enables protective actions, and institutional coordination accelerates emergency responses;
- Post-event stage: governance structures influence response efficacy, continuity of services and long-term recovery.

Earthquake Impact Pathway

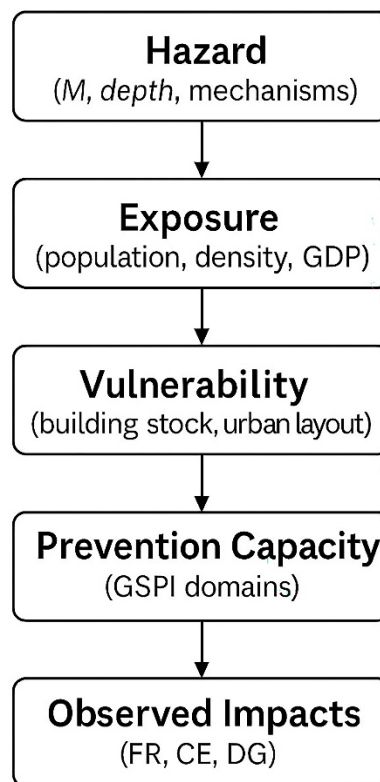


Fig. 3 – Earthquake Impact Pathway illustrating how hazard, exposure, vulnerability, and prevention capacity jointly shape human and economic losses. Prevention influences multiple stages of the pathway, explaining why impacts cannot be predicted from hazard alone.

This layered conceptualization clarifies why prevention alone does not fully explain national-scale impacts when considered across multi-decadal timelines. Instead, prevention interacts with socio-economic conditions, spatial development patterns, and hazard variability to determine the probability distribution of losses. Therefore, the absence of strong correlations between GSPI and aggregated national losses reflects the complexity of seismic risk as an emergent property of intertwined physical and social dimensions.

From a policy perspective, this work offers three contributions. First, the GSPI provides a diagnostic tool for comparing national prevention architectures and identifying priority gaps—such as enforcement deficits, retrofitting needs, or weaknesses in governance and preparedness. Second, the results demonstrate the limits of country-scale, long-term impact indicators and emphasize the need for finer spatial granularity (regional or urban scales) and event-level analyses that link prevention measures to shaking intensity, damage patterns and response performance. Third, by integrating social, institutional and infrastructural dimensions, the GSPI and Earthquake Impact Pathway contribute to bridging disciplinary boundaries between geophysics and social disaster science, strengthening the evidence base for integrated Disaster Risk Reduction strategies aligned with the Sendai Framework.

Overall, this study highlights substantial global inequalities in seismic prevention and demonstrates that risk is deeply rooted in social structures, governance systems and collective behaviours. While prevention capacity does not predict national-scale losses in a simple monotonic way, it establishes the conditions under which earthquakes become disasters. Extending the GSPI to include temporal evolution, sub-national indicators, and links to ground-motion and vulnerability models represents a key direction for future research. Such advances will improve our ability to quantify how prevention investments translate into lives saved and economic resilience strengthened, thereby supporting more equitable and evidence-based seismic risk governance worldwide.

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Legal Instruments for Reducing Territorial Vulnerability to Natural Hazards

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Reducing territorial vulnerability requires legal instruments capable of addressing social, economic, and institutional factors. This abstract explores the preventive potential of regulatory frameworks governing public spending and contractual arrangements. The analysis focuses on how laws and administrative practices can anticipate risks by directing resources toward vulnerable populations and areas. By examining the interaction between legal obligations and social needs, the paper highlights the role of preventive law in fostering resilience. The contribution stresses that vulnerability reduction is not only a technical task but a legal and social responsibility.

In this perspective, public law is examined not merely as a reactive system responding to emergencies, but as a proactive framework capable of shaping policy choices before critical situations materialize. Budgetary rules, procurement procedures, and accountability mechanisms are assessed as tools that can embed prevention into ordinary administrative action. Particular attention is paid to how discretionary powers are structured and constrained in order to ensure that public resources are allocated in a manner consistent with principles of equity, sustainability, and social cohesion.

The paper also considers the role of institutional coordination and multilevel governance in mitigating territorial disparities. Legal obligations imposed on public authorities, when combined with data-driven risk assessment and social impact evaluation, can transform public spending into a strategic instrument for reducing exposure to systemic risks. Contractual mechanisms, including performance clauses and social criteria in public procurement, are analyzed as means to align economic efficiency with broader public interests.

Ultimately, the abstract argues that preventive legal frameworks contribute to redefining vulnerability as a collective concern, requiring long-term planning and normative coherence. By integrating social protection objectives into financial and administrative law, preventive regulation can enhance the resilience of territories and communities, reinforcing trust in public institutions and strengthening the legitimacy of public intervention.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance
(IFRC / Disaster Law Database)

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Territorial vulnerability and Contractual Choices in Risk Prevention Policies

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Territorial vulnerability is not only a physical condition but also the result of legal and administrative decisions. This abstract examines how public contracts and procurement procedures shape preventive risk policies at the local level. By analysing the social implications of awarding works and services related to natural risk mitigation, the paper highlights the importance of integrating vulnerability indicators into contractual design. Legal tools are presented as key instruments for steering preventive action, ensuring that public spending addresses social fragilities and territorial disparities. The study underscores the need for a preventive legal culture capable of transforming contracts into tools of social protection.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance (IFRC / Disaster Law Database)

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Echoes of the earthquake: Evidence-based suggestions for the management of psychological consequences of earthquakes

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Experiencing an earthquake can be a traumatic event, sometimes followed by another negative experience represented by post-earthquake temporary displacement. Both can have serious and lasting consequences on people's wellbeing, quality of life, and life satisfaction even years after the traumatic event. These consequences can hinder the recovery of individuals and communities affected by an earthquake. After summarizing our previous investigations of psychological consequences in individuals who faced different experiences in terms of temporary displacement from their home after an earthquake, we provide a new empirical contribution on the predictors and correlates of autobiographical memory of post-traumatic stress disorder (PTSD) symptoms in individuals who had or had not been displaced from their homes after three Italian earthquakes ($n = 340$). We also examined the association between the PTSD memory measure and measures of wellbeing, quality of life, life satisfaction, and event-related health impairment. Being female, having lower individual resilience and stronger place attachment, having been or still being displaced from home, and having higher current risk awareness were associated with higher scores on the PTSD memory measure. Higher scores were also associated with lower current wellbeing, lower current and expected quality of life, lower life satisfaction during displacement, and more severe perceived health consequences. The results suggest that experiencing an earthquake followed by prolonged displacement hinders recovery from the negative psychological effects of the disaster. Overall, the reviewed research suggests the need for tailored interventions at the individual, social, and management levels to prevent and manage the negative psychological consequences of earthquakes at different stages of the disaster risk management cycle.

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From Emergency to Prevention: Rethinking Legal Frameworks for Natural Risk Governance

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Emergency-driven governance remains a dominant approach to natural risks, often privileging reactive measures over long-term prevention and structural mitigation. This contribution critically examines the legal and social limits of emergency-based models, highlighting how reliance on extraordinary powers, derogatory procedures, and post-event financing tends to weaken planning capacity, reduce transparency, and reproduce territorial inequalities. Against this backdrop, the paper proposes a shift toward preventive frameworks rooted in territorial analysis and informed by social vulnerability assessments.

The analysis focuses in particular on the regulation of public works and service contracts, showing how preventive planning can be embedded into ordinary legal procedures governing procurement, infrastructure development, and public service delivery. By examining the legal design of planning instruments, ex ante evaluations, and contractual clauses, the paper demonstrates how prevention can be institutionalized within administrative action, rather than confined to exceptional or emergency contexts. Preventive governance is thus framed as a legal strategy that integrates risk knowledge, territorial specificity, and financial programming into binding decision-making processes.

By emphasizing vulnerability reduction and anticipatory public spending, the study shows how prevention-oriented governance contributes to improving legal certainty, social equity, and territorial sustainability. Allocating resources on the basis of differentiated risk and vulnerability profiles allows public authorities to prioritize interventions where social exposure is highest, aligning public expenditure with constitutional principles of equality, solidarity, and protection of fundamental rights. In this sense, prevention operates not only as a technical objective but as a normative criterion guiding administrative discretion and public investment choices.

The contribution ultimately argues that prevention should be recognized as a structural principle of risk governance rather than an exceptional policy choice triggered by crises. Moving beyond emergency-driven approaches requires a reconfiguration of legal frameworks governing public contracts and spending, capable of embedding anticipatory logic, accountability, and long-term resilience into ordinary administrative practice. Such a shift enhances the capacity of public law to address complex environmental risks while fostering more just, sustainable, and territorially sensitive governance models.

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Policy Brief: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance (IFRC / Disaster Law Database)

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Preventive Public Action and Trust: Legal Transparency in Risk-Related Expenditures

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Trust between public institutions and communities is essential for effective natural risk prevention, particularly in contexts marked by high exposure to environmental hazards and increasing social sensitivity to public decision-making. This paper analyses how transparency in public spending and public contracting contributes to the social acceptance and long-term sustainability of preventive measures. Focusing on territorial risk management, the study examines the legal and administrative frameworks that govern openness, traceability, and accountability in procurement processes related to prevention, mitigation, and adaptation policies.

Through a legal and institutional analysis, the paper highlights how transparency obligations—such as access to information, justification of choices, and clear allocation of financial resources—play a crucial role in shaping public trust. Particular attention is paid to the preventive phase, where investments often produce benefits that are indirect, delayed, or not immediately visible to affected communities. In this context, the absence of transparency can foster mistrust, resistance, and social conflict, undermining the effectiveness of risk prevention strategies.

The analysis shows that preventive investments, when clearly justified, proportionate, and legally sound, strengthen institutional credibility and enhance cooperative relationships between public authorities and local communities. Transparent procurement procedures not only reduce the risk of corruption and mismanagement but also function as instruments of communication, making public action intelligible and socially legitimate.

The contribution ultimately frames transparency as a preventive tool in itself, capable of reinforcing both social cohesion and legal compliance. By integrating legal guarantees with participatory and informative practices, transparency supports a model of risk governance in which prevention is understood not only as a technical or financial issue, but also as a relational and institutional process grounded in trust.

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Policy Brief; 2022: Legal Frameworks for Effective and Integrated Disaster and Climate Risk Governance (IFRC / Disaster Law Database)

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Voices of Resilience: Exploring Citizens' Risk Perceptions, Communicative Practices and Insular Response Strategies

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The sociology of risk (Beck, 1992; Giddens, 1999) highlights that modernity is characterized by a progressive shift from natural danger to reflexive risk - that is, a form of risk generated or amplified by the very social and technological practices designed to control it. Alongside the several dimensions that characterize the concept of risk, communication is being considered as one of the most crucial ones (Heath & O'Hair, 2009). Indeed, the increasing frequency and intensity of natural disasters, exacerbated by climate crises, have made risk communication a crucial dimension of contemporary society, for understanding persistent and emerging problems that occur in different part of the world (Diers-Lawson & Meißner, 2021; Massa & Comunello, 2024). The impacts of climate change, which are distributed unequally across the world, have become clearly visible through floods, droughts, wildfires, heat waves and sea level rise (Reyes et al., 2021), and are strongly shaping how public sector organizations communicate with citizens and the media and their relationships (World Economic Forum, 2024).

The different forms of citizens' response are closely linked to risk and emergency communication management by government and public sector organizations (i.e., regions, municipalities, civil protections), whose legitimacy depends on trust in institutions (OECD, 2021). Public sector communication (Canel & Luoma-aho, 2019) is the leverage to transparently inform and actively engage multiple stakeholders in local territories also during uncertain situations and critical events that can harm different publics (Lovari, D'Ambrosi & Bowen, 2020). Indeed, in an era characterized by mega crises and mega risks (Sellnow-Richmond & Lukakovic, 2025), as well as by the proliferation of digital platforms, the challenge therefore lies not only in communicating risk, but in nurturing intangible assets, like trust, legitimacy and social capital around its management. Thus, when risks turn into disasters and emergencies, communicative effectiveness is influenced by the ability of institutions to maintain an ongoing dialogue with media and citizens (Ducci & Lovari, 2021), acknowledging the plurality of knowledge and the narrative dimension of collective safety, while integrating digital communication tools to foster civic engagement and enable digital volunteerism (Comunello, 2014; Smith et al. 2021).

In contemporary contexts, risk communication plays a strategic role not only in disseminating information and warnings, but also in shaping perceptions, trust, resource mobilization, and communities' capacity to adapt and respond to disasters. This contribution presents the activities of Work Package 3 (WP3) of the research project PRIN PNRR INSULANDER (INvestigating the Strategic role of commUnication for resiLient islAnds copiNg DisastErs Risk management), which aims to support more participatory, inclusive, and informed public policies through an extensive survey on citizens' risk perception, communication practices, and response strategies. These

activities were carried out using a survey that focuses on the two major Italian islands, Sicily and Sardinia, where insularity constitutes a crucial dimension affecting vulnerability (Ivčević et al. 2021; La Rocca & Lovari 2024), access to resources, emergency management, and communicative resilience. By “capturing the voices of citizens,” the study explores how inhabitants perceive natural disaster risks, which information sources and channels they rely on during emergencies, the barriers they encounter in accessing information, and how individual and community resources are activated in natural disasters and critical situations. Adopting an integrated and multidisciplinary approach, the research conceptualizes resilience not merely as a technical capacity to return to normality, but as a social and cultural process rooted in trust, information sharing, institutional relationships, and active citizen participation in risk governance

Data collection was conducted between May and July 2025 using a mixed-method approach. Specifically, the survey combined CAWI (Computer Assisted Web Interviewing), administered through the Opinione.net panel, and CATI (Computer Assisted Telephone Interviewing), based on telephone interviews conducted on randomly generated numbers stratified by geographical area. A total of 3,022 interviews were completed, of which 2,245 (74.3%) were collected via CAWI and 777 (25.7%) via CATI. The CATI mode was primarily used to interview respondents aged over 65, who accounted for approximately 60% of the CATI sample, to enhance inclusivity and mitigate generational digital divides. The study adopted a probabilistic, multi-stage stratified sampling design structured around three main variables: territorial distribution, degree of urbanization, and age and gender. The territorial stratification covered the nine provinces of Sicily and the five provinces of Sardinia, further differentiated into metropolitan, urban, and rural areas. Within each stratum, quotas were defined according to four age groups (15–25, 26–45, 46–65, and over 65) and gender, reflecting the actual distribution of the resident population aged between 15 and 99 years. The same sampling logic was applied to a national comparison sample, stratified by the four ISTAT macro-regions (North-West, North-East, Centre, South) and subsequently by settlement type, age, and gender. The final sample consisted of 1,356 interviews in Sicily (44.8%), 443 in Sardinia (14.7%), and 1,223 in the national comparison sample (40.5%). This composition enables a robust comparative analysis between the two insular contexts and mainland Italy, while ensuring methodological consistency across territorial scales.

This abstract presents selected empirical findings on information sources, trust, and risk communication. Both direct experience of natural disasters and risk perception are strongly shaped by territorial context. At the national level, events such as heat and cold waves, storms, and strong winds are reported more frequently, whereas insular contexts display specific risk profiles, including a high perceived exposure to drought, wildfires (particularly in Sardinia), and earthquakes and volcanic eruptions (especially in Sicily). However, lived experience does not always correspond to perceived risk, suggesting the influence of additional cognitive, cultural, and social factors.

In terms of reliance and trust, family and friends emerge as the primary reference points for coping with disaster impacts, especially in the islands, where community cohesion appears stronger. Emergency services also enjoy high levels of trust, although with lower intensity in Sicily. A pronounced sense of self-reliance and individual responsibility characterizes insular populations: more than one quarter of respondents in Sardinia and Sicily believe that island residents must largely cope on their own in the event of a disaster, a proportion almost double that observed at the national level. Responsibility for disaster prevention, management, and recovery is mainly attributed to regional, municipal, and national institutions, while the role of the European Union is perceived as marginal. Attitudes toward citizen involvement are divided between support for more active civic participation and a preference for institutional management, with a non-negligible share of undecided respondents, particularly in Sicily. Regarding institutional trust, Fire Brigades and Civil Protection are consistently rated as the most reliable actors, whereas regional, national, and

European institutions receive lower evaluations, again more markedly in Sicily. Finally, only slightly more than half of respondents report awareness of the existence of a Municipal Civil Protection Plan, and this information is often acquired through informal or non-institutional channels. This highlights a persistent communication gap: risk awareness and knowledge of emergency plans are essential preconditions for effective prevention and response, and they require strengthened public communication strategies and more inclusive information channels, especially in insular contexts where digital and cultural divides remain significant.

A community's capacity to respond effectively to emergencies is closely linked to the quality of information, trust in institutional channels, and perceptions of adopted communication strategies. The empirical evidence shows that, across all the contexts considered (Italy, Sardinia, and Sicily), institutional channels and traditional media (television, newspapers, and official websites) are regarded as the most reliable sources of information before, during, and after emergencies. Emergency management actors, such as Civil Protection and law enforcement agencies, are consistently perceived as the most trustworthy institutions, with approval levels around 60% across all phases of the emergency cycle. Local and regional media play a particularly relevant role in insular contexts, especially in Sardinia, reflecting their importance in territorially embedded communication systems. By contrast, trust in social media and informal sources remains limited, although it is slightly higher in the islands, particularly in Sicily. A further critical issue concerns the low level of awareness of institutional risk communication campaigns, such as "Io non rischio" by Civil Protection, which is known by fewer than one in five respondents. Moreover, especially in Sardinia, respondents report difficulties in accessing timely and coherent information during emergencies. Overall, only a minority of the population considers itself adequately informed, while perceptions of the clarity, accessibility, and coherence of public sector communication remain at medium to moderately low levels. These findings aim at strengthening public risk communication by improving its clarity, timeliness, and territorial reach, particularly in insular settings.

The findings aim to contribute to a territorially grounded understanding of social resilience and the strategic role of communication in strengthening collective capacities to face and transform natural disasters and environmental crises. Territorial resilience does not rely solely on infrastructure and material preparedness, but is deeply intertwined with social, relational and psychological factors, which appear to be particularly salient in insular contexts. Investing in these dimensions—such as strengthening neighborhood networks, fostering shared values, and enhancing individual adaptive strategies—can play a crucial role in effective emergency management and in reinforcing social cohesion.

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Addressing Inequalities in Disaster Risk through Participatory Research: Evidence from REACT and PREPSHIELD

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Disasters do not affect all populations equally: older adults, migrants, women, and people with disabilities often experience disproportionate impacts due to heightened exposure and vulnerability, as well as structural barriers that limit access to preparedness resources and constrain their capacity to respond effectively. Addressing these differentiated impacts requires moving beyond technocratic models of disaster risk management toward a whole-of-society approach, as advocated by the World Health Organization (WHO, 2021). This approach recognises the interdependencies between diverse societal actors and emphasises the shared responsibility of governments, civil society organisations, businesses, and vulnerable communities in building preparedness and resilience. In this perspective, citizen engagement and participatory approaches are essential to effective risk governance, enabling the co-production of knowledge, the inclusion of marginalized voices, and the redistribution of preparedness capacities across all phases of the disaster risk cycle.

This contribution presents two multi-phase participatory research frameworks implemented in disaster research that operationalise these principles through inclusive, multi-actor co-production. Drawing on the work of CRIMEDIM – Università del Piemonte Orientale, this contribution examines how participatory approaches can enhance disaster risk governance, with a specific focus on vulnerable and non-compliant groups. The analysis is grounded in two transdisciplinary projects operating at different scales and addressing different hazards, REACT (Resilience Enhancement of Migrants through Active Community Participation and peer-Training) and PREPSHIELD (Preparedness for society in health crises and disasters), funded respectively by Fondazione Cariplo and the European Union.

REACT focuses on hydrometeorological hazards such as heatwaves and floods and empowers migrants as active agents of resilience through a community-based participatory research (CBPR) approach. Through the co-creation of a disaster risk reduction toolkit and the promotion of peer-to-peer training focused on extreme weather events in Milan, REACT demonstrates how CBPR can enhance preparedness and resilience among vulnerable populations. The methodology, illustrated in Fig. 1, unfolds across five phases: (0) mapping and trust-building through community engagement

and stakeholder identification; (1) exploration of disaster perceptions via in-depth interviews using an intersectional lens to capture diverse experiences and priorities; (2) co-creation of a disaster risk reduction toolkit through focus group discussions and joint sessions with disaster risk reduction experts, emphasising awareness-raising and locally grounded self-protection strategies; (3) peer-to-peer delivery and community dissemination of the toolkit to enhance legitimacy, trust, and collective capacity; and (4) participatory evaluation, treating co-creation itself as an intervention and assessing empowerment, engagement, and methodological effectiveness.

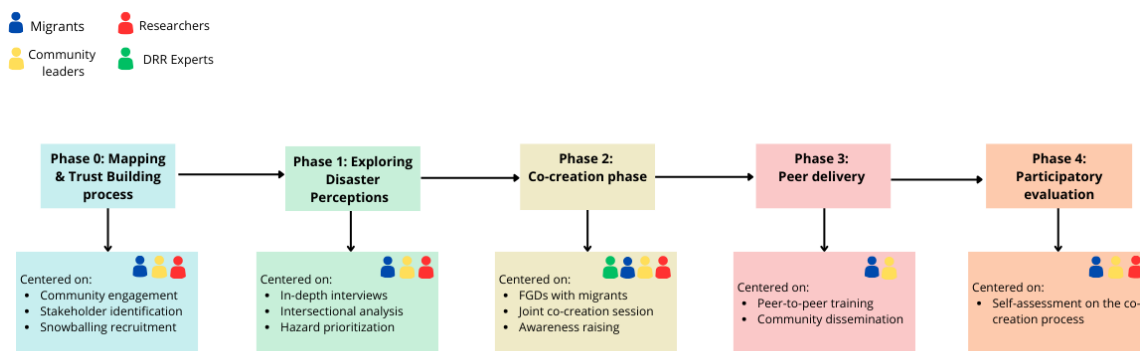


Fig. 1 – REACT Methodology

The Horizon Europe project PREPSHIELD focuses on social and societal preparedness to health crisis and disasters, adopting a multi-actor co-creation process that brings together healthcare institutions, policymakers, civil society organisations, and vulnerable or non-compliant citizens. These stakeholders are actively engaged through table-top exercises and online simulations, fostering the development of collaborative preparedness and targeted risk communication strategies. Project outcomes include a mobile app designed for citizens and a decision-support platform that incorporates agent-based modelling to better understand public responses to pandemic-related measures.

The methodology adopted by PREPSHIELD, illustrated in Fig. 2, adopts an iterative process that begins with a needs analysis integrating institutional priorities and the perspectives of vulnerable and non-compliant groups. These insights inform the co-development of best practices addressing crisis management challenges, healthcare governance, risk communication, and health literacy. Best practices are subsequently tested and refined through tabletop and online exercises, involving institutions, researchers, crisis management experts, and affected communities. Evaluation and iterative refinement underpin the process, culminating in policy-oriented recommendations aimed at strengthening inclusive communication, institutional learning, and knowledge transfer. This framework highlights how digital tools, training, and scenario-based exercises can reshape trust, decision-making, and preparedness under uncertainty.

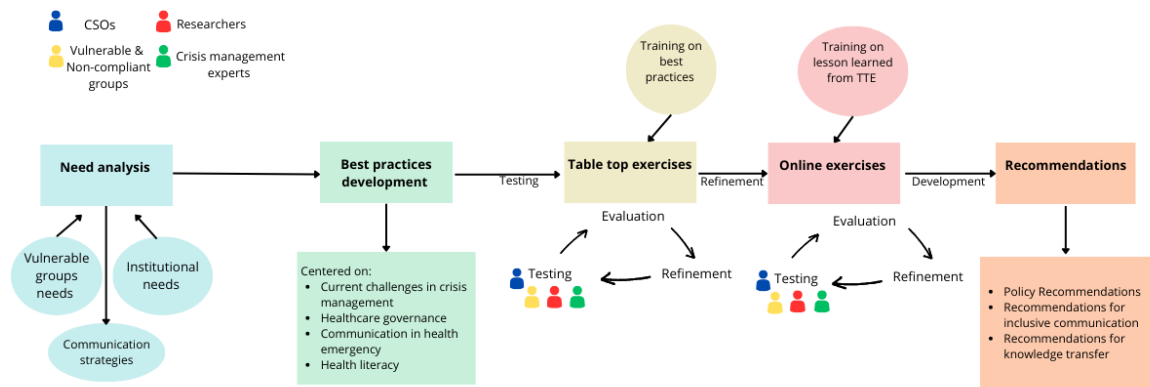


Fig. 2 – PREPSHIELD Methodology

Together, these two frameworks illustrate how risk perception, risk communication practices, governance structures, technologies, and social inequalities interact in shaping exposure, preparedness, and resilience. By combining scenario-based testing, digital platforms, and participatory co-production, REACT and PREPSHIELD projects demonstrate how inclusive engagement can transform risk management practices and contribute to more equitable and socially grounded disaster preparedness and response. Besides presenting the REACT and PREPSHIELD projects, this contribution will also highlight key barriers and facilitators to citizen engagement, drawing on evidence from both projects as well as from the existing literature.

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Acknowledgments

PREPSHIELD is a project funded through the European Union's Horizon Europe research and innovation programme under grant agreement no 101168124. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them. The REACT project is funded by Fondazione Cariplo under grant no. 2025-1798.

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Public Spending and Prevention: Legal Accountability in Natural Risk Management

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Preventive action in natural risk management is strongly conditioned by public spending decisions and their legal frameworks. This paper explores how budgetary choices reflect priorities between emergency response and long-term prevention, with significant social consequences for vulnerable territories. In many legal systems, public expenditure continues to be predominantly oriented toward post-disaster intervention, often justified by urgency and political visibility, while preventive investments remain structurally underfinanced and legally fragmented.

The analysis situates preventive policies within the broader context of public finance law, administrative discretion, and procurement regulation, emphasizing how legal constraints and accounting rules shape the capacity of public authorities to plan anticipatory actions. Particular attention is paid to the role of public contracts and service procurement as strategic tools for risk mitigation, infrastructure maintenance, and territorial resilience. Through this lens, prevention is not merely a technical or scientific issue, but a legally mediated choice that reflects institutional priorities and interpretations of the public interest.

The paper highlights the legal obligations of public authorities to ensure efficiency, transparency, and social utility in spending decisions, arguing that these principles acquire specific relevance in the field of natural risk management. Preventive expenditure, when properly framed within procurement law and budgetary discipline, can reconcile cost-effectiveness with long-term social benefits. Conversely, the systematic preference for emergency spending tends to produce distortive effects, including higher overall costs, reduced accountability, and unequal protection for peripheral or economically fragile areas.

The study further examines how preventive policies contribute to social cohesion and institutional trust. Investments in risk reduction, early warning systems, and territorial planning signal a commitment to safeguarding communities before disasters occur, thereby strengthening the relationship between public institutions and local populations. From this perspective, prevention functions as a form of social investment, capable of mitigating not only physical damage but also social vulnerability and administrative conflict.

The contribution ultimately emphasizes the need for legal mechanisms and budgetary instruments that support anticipatory investments rather than reactive spending. This includes multi-year financial planning, adaptive procurement models, and regulatory frameworks that integrate scientific risk assessment into administrative decision-making. By rebalancing public spending priorities in favor of prevention, the paper argues, legal systems can enhance resilience, reduce long-term public expenditure, and promote a more equitable and sustainable approach to natural risk governance.

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The contentious social construction of hydraulic risk: a critical thematic analysis of the controversial flood risk management of the Piave river

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This paper is based on data collected during my PhD project, which examined two environmental controversies concerning hydraulic infrastructures designed to reduce flood risk in the rural context of the Veneto region. The two case studies focus, on the one hand, on the conversion of the Padua–Venice waterway into a flood diversion channel and, on the other, on the planning and construction of a flood retention basin in the Grave di Ciano area. Both cases lie at the intersection of flood risk governance, territorial transformation, and socio-environmental conflict, offering a privileged analytical vantage point from which to investigate the role of discourse in the construction of legitimacy around infrastructural choices.

This contribution focuses on the Piave River case study, where since 2018 a conflict has emerged between the Veneto regional authorities and a coalition of local actors associated with the Municipality of Crocetta del Montello. Despite the complexity of the interests at stake and the plurality of actors involved, the conflict has progressively polarized into two opposing discursive positions: one in favor of the flood retention basin and one against it. Proponents frame the infrastructure as the only technically effective solution to the flood risk of the Piave River, thereby justifying its ecological and territorial impact in the name of safety and the protection of human life. Opponents, by contrast, challenge this framing by advocating alternative models of flood risk management and questioning both the necessity of the project and the epistemic assumptions on which it is based.

The aim of the paper is to show how the different components of flood risk are symbolically constructed and rhetorically mobilized within the controversy, contributing to the legitimation of conflicting positions. The analysis is situated within critical scholarship on risk and infrastructure, and adopts the premise that risk should not be understood as a purely technical object, but rather as a discursive and political one.

The methodology draws on the qualitative research tradition and is based on a critical thematic mapping of the conflicting discourses produced by the actors involved. More specifically, the analysis combines Braun and Clarke's thematic discourse analysis with Critical Discourse Analysis as

developed by Fairclough and Wodak, allowing for an integrated examination of textual features, discursive practices, and broader social practices.

The findings show how these dimensions are closely intertwined with the main thematic tropes structuring the conflict, highlighting their rhetorical and ideological functions within the controversy. In particular, three core discursive nuclei emerge through which flood risk is contested in the debate over the retention basin: the ontology of the basin itself, oscillating between technical necessity and environmental threat; the protection of life, mobilized as a moral and interpolitical argument; and the esoteric character of hydraulic expertise, which contributes to reinforcing power asymmetries between experts, institutions, and local communities.

Plausible scenario-based multi-risk storylines: development and testing for selected coastal areas in the Northeastern Adriatic

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Physical modelling of earthquakes and cascading hazards (e.g. earthquake induced tsunamis or landslides), as well as concurrent hazards (e.g. a storm surge followed by a tsunami), provides the basis for defining plausible (yet unobserved) multi-hazard and risk scenarios. The developed scenarios supply a systematic method for exploring how the complex interplay between hazards and urban systems may impact society, and can be applied to support and rationalise decision making and inform preparedness for multi-risk management and mitigation (e.g. Strong, Carpenter and Ralph, 2020).

Significant earthquake-induced tsunamis in the Northern Adriatic are rare events. Since most of these events occurred in historical times and at large distances, awareness and understanding of their potential impacts in the region remain limited. To address this issue, we develop a wide set of hazard scenarios for tsunamis generated by offshore earthquakes, for selected urban areas (e.g. Lignano and Trieste) along the coast of North-eastern Adriatic (Peresan & Hassan, MEGR 2024). Tsunami modelling is carried out by NAMI DANCE code (Yalciner et al., 2019), which incorporates seismic source parameters, bathymetry, topography, and non-linear effects in wave propagation. Potential earthquake-induced tsunamis, with sources defined from historical catalogues and active fault databases, are modelled to provide various hazard parameters, such as arrival times and inundation maps. Existing bathymetry and topography datasets are revised considering available high-resolution information to better capture small-scale coastal features that may influence tsunami inundation patterns (Hassan & Peresan, EGU 2025). The modelling yields a set of tsunami hazard-related parameters, such as arrival times and inundation maps, which are critical for planning emergency and mitigation actions in these areas. For the definition of possible impacts, high-resolution exposure models and descriptions of the social context are also needed at the local scale, especially for hazards which exhibit high spatial variability. In this study the methodology by

Badreldin et al., (2025) is considered, which allows us to develop high-resolution exposure models for population and residential buildings.

This study explores the possibility of adopting a scenario based approach, which relies on the physical modelling of plausible hazardous events, to develop realistic site specific multi-risk storylines for urban contexts of different typologies (Marciano et al., 2024). Properly defining the urban context of interest is essential for the development of risk storylines, as it enables the identification of relevant hazards, exposure and local vulnerabilities affecting the urban system. The socio-economic characteristics and possible social vulnerabilities are also important factors that may influence impacts and the effectiveness of response and mitigation strategies. The experimental testing of the multi-risk storyline methodology was carried out for two selected coastal areas along the Northern Adriatic, considering both frequent (storm surge) and rare (tsunami) events. The proposed approach can be easily replicated in other urban areas with similar features, e.g. those located along the coasts of Western Adriatic. The first phase of this experimentation aimed to identify the potential impacts of the proposed scenarios on the different components of the urban ecosystem, while the second phase explored the possible interventions and mitigation strategies, in order to highlight relevant complexities and interactions. Through a participatory process, the multi-risk storylines engaged institutional actors, technical experts, and local communities, transforming data, experiences, and perceptions into dynamic and shared risk scenarios. The resulting narratives do not intend to merely describe past events, but rather to anticipate plausible future scenarios and viable response, recovery and mitigation actions, contributing towards integrated multi-risk management strategies.

The study shows that the developed scenarios provide a systematic methodology for exploring how the complex interplay between hazards and urban systems may impact a society, and can be applied to support and rationalise decision making and inform preparedness for multi-risk management and mitigation.

Acknowledgements

This research is a contribution to the RETURN Extended Partnership (European Union Next-Generation EU—National Recovery and Resilience Plan—NRRP, Mission 4, Component 2, Investment 1.3—D.D. 1243 2/8/2022, PE0000005).

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“Your Choice”: a story, a game, and a test of your relationship with Risk

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The 2024 edition of the "Futuro Remoto" Science Festival, held in Pozzuoli, Italy, was centered on the theme "CO-SCIENZE" (CO-SCIENCES). The event aimed to place natural and human sciences at the heart of our ability to discern, evaluate, and act within a multifaceted and interconnected world. In this context, we developed an interactive exhibit designed to investigate the relationship between citizens and natural risk. Our approach was rooted in the conviction that risk education must consider people's lived experiences, imagination, and conscience.

Visitors, including both students and adults, were engaged in a storytelling and role-playing activity structured into four sequential episodes (Fig. 1):

1. Choosing a travel destination
2. Selecting accommodation
3. Reacting to an unexpected event
4. Engaging in a final action



Fig. 1 – Setting up the story: the first panel briefly describes the purpose of the activity, followed by 4 panels representing the 4 scenes that make up the story, and finally a panel explaining the meaning of the risk profiles.

For each narrated and illustrated scene, which deal with risk, participants were faced with three behavioural alternatives and after making a choice, they randomly drew a corresponding card to reveal the outcome of their action. The participants' choices lead to a deeper discussion of behaviours: these outcomes emphasized the potential consequences of their choices not only for the individual but also for the community and "the world" at large.

Data from these interactions were synthesized to identify six discrete risk profiles, aimed at quantifying individual risk propensity in daily life. The profile pairs are: Prudent / Temerarious, Collettivist / Individualist, Organized / Disorganized.

While these profiles were intentionally exaggerated to spark reflection and debate, they do not imply any moral judgment: there is no "right" or "wrong" profile. Instead, the exercise suggests that only the extremes of any attitude may become problematic for oneself or others.

This comparison encourages participants to confront complex questions. Should we remain cautious even when facing a risk might serve a greater good? Is it right to prioritize the well-being of others to the point of overlooking our own needs? Does absolute organization border on a mania for control, and are risks ever truly controllable? Is it perhaps more useful to learn to live with certain aspects of uncertainty?

The proposed activity held significant relevance for the local audience in Pozzuoli, a population that had been experiencing the effects of a bradyseismic crisis and repeated seismic swarms for nearly a year.

However, the modular nature of the exhibit allows it to be adapted and repeated in any context.

Ultimately, the central objective of this activity is to determine whether individuals translate their knowledge of risk into concrete preventative actions. Exploring the discrepancy between perception and action is crucial to enhancing the efficacy of risk communication directed toward the general public.

Acknowledgments

The proposed activity is the citizen-adapted version of a teacher training module designed within the "A Scuola di Protezione Civile" 2024-27 project, funded by the Civil Protection Department of the Calabria Region.

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When the Storm Hits: An Analysis of Institutional Public Communication after the Mortegliano Hailstorm

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Institutional public communication (Lovari & Ducci, 2022) plays a crucial role in post-event emergency management, integrating functions of alerting, operational coordination, and the construction of public legitimacy, with significant implications for access to information and the response capacities of people in conditions of vulnerability. Drawing on a theoretical framework that combines Crisis and Emergency Risk Communication (CERC) (Reynolds & Seeger, 2005) with scholarship on the social construction of vulnerability (Cutter et al., 2003), this study examines how two key actors—the Friuli Venezia Giulia Regional Government and the Regional Civil Protection Agency—communicated the emergency on their Facebook and Instagram pages during the thirty days following the severe hailstorm that struck Mortegliano (Udine) in July 2023. Particular attention is also paid to the forms of reaction and interaction emerging from users' comments in response to this content.

Using a mixed-methods approach based on topic modelling of posts (N = 195) and comments (N = 1,499) from the aforementioned platforms, complemented by a qualitative thematic analysis of selected Facebook posts relevant to the analytical dimensions, the study investigates communicative strategies, linguistic choices, and representations of vulnerability.

The findings reveal a marked communicative asymmetry. Despite some predictable differences in communicative registers, the social media communication of both the Regional Government and the Civil Protection Agency portrays people in conditions of vulnerability as passive actors, primarily defined by physical exposure and material damage, and framed exclusively as recipients of assistance. Vulnerability is thus constructed in narrowly physical and economic terms, neglecting relational, psychological, and informational-access dimensions. By contrast, the analysis of comments uncovers a counter-narrative structured along three main thematic axes: expressions of solidarity with affected communities and appreciation for first responders; contextualization of the event within the broader debate on climate change, accompanied by demands for preventive policies; and criticism of institutional action. This reveals an unresolved tension between the institutional representation of the emergency as an exceptional event to be managed through technical means and the public perception of a systemic emergency requiring transformations in territorial and policy approaches.

Overall, the study highlights how the observed emergency communication remains strongly anchored in top-down, reactive logics and is only marginally inclusive, lacking a strategy to systematically incorporate the broad spectrum of vulnerabilities and to establish a constructive dialogue with the affected community. The absence of a communication strategy oriented toward dialogue and interaction ultimately turns social media from potential spaces for the co-construction of resilience into arenas of conflict between institutional logics and civic expectations.

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How unequal? Why vulnerable? Clearly differentiated

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Natural hazards such as earthquakes, eruptions, floods, and heat waves can severely affect society. In principle, they are natural phenomena by which nature expresses itself, but they may transform into disasters if proper measures are not taken.

Traditionally, scientific institutions conduct outreach, communication, and public engagement activities to explain these phenomena, as better knowledge and awareness can mitigate the effects of such natural hazardous events. Preparedness is crucial.

Both education and communication are very challenging. Digital communication has disrupted the traditional communication channels. The deficit model is still used, but dialogues have been started to listen to the voices of citizens and non-expert stakeholders, to better understand both the context and the public's concerns. Scientists study complex phenomena and are skilled at providing simple explanations, primarily from a scientific perspective. However, in vulnerable or at-risk areas, what do citizens want to know? On the one hand, when a phenomenon occurs and the crisis is ongoing, there is a demand for information that can disrupt scientists' routines, requiring them to adjust and adapt their contributions. On the other hand, pressures from citizens and other stakeholders are significant (Fig. 1).

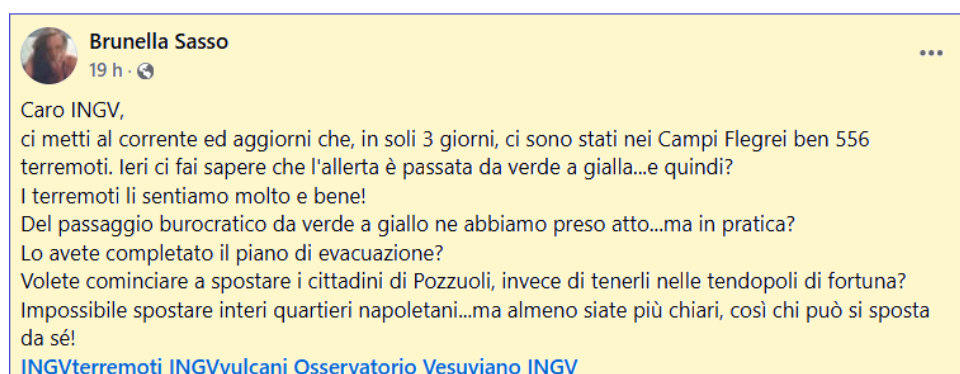


Fig. 1 – INGV Facebook follower's comment asking for an evacuation plan (for which INGV is not responsible).¹

¹ "Dear INGV, you informed us and update that, in just 3 days, there have been 556 earthquakes in the Campi Flegrei. Yesterday you let us know that the alert went from green to yellow... so what? We feel earthquakes a lot and well! We have taken note of the bureaucratic transition from green to yellow... but in practice? Have you completed the evacuation plan? Do you want to start moving the citizens of Pozzuoli, instead of keeping them in makeshift tent cities? It's impossible to move entire Neapolitan neighborhoods... but at least please be clearer, so."

Comments on social channels, such as "Yes, you are explaining the magnitude to us, but so what? What about an evacuation plan?" illustrate the unavoidable issue "who is asking what from whom", a dimension still crucial in current scientific communication debates (Bucchi & Schäfer, 2025).

Moreover, natural hazards affect men and women, boys and girls in different ways, due to biological, cultural, and social characteristics. Communication should consider these factors to be effective and new tools are needed for intersectional analysis of social media communication.



Fig. 2 – Gendered analysis of social media interaction in May 2024. From Rubbia et al, 2025.

The importance of adopting gender-sensitive and intersectional approaches in disaster risk reduction (DRR) is well documented in the literature, with room for implementation (Erman et al. 2021). The Midterm Review of the Sendai Framework for Disaster Risk Reduction (UNDRR 2022) clearly stated that disaster risk is gendered, noting that higher death rates among women and girls in many recent disasters are attributable to existing gender inequalities, and called for actions to close gender gaps in disaster risk prevention, mitigation, preparedness, and recovery. Beyond gendered impacts in countries prone to extreme phenomena, various studies highlight that gender should not be polarised between men and women, but should also include gender minorities (Sharan & Gaillard, 2025). Some studies also highlight that violence and gender-based violence tend to increase during crises (Muñoz-Nieves et al., 2025). Some others begin with the concept of women's vulnerability during an event, and move on to that of resilience, reconsidering the event as an opportunity for women to be not just victims, but agents of change, with the consequent improvement of conditions for both women and men (Luna & Hilhorst, 2022).

If we look at the narratives of the Genoa flood of 4 November 2011, Italy, (Fig. 3) which resulted in six fatalities, all of whom were women or girls, we understand that disaster risk-reduction frameworks must acknowledge caregiving, more often up to women, as a determinant of vulnerability. That event stands as a reminder that disasters are never purely natural.

Meteorological extremity interacted with urbanisation and with deeply ingrained social roles. Evacuation planning, transport logistics, and communication strategies should take into account people's social roles and attitudes and focus primarily on those most at risk.



Fig. 3 – The Bisagno River overflowed during the severe flooding in Genoa on November 4, 2011. *Source:* ARPAL Liguria, *Quaderno ARPAL – Genova, Settembre* (2011), available at: *QuadernoArpalGenovaSettembre_WEB.pdf*

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Communicating flood risk in the context of climate change

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Weather events are environmental hazards that can occur daily (IPCC, 2022). Among these types of risks, river floods represent the one with the greatest economic impact in Europe (Paprotny et al., 2018) and are expected to increase further in the near future (Jongman, 2018). Effective risk communication is therefore essential to link expert knowledge and management practices with the development of resilience in local communities at risk (Butler & Pidgeon, 2011). However, current risk communication often fails to meet the information needs of citizens (Rollason et al., 2018) and is often accompanied by a high level of mistrust in the organisations responsible for communication and management (O'Sullivan et al., 2012).

Numerous studies have shown that understanding the factors that influence the perception of flood risk at the local level is essential for effective risk communication (Burns & Slovic, 2012) and for improving the resilience of local communities to natural hazards (Bradford et al., 2012). However, risk communication in Italy seems to focus mainly on the emergency phase, i.e. the disaster management phase. We believe, in line with international literature, that risk communication should also serve to increase trust between citizens and institutions, and that this could be achieved through transparent and participatory dialogue.

In line with these premises, our contribution will present the results of two sample surveys and a public consultation event conducted as part of the PRIN-PNRR project “Risk Communication and Engagement for Societal Resilience”, funded by the Ministry of University and Research. The two surveys, which involved a sample of 2,500 respondents proportionally representative of the Italian adult population by gender, age, level of education and area of residence, investigated Italians' perception of the risk of natural disasters from various perspectives, with a particular focus on climate change and the perception of flood risk. The results were then used to inform a public consultation event held in April 2025 in Bologna (Emilia-Romagna). Conceived as a multi-stakeholder initiative, the event brought together 100 Italian citizens and experts in risk management and communication.

Using a mixed methodological approach, the project aimed to identify gaps in flood risk communication strategies in Italy and develop tailored guidelines that better respond to citizens' needs.

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The contentious social construction of hydraulic risk: a critical thematic analysis of the controversial flood risk management of the Piave river

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This paper is based on data collected during my PhD project, which examined two environmental controversies concerning hydraulic infrastructures designed to reduce flood risk in the rural context of the Veneto region. The two case studies focus, on the one hand, on the conversion of the Padua–Venice waterway into a flood diversion channel and, on the other, on the planning and construction of a flood retention basin in the Grave di Ciano area. Both cases lie at the intersection of flood risk governance, territorial transformation, and socio-environmental conflict, offering a privileged analytical vantage point from which to investigate the role of discourse in the construction of legitimacy around infrastructural choices.

This contribution focuses on the Piave River case study, where since 2018 a conflict has emerged between the Veneto regional authorities and a coalition of local actors associated with the Municipality of Crocetta del Montello. Despite the complexity of the interests at stake and the plurality of actors involved, the conflict has progressively polarized into two opposing discursive positions: one in favor of the flood retention basin and one against it. Proponents frame the infrastructure as the only technically effective solution to the flood risk of the Piave River, thereby justifying its ecological and territorial impact in the name of safety and the protection of human life. Opponents, by contrast, challenge this framing by advocating alternative models of flood risk management and questioning both the necessity of the project and the epistemic assumptions on which it is based.

The aim of the paper is to show how the different components of flood risk are symbolically constructed and rhetorically mobilized within the controversy, contributing to the legitimation of conflicting positions. The analysis is situated within critical scholarship on risk and infrastructure, and adopts the premise that risk should not be understood as a purely technical object, but rather as a discursive and political one.

The methodology draws on the qualitative research tradition and is based on a critical thematic mapping of the conflicting discourses produced by the actors involved. More specifically, the analysis combines Braun and Clarke's thematic discourse analysis with Critical Discourse Analysis as

developed by Fairclough and Wodak, allowing for an integrated examination of textual features, discursive practices, and broader social practices.

The findings show how these dimensions are closely intertwined with the main thematic tropes structuring the conflict, highlighting their rhetorical and ideological functions within the controversy. In particular, three core discursive nuclei emerge through which flood risk is contested in the debate over the retention basin: the ontology of the basin itself, oscillating between technical necessity and environmental threat; the protection of life, mobilized as a moral and interpolitical argument; and the esoteric character of hydraulic expertise, which contributes to reinforcing power asymmetries between experts, institutions, and local communities.

Social Dimensions of Public Procurement in Natural Risk Prevention

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Public procurement plays a central role in shaping preventive strategies for natural risks. This paper investigates how procurement rules can incorporate social vulnerability considerations into the allocation of public resources. Focusing on territorial contexts, the study analyses contracts for infrastructure, monitoring, and maintenance services, assessing their impact on community resilience. The legal dimension of procurement is examined as a tool for guiding preventive investments toward socially sensitive outcomes. The contribution argues that socially informed procurement enhances both legal legitimacy and preventive effectiveness, reinforcing the link between public spending and collective safety.

Building on this premise, the paper situates public procurement within the broader framework of risk governance, where prevention is no longer conceived as a purely technical activity but as a multidimensional policy integrating social, environmental, and institutional factors. In this perspective, procurement procedures become a strategic lever for anticipating risks, reducing exposure, and mitigating the differentiated effects of natural hazards on vulnerable populations. The analysis highlights how award criteria, contract design, and performance requirements can be calibrated to reflect territorial fragilities, demographic conditions, and socio-economic inequalities. Special attention is devoted to the interaction between procurement law and principles such as proportionality, non-discrimination, and equal treatment, assessing their compatibility with vulnerability-sensitive approaches. The paper argues that the inclusion of social vulnerability indicators does not undermine competition or transparency, but rather redefines value for money in light of preventive objectives and long-term public interest.

Through a legal and functional analysis, the study demonstrates that preventive procurement contributes to strengthening institutional accountability and to aligning public spending with constitutional and administrative principles related to safety, solidarity, and sustainable development. Ultimately, the paper suggests that procurement law can operate as a normative bridge between disaster prevention policies and social protection goals, fostering resilient territories and more inclusive forms of public action.

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