ROADMAP

Good practices in risk and crisis communcation

THEMATIC PAPER 02

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Cite as:
Tagliacozzo, S., Rizzoli, V., Morsut, C., Di Bucci D., Casarotti C., Polese, M., Kruke, B.I., Fagà G., Rebora N., Dolce M., Prota A., Viegas D.X. (2022). Good practices in risk and crisis communication. ROADMAP Project Thematic Paper 2. DOI: 10.57580/TP2DOI

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Project Details

Start date:
1st January 2021

End date:
30th June 2022

Duration:
18 Months

Reference:
101017776 – ROADMAP – UCPM-2020-KN-AG

Website:
https://roadmap.ci3r.it/

Foreword

ROADMAP (European observatory on disaster risk and crisis management best practices) is a project funded by the EU under the UCPM-2020-KN-AG call. The project is carried out by a partnership of highly specialised institutions from Italy (The Consortium Italian Centre for Risk Reduction - CI3R and the Italian Civil Protection Department - ICPD), Portugal (Association for the Development of Industrial Aerodynamics - ADAI) and Norway (University of Stavanger - UiS).

The main goal of the project is to establish a European Doctrine on disaster risk and crisis management funded on the cooperation of scientific communities and disaster risk management (DRM) authorities. In this light, ROADMAP will contribute to increase access to information on DRM and disaster risk reduction (DRR) by systematically collecting, reviewing, and analysing past and ongoing experiences. To reach its main goal, ROADMAP activities foresee the identification of good practices, successful stories and lessons learnt to make them available and usable to the communities of DRM and DRR practitioners to further increase their understanding of DRM solutions, in compliance with the United Nations' Sendai Framework for Disaster Risk Reduction 2015-2030. The findings of the project are disseminated through periodical bulletins, webinars and three thematic papers, each focusing on a selected relevant topic. The thematic papers will feed into another relevant project's output, the web tool Solutions Explorer. In addition, mainly drawing from the analysis carried out in the thematic papers, a Vision Paper to the DG ECHO is also included among the products as the final step of the project. The Vision Paper aims at setting the baseline for the creation of a European Doctrine on disaster risk and crisis management.

This is the second ROADMAP thematic paper, and it aims at identifying good practices in risk and crisis communication. By establishing a set of criteria based on the Sendai Framework, the paper extrapolates good practices in risk and crisis communication from case studies of disastrous situations where good practices were already successfully applied, according to the evaluation of the author(s) writing about the case.

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1. Introduction

Risk and crisis communication[1] is an extremely difficult and articulated task. Experts and authorities are requested to deliver information and provide precise answers to situations that are by nature complex and multifaceted and that involve a high level of uncertainty. In addition, citizens are increasingly more informed and have become active participants in the communication (Bianchi & Carra, 2021).

Such premise emphasises the need to consider several assumptions in the process of risk and crisis communication, namely: a) different types of hazards[1], risks[1] and disasters can occur simultaneously (cf. Capone et al., 2022), and they are linked to different risk perceptions and vulnerabilities (Garcia-Aristizabal et al., 2015), thus implying that diverse strategies of communication need to be adopted; b) communication is often context-specific, which means that a communication strategy that is effective in one context is not necessarily so in another; c) communication is not unidirectional (i.e., transmission of information from the sender to the receiver), but it is built from and with the community with the involvement of several actors (including policymakers and risk/crisis managers; cf. McMackin & Lundgren, 2018). All of these caveats must be considered when studying risk and crisis communication.

A special responsibility lies with decision-makers, disaster risk managers, and civil protection experts particularly in terms of the effects of the communication on the public. An assessment of the good practices (GPs) in risk and crisis communication, therefore, could be of great help for policymakers and risk/crisis managers for establishing better communication strategies with their communities. GPs consist of "methods or techniques that are applied to solve existing problems producing effective results and bringing benefits to the users" (Capone et al., 2022, p. 11)[1].

The objective of this second ROADMAP thematic paper is to map out and evaluate, against established criteria, communication GPs in risk and crisis management in multi-hazard risk scenarios. For scenarios we mean "descriptions of plausible events that may occur in the future, leading to a particular set of outcomes. They are based on assumptions about key driving forces, interconnections, and relationships, and can capture the uncertainties and complexities of a system in a coherent manner" (CCRS, 2020, p. 11)[1]. Starting from the analysis of case studies[1], evidence-driven GPs for effective risk and crisis communication are provided.

Risk communication is strictly related to risk perception and aims at informing on and preventing risky choices and behaviours based on how the same risk is perceived. It is "grounded in an assumption that the public has a generalized right to know about hazards and risks. The availability of information allows the public to make informed choices regarding risk. In this way risk communication facilitates decision making and risk sharing" (Reynolds & Seeger, 2005, p. 45). More in general, the availability of information allows both the authorities and the public to make informed decisions.

While risk communication focuses on preventing harm, crisis communication focuses on the communication in the imminence or during a negative event (Steelman & McCaffrey, 2012; for an extensive explanation cf. Reynolds & Seeger, 2005) with the aim to mitigate its impact. The term often refers to communication during emergencies (Reynolds & Seeger, 2005).

Going beyond the origins and uses of terms and placing the attention on the timeframe when the communication takes place (e.g., in ordinary times, or before, during and after the outbreak of a crisis), the choice of terminology that includes both risk and crisis communication is warranted by the will to consider communication in all the disaster stages. In other words, we intend to consider all the disaster risk management cycle in its most comprehensive definition: adaptation, mitigation, prevention, preparedness, response, recovery and reconstruction (e.g., Morsut, 2019; cf. Capone et al., 2022). Indeed, risk perception is a process that encompasses all stages of the risk cycle: difficulties in communicating during the emergency are rooted into the communication strategy (or lack thereof) in previous stages. It is vital for risk and crisis communication to understand, stay abreast of and forecast the developments of the situation to take informed decisions (i.e., situational awareness; Endsley, 2017). This stands at any governance level and involves citizens, technicians, scientists and decision makers.

This paper is organised as follows:

First (Section 2 – Setting the scene), the knowledge background that underpins the GPs in risk and crisis communication is explained. Some risk and crisis communication models, frameworks and approaches are briefly described and, in particular, the Sendai Framework).

Then (Section 3 - Method), details are provided on the analytical framework of this paper consisting of a list of premises, which constitute its general approach, fol-

[1] For this and other definitions, please refer to the Glossary at the end of this thematic paper.

lowed by the evaluation criteria generated through an analytical reading of the Sendai Framework. The analytical framework is used to guide the selection of the case studies and the search for GPs therein as well as to discuss critically the effective application of these practices into disaster situations.
Once identified, the case studies have been summarised and analytically presented by illustrating: a) which and how the criteria extrapolated from the Sendai Framework were met and; b) if and how they were met in multi-stakeholder, multi-scale, multi-hazard risk, multi-phase, multi-dimensional risk and crisis approach (Section 4 - Identification of good practices).
Section 5 contains the discussion, while Section 6 concludes the thematic paper.

2. Setting the scene

2.1 Multi-hazard risk approach

The EU regulation 2021/836 of the European Parliament and Council (European Parliament & Council, 2021) advocates the necessity to prevent, prepare, and respond to natural and manmade disasters, making explicit reference to the situation that the Covid-19 pandemic has forced the entire world to face. In particular, it mentions different dimensions affected by such situation, namely, human health, the environment, society, and the economy. The coexistence of all these dimensions entails the need to prevent, prepare for, and respond to different types of risk that can occur in a given context, of which the health-related ones represent only one possible aspect. Moreover, it is not only a matter of considering co-existing risks but also how they are interrelated. For instance, climate change generates a number of consequences, some of which have been identified as the originating factors of the spread of the Covid-19 virus (Beyer et al., 2021).
The context just outlined warrants the need for a multi-hazard risk approach for risk and crisis management (cf. European Parliament & Council, 2021). According to the analysis of Kappes and colleagues (2012), the term *multi-hazard* simultaneously defines two approaches: 1) one, spatially oriented, that aims at including all relevant hazards in a defined area; 2) the second, thematically defined upon the objectives of the research study which apply such approach, that considers a specific event related to multiple hazards. In the first case, the need is to define a geographic area and make it explicit what one means by *relevant* (quantify). For example, the European Commission proposed a set of criteria to establish all the significant hazards at a national level (cf. the Working Paper *Risk Assessment and Mapping Guidelines for Disaster Management*; European Commission, 2010). In addition, the time frame of interest should be defined and, when possible, the related probabilities of occurrence. In the second case, the focus is on a single hazard and its cascading effects.
In both cases, the assumptions and challenges are the same (Kappes et al., 2012, p.1927):

1. different hazards involve different characteristics, which need to be addressed differently;
2. hazards are related and influence each other (i.e., chains, cascades, etc.);
3. natural processes exert diverging impacts on elements at risk, and methods to describe vulnerability vary between hazards;
4. a variety of risk description and quantification measures exists and has to be adapted to enable the comparison of multiple risks.

Moreover, it is important to bear in mind that the impacts of multiple hazards are not related only to how they combine and interact to minimise or intensify one another but they may vary also according to the reference context (i.e., the situation in which they occur), including the physical and social vulnerability and the exposure of the elements at risk.
In line with the objectives proposed in this paper and the examination of the multi-hazard risk approach presented in the ROADMAP first thematic paper by Capone et al. (2022), the spatially oriented perspective is adopted here by placing the context at the centre. As Capone et al. (2022) showed, the terms multi-hazard and multi-risk are linked in many studies and often only multi-hazard is mentioned. With reference to the perspective presented by Garcia-Aristizabal et al. (2015) for the multi-risk assessment, we choose here to adopt the term *multi-hazard risk*: "A full multi-risk assessment should consider all the possible hazard sources and the effects on all the exposed elements, and should identify all the possible interaction scenarios (cascading effects). […]. In practice, it is necessary to set the problem in a way that the transition single risk > multi hazard risk > multi risk is feasible, and the multi risk level can be reached when it is possible and necessary." (Garcia-Aristizabal et al., 2015, pp. 231-232).

2.2 Risk and crisis communication in multi-hazard risk scenarios

The same EU document previously cited (European Parliament and Council, 2021) repeatedly emphasises, on the one hand, the importance of being prepared for, and, on the other, to prevent disasters. A key role in this is played by risk and crisis communication. Communication aims not only to inform but also to increase knowledge and construct the perception of a phenomenon (cf. risk construction; Joffé, 2003). Its functioning is fundamental because it underpins action and behaviour. In this sense, GPs in risk and crisis communication are a subset of GPs in risk and crisis management.
On how and for what purpose to implement risk and crisis communication, Heath and O'Hair (2009, p. 5) state:
"Get a credible spokesperson who can deliver a knowl-

edgeable message in a clear manner. Communicate in ways [...] that encourage audiences to identify with risk communicators. Be clear to be understood. Be sensitive to the audience members' outrage and concerns. [...] Know the risk, frame the risk with a fear appeal (of varying degrees), report the risk, and gain the advantage of behavioural change to alter targeted audiences' health-related behaviour."

"Knowing, framing and reporting the risk" comes back to the public understanding of risk, where scientific knowledge is shared. Constructing the perception of risk through communication "invests evaluation into the process in many profound ways beyond the mere efforts to affect probabilities of occurrence, harms, and magnitudes" (Heath & O'Hair, 2009, p. 14). It requires considering many factors (e.g., emotions, motivation) together with technical knowledge. This necessitates various experts with different disciplinary backgrounds to work in concert so that they know what to communicate and how ("knowledgeable message in a clear manner"; Heath and O'Hair, 2009, p. 5). Communication has to be built on a knowledge that may sometimes be uncertain but nevertheless has to be understandable. In order for it to be understandable and effective, disaster managers must consider the socio-cultural context within which information flows and communication happens, therefore considering aspects that go beyond mere information. This implies overcoming models of communication as transmission of information and considering this activity as a construction process that takes place between all actors involved and considers all stages that constitute the same process from creating to re-using data (i.e. all the information management cycle).

To be understandable and effective, communication has to be constructed according to the socio-cultural context of reference: "The fact that knowledge travels, and is read differently by different audiences, strongly suggests that robust risk communication that can withstand social questioning must be built on protocols that are derived with the knowledge itself, paying attention to the relationships between authors and readers" (Donovan et al., 2019, p. 16).

The above considerations raise another question: Who are the actors involved in this process? In order to boost the effectiveness of communication, it is necessary that the approach taken considers the multiplicity of stakeholders involved, promoting communication between them in different risk cycle phases (i.e., multi-stakeholders approach).

Given this standpoint, it is also necessary to keep abreast of the modes and channels of communication, which are constantly and rapidly evolving. An emblematic case is the impact of social media, which has implied a change both in the means of communication and in the way in which communication is constructed (cf. Hallahan, 2009). Social media involve top-down processes, with institutional communication and emergency management practices, and bottom-up processes, with self-organizing activities (Sarrica et al., 2018). Moreover, social media allow also citizens to be an active part of the information sharing processes, challenging the traditional hierarchies of media and agency systems (cf. Helsloot & Ruitenberg, 2004). A glaring example of this is crowdsourcing: in risk and crisis communication, with particular reference to the use of social media, crowdsourcing is the outsourcing to the public of collecting large amounts of risk and crisis related data (e.g., through measurement or observation) in real time (Robinson, 2017: cf. Weiner, 1985; Seltzer & Mahmoudi, 2013; Van der Windt & Humphreys, 2016). Similarly to citizen science and participatory mapping, this approach fosters public participation in gathering scientific observation and is facilitated by the use of information and communication technologies such as social media.

The importance of risk and crisis communication is also proved by many projects financed by the European Union. Among others, for example, in the Horizon2020 BuildERS project[2], one part is aimed at improving the understanding of how communication-related issues and actions may affect vulnerability and resilience (cf. Hansson et al., 2020). A work package (WP8) of the Horizon2020 CARISMAND project is devoted to risk communication, with a specific focus on the role of the media in this field[3]. More recently, the Horizon2020 COVINFORM project[4] deals with the communication strategies during the Covid-19 pandemic. Finally, the Horizon2020 ENGAGE project[5] aims at understanding how authorities and first responders use various communication channels to promote societal resilience.

To sum up, risk and crisis communication GPs must not only be defined but also continuously updated by taking into account a) multi-hazard risk scenarios; b) all the phases of the DRM cycle; c) all possible disaster stages and; d) the context (including all the actors and their relations in a specific time and space). This involves a major challenge: considering different strategies according to the type of risks involved and their interaction, and the DRM cycle phase, with a context-driven approach. These premises suggest the need to proceed according to a body of established knowledge and underline the importance of learning from experience. For this reason, first, some models, theories and frameworks for risk and crisis communication are presented. Second, we extrapolate good communication practices from concrete situations (i.e., case studies), applicable in multi hazard risk scenarios, along the dimensions identified in the established analytical framework (see Section 3).

2 https://buildersproject.eu/
3 https://www.carismand.eu/activities/work-packages.html#wp8
4 https://www.covinform.eu/
5 https://www.project-engage.eu/

2.3 Background on risk and crisis communication

Various frameworks, models, theories have been proposed to better understand how risk and crisis communication works.

The Situational Crisis Communication Theory (SCCT; Coombs, 2007) is specifically devoted to crisis communication and provides a set of guidelines, which relies on experimental studies, on "how crisis managers can use crisis response strategies to protect a reputation from the ravages of a crisis" (Coombs, 2007, p. 163). The theory can be applied by (and is addressed to) both profit and non-profit organisations (cf. Sisco et al., 2010). The SCCT is based on the Attribution Theory (Weiner, 1985), which states that people tend to search for a subject to which to attribute responsibility of (mainly negative and unexpected) events. The SCCT individuates a system of relations among factors that ultimately influence organisational reputation and behavioural intention. Understanding how stakeholders will respond to the crisis should inform how to build the post-crisis communication. The strategies suggested by the application of this theory aim at protecting organisations against negative reactions to a crisis. More recently Coombs (2017) revised the theory considering the role of social media, primarily as a channel of crisis communication and stating the increasingly public nature of the pre-crisis phase.

The Crisis and Emergency Risk Communication (CERC) is a five-stage model first theorised by Reynolds and Seeger (2005) and developed by the Center for Disease Control and Prevention (Atlanta, US). Unlike the above mentioned SCCT, it tries to combine the notions of risk and crisis communication in the public health domain. The model individuates five stages of a crisis and identifies communication strategies for each of these: "The blended form of crisis and risk communication, then, incorporates principles of effective risk communication and crisis communication throughout the evolution of a risk factor into a crisis event and on through the clean-up and recovery phase" (Reynolds & Seeger, 2005, p. 51). The five stages are (cf. also Miller et al. 2021 for a review of the model and its uses): 1) *pre-crisis*, where the potential threat is detected and the communication is aimed at the public understanding of risk and how to cope if the threat evolves into a crisis; 2) *initial event*, where communication is aimed at reducing uncertainty, and promote reassurance; 3) *maintenance*, where the purposes of communication remain the same as before, and the organisation continues to work on the public understanding of risk; 4) *resolution*, that refers to the communication that characterises the end of the crisis event, and is aimed at the reporting findings on the causes of the crisis, restoration and rebuilding both of the public and the agencies and organisations; 5) *evaluation*, which includes assessment of all the communications and discussion on the adequacy of the response. While it has the advantage of providing clear guidelines and considering all the crisis stages, according to Miller et al. (2021) this model shows a particular criticality which became evident with the Covid-19 pandemic, namely the lack of explicit guidance for shifting communication needs during a long-term maintenance phase.

The Communication Ecology Approach (Spialek et al., 2016; Spialek & Houston 2018; 2019) poses the attention not only to local emergency management, media, and other community-based organisations (meso-level communication resources, like the previously presented model), but also on interpersonal connections among citizens affected by the disasters (micro-level communication resources) and stresses the coping function that communication can play (cf. Spialek & Houston, 2018). The communication process involved in this approach is defined by Spialek and Houston (2018, p. 937) as the activation of "networks of communication resources (e.g., organisations, media, and residents) that are utilised to cope with mental, behavioural, and physical health challenges occurring at different disaster phases" and interact across ecological levels. More than how to build effective communication strategies, this approach suggests how to construct an effective communication infrastructure to foster civic engagement and disaster preparedness (Spialek et al., 2016).

Referring specifically to the health sector, the European Centre for Disease Prevention and Control stresses the importance of risk and crisis communication proposing some principles for effective health communication practices and message development (https://www.ecdc.europa.eu/en/health-communication). These are: a) accuracy; b) availability (to the audience); c) balancing benefits and risks of potential actions; d) consistency; e) considering the cultural competence of the selected population; f) evidence-based practice guidelines, performance measure, review criteria, and technology assessments; g) reaching the largest possible number of people in the target population; h) reliability (of the source) and keeping up to date contents; i) repetition overtime of the contents; j) timeliness of the content based on the receptivity of the audience; and k) understandability (reading or language level and format).

The Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework, 2015) was adopted at the Third United Nations World Conference on Disaster Risk Reduction. Unlike the other presented model/approaches/theories, it does not specifically address communication, although it does include it. The strength of this framework relies on promoting multi-hazard risk and multi-sectoral practices considering each context and relative capabilities in different risk cycle phases, from prevention to recovery. It is widely used by both academic and professional as a resilience framework of reference to manage the different aspects of risk and crisis management.
There are various frameworks, models, and theories that guide risk and crisis communication and, given the com-

plexity of the subject, it makes no sense to state that one is better than the other, nor that there can be one that encompass them all. It is important to refer to the one that best adheres to the prefixed objectives. Here, we intend to adopt a multi-hazard risk, multi-stakeholder, and multi-scale approach, considering both risk and crisis communication, to produce an output that is usable by policymakers and risk and crisis managers. Therefore, we decided to adopt the Sendai Framework that encompasses these aspects, and which is already a well-known reference for our audience.

3. Method

To pursue the objective of identifying GPs of risk and crisis communication applicable in multi-hazard risk scenarios, we examine case studies (CSs) of disastrous situations where these practices were already successfully applied, according to the evaluation of the documents' author(s). While CSs on this topic available in the scientific and grey literature are numerous, there is the need to set up an analytical framework with indicators that allow to distinguish CSs highlighting GPs from those that just describe risk and crisis communication in general.
Thus, we proceed as follow. First, following the premises outlined in the introduction, we characterise the general approach underpinning the risk and crisis communication GPs (paragraph 3.1). Second, we extrapolate the criteria for the evaluation of CSs from the Sendai Framework (paragraph 3.2). From these criteria, a list of keywords and themes is derived to serve as a guide for the identification of a preliminary list of possible CSs (paragraph 3.3). Then, after describing the procedure guiding the identification, a second stage of selection is performed (and reported) on the basis of exclusion and inclusion criteria (paragraph 3.4). As a further step, in order to be included in the analysis, CSs that fall within the inclusion criteria have to fulfil at least two criteria extrapolated from the Sendai Framework. Finally, CSs are presented (paragraph 3.5).
In order to discuss GPs in diverse hazards and risk scenarios, we consider: 1) how CSs meet the premises and the general approach that drive this thematic paper; 2) the ways in which the GPs materialise the theoretical criteria extracted from the Sendai Framework in a real DRM context (this procedure is explained in paragraph 3.6).

3.1 General approach

The premises of this thematic paper underline the value of an approach that is:

- *Multi-stakeholder*: For each CS the interactions among the multitude of stakeholders involved in disaster risk and crisis communication have been considered across all the phases of the disaster cycle. Thus, the CSs have not focused on a single emergency actor; rather they illuminated how communication occurred within a network of stakeholders and in different risk cycle phases.
- *Multi-scale*: While the Sendai Framework aims for a global outreach, it contains several references to all the governance levels (global, regional, national and local), stressing the need to tailoring and adapting recommendations to the specific contexts and realities. Along this line, selected CSs have elucidated how the practice worked at multiple scales.
- *Multi-hazard risk:* Scientific and empirical evidence has proved the need for a multi-hazard risk approach in addressing disaster risk. Opposed to much literature that has highlighted practices of communication for a single hazard and/or a single risk (e.g., flood risk communication), the selection of CSs for this thematic paper preferably focused on practices that showed to work in a multi-hazard risk context.

The same approach has to consider:

- *All the information management cycle:* In line with the Sendai Framework, the present thematic paper gathers CSs illuminating effective strategies for dealing with risk data across all the information management cycle, including data and information collection, analysis, management, use, dissemination and preservation.
- *All the disaster risk management cycle:* The inclusion of both risk and crisis communication relies on the necessity to take into account all the DRM cycle phases (from prevention to recovery).

3.2 Extrapolation of the criteria from the Sendai Framework

The Sendai Framework states the objective of achieving a "substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets persons, businesses, communities and countries" by 2030. In the pursuit of this end, it lays out several principles to guide concrete actions, including an all-of-society engagement and partnership (19d), the establishment of coordination mechanisms (19e) and the importance of risk-informed decision making and disaster risk reduction (DRR) policies and investments (19h, 19j), thanks to the open access to, dissemination and exchange of updated and disaggregated risk data (19g) and the development of global partnerships (19l).
The theme of risk and crisis communication is particularly developed under Priority 1 (Understanding Disaster Risk) wherein the Framework advises:
"To promote the collection, analysis, management and use of relevant data and practical information and ensure its dissemination, taking into account the needs of different categories of users, as appropriate" (art. 24a).
The different components of the data management cycle are then better specified in following articles and

paragraphs. For example, art. 24c addresses the need to develop location-based risk information and disseminate it to a range of audiences and in an appropriate format. This should be done by seizing the opportunities offered by GIS technologies and ICTs, as also expressed in art. 24f.

EVALUATION CRITERION 1: Location-based risk data

GPs in risk and crisis communication should include the collection and dissemination to a wide audience and in an appropriate format of location-based risk data, also by the leveraging of new information and communication technologies, including GIS.

Other three articles address specifically the aspects concerning the access to, use and dissemination of risk data and information. As for the access, it is recurrently mentioned that risk data has to be provided in a free and fully open fashion (art. 24e).

EVALUATION CRITERION 2: Risk data accessible and open

GPs in risk and crisis communication should ensure that risk data and information are freely accessible and provided as an open source.

Concerning the aspect of dissemination, the Sendai Framework promotes tailored public education and awareness campaigns on DRR topics, both at local (art. 24e) and international level (art. 25f), also by employing new communication media such as social media and community mobilisation and by building on existing campaigns that proved successful. These initiatives can be aimed "to promote a culture of disaster prevention, resilience and responsible citizenship, generate understanding of disaster risk, support mutual learning and share experiences; and encourage public and private stakeholders to actively engage in such initiatives and to develop new ones at the local, national, regional and global levels" (art. 25f).

EVALUATION CRITERION 3: Risk awareness and education through social media and social mobilization

GPs in risk and crisis communication should be aimed at risk education and awareness, both at local and international level, also by the support of innovative communication channels, such as social media, and by social mobilization.

Furthermore, it appears critical to make appropriate use of the collected risk data and information to design DRR policies/plans (art. 24m) and formal and informal education curricula, including civic education (art. 24l).

EVALUATION CRITERION 4 (a): Risk data into DRR policies and plans

GPs in risk and crisis communication should ensure the incorporation of risk data and information into DRR policies and plans.

EVALUATION CRITERION 4 (b): Risk data into formal and informal education

GPs in risk and crisis communication should ensure the incorporation of risk data and information into DRR formal and informal education.

According to the Sendai Framework, local stakeholders play a key role in the development and implementation of DRR strategies. For this reason, it is advised to collaborate with local groups, including community-based and non-governmental organisations, for the dissemination of disaster risk information (art. 24o) and to harness local and indigenous knowledge to complement scientific knowledge and to adapt strategies to the specific contexts (art. 24i).

EVALUATION CRITERION 5: Harness Community-Based Organizations (CBOs) and Non-Governmental Organizations (NGOs) and local and indigenous knowledge

GPs in risk and crisis communication should harness local CBOs and NGOs for the dissemination of disaster risk information and value local knowledge as complementary to scientific information.

Throughout the Sendai Framework, particular emphasis is placed upon the sharing of knowledge, lessons learned and experiences and the development of dialogue and partnerships among stakeholders (art. 24g). Collaboration is fostered among the scientific, technical and policy communities to facilitate a science-policy interface for effective decision making in disaster risk management (art. 24h) as well as in the form of international cooperation, including transfer of technology for DRR (art. 25c). The exchange of GPs and lessons learned can be facilitated through the development of local, national, regional and global user-friendly systems and services (art. 25e).

EVALUATION CRITERION 6: Promote info exchange and dialogue among stakeholders

GPs in risk and crisis communication should promote the exchange and transfer of effective practices, lessons learned and technology for DRR at local, national, regional and global level, by the employment of user-friendly systems and services and the dialogue and cooperation among stakeholders, including the creation of science-policy interfaces for effective decision-making.

These six criteria can be applied to the communication that takes place in all the phases of the risk management cycle and whoever are the players involved in the communicative process. Furthermore, they work well in multi-hazard risk scenarios and across all the governance scales.
Since its guiding principles, the Sendai Framework articulates the topic of risk and crisis communication in its broader meaning, shying away from a conceptual model of one-way communication toward a more compre-

hensive and multi-stakeholder conceptualization which emphasizes the role of risk data and risk information in the attainment of DRR goals.
The analytical framework resulting from the combination of the general premises and the evaluation criteria derived from Sendai Framework is summarized in table 1 in the Appendix.

3.3 Extracting keywords and key themes

The above review of the risk and crisis communication references within the Sendai Framework makes it clear that communication is to be intended as a process, rather than a product, emanating from the concerted effort of different actors. This process needs to:

- Be thoroughly informed by risk data;
- Foster risk education and awareness;
- Pay attention to all the components of data and information management, including data collection, analysis, use and dissemination;
- Be based on open and fully accessible data;
- Promote collaboration with local stakeholders and the leveraging of local resources, including indigenous knowledge;
- Be based on the collaboration between different stakeholders at multiple levels, including international cooperation and be aimed at forging partnerships between the technical, scientific and policymaking communities;
- Be sensitive to the needs of different categories and local contexts and realities, as well as of vulnerable people;
- Seize the opportunities offered by new information and communication technologies, such as social media and GIS.

Building on the above criteria, we performed a critical review of the existing literature to sift through CSs of risk and crisis communication that incorporated these themes. Unlike other types of literature analysis (e.g., systematic reviews), a critical review is not intended to present all the extant literature on a topic under review; rather it purposely researches literature making a critical evaluation of it (Grant & Booth, 2009). It follows that this type of review may emphasise some examples of practices that fit well into the established framework of criteria at the expense of other practices that have also proved relevant in the risk and crisis communication domain. For example, the criteria leave out important aspects of risk and crisis communication such as the role of trust in the information sources (e.g., Longstaff & Yang, 2008), the public communication needs (Spialek & Houston, 2018), the communication objectives and style (Sturges, 1994; Davis & Gardner, 2012) and the relationship between risk perception and risk communication (Ellen et al., 2007). Despite the specific references to local realities and contexts, little emphasis is also given to the disaster communication ecologies, namely to the interaction and mutual influences between the information that flows from a variety of sources (e.g., Spialek et al., 2016).
Key words and themes extrapolated from our framework have informed the search for relevant CSs, which were selected globally to ensure worldwide geographical coverage.

3.4 Case studies identification and selection

The following platforms have been used to collect information about projects and CSs:

- Google Scholar
- Preventionweb
- CDAC Network (https://www.cdacnetwork.org/)
- Global Facility for Disaster Reduction and Recovery (GFDRR; https://www.gfdrr.org/en)
- Open Data for Resilience Initiative (https://opendri.org/)
- UNICEF (https://www.unicef.org/lac/en)
- Kathmandu Living Lab (https://www.kathmandulivinglabs.org/)

In generalist platforms such as Google Scholar, we applied strings like “case study” and at least one of the following strings “risk communication” or “crisis communication” ina period between 2010 and 2022. With regard to more specific platforms for project identification, the items were directly searched without using queries. The identification was made based on the extracted keywords and themes (cf. paragraph 3.2). Then, documents containing CSs were selected in line with the conditions listed below.

3.4.1 Conditions of exclusion

- The source presents only an analysis of the literature or of the state of the art on risk and crisis communication;
- The source details the technical characteristics of a technology or platform for disaster response or risk management;
- The source lists the communication challenges/weaknesses in a CS and provides recommendations on how communication could work better;
- The source describes communication dynamics on a social media platform (e.g., Twitter communication during the response to a disaster);
- The source presents a practice that could potentially work in a context but has not been applied yet;
- The source addresses crisis communication in an organisational context.

3.4.2 Conditions of inclusion

- The source describes a CS wherein the practice of risk and/or crisis communication has been successfully applied in a real context;
- The source provides enough details to understand how the practice has been realised in a given context (e.g., how crisis communication has occurred in a disaster response);
- The source contains practices that fulfil at least 2 evaluation criteria extracted from the Sendai Framework.

- The source provides evidence of the effectiveness of the practice(s) in the reference context, not just a description of its application.

3.5 Case studies presentation

For each identified CS, we have presented the following information:

- Source of the information;
- Brief description of the CS[6];
- List of the evaluation criteria fulfilled by the practice(s) highlighted in the CSs (to see how they were satisfied cf. paragraph 4.2);

Moreover, we have included information related to this thematic paper's premises (paragraph 3.1), namely:

- Governance level in which the practice played out (scale);
- Type of hazard associated with the practice(s);
- Phase of the DRM cycle;
- Dimensions of the information management cycle considered (creating, processing, analysing, preserving, re-using data).

The premise related to the multi-stakeholder approach partially overlaps with the evaluation criteria six (EC6) extrapolated from the Sendai Framework, therefore it was not repeated.

3.6 From case studies to scenarios

In the table in paragraph 4.2, for each CS it was explained if and how the criterion described in the analytical framework was met. A comparison was made on how the practice(s) met the criteria in relation to the characteristics of the CS (scale, hazard, phase, communication dimension, etc.). This exercise was useful for: (i) considering the effectiveness of the practice in relation to the specific context and; (ii) understanding whether similar practices were replicated in different contexts and disastrous situations. This comparison allowed for the identification of GPs in risk and crisis communication that can be incorporated into future multi-hazard risk scenarios for emergency preparedness and response planning.

4. Identification of the good practices

For the description of the case studies, we cited the text as it appeared in the source which is mentioned in the top row of the table. In order to make the description more concise, we cited only the parts of the text that provided information relevant to the TP's goals.

4.1 Case Studies Summaries

In the following tables, we summarise the case studies analysed.

[6] The description is taken from the corresponding cited document with some reworking for the sake of synthesis.

CS1 - Communication between institutional and local actors on health prevention (SENTIERI project)	
SOURCE	Marsili, D., Pasetto, R., Iavarone, I., Fazzo, L., Zona, A., & Comba, P. (2021). Fostering Environmental Health Literacy in Contaminated Sites: National and Local Experience in Italy from a Public Health and Equity Perspective. Frontiers in Communication, 175. https://www.frontiersin.org/articles/10.3389/fcomm.2021.697547/full

DESCRIPTION

SENTIERI is a nationally coordinated initiative to share and adopt strategies for communication in contaminated sites. The SENTIERI communication strategy emphasised the engagement of local institutional and social actors to foster health prevention, environment remediation and participatory engagement in decision-making by integrating the environment and health sectors. The project was applied in two settings both located in Italy, namely Milazzo in Sicily and Porto Torres in Sardinia. In Sicily, the SENTIERI initiative benefited from the existence of a long-standing collaboration and two-way communication between the Committee of the persons formerly exposed to contamination and the Italian Institute of Health (ISS). This interaction was facilitated by the participation of researchers and social actors in local communication events. The study findings contributed to the design of novel preventive actions by the Committee and affected workers for the recognition of occupational disease and the access to social security benefits. Public meetings with citizens and social actors were held to communicate health risks. This contributed to strengthening prevention and behavioural change initiatives. A key indicator demonstrating the successful communication is seen by the inclusion of the shared prevention actions in the Sicilian Regional Plan of Health Interventions in the contaminated site of Biancavilla. In Porto Torres an epidemiological study has been designed and implemented to describe the health profile of the population residing in the municipality of Porto Torres by adopting a systematic and inclusive approach for the collection of environmental and health data and the communication of the study findings to the community. Also, an interactive map was developed including a glossary with definitions translating commonly used scientific words into lay language. Local educational institutions were involved through the realisation of training-to-trainers and peer-to-peer activities. The project allowed better inter-sectoral relationships between the involved environmental and health institutional actors at local level.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk data accessible and open (#EC2) Risk data into DRR policies and plans (#EC4a) Formal and informal education (#EC4b) Harness community-based organizations-CBOs and non-governmental organizations-NGOs and local knowledge (#EC5) Promote dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
National project with local applications	CBRN
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, analysis (methodology), use and dissemination

CS2 - Communication before and during Gunbarrel fire (USA)	
SOURCE	Steelman, T. A., & McCaffrey, S. (2013). Best practices in risk and crisis communication: Implications for natural hazards management. Natural hazards, 65(1), 683-705. https://link.springer.com/article/10.1007/s11069-012-0386-z

DESCRIPTION

During the Gunbarrel Fire (Shoshone National Forest, Wyoming, US), both local forest employees and the Incident Management Team (IMT) members in charge of information communicated actively with local government actors (sheriff, fire chief, emergency operations), so they could pass information on to local constituents. Local forest employees also made one-on-one visits to residents who were most affected by the fire and officials from the local forest and local government agencies as well as from the IMT remained after these meetings to answer questions. This strict collaboration was made possible by a prolonged engagement of the agencies with the citizenry. Indeed, in the years that preceded the fire, the county worked to educate property owners on defensible space in partnership with the local Forest Service. Local Forest Service employees worked cooperatively with local government and held an annual picnic with property owners to raise awareness of their role. The District Ranger was on a local radio show at least once a month. In addition, starting in 1989, local schools began to implement a school-based fire education program. This engagement helped the local Forest Service employees understand how risk was perceived and what types of actions would be tolerated. Cumulative interaction over time created credibility for the Forest Service when the fire came.

FULFILLED CRITERIA

Risk awareness and education through social media and social mobilisation (#EC3) Risk data into formal and informal education (#EC4b) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
Local	Forest fire
DRM PHASE	**COMMUNICATION PROCESS**
Prevention, Preparedness & Response	Use and dissemination

CS3 - Promote info exchange and dialogue among stakeholders	
SOURCE	Community-led-partnership-resilience report https://www.gfdrr.org/en/publication/community-led-partnership-resilience (Source: GFDRR Community participation and citizen engagement https://www.gfdrr.org/en/citizen-engagement)

DESCRIPTION

WAGUCHA is a community-based organization of the afro-indigenous Garifuna people (Honduras) led by women who organized rescue, recovery and reconstruction in coastal towns after Hurricane Mitch in 1998. WAGUCHA has built an active multi-stakeholder platform linking national ministries to community priorities, creating a place for communities to participate in government emergency response and early warning strategies, land-use planning processes and to access livelihoods support. In 2008, WAGUCHA learned community-led risk mapping in a four-country peer learning exchange and showcased their seed banks and other adaptive practices to peers from Guatemala, Honduras, Nicaragua, and Jamaica. Systematically building on their relationships with policy makers, in 2010, WAGUCHA initiated the Inter-Agency Partnership for Community Resilience in Honduras. Since then, this multi-stakeholder partnership has linked grassroots priorities to national government agencies, giving local community access to information, budgets, and training, and influencing planning processes to address community resilience priorities. In 2014, the Permanent Commission for Contingencies in Honduras (COPECO) signed a Memorandum of Understanding formalising its partnership with WAGUCHA, through technical training and assistance to WAGUCHA to supplement information generated by community risk and vulnerability maps. This might include satellite maps and the use of GPS to improve communities' understanding of risks and help identify nearby evacuation shelters in the event of emergencies, the provision of emergency preparedness and response training for community volunteers and WAGUCHA's volunteer networks for emergency preparedness and response. COPECO's certification of community volunteers indicates a shift from working solely through government agencies to broader partnerships that incorporate community leadership and indicate that local and national governments are increasingly seeing grassroots leaders as expert practitioners whose collaboration is essential for developing more effective, robust climate and disaster resilience strategies.

FULFILLED CRITERIA

Location-based risk data (EC1#) Risk awareness and education through social media and social mobilisation (EC3#) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (EC5#) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
Cross-nations	Multi-hazard risk
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, use, and dissemination

CS4 - Risk Communication Programme of the city of Santa Fe (Argentina)	
SOURCE	Fontana, S. E., & Maurizi, V. F. (2019). Building capacity through risk communication strategies in Santa Fe city, Argentina. https://www.unisdr.org/files/66715_f446finalmaurizifontanariskcommunic.pdf

DESCRIPTION

The Risk Communication Programme of the city of Santa Fe was created in 2007 with the aim to increase the knowledge and understanding of flood risk in the city and to generate more information and awareness about the risks in the population. The efforts made by the city of Santa Fe to communicate risks concerning floods have been diverse, incorporating different strategies. These strategies included initiatives such as: 1) training activities such as workshops, courses, talks and conferences are identified; 2) fieldworks consisting in the collection of information in vulnerable areas; 3) talk and distribution of information to neighbours; 4) creating linkages with community actors through agreements with the media and dissemination of information in radio and television campaigns and; 5) the institutionalisation of actions taken in the elaboration of contingency manuals and protocols. In general, the risk communication of the city follows the communication for care approach whereby the communication is about a risk that is well-perceived among the population and, based on this, many of the graphic materials include content related to the preparation for this risk. Another relevant aspect is that most of the information generated is free and publicly available through traditional means of communication such as radio or television, but also through a blog, a website, YouTube and the city's Facebook account. Likewise, opportunities for face-to-face communication were created and coordinated by local authorities, with a participatory approach, where activities to improve risk understanding were carried out. All this information was added on the Contingences Plans made for every region of the City.
The Risk Communication Programme has included a series of publications that are disseminated among the population and have mainly been generated by the local government. Another action within the dissemination strategy has been the creation of the Blog on DRR associated with the city's web page, where all the elaborated communication materials are available. Disaster risk awareness strategies have focused on increasing risk perception through the understanding of its components. These consist of training workshops given to municipal servants and to different actors that make up the municipal DRR system, such as neighbours, organisations, teachers, students, journalists and the public. Cultural and artistic interventions are another type of action that has manifested. Finally, the work in schools with the "classroom-city" project constitutes the most complete awareness-raising action, bringing the governmental, school, family and students' sectors together through activities centred on historical risk understanding.

FULFILLED CRITERIA

Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (#EC5) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
Local	Multi-hazard risk
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, analysis, use and dissemination

CS5 - Communication about fires Kythira fires (Greece)	
SOURCE	Xanthopoulos, G., Athanasiou, M., Nikiforaki, A., Kaoukis, K., Mantakas, G., Xanthopoulos, P., ... & Varela, V. (2022). Innovative Action for Forest Fire Prevention in Kythira Island, Greece, through Mobilization and Cooperation of the Population: Methodology and Challenges. Sustainability, 14(2), 594. https://www.mdpi.com/2071-1050/14/2/594/pdf

DESCRIPTION

The island of Kythira in Greece suffered a major forest fire in 2017 which revealed many challenges regarding fire management. Following that, the Hellenic Society for the Protection of Nature (HSPN) joined forces with the Institute of Mediterranean and Forest Ecosystems (IMFE) in a project aiming to improve fire prevention through the mobilization and cooperation of the population. This work included: a) a series of workshops run by the fire experts of the two partners with inhabitants of Kythira on fire prevention. In the first meetings of this series, the teams of volunteers were formed to help assess the risk of destruction of individual homes; b) a series of workshops with elementary and high school students, aiming to make them aware of the issue of forest fires, providing them with practical information on prevention and with simple and effective take-home messages, including fire prevention leaflets to carry home; c) regarding dissemination of prevention messages at mass scale, the teams of the two partners prepared a four-page brochure that was distributed to the population at the start of the fire season of 2021. Local entrepreneurs suggested to print a similar brochure in foreign languages, to be distributed through hotel owners and other professionals to the numerous tourists visiting the island every summer; d) Voluntary field activities by volunteers and students including reforestation of selected sites, and understory fuel management in selected stands along roads; e) Production and distribution by local media and uploaded to YouTube of two short informative videos that addressed the following two topics: (1) how to make safe a home situated near forest vegetation; and: (2) how a person should react if threatened by a fire. A third video was also produced, documenting all the activities of the project. The interaction of experts with the citizens, the two-way communication, and the feeling that they were all participants in a common effort were keys to success.

FULFILLED CRITERIA

Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (#EC5)

GOVERNANCE SCALE	HAZARD
Local	Forest fire
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, analysis and dissemination

CS6 - Communication about floods	
SOURCE	Global Facility for Disaster Reduction and Recovery. (2018). Identifying success factors in crowd-sourced geographic information use in government. World Bank. https://opendri.org/wpcontent/uploads/2018/05/Crowdsourcing_VGI_Full_Report.pdf (p.78) and Holderness, T., & Turpin, E. (2015). From social media to geosocial intelligence: crowdsourcing civic co-management for flood response in Jakarta, Indonesia. In Social media for government services (pp. 115-133). Springer, Cham.

DESCRIPTION

Jakarta (Indonesia) is a megacity that has frequent seasonal flooding issues. In 2012, the Jakarta's disaster management agency (BPBD DKI Jakarta) needed better data to prepare for the flood season. By involving DFAT-Australia, UNOCHA, HOT, GFDRR, the University of Indonesia and the heads of the 267 urban villages, government maps to report flood conditions were created in addition to an open dataset that could be used for a variety of analyses at the village, district and provincial levels. In 2013, the Jakarta's disaster management agency (BPBD DKI Jakarta), together with SMART Infrastructure Facility (University of Wollongong, Australia) and Twitter Inc. conducted a pilot study to develop PetaJakarta.org platform, enabling Jakarta's citizens to report the locations of flood events using the social media network Twitter. The pilot study contributed to a public web-based real-time map of flood conditions powered by CogniCity OpenSource Software with megacity-scale visualisation of disasters, crowd-sourced reporting, and government agency validations in real time. The project demonstrated the value of social media in disaster management as an operational tool to provide decision support in the event of disaster. Since its debut in 2013, the PetaJakarta.org platform has grown into a single robust platform that integrates local knowledge from various crowdsourcing tools (mainly social media and instant messaging) and formal knowledge from government agencies. The project expanded to PetaBencana.id platform by the end of 2016. Since then, the PetaBencana.id platform has been used by millions of Jakarta resident users to make time-critical decision about safety and navigation during emergency flood events; it has also been adopted by the National Emergency Management Agency (BNPB) to monitor flood events, improve response times, and share time-critical emergency information with residents.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a) Harness CBOs and NGOs and local knowledge (#EC5) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
National	Floods
DRM PHASE	**COMMUNICATION PROCESS**
Prevention, Preparedness & Response	Collection, use, and dissemination

CS7 - Communication and community engagement platform	
SOURCE	CDAC Netwok (2019). Practical Experiences Building A Government-Led CCE Platform In Vanuatu https://www.cdacnetwork.org/case-studies/vanuatu-english

DESCRIPTION

Over the last two years (characterised by two major crises in Vanuatu: Tropical Cyclone Harold and the Covid-19 pandemic), the Australian Department of Foreign Affairs and Trade (DFAT) has sponsored a programme to build sustainable next-generation Communication and Community Engagement (CCE) capability in Vanuatu. This nationally grounded initiative has been led by Vanuatu's National Disaster Management Office (NDMO) with coordination support from the CDAC Network (organisations working on communication, community engagement and accountability in humanitarian action) and Ground Truth Solutions (GTS). The aim of the programme is 1) to establish the foundation for resilient two-way collaboration between people facing crises and the many organisations that seek to support them; 2) to build this capability as a platform that broadly integrates communication capabilities across the diverse ecosystem of organisations responding to a crisis (government, private sector, international actors, and civil society). Each of the capabilities needed to create a cycle of engagement (Speaking, Listening, Adapting, Preparing, Sharing, and Acting) across many different stakeholders. The resulting platform - a (sustainable and multi-stakeholder) platform - is designed to bring together the varied elements needed to generate timely content, communicate through multiple channels, collect and share insights from diverse sources, and conduct real time analysis. The heart of platform-building activities focused on creating a recognised home for sustainable communications capabilities centred in Vanuatu's existing disaster response system. While technology does play a part, the foundation of the platform is rooted in people and organisations. The CCE Platform is designed to evolve in response to actual experience. As new pieces are put in place, they can be tested against real life situations, providing new insights and guiding improvements in approach. This has been done for Tropical Cyclone Harold and the Covid-19 pandemic and resulted in activations of the CCE subcluster, where multiple stakeholders collaborated on the design and execution of new communication strategies. Tailored feedback tools were developed and the level of collaboration within the sub-cluster substantially increased, indicating that the platform is a working resource. The many elements of practice have been incorporated in a CCE Handbook, which can continue to evolve with the overall CCE effort.

FULFILLED CRITERIA

Risk data into DRR policies and plans (#EC4a) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (#EC5) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
National	Multi-hazard risk
DRM PHASE	**COMMUNICATION PROCESS**
All	Collection, analysis and dissemination

CS8 - Communication during the Kaikoura earthquake (NZ)	
SOURCE	Blake, D. M., Stevenson, J., Wotherspoon, L., Ivory, V., & Trotter, M. (2019). The role of data and information exchanges in transport system disaster recovery: A New Zealand case study. International journal of disaster risk reduction, 39, 101124. https://www.sciencedirect.com/science/article/pii/S2212420918314699

DESCRIPTION

The Mw7.8 earthquake on 14 November 2016 near Kaikōura (New Zealand) had major impacts on the country's transport system. Many information exchanges were effective, enabling the transport system to respond and adapt successfully, and allowing the continued mobility of users and goods. Organisations responding to transport disruptions drew on existing data sources in new ways, collected novel datasets, and leveraged relationships to manage information exchanges. Pre-existing data was repurposed in novel ways for decision-makers. For example, vehicle telematics and engine management systems, typically used by freight companies to monitor vehicle and operator performance, was repurposed to monitor road use, allow police to manage safety on the more dangerous 'alternate route', and to inform road maintenance decisions. Additionally, road user GPS was used in aggregate to model road use trends and patterns in the area, which informed police and tourism response activities. A large amount of new post-event data was collected and distributed by researchers, contractors, and government agencies in the aftermath of the earthquake. In addition to transport damage assessments, a transport damage and level of service classification system was enhanced and maintained by KiwiRail and the NZ Transport Agency to facilitate communication about damage states between multiple organisations. Similarly, data about repair costing, sequencing, and progress was created and shared through mechanisms established by the North Canterbury Transport Infrastructure Recovery (NCTIR) alliance, a partnership between private engineering and construction firms, the NZ Transport Agency, and KiwiRail. Several software-based technical systems assisted the response and recovery from the earthquake. Web-portals, which integrate diverse information sources into a consistent management interface, were developed and used to manage information about road risks, incidents and conditions, and to assist with information exchanges between port companies and transport operators. The Coordinated Incident Management System (CIMS), an incident management structure established to assist with how roles are assigned, was used as an emergency information management and decision-making tool by some organisations involved in the response including Maritime NZ and Air New Zealand as part of their incident management structure. Groups such as the MoT-led Transport Response Team activated to assist with the transfer of new information and data sources and to provide co-ordinated advice in the emergency. MoT's Joint Analytical Unit provided specific analysis, briefings and regular reports to Ministers and official groups, and commissioned external work. Existing and newly developed relationships and communication channels were key to the smooth information and data flows that occurred within and between organisations.

FULFILLED CRITERIA

Risk data accessible and open (#EC2) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
Local	Earthquake
DRM PHASE	**COMMUNICATION PROCESS**
Response & Recovery	Exchange & dissemination

CS9 - Infusing DRR into formal education curricula using a local content curriculum (LCC) space	
SOURCE	UNICEF. (2012). Disaster risk reduction in school curricula: Case studies from thirty countries. https://www.preventionweb.net/files/26470_drrincurriculamapping30countriesfin.pdf

DESCRIPTION

This is a collection of case studies included in the project of UNICEF/UNESCO "Mapping of Global DRR Integration into Education Curricula". It focuses on key national experiences and identification of good practices in the integration of disaster risk reduction (DRR) in the curricula. The report documented case studies from thirty countries. Here we report the case study from Indonesia. Indonesia offers an example of informing about DRR through formal curricula using a 'local content curriculum' (LCC) which allows for locally driven DRR curriculum development that is sensitive to the specific local needs and contexts. In this way, DRR is taught as a special subject within the LCC. In addition, DRR themes and topics are integrated into existing subjects. A self-development programme that takes place during the academic school year includes also DRR topics. To support teachers, a training manual with DRR modules, and reference materials have been developed in local languages. With regards to the teacher professional development, the Disaster Awareness in Primary Schools (DAPS) project was implemented with the aim to develop understanding of natural hazards as well as disaster prevention and mitigation knowledge and skills among primary school pupils. DAPS first trained key people (e.g., local consultants in targeted provinces) on major hazards (earthquakes, landslides, floods, and tsunami) who then spread information on what they had learned to school directors, teachers and other key stakeholders, who, then taught the pupils. Another initiative in integrating (at the elementary level) emerged through the Save the Children Yogyakarta earthquake response programme which supported 99 elementary schools in Bantul and Klaten districts. It included components of teacher training, curriculum development (including pilot testing), and advocacy. Teachers from 30 schools drafted Samples of Lesson Plans on Integrating Disaster Preparedness into Elementary School Subjects, which were fully in line with the national curriculum. After field tests in two schools for two months, this was finalized and printed as a manual. This project partnered with the government education office at sub-district level and four NGOs implemented the Emergency Education Preparedness and Psycho-Social Support (EEPS) that trained teachers using a cascade approach.

FULFILLED CRITERIA

Risk data accessible and open (#EC2) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (#EC5) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
National with local applications	Multi-hazard risk
DRM PHASE	**COMMUNICATION PROCESS**
Preparedness	Dissemination & use

CS10 - Communication through Maps for Everyone	
SOURCE	Kathmandu Living Lab website (no date) https://www.kathmandulivinglabs.org/projects/map-for-everyone

DESCRIPTION

Kathmandu Living Lab (KLL) is a leading civic-tech company based out of Nepal which supported the Government of Nepal by developing a tech system to conduct a post-disaster mobile data collection effort. Among them, there is Maps for Everyone - OpenStreetMap (OSM) – a free and editable map of the world. It is free to view, free to contribute and even free to download. The aim of the project is: a) sensitise students, development agencies, government and non-government organizations about OSM through Sensitization Presentations; b) deliver Mapping Workshops (also called Mapping Parties) to train people on mapping; c) expand its coverage and enhance the quality of OpenStreetMap data; d) stimulate innovations around OSM and OSM data. The OSM community members from Nepal were among the 9000+ digital volunteers who helped map post-disaster Nepal immediately after the 2015 Gorkha earthquake. Among other things, these maps helped the Nepal Army plan around 300 rescue operations, and helped a number of national and international organisations like the USAID, Canadian DART (Disaster Assistance Response Team) plan their relief and response operations. The base map prepared by the OSM community also helped QuakeMap to give locational context to its reports. These geo-located reports were used by aid organisations and voluntary groups to plan and execute their relief efforts. Map data produced by the OSM community have been used in the various places across nations to give locational context to Vulnerability Capability Assessment of communities across the nation.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a) Risk data into formal and informal education (#EC4b)

GOVERNANCE SCALE	HAZARD
National	Multi-hazard risk
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, use, and dissemination

CS11 - Revitalising Informal Settlements and their Environments (RISE)	
SOURCE	Wolff, E. (2021). The promise of a "people-centred" approach to floods: Types of participation in the global literature of citizen science and community-based flood risk reduction in the context of the Sendai Framework. Progress in Disaster Science, 10, 100171. https://www.sciencedirect.com/science/article/pii/S2590061721000314

DESCRIPTION

The RISE flood-monitoring project commenced in December 2018 and was conducted in seven settlements in Suva (Fiji) and in six settlements in Makassar (Indonesia). Community-members with no previous training in flood mapping actively contributed to the development of a database on water-level documentation to support infrastructure planning. All of the participants lived in the communities and were familiar with the floods experienced in the sites. A gauge and a crest level indicator were installed in close proximity to their homes in a position expected to register significant water level fluctuations according to anecdotal flood descriptions shared by the community. The participants were instructed to use their personal smartphones to send photos of the flood gauges daily in order to keep a record of the water levels throughout the whole rainy season, including photos, which were shared in a common messaging group. This connection played a significant role in creating an identity for the monitoring programme and motivating participation in the community. The photos allowed for a comprehensive documentation of water levels in different settlements across the same catchment and, therefore, provided useful evidence of flood risks in the area.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a)

GOVERNANCE SCALE	HAZARD
Cross-nations	Floods
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection and dissemination

CS12 - Communication about recovery after Canterbury earthquake (NZ)	
SOURCE	Tagliacozzo, S. (2017). Communication practices and social media usage by government agencies and citizens in the post-disaster reconstruction phase https://discovery.ucl.ac.uk/id/eprint/1563493/1/Serena%20Tagliacozzo%20-%20PhD.pdf (chapter 6)

DESCRIPTION

During the recovery process from the Canterbury earthquakes (New Zealand, 2010-2011), various participatory initiatives were organised by the New Zealand Government at both the local and national levels. One of the most famous initiatives was "Share an Idea", a campaign launched by Christchurch City Council a few months after the February 2011 earthquake. This campaign was mainly run on line over six weeks in order to seeking citizens' opinions and visions about how they wanted their city to be rebuilt. The inputs were used by the City Council to inform the draft of the Central City Plan, which had then to be integrated into the final blueprint for reconstruction produced by Canterbury Earthquake Recovery Authority (CERA). Another initiative was "In the Know Hub", which aimed to convey information to people faced with recovery issues. In order to see their questions on reconstruction and repair answered, residents could attend public seminars and Q&A sessions or consult the project's website and submit questions. Similarly, the "Future Christchurch" aimed to provide Canterbury residents with information on the ongoing projects and activities, in particular with regard to the rebuilding of Christchurch. The Future Christchurch website offered various kinds of information on the central city, residential properties and public transportation in Christchurch. A colorful container was placed in the Cathedral Square to give national and international visitors a direct insight into the Canterbury recovery and collect residents' inputs on recovery plans and documents. In July 2014, the Minister of the Canterbury Recovery launched the "Canvas: Your Thinking for the Red Zones" campaign. The core objective of the campaign was to gather people's visions on the land in order to inform how Crown-owned red zone lands should be used. People could make their voices heard by submitting ideas on the website, or returning the Ideas Card distributed via post or providing feedbacks during public meetings and workshops. Besides the consultation campaigns, initiatives have been launched to monitor and promote public health in the Canterbury region after the earthquakes. The "All Right?" campaign created by the Canterbury District Health Board made massive efforts to reach out to the most vulnerable social groups and give information about mental health support services by adopting a series of communication channels, including social media, to reach out to the most vulnerable and ensure that their mental health needs were being addressed. An example of efficient and effective public-private alliance in long-term recovery is given by Stronger Christchurch Infrastructure Rebuilding Team (SCIRT). SCIRT communication campaign used public meetings and printed materials to convey difficult messages about infrastructure and road works. Brochures, leaflets and pamphlets were left in letterboxes, inviting people to attend drop-in sessions, while posters were affixed in public malls and shopping centres Whenever possible, in order to ensure the engagement of ethnic minorities, printed material was made available in languages other than English.

FULFILLED CRITERIA

Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
Local	Earthquake
DRM PHASE	**COMMUNICATION PROCESS**
Recovery	Collection, use and dissemination

CS13 - A risk communication framework for reducing landslide losses	
SOURCE	West, J., Davis, L., Bendezú, R. L., Gandía, Y. D. Á., Hughes, K. S., Godt, J., & Peek, L. (2021). Principles for collaborative risk communication: Reducing landslide losses in Puerto Rico. Journal of Emergency Management, 19(8), 41-61. https://www.wmpllc.org/ojs/index.php/jem/article/view/3044

DESCRIPTION

Landslides are frequent and damaging natural hazards that threaten the people and the natural and built environments of Puerto Rico. In 2017, more than 70,000 landslides were triggered across the island by heavy rainfall from Hurricane María, prompting requests by local professionals for landslide education and outreach materials. A novel collaborative risk communication framework was developed to meet those requests and shaped the creation of Landslide Guide for Residents of Puerto Rico in both Spanish and English language. Input from physical and social scientists, planners, government employees, emergency managers, and residents of at-risk communities was incorporated into a complete draft through a stepwise review process that involved the review of multiple versions of the guide. Collaborative risk communication is defined as an iterative process guided by a set of principles for the interdisciplinary coproduction of hazards information and communication products by local and external stakeholders. The process that supports this form of risk communication involves mapping out the risk communication stakeholders in the at-risk or disaster- affected location—in this case Puerto Rico—and collaborating over time to address a shared challenge, such as landslide hazards. This framework was established thanks to the collaboration of a core team of government and university partners that expanded in membership by including an informal network of hazards professionals from diverse sectors in Puerto Rico. The following principles guided this process: cultural competence, ethical engagement, listening, inclusive decision making, empathy, convergence research, nested mentoring, adaptability, and reciprocity. These principles and the associated process could motivate collaborative risk communication efforts in different geographic and cultural contexts, including transferring the process to other natural and man-made hazards.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a) Risk data into formal and informal education (#EC4b)

GOVERNANCE SCALE	HAZARD
National	Landslides
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, use and dissemination

CS14 - KnowRISK	
SOURCE	Musacchio, G., Falsaperla, S., Solarino, S., Piangiamore, G. L., Crescimbene, M., Pino, N. A., ... & Accardo, M. (2017, June). KnowRISK on Seismic Risk Communication: the set-up of a participatory strategy-Italy Case study. In International Conference on Earthquake Engineering and Structural Dynamics (pp. 413-427). Springer, Cham (from p. 413); Project website: https://knowriskproject.com/the-project/?lang=it

DESCRIPTION

KnowRISK (Know your city, Reduce seISmic risK through non-structural elements) was a project funded by the European Commission that aimed to help the population reduce non-structural damage caused by earthquakes. The risk communication took place in pilot areas of the three participating countries: Portugal, Iceland, and Italy. Scientific and technological knowledge was translated into practical knowledge for the citizen through the direct involvement of the local community. Non-structural elements of buildings include their architectural parts such as partitions, ceilings, cornices, installations (gas, electricity, water and sewage) and furniture. Damage to them can obstruct escape routes and make evacuation difficult but can sometimes result in death. The target audience of project consisted in building and furniture construction professionals, civil protection organisations, schools, families and citizens. The public was involved in the communication by listening to its needs, opinions, preconceptions. New easy-to-read risk maps, Augmented Reality application scenarios, videos and the direct involvement of students from middle and high schools were be part of the communication activity. A Practical Guide containing useful and low-cost suggestions to intervene on the vulnerability of furniture elements was made available to the public free of charge. The setting up of risk communication strategies stood on the understanding of the local communities' fragility, on their direct engagement, and on a holistic approach to vulnerability. Strategies for risk communication in KnowRISK relied on schools and citizen's engagement also in assessing the risk communication, citizen science activities, tools for raising awareness.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into formal and informal education (#EC4b)

GOVERNANCE SCALE	HAZARD
Cross-nations	Earthquake
DRM PHASE	**COMMUNICATION PROCESS**
Prevention & Preparedness	Collection, use, dissemination

CS15 - Comprehensive communication strategy (Gardenroots)	
SOURCE	Ramirez-Andreotta, M. D., Brusseau, M. L., Artiola, J., Maier, R. M., & Gandolfi, A. J. (2015). Building a co-created citizen science program with gardeners neighboring a Superfund site: The Gardenroots case study. International public health journal, 7(1). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4420190/

DESCRIPTION

Gardening and consuming edible plants grown in contaminated soils presents a health hazard that may affect home gardeners neighboring contaminated environments. The town of Dewey-Humboldt is in an arsenic endemic region of Arizona and is adjacent to the Iron King Mine and Humboldt Smelter Superfund site (Iron King). The site serves as a persistent source of pollution, introducing a host of potential human-health risks and concomitant risk communication challenges. In Gardenroots project, thanks to a genuine co-creation process between the researcher and the local communities, a comprehensive communication strategy was developed by establishing a community-academic partnership and building a co-created citizen science programme. Academics and community members maintained a reciprocal dialogue and managed to 1) define the question for study, 2) gather information, 3) develop hypotheses, 3) design data collection methodologies, 4) collect environmental samples (soil, irrigation water, and vegetables), 5) interpret data, 6) disseminate results and translate results into action, and 7) discuss results and ask new questions. Participants shared data with others outside of the Gardenroots project. Gardenroots culminated in a large report-back gathering "Results for Lunch: Your Soil, Water and Vegetable Outcomes". After that, participants requested an overall summary of results and presentations that would be open to the broader community. In response, three additional presentations were given and a "Summary of Results" booklet was generated and distributed to participants and other community members in the Dewey-Humboldt, Arizona area. Public participation in scientific research improved environmental health assessment, information transfer, and risk communication efforts. Furthermore, incorporating the community in the scientific process produced both individual learning outcomes and community-level outcomes. The comprehensive communication strategy illustrates the benefits of a community-academic co-created citizen-science programme in addressing the complex problems that arise in communities neighbouring a contaminated site. This can increase the community's involvement in risk communication and decision-making, which ultimately has the potential to help mitigate exposure and thereby reduce associated risk.

FULFILLED CRITERIA

Location-based risk data (#EC1), Risk data accessible and open (#EC2) Risk awareness and education through social media and social mobilisation (#EC3) Risk data into DRR policies and plans (#EC4a, partially) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (#EC5)

GOVERNANCE SCALE	HAZARD
Local	CBRN
DRM PHASE	**COMMUNICATION PROCESS**
Prevention	All

CS16 - Communication efforts to involve citizens (FloodRISE)	
SOURCE	Cheung, W., & Feldman, D. (2019). Can citizen science promote flood risk communication? Water, 11(10), 1961. https://doi.org/10.3390/w11101961

DESCRIPTION

The Flood Resilient Infrastructure and Sustainable Environments (FloodRISE) project was aimed at researching the potential for metric resolution flood hazard simulations to enhance flood risk management in Southern California. Under FloodRISE, an interdisciplinary research team worked with stakeholders in three communities affected by different types of flooding (e.g., coastal, fluvial, pluvial) to co-develop sets of flood hazard visualizations that are responsive to local decision-making needs. Stakeholder engagement was iterative and involved meetings with authorities, household surveys, focus group meetings and training sessions. The coproduced flood hazard maps are available via on-line flood hazard viewers. While visualisation tools may illuminate flood hazards, interactive exchanges between map-creators and decision-makers allow for a sharing of policy-specific knowledge regarding flood vulnerabilities from the vantage point of communities. Thus, information discerned from the focus groups can be used to refine the visualisation tools themselves. The citizen-science approach adopted in the project helped change how experts and non-experts can engage each other as they seek to reduce the impacts of flooding and build more resilient communities.

FULFILLED CRITERIA

Location-based risk data (#EC1) Risk data accessible and open (#EC2) Risk data into formal and informal education (#EC4b) Harness CBOs and NGOs and local knowledge (#EC5) Promote info exchange and dialogue among stakeholders (#EC6)

GOVERNANCE SCALE	HAZARD
Regional	Floods
DRM PHASE	**COMMUNICATION PROCESS**
Preparedness	Collection and dissemination

4.2 Comparing GPs in risk and crisis communication[7]

The following table plays a double purpose. On the one hand, it graphically summarises the GPs extracted from the case studies that were presented in the above section. On the other, it illustrates how the same criterion can be fulfilled by a wide and diverse range of GPs. This comparison makes it also possible to highlight aspects of risk and crisis communication that are poorly addressed in the selected case studies. These points will be further elaborated on in the discussion section.

[7] For the labels description see Table 2, Appendix.

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS1	**Communication between institutional and local actors on health prevention (Sentieri project)**	CBRN	National with local applications	Prevention & Preparedness	Collection, analysis (methodology), use and dissemination	Production of an interactive map of the epidemiological study	Creation of interactive map with a glossary with definitions translating commonly used scientific words into lay language
CS2	**Communication before and during Gunbarrel fire (USA)**	Forest fire	Local	Prevention, preparedness & Response	Use and dissemination		
CS3	**Promote info exchange and dialogue among stakeholders**	Multi-hazard risk	Cross-nations	Prevention & Preparedness	Collection, use and dissemination	grassroots advocacy based on risk mapping resulted in authorities' construction of a footbridge, ensuring safe pedestrian travel across flooded creeks	
CS4	**Risk Communication Programme of the city of Santa Fe (Argentina)**	Multi-hazards risk	Local	Prevention & Preparedness	Collection, analysis, use and dissemination		1) Information generated were free and publicly available and distributed through various channels such as radio or television, but also through a blog, a website, YouTube and the city's Facebook account. 2) Opportunities for face-to-face communication were created and coordinated, with a participatory approach, where activities to improve risk understanding were carried out.

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
	Design of novel preventive actions and recognition of occupational disease and the access to social security benefits.	Delivery of training-to-trainers and peer-to-peer activities for local educational institutions aimed at fostering the empowerment of the young population	Setting up of a collaboration between the Committee of the persons formerly exposed to contamination and the Italian Institute of Health (ISS). 2. A collaboration agreement between ISS, the Committee and the Local Health Authority was signed. They then jointly identified the list of exposed workers and of occupational diseases	1) Integration of the environment and health sectors. 2) Participation of researchers and social actors in local communication events. 3) Periodical meetings between the involved researchers and the Committee to discuss methodology and dissemination of results.
1) The county worked to educate property owners on defensible space in partnership with the local Forest Service. 2) Forest service organised a tour with local print media to show the work that had been undertaken. 3) The District Ranger was on a local radio show at least once a month.		Since 1989, local schools began to implement a school-based fire education program.		1) Local forest employees and the IMT member communicated actively with local government (sheriff, fire chief, emergency operations). 2) Before the fire, local Forest Service employees worked with local government and held an annual picnic with property owners to raise awareness of their role.
WAGUCHA trained sixty grassroots leaders on community risk mapping.		Eco-tourism training for 300 youth from fishing communities. Cross-countries training sessions for municipal officials. COPECO's certification of community volunteers.	Grassroots leaders from WAGUCHA led a two-day training session for 25 municipal officials	1) Cross-countries peer learning exchange on community-led risk mapping. 2) Establishment of a Inter-Agency Partnership for Community Resilience which linked grassroots priorities to national government agencies, connecting them with decentralized programs and resources from the national ministries; 3) COPECO signed an MOU with WAGUCHA to supplement information generated by community risk and vulnerability maps and providing training for community volunteers.
1) The citizens analysed the risk in their own blocks and houses. The local authorities coordinated the work with neighbours. 2) Creation of the Blog on DRR associated with the city's web page, where all the elaborated communication materials were made available.	Information from citizens was added on the Contingency Plans for every region of the City	1) Training workshops on risk components was given to municipal servants and to different actors such as neighbours, organisations, teachers, students, journalists and the public.; 2) Work in schools with the "classroom-city" project, bringing the governmental, school, family and students' sectors together, combining it with field activities.	Local government collaborated with approximately 60 organisations, 45 of which are neighbourhoods.	Local governernment performed training activities such as workshops, courses, talks and conferences, field works to collect information in vulnerable areas, talk to neighbours, distribution of information; creation of linkages with actors through agreements with the media and dissemination of information in radio and television campaigns.

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS5	**Communication about fires Kythira fires (Greece)**	Forest Fire	Local	Prevention & Preparedness	Collection, analysis and dissemination		Risk awareness talks in schools tailored to the school level (talks and conversation wigh high school students and interactive games with elementary school pupils)
CS6	**Communication about floods**	Floods	National	Prevention, Preparedness & Response	Collection, use and dissemination	1) Production of public web-based real-time map of flood conditions; 2) Production of a megacity-scale visualisation of disasters using OSM basemap, crowd-sourced reporting, and government agency validations in real time	Creation of an open dataset that can be used for a variety of analyses at the village, district and provincial levels for flood management.

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
1) A series of talks by the fire experts of the two partners to inhabitants of Kythira on fire prevention 2) Contribution of the volunteers to the assessment of the risk of structures. Teams of volunteers were formed to help assess the risk of destruction of individual homes in the three settlements. Voluntary field activities were performed by volunteers and students including reforestation of selected sites. 3) Production of two informative videos distributed to local media, to the local authorities and to the volunteers and uploaded to YouTube. 4) Preparation of a four-page brochure that was distributed to the population at the start of the fire season of 202		Series of talks to elementary and high school students, aiming to make them aware of the issue of forest fires. The talks to the high school students were delivered by the fire experts of the partners and were followed by discussions. Specialized environmental educators of the HSPN, employing interactive games in the schoolyard, delivered the message to the younger pupils	Many owners of restaurants and coffee shops offered their space and infrastructure for free for fire prevention talks and activities. The elementary and high-school teachers on the island also contributed enthusiastically, facilitating the work of the environmental educators of the HSPN. The delivery of the risk assessment forms by the volunteers to the structure owners, on a personal basis, further increased awareness and provided motivation by example.	
Setting up of PetaJakarta.org platform, enabling Jakarta's citizens to report the locations of flood events using the social media network Twitter.	The data used to create government maps to report flood conditions and village heads have used poster maps to plan logistics when responding to flooding. PetaBencana adopted by the National Emergency Management Agency (BNPB) to monitor flood events, improve response times, and share time-critical emergency information with residents.		Heads of the 267 urban villages provided the location of their critical infrastructure and university students helped with technical mapping.	PetaJakarta.org relayed information about flood locations from citizen to citizen and from citizens and the city's emergency management agency integrating local knowledge from various crowdsourcing tools (mainly social media and instant messaging) and formal knowledge from government agencies.

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS7	**Communication and community engagement platform**	Multi-hazard risk	National	All	Collection, analysis and dissemination		
CS8	**Communication during the Kaikoura earthquake (NZ)**	Earthquake	Local	Response & Recovery	Exchange & dissemination		Organisations responding to transport disruptions drew on existing data sources in new ways, collected novel datasets, and leveraged relationships to manage information exchanges. Pre-existing data was repurposed in novel ways for decision-makers. Web-portals, which integrate diverse information sources into a consistent management interface, were developed and used to manage information about road risks, incidents and conditions, and to assist with information exchanges between port companies and transport operators.

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
	Creating sustainable communications capabilities centered in Vanuatu's existing disaster response system.	Many elements of practice have been incorporated in a CCE Handbook- This Resource Pack provided an opportunity to empower additional local instructors- Workshops and classes were conducted in partnership with other training initiatives serving provincial offices and local communities. CDCCC community training programmes to reach over 20 communities-	Vanuatu-led organisations and people be at the center of the programme collaboration, with supporting roles from international actors.	The Platform establishes two-way collaboration between people facing crisis and the many organisations that seek to support them, broadly integrates communication capabilities across the diverse ecosystem of organisations responding to a crisis (government, private sector, international actors, and civil society) and bringing together the government's official disaster response community communications channel with the broader national response coordinating system. The new CCE sub cluster has been set up within the government's National Emergency Telecommunications Cluster (NETC). The CCE Sub-Cluster provides an ongoing forum for collaboration among government ministries and crisis response clusters, as well as international NGOs, local NGOs and key private sector actors such a telecom providers and media channels. Standard approaches for data collection templates, assessment questions, data analysis templates, and partnership agreements are collaboratively created and reviewed through the CCE Sub cluster.
				A transport damage and level of service classification system was enhanced and maintained by KiwiRail and the NZ Transport Agency to facilitate communication about damage states between multiple organisations. Similarly, data about repair costing, sequencing, and progress was created and shared through mechanisms established by the North Canterbury Transport Infrastructure Recovery (NCTIR) alliance, a partnership between private engineering and construction firms, the NZ Transport Agency, and KiwiRail. Groups such as the MoT-led Transport Response Team activated to assist with the transfer of new information and data sources and to provide co-ordinated advice in the emergency. MoT's Joint Analytical Unit provided specific analysis, briefings and regular reports to Ministers and official groups, and commissioned external work.

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS9	**Infusing DRR into formal education curricula using a local content curriculum (LCC) space**	Multi-hazards risk	National with local applications	Preparedness	Dissemination & use		Integration of Child-centred DRR contents into the formal school curriculum
CS10	**Communication through Maps For Everyone**	Multi-hazards risk	National	Prevention & Preparedness	Collection, use and dissemination	Actively mapped major points-of-interest (POIs) and critical infrastructure in OpenStreetMap.	The project built a community which contributed to OpenStreetMap - a free and editable map of the world.

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
		DRR themes and topics are integrated into existing subjects. Second, DRR is taught as a special subject within the Local Content Curriculum (LCC). Third, DRR is taught through a self-development programme that takes place during the academic school year. To support teachers, a training manual, DRR modules, and reference materials have been developed in local languages. The Disaster Awareness in Primary Schools (DAPS) project first trained key people (e.g., local consultants in targeted provinces) on major hazards (earthquakes, landslides, floods, and tsunami) who then spread information on what they had learned to school directors, teachers and other key stakeholders. In terms of curriculum development, after receiving School Based Curriculum Development Training, the selected 30 teachers from 30 schools drafted Samples of Lesson Plans on Integrating Disaster Preparedness into Elementary School Subjects, which were fully in line with the national curriculum. After field tests in two schools for two months, this was finalized and printed as a manual.	Decentralized curriculum framework allows for locally driven DRR curriculum developments that are sensitive to the specific local needs and contexts in the world's largest archipelago.	Another example in integrating child-centred DRR into the formal school curriculum (at the elementary level) emerged through the Save the Children Yogyakarta earthquake response programme which supported 99 elementary schools in Bantul and Klaten districts. It included components of teacher training, curriculum development (including pilot testing), and advocacy. This project partnered with the government education office at sub-district level and four NGOs implemented the Emergency Education Preparedness and Psycho-Social Support (EEPS) that trained teachers using a cascade approach
Sensitise students, development agencies, government and non-government organizations about OSM through Sensitization Presentations.	After 2015 Gorkha earthquake, OSM members' maps helped the Nepal Army plan around 300 rescue operations, and assisted a number of national and international organisations like the USAID, Canadian DART (Disaster Assistance Response Team) plan their relief and response operations. Map data produced by the OSM community have been used in the various places across nations to give locational context to Vulnerability and Capability Assessment of communities across the nation.	Deliver Mapping Workshops (also called Mapping Parties) to train people on mapping		

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS11	**Revitalising Informal Settlements and their Environments (RISE)**	Floods	Cross-nations	Prevention & Preparedness	Collection and dissemination	Community-members had no previous training in flood mapping, yet actively contributed to the development of a database on water-level documentation to support infrastructure planning.	
CS12	**Communication about recovery after Christchurch earthquake (NZ)**	Earthquake	Local	Recovery	Collection, use and dissemination		Future Christchurch set up in Cathedral Square a colorful container to give national and international visitors a direct insight into the Canterbury recovery and collect residents' inputs on recovery plans and documents. SCIRT's communication campaign used public meetings and printed materials to convey difficult messages about infrastructure and road works. Brochures, leaflets and pamphlets were left in letterboxes, inviting people to attend drop-in sessions, while posters were affixed in public malls and shopping centres Whenever possible, in order to ensure the engagement of ethnic minorities, printed material was made available in languages other than English. The campaign "All Right?" adopted a series of communication channels, including social media, to reach out to the most vulnerable and ensure that their mental health needs were being addressed

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
The project involved community members in the documentation of flood-levels in informal settlements. The participants were instructed to use their personal smart phones to send photos of the flood gauges daily in order to keep a record of the water levels throughout the whole rainy season. During flood events, the volunteers were asked to photograph the gauge periodically at two hour intervals.	The photos sent by community members allowed for a comprehensive documentation of water levels in different settlements across the same catchment and, therefore, provided useful evidence of flood risks in the area. The water-levels registered were used within RISE to calibrate small-scale bucket flood models. These references were compared to rainfall data collected from an external dataset and used as a preliminary indication of the local flood risk profile.			
Share an Idea", a campaign launched by Christchurch City Council a few months after the February earthquake. This campaign was run on line over six weeks in order to seeking citizens' opinions and visions about how they wanted their city to be rebuilt.	The inputs of Share an Idea were used by the City Council to inform the draft of the Central City Plan, which had then to be integrated into the final blueprint for reconstruction produced by CERA			Participatory initiatives were organised by central government in collaboration with Christchurch City Council and local community groups. SCIRT (Stronger Christchurch Infrastructure Rebuilding Team), an organization created after the Canterbury earthquakes in New Zealand to oversee the rebuilding of the regional infrastructure that was severely damaged by the earthquakes. SCIRT is led by CERA, Christchurch City Council and the New Zealand Transport Agency, which work alongside private companies that have been chosen to carry out repair works in Christchurch and the surrounding are

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS13	**A risk communication framework for reducing landslide losses**	Landslides	National	Prevention & Preparedness	Collection, use and dissemination	Informal interviews with risk communication professionals and residents of Puerto Rico who live in areas of high landslide susceptibility)	Creation of a Spanish- and English-language Landslide Guide for Residents of Puerto Rico
CS14	**KnowRISK**	Earthquake	Cross-nations	Prevention & Preparedness	Collection, use and dissemination	The project is aimed at a diverse audience of building and furniture construction professionals, civil protection organisations, schools, families and citizens. The public is involved in the communication by listening to their needs, opinions, preconceptions.	New easy-to-read risk maps, Augmented Reality application scenarios, videos and the direct involvement of students from middle and high schools will be part of the communication activity. A Practical Guide containing useful and low-cost suggestions to intervene on the vulnerability of furniture elements will be made available to the public free of charge.

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
Interdisciplinary coproduction of hazards information and communication products by local and external stakeholders		Input from physical and social scientists, planners, government employees, emergency managers, and residents of at-risk communities was incorporated into a complete draft through a stepwise review process that involved the review of multiple versions of the Landslide Guide for Residents of Puerto Rico	Input from physical and social scientists, planners, government employees, emergency managers, and residents of at-risk communities was incorporated into a complete draft through a stepwise review process that involved the review of multiple versions of the guide.	1) The initiative involved the formation of a core team of government and university partners that expanded in membership to conduct collaborative work with an informal network of hazards professionals from diverse sectors in Puerto Rico 2) In order to create useful landslide education and outreach materials, relationships were developed with a diverse array of professionals who had expertise in landside science, risk communication, emergency management, land-use planning, and other allied fields. 3) Building of a network by having conversations and conducting informal interviews, drawing upon referrals within participants' social networks. For example colleagues at the USGS provided first introductions to people with whom they had established contact during the response to Hurricane María, including the Puerto Rico Seismic Network. Those participants introduced the researchers to other professionals they believed had relevant knowledge, and so on. Information about the culture, language, and behavior collected through this network informed the content and presentation of the educational materials.
New easy-to-read risk maps, Augmented Reality application scenarios, videos and the direct involvement of students from middle and high schools are part of the communication activity.		New easy-to-read risk maps, Augmented Reality application scenarios, videos and the direct involvement of students from middle and high schools are part of the communication activity		

		Premises				Evaluation Criteria (SENDAI)	
ID	**Case Study**	**Hazard**	**Governance scale**	**DRM Phase**	**Communication process**	**Location-based risk data (#EC1)**	**Risk data accessible and open (#EC2)**
CS15	**Comprehensive communication strategy (Gardenroots)**	CBRN	Local	Prevention	All	Two trainings were formally offered and community members that participated in the training brought home an instructional manual and a tool kit with all supplies required for sample collection from their home garden.	Participants shared data with others outside of the Gardenroots project. Gardenroots culminated in a large report-back gathering "Results for Lunch: Your Soil, Water and Vegetable Outcomes" (Results for Lunch). After the Results for Lunch gathering , participants requested an overall summary of results and presentations that would be open to the broader community. In response, three additional presentations were given and a "Summary of Results" booklet was generated and distributed to participants and other community members in the Dewey-Humboldt, Arizona area.
CS16	**Communication efforts to involve citizens (FloodRISE)**	Floods	Regional	Preparedness	Collection & dissemination	Teams of interdisciplinary researchers co-produced flood hazard maps and geographic information system tools by engaging diverse stakeholder groups in a series of surveys, focus groups, as well as training and outreach workshops.	The coproduced flood hazard maps are available via on-line flood hazard viewers

Evaluation Criteria (SENDAI)				
Risk awareness and education through social media and social mobilisation (#EC3)	**Risk data into DRR policies and plans (#EC4a)**	**Risk data into formal and informal education (#EC4b)**	**Harness CBOs and NGOs and local knowledge (#EC5)**	**Promote info exchange and dialogue among stakeholders (#EC6)**
Public participation in scientific research improved environmental health assessment, incorporating the community in the scientific process produced both individual learning outcomes and community-level outcomes	Using their data, participants have translated the results into personal action and have modified their gardening practices.	Gardenroots participants were asked to attend a 1.5-hour training session wherein they were provided information on how to properly collect soil, water, and vegetables samples from their home garden for laboratory analysis. Two trainings were formally offered and community members that participated in the training took home an instructional manual and a tool kit with all supplies required for sample collection from their home garden. Gardenroots culminated in a large report-back gathering “Results for Lunch: Your Soil, Water and Vegetable Outcomes” (Results for Lunch). After the Results for Lunch gathering , participants requested an overall summary of results and presentations that would be open to the broader community. In response, three additional presentations were given and a “Summary of Results” booklet was generated and distributed to participants and other community members in the Dewey-Humboldt, Arizona area.	The project brought scientists from various disciplines together within the University of Arizona and to work in collaboration with the affected community to: (1) determine the uptake of arsenic in garden vegetables grown by the Dewey-Humboldt, AZ community, and (2) conduct an exposure assessment and characterize the potential risk posed by gardening and consuming vegetables from residential home gardens	
		Flood hazard maps and geographic information system tools were created by engaging diverse stakeholder groups in a series of surveys, focus groups, as well as training and outreach workshops	Incorporation of a citizen science component that would combine the resources of experts (who developed visualization tools to depict flood hazard) with the preferences and the needs of community members (whose aspirations centered around making such tools useful and useable). Interactive exchanges between map-creators and decision-makers allow for a sharing of policy-specific knowledge regarding flood vulnerabilities from the vantage point of communities.	Under FloodRISE, an interdisciplinary research team worked with stakeholders in three communities affected by different types of flooding (e.g., coastal, fluvial, pluvial) to co-develop sets of flood hazard visualizations that are responsive to local decision-making needs. Stakeholder engagement was iterative and involved meetings with authorities, household surveys, focus group meetings and training sessions. Interactive exchanges between map-creators and decision-makers allow for a sharing of policy-specific knowledge regarding flood vulnerabilities from the vantage point of communities.

5. Discussion

5.1 Discussion of the case studies' findings

The present thematic paper sought to collect and highlight GPs in risk and crisis communication. The collection of GPs followed an iterative process. First, we established an analytical framework that consisted of the criteria derived from the Sendai Framework and a set of premises linked to a multi-stakeholder, multi-scale, multi-hazard risk, multi-phase, multi-dimensional perspective. This framework, summarised in Table 1 in the Appendix, was used to guide the search, selection and evaluation of CSs describing risk and crisis communication practices. The main shortcoming of the case study methodology is the little generalisability of the results to different contexts and settings. In order to overcome this shortcoming and generate widely applicable knowledge, we selected diverse CSs and compared the GPs in communication extracted from them in paragraph 4.2. This procedure made it possible to spot communication practices that materialised across diverse disaster situations, contexts and phases.

In the paragraphs that follow, we discuss the GPs extracted from the CSs as well as how the CS fulfilled the premises highlighted in the analytical framework.

5.1.1 Discussion against the evaluation criteria

From the Sendai Framework we identified six criteria to evaluate whether or not the identified CS contained a set of GPs in risk and crisis communication.

- **Collection and dissemination of location-based risk information (criterion 1).** Maps displaying the spatial distribution of risk data were widely employed and produced through web apps and other information and communication technologies. While risk maps are certainly a powerful instrument for DRM, the knowledge required to create them may not be within everyone's reach. Thus, the collection and provision of location-based risk data need to be coupled with initiatives for risk education and social mobilisation (criterion 3), organisation of workshops and trainings (criterion 4b) and frequent collaboration and information exchange with CBOs and other social actors (criteria 5 and 6). Evidently, risk maps are the most immediate outputs to provide location-based risk information. However, this information can be collected also in other forms by, for example, giving value to data associated to land markers and place-based memories. For instance, the communication programmes of the city of Santa Fe in Argentina (CS4) built upon the representation of the city-river relationship and the residents' memory of past water-related disasters.

- **Risk data accessible and open (criterion 2).** In the CSs analysed, accessibility to disaster risk data and information, expressed in criterion 2, is realised primarily through the creation of open web-based databases and applications as well as through the use of multiple communication channels including participatory approaches (e.g., CS4 and CS15). However, accessibility also means that risk data are not only publicly available but also fully comprehensible to the targeted audience. This is made possible by, for example, translating scientific information into lay language (CS1), by offering risk information in multiple languages (CS12, CS13), and by adapting communication modes to the capacity level of the audience (see, for example, the student-centred programs developed in CS5 and CS9). A further way to make disaster risk data accessible is illustrated in CS8 with the creation of a portal to integrate information from different sources, enabling data to be repurposed for decisions making in DRM.

- **Risk awareness and education through social media and social mobilisation (criterion 3).** Communication initiatives for risk education and awareness appeared frequently in the CSs and this goal was achieved through the mobilisation of groups of citizens and volunteers and by the delivery of trainings to grassroots leaders (e.g., CS3) and talks to various social actors. For example, in CS2 and CS5 risk education was enabled by the engagement of local media, business owners, students and volunteers in fieldworks. The city of Santa Fe in Argentina (CS4) created a DRR blog associated with the city's webpage. New communication media allowed to educate citizens through interactive apps and scenarios enabled by augmented reality (e.g., CS14). CS15 suggests that the co-production of risk information in collaboration with citizens' groups paves the way for enduring risk education. Social media campaigns were not featured in the selected CSs as tools for risk awareness raising. This echoes the findings by Dufty (2015) who, despite highlighting some examples of social media campaigns for risk education, noted that social media are generally underutilised in DRR awareness strategies.

- **Risk data into DRR policies and plans (criterion 4 a).** As a positive note, the CSs frequently featured the usage of risk data to improve DRR policies, plans and official documents. Risk data were used to design novel preventive actions and update criteria to access social security benefits (CS1) and country risk profiles (CS11). In addition, they were incorporated into government maps and contingency plans (CS4 and CS6) and informed vulnerability and capability assessments (CS10) and recovery plans (CS12). As a further example, the creation of a communication and community engagement platform (CS7) in Vanuatu aimed at building sustainable communications capabilities within the existing national disaster response system.

- **Risk data into DRR formal and informal education (criterion 4b).** Incorporation into formal and informal education was realised by developing risk-based school programs (e.g., CS2) and by delivering trainings to social actors, including civil servants, students and neighbourhoods. In order to consolidate the work done, resource packages and DRR training handbooks were produced to support educators in teaching DRR contents and skills (e.g., CS7 and CS9). The creation by a government agency of an official certification programme for community volunteers involved in the collection of risk data could also be regarded as a further way to integrate DRR into new risk education pathways (e.g., CS3).

- **Harness CBOs and NGOs and local knowledge (criterion 5).** Collaboration with local CBOs was consistently featured in several CSs, highlighting the importance of a decentralised and distributed approach in disaster risk communication. While this collaboration took place mostly on an informal basis, some cases revealed the relevance of signed agreements between entities (e.g., CS1 and CS3). Furthermore, as also demonstrated by CS3, the collaboration with CBOs allows not only to maximise the dissemination of risk and crisis information but also to create links between humanitarian operators, government agencies and lay citizens.

- **Promote info exchange and dialogue among stakeholders (criterion 6).** Across the selected cases, prolonged engagement between social actors was instrumental for multi-stakeholder collaboration in disaster risk management. Indeed, even when the CS illustrated collaboration during a disaster response phase (e.g., CS2), that collaboration was seemingly initiated long before that the disaster occurred. Dialogue with community stakeholders is sustained through the time through periodical meetings with CBOs (CS1), annual events (CS2) and the organisation of talks and conferences (CS4). In other cases, collaborative efforts were sustained through the establishment of official networks (under the form of Alliances, Partnerships or Platforms) among national and local government agencies and other social actors such as private companies, NGOs and CBOs (e.g., CS3, CS7, CS8 and CS12). Citizenry is always involved (otherwise it would not be possible to meet most of the criteria) in interaction with the scientific community (e.g., CS15), local government (e.g., CS4, CS6), or private companies (e.g., CS8; CS12).

5.1.2 GPs of risk and crisis communication in a multi-stakeholder, multi-scale, multi-hazard risk, multi-phase, multi-dimensional perspective

Here we elaborate on the extent to which collected practices reflected a holistic approach to risk and crisis communication, namely one that considers communication among multiple stakeholders and across diverse hazards, governance scales and disaster stages. Furthermore, we evaluate whether different communication dimensions (e.g., data collection, analysis, preservation, dissemination, re-use) were addressed by the communication practices.

- **Multi-stakeholder perspective.** As highlighted by the Communication Ecology Approach (Spialek et al., 2016), there is the need to surface the mutual interactions and influences between actors that exchange information in the different DRM phases. This multi-stakeholder perspective resonates also in the Sendai Framework that emphasises the creation of opportunities for dialogue, information exchange and active collaboration and partnerships between several actors, such as the scientific and technical communities, the policymaking institutions and the general public. For this reason, the multi-stakeholder perspective partially overlapped with the criterion 6 of our analytical framework. In the selected CSs, national and local government agencies actively team up with social actors, including educational institutions, grassroots organisations and emergency and public services in DRR, response and recovery efforts. Lay citizens emerged as both recipient and active producers of information. Private companies played also an active role in the risk communication practices, highlighting that they are an important asset for collecting, analysing and distributing disaster risk data and knowledge. For example, in New Zealand, recovery activities described in CS8 and CS12 were often carried out by an alliance of private companies and public services. Risk data were also diffused frequently through local media outlets, which were actively involved in risk and crisis communication efforts (e.g., CS2, CS4 and CS5). Teachers and students demonstrated to play an active role in risk communication in several of the selected cases.

- **Multi-hazard risk approach**. As we embraced a multi-hazard risk approach, we tried to collect CSs of communication practices that consider the co-presence and interaction of multiple hazards. However, this was not always possible not only because a one-hazard approach is still very much diffuse in risk and crisis communication, but also because CSs are grounded into real DRM experiences, which, in some cases, occur in a single hazard disaster situation (e.g., CS2 describes risk and crisis communication in a forest fire situation). Furthermore, there is a general dearth of publications analysing the communication in the context of cascading or compounding risks and crises (the paper by Alexander and Pescaroli, 2020, is one of the few), and dedicated CSs are largely absent. That said, risks were quite evenly represented in the selected CSs. In those ones featuring CBRN risks (CS1 and CS15), collaborations between sectors and

researchers from different disciplines proved particularly relevant, reflecting the complexity of this type of risk. For forest fires, CS2 and CS5 described communication initiatives based on school programmes and field visits, revealing the importance of place-based interventions for the collection and dissemination of risk data during and before forest fires. CS6, CS11, and CS16 focused on floods, highlighting the collaboration between experts and lay citizens for the detection of flood levels and for flood risk mapping. The analysis of CS8, CS12, and CS14 revealed that risk and crisis communication about seismic risk has to be approached through the concerted effort of a multitude of stakeholders. This is probably due to the multisectoral and multi-dimensional impacts of this type of risk. However, apart from these general considerations, the data collected are not sufficient to claim that some risk and crisis communication practices are to be preferred in certain hazard scenarios than in others. When multi-hazard risk approach is adopted (CS3, CS4, CS7, CS9, CS10) emphasis is placed on the communication involving a wide range of stakeholders in (formal and informal) education. An example consists of the integration of the study results into the school curricula and the use of educational situation for continuous data collection (e.g., CS9).

- **Multi-phase approach.** The Sendai Framework made evident that communication had to be approached in such a way to encompass all the phases of the DRM cycle. However, CSs described predominantly communication initiatives conducted during disaster response and for disaster prevention and preparedness, while the communication occurring in post-disaster recovery received way less attention. Disaster recovery is considered as the least understood of the emergency phases (Twigg, 2015) and this is particularly true when it comes to communication dynamics (Tagliacozzo & Magni, 2018). Furthermore, it was not possible to identify CSs that illustrated good communication practices across all the phases of the DRM cycle. This points at the need for longitudinal studies that explain how communication should evolve based on the specificities of each disaster stage.

- **Multi-scale approach.** It is important to consider how communication needs and dynamics vary across governance scales: for example, international and national agencies may have more capabilities in terms of staff and resources and have a wider outreach than local bodies; however, these latter could rely on stronger connections with the local reality with the result that practices implemented can better respond to immediate needs. For this reason, we aimed to collect CSs on different scales to capture practices that worked well across multiple governance levels. A large share of identified CSs unfolded at local level while in some cases, such as in CS1 and CS9, national initiatives were adapted to local realities. As CSs are by definition situated, the local level is the most represented. However, some CSs (e.g., CS11) are part of larger projects involving different contexts, allowing for cross-countries interventions. Interestingly, mainly when a nationally implemented practice is considered, risk data are translated into DRR policies and plans (cf., CS6; CS7; CS10; CS11). This may be due to the fact that national government agencies have greater capability to update DRR policies and plans.

- **Multi-dimensional approach.** The Sendai Framework stresses that communication for DRM needs to encompass not only the dissemination of risk data and information but also their collection, analysis and use. Data storage is not mentioned by the Sendai Framework, but we included it into our analysis, given that it is one of the dimensions of the information management. Interestingly enough, all the identified CSs deal with more than one communication dimensions, with risk information collection and dissemination being the most represented. The dimension concerning the use of risk data into DRM policies, plans and strategies, as well as into formal and informal education curricula, represented two components of the criterion 4 of our analytical framework. The 'analysis' dimension received less coverage compared to the others, probably because the co-interpretation of risk data is a difficult and energy-consuming task. In the CSs that featured this communication dimension (e.g., CS1, CS15), GPs suggest that risk data should not only be collected but also analysed through a collaboration between experts, being them scholars or DRM practitioners, and community-based organisations. This allows risk information to be framed in a way that it is in line with the local understandings of risk and to avoid the mismatch between expert and indigenous risk knowledge, a phenomenon that has been illuminated also in the scientific literature (e.g., Aragón-Duran et al., 2020). None of the CSs deal with storage and preservation of data and information collected for DRM. This represents a significant gap as some of this information can be sensitive in nature (e.g., data about vulnerable groups). Moreover, information that is poorly structured, incomplete or for which collection methodology is not adequately explained, is more difficult to share and re-use.

5.2 Discussion on scenario-building

As already mentioned in the Introduction, scenarios are "descriptions of plausible events that may occur in the future, leading to a particular set of outcomes. They are based on assumptions about key driving forces, interconnections, and relationships, and can capture the uncertainties and complexities of a system in a coherent manner" (Cambridge Centre for Risk Studies, 2020). Thus, scenarios build on the knowledge of what is avail-

able at present times to forecast possible and plausible future developments, surfacing gaps in preparedness and planning. This makes it possible to apply adjustments in the present situations to avert future undesired outcomes. Another technique to build scenarios is back-casting (Kok et al., 2011), which involves working backwards by starting from a preferred future and identifying pathways that bridge the present conditions with this desired future. In the view of this thematic paper, the desired future consists of the development of disaster communication strategies that incorporate all or the majority of elements of the analytical framework constructed in the methodology and that adopt by design an approach that is as holistic and inclusive as possible. With this end in mind, this thematic paper has emphasised GPs in risk and crisis communication that represent credible (because already tested in a real DRM context) pathways to this intended future.

Decalogue of GPs in risk and crisis communication for policymakers and practitioners

1. Risk maps produced though web apps and ICTs should be harnessed for risk communication and risk education (e.g., through the engagement of lay citizens in risk data collection and analysis). However, the use of these risk maps is effective only if coupled with initiatives for risk education and social mobilization, organisation of workshops and trainings and frequent collaborations and information exchanges with CBOs and other social actors.
2. For the provision of location-based risk data, policymakers and practitioners should place value on data associated to landmarks and place-based memories.
3. Accessibility of data should consider aspects related to both the physical access and the comprehensibility and interpretability of the data by the user. Physical accessibility can be enhanced through open web-based databases and applications and the use of multiple communication channels including participatory approaches. Comprehensibility and interpretability of the data can be realized by translating scientific information into lay language, by offering risk information in multiple languages and by adapting communication modes to the capacity level of the audience and by gathering information from multiple sources in a single interface.
4. Risk education and awareness should be achieved through the mobilization of groups of citizens and volunteers, by the delivery of trainings to grassroots leaders (e.g., Train of Trainers activities) as well as through augmented reality-mediated scenario building exercises. Essential for risk education is the co-production of risk information in collaboration with citizens' groups.
5. In addition to being incorporated into national disaster risk management policies and strategies, disaster risk data should also inform country risk profiles, employment-related policies, government maps, vulnerability and capability assessments, recovery plans as well as the integration of specific capabilities into the disaster response system.
6. Risk data should be incorporated into formal and informal DRR education by developing new school curricula or integrating the existing ones with DRR subjects, designing training activities for social actors and establishing official certification programs for people wanting to gain skills on disaster risk data collection, analysis and management.
7. Multi-stakeholder collaboration for disaster risk management should be nurtured through prolonged engagement among social actors. For government agencies in charge of DRM, this engagement can be realized by the means of periodical meetings with Community-Based Organisations (CBOs) annual events, the organization of talks and conferences and the establishment of official networks (under the form of Alliances, Partnerships or Platforms).
8. Risk and crisis communication strategies should by design take into consideration the interactions and mutual influences between the actors that exchange information in the DRM communication landscape. These actors can include scientific and technical communities, policymaking institutions, educational institutions, grassroots organisations, emergency and public services, local residents and citizens living abroad (e.g. so-called diaspora).
9. Risk and crisis communication strategies should address all the communication dimensions (data collection, management, analysis, re-use and dissemination) and be responsive to the needs and features of each DRM phase.
10. Risk and communication practices should consider by design all the possible risks that occur (or may occur) in a given context. These practices may need to be adapted according to the governance scale (e.g. local, national, regional or global) in which the practice is implemented.

6. Conclusions

In the present thematic paper, we used CSs to extract GPs that already proved their effectiveness in real DRM experiences. This posed two main challenges: (i) define criteria to evaluate which CS contained GPs and; (ii) ensure the replicability and transferability of the practice in contexts different from the one where it originally took place. The first point was addressed by adopting the Sendai Framework as a reference to identify criteria/indicators for the evaluation. The replicability was guaranteed through the comparison of the practices identified across a breadth of disaster situations in a multi-hazard risk perspective.

Here it is important to remark that it was not easy to find cases that embedded a multi-hazard risk perspective as premise. Indeed, such a perspective requires considering many co-existing and interacting risks, but effective communication has to be contextualised and, thus, practices working in one risk scenario may not necessarily work (or should even be avoided) in another. For this reason, the CS analysis needs to consider by design[7] all the possible risks that occur (or may occur) in a given context without placing the focus only on one risk at a time. This would allow the CS to capture accurately the driving mechanisms of risk creation and reduction and the mutual interconnections and interactions between risks in a systemic thinking perspective.

One of the aspects considered crucial was to adopt a multi-stakeholder perspective, which coincided with one of the evaluation criteria extrapolated from the Sendai Framework. This perspective is applied across the board in communication in almost all the analysed CSs. Similarly, all the identified CSs deal with more than one communication dimensions, emphasising that effective communication practices must aim to address the entire information management cycle.

Regarding the governance scale, good communication practices are often found at a local level, probably due to the use of CS methodology, which tends to focus on local contexts and experiences. Faced with the need to find practices that work across governance scales, the challenge relates to how to scale up or scale down existing initiatives. This requires adjustments in the approach whose impacts depend upon factors such as intermediaries, trust and dialogue, and finding a balance between conflicting objectives, as also noted by Lizarralde et al. (2022).

Among the multiple perspectives considered, the most disregarded one turned out to be the multi-phase approach. In fact, there is a general lack of understanding on the evolution of risk and crisis communication practices across the DRM phases and very little is known, in particular, on the post-disaster phase. In that, longitudinal risk and crisis communication (Sutton et al., 2021) is a venue worth of further exploration in future research.

To conclude, this thematic paper provides concrete examples on how risk and crisis communication can be put into practice effectively. Taken together, the highlighted GPs can pave the way toward a more holistic risk and crisis communication that goes beyond the simple dissemination of risk and crisis information.

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[8] The term "by design" is used to indicate the incorporation of some principles in a practice (e.g. ethics by design or privacy by design).

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Appendix

PREMISES

- **Multi-stakeholders**
- **Multi-scale**
- **Multi-dimensional**
- **Multi-hazard risk**
- **Multi-phase**

EVALUATION CRITERIA

1. Good practices in risk and crisis communication should include the collection and dissemination to a wide audience and in an appropriate format of location-based risk data, also by the leveraging of new information and communication technologies, including GIS **(location-based risk data);**

2. Good practices in risk and crisis communication should ensure that risk data and information are freely accessible and furnished as an open source **(risk data accessible and open);**

3. Good practices in risk and crisis communication should be aimed at risk education and awareness, both at local and international level, also by the support of innovative communication channels such as social media and by social mobilization **(risk awareness and education through social media and social mobilization);**

4.(a) Good practices in risk and crisis communication should ensure the incorporation of risk data and information into DRR policies, plans and strategies **(risk data into DRR policies and plans);**

4.(b) Good practices in risk and crisis communication should ensure the incorporation of risk data and information into formal and informal education **(risk data into formal and informal education);**

5. Good practices in risk and crisis communication should harness local community-based organizations and non-governmental organisations for the dissemination of disaster risk information and value local knowledge as complementary to scientific information **(harness CBOs and NGOs and local knowledge);**

6. Good practices in risk and crisis communication should promote the exchange and transfer of good practices, lessons learned and technology for DRR at local, national, regional and global level, by the use of user-friendly systems and services and the dialogue and cooperation among stakeholders, including the creation of science-policy interfaces for effective decision-making **(promote info exchange and dialogue among stakeholders).**

Table 1: Framework for the analysis of risk and crisis communication practices.

CATEGORY	DESCRIPTION
Hazards	type(s) of hazards involved in the case study and communication practices under examination;
Disaster Risk Management phase	phase(s) of the DRM cycle in which the communication practices take place;
Communication processes	dimensions of the communication process that the practices involve (e.g. info collection, use, dissemination, exchange, analysis);
Location-based risk data	provision of information about the spatial distribution of risk data (e.g. crisis and risk maps);
Risk data accessible and open	provision of risk data in open-source format (e.g., through open source software or open web-based platforms). It includes provision of data in an accessible manner for diverse audiences (e.g., ethnic and linguistic minorities, people with disabilities, non-expert audience);
Risk awareness and education through social media and social mobilisation	communication practices to increase awareness and educate about risk especially realised through social media platforms or the mobilisation of individuals and groups of citizens (e.g., collection and sharing of risk data);
Risk data into DRR policies	use of collected risk data into DRM policies, plans and official strategies, regulations and documents;
Risk data into formal and informal education	use of risk data to inform the development of formal (e.g., school curricula and handbooks) and informal (e.g. training, workshop) educational contents and material;
Harness CBOs and NGOs and local knowledge	communication practices involving the collaboration with Community-based organisations and non-government organisations in risk awareness and risk data collection, analysis and dissemination. It includes integration of indigenous knowledge in risk data;
Promote info exchange and dialogue among stakeholders	communication practices aimed at realising or improving information exchange and dialogue among a wide range of stakeholders involved in DRM.

Table 2: Categories description (paragraph 4.2. Extraction of GP in risk and crisis communication).

Glossary

Case Study (CS)	The CS, according to the Merriam-Webster dictionary is an intensive analysis of an individual unit (such as a person or community) stressing developmental factors in relation to environment. The Enciclopedia of the case study states that it serves to illuminate phenomena through detailed study of their occurrences in a particular context. Therefore, the case study coincides with a method and consists in a concrete research application in a specific context.
Crisis communication	Crisis communication focuses on the communication in the imminence or during an event with the aim to mitigate its impact.
Disaster risk	The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. (https://www.undrr.org/terminology/disaster-risk).
Disaster risk management (DRM)	Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses. (https://www.undrr.org/terminology/disaster-risk-management).
Good practice (GP)	"Methods or techniques that are applied to solve existing problems producing effective results and bringing benefits to the users" (Capone et al., 2022, p. 11). In the specific case study analysed in this thematic paper, they correspond to actions implemented which has proved effective in such particular case and can be extrapolated for possible similar future scenarios.
Hazard	A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. It can be natural, anthropogenic or socionatural in origin (https://www.undrr.org/terminology/hazard).
Multi-hazard	Multi-hazard means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects. (https://www.undrr.org/terminology/hazard). The use of the term multi-hazard lies in the willingness to maintain the terminology most in use (multi-hazard), stressing the intention to consider all the possible hazard sources and the effects on all the exposed elements.
Risk	The probability of an event combined with the magnitude of the losses and gains that it will entail (Douglas 1994, p. 40).
Risk communication	Risk communication is strictly related to risk perception and aims at informing on and preventing risky choices and behaviours based on how the same risk is perceived. It focuses on preventing harm.
Risk perception	Risk perception is an individual's subjective assessment of the level of risk associated with a particular hazard (APA Dictionary of Psychology). It consists of an intuitive risk judgment on which citizens rely upon in taking decision about risks (Slovic, 1987).
Scenario	"Descriptions of plausible events that may occur in the future, leading to a particular set of outcomes. They are based on assumptions about key driving forces, interconnections, and relationships, and can capture the uncertainties and complexities of a system in a coherent manner" (The Cambridge Centre for Risk Studies, 2020, p. 11).

Situational awareness	Conscious knowledge of the immediate environment and the events that are occurring in it. Situation awareness involves perception of the elements in the environment, comprehension of what they mean and how they relate to one another, and projection of their future states(APA Dictionary of Psychology).

European observatory on disaster risk and crisis management best practices
Project co-funded by the European Union Civil Protection