ROADMAP

Good pratices in multi-hazard risk scenarios

THEMATIC PAPER 01

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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 first ROADMAP thematic paper, and it aims at identifying good practices in multi-hazard risk scenarios. Therefore, the paper focuses on concurrent hazardous events, i.e. different (independent) hazards threatening a given (common) area, and related impacts that a selected number of countries have had to face, in particular over the past two years, to single out designed and implemented good practices. This will provide the readers with a comprehensive, although of course not exhaustive, critical analysis of how DRR and DRM can be improved in a multi-hazard risk context.

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1. Introduction

1.1 Goal of the first ROADMAP thematic paper

The goal of this first thematic paper is manifold as it aims at achieving different, albeit all interrelated results. The overarching scope of this paper is to fill a gap in the existing literature by covering a topic that is still under-researched despite its increasing importance: how to enhance disaster risk management (DRM) and disaster risk reduction (DRR) in multi-hazard risk scenarios that are characterised by the occurrence of two or more disaster events at a time in the same area. Risk management is a complex task for any government since it requires flexibility and agility, effective communication, long-term thinking, and planning for situations of high uncertainty. It becomes even more challenging when the authorities have to cope with different negative events occurring at the same time. To achieve the above goal, we decided to consider the occurrence of some hazardous events in conjunction with the COVID-19 pandemic as a proxy for the many multi-hazard disaster events that can be considered.

In particular, out of the many issues and challenges that multi-hazard risk scenarios may pose, this paper focuses on the need to identify and disseminate good practices (GPs). These have been extracted through different, but interrelated processes: 1) five different real-life scenarios (wildfires and pandemic, severe weather events and pandemic, earthquakes and pandemic, floods and pandemic, volcanic eruptions and pandemic) were selected, in which one or more states addressed a disaster related to a natural hazard while the pandemic was ongoing. The selection of so called real-life scenarios has been based mainly on the availability of relevant resources as well as the widespread occurrence of the additional hazards and the actual or potential damage; 2) measures and strategies implemented at the national and regional level to deal with the pandemic, identifying GPs that are applicable also in multi-hazard risk scenarios; 3) tools/technologies/frameworks/guidelines that have been or can be used to improve DRM and/or support recommended strategies. While selecting real-life scenarios, national strategies and new tools/technologies/frameworks from which we extracted the good practices, we also tried to contribute to building a common terminology for practitioners and researchers working in this field.

We believe that the present study can contribute to shedding light on some under-researched aspects that characterise multiple and overlapping disasters of civil protection interest.

1.2 Setting the scene

All the countries in the world are far from being immune to the impact of natural disasters. In 2020, 389 natural disasters were reported in EM-DAT killing 15,080 people, affecting 98.4 million others and costing 171.3 billion US$ all over the world (CRED Crunch, 2021). More in detail, the 2020 Joint Annual Report on Global trends and perspectives issued by the Centre for Research on the Epidemiology of Disasters (CRED) and UNDRR (CRED and UNDRR, 2020) shows that several countries have been affected by more than one natural disaster at the same time. European countries have been hit by 41 disasters in 2020, while some countries, like Italy and France, have been affected by more than 5 disasters (CRED and UNDRR 2020, p. 5) in one year. Furthermore, an increase in the magnitude, frequency and geographic distribution of natural disasters has been scientifically demonstrated, particularly for those related to climate change (IPCC, 2012).

In addition, CBRNE events, including biological hazards, which cover a range of hazards of organic origin, have also increased. For example, large outbreaks, epidemics or pandemics, that happened recently, include Ebola in the Democratic Republic of Congo (2018–2020) and West Africa (2013–2016), and the Zika virus in the Americas and Pacific regions (2015–2016) (UNDRR 2020a, p. 29). Of course, the COVID-19 pandemic represents a timely reminder of how hazards within the complex and changing global risk landscape can affect lives, livelihoods and health, pushing the world to recognize and focus more on the importance of addressing biological hazards. The COVID-19 pandemic does, indeed, provide a compelling case for an all-hazards approach to achieve risk reduction as a basis for sustainable development and long-lasting responses. Ultimately, the pandemic has demonstrated the complex interplay and impacts that such hazards can have on people's lives, livelihoods and health, calling even more urgently for the implementation of the United Nations' Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework, 2015).

Since the present paper focuses on the occurrence of multiple hazard scenarios at the same time, some terminological clarifications are needed. According to the definition provided by United Nations International Strategy for Disaster Reduction (UNISDR), hazard refers to

> *"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... Haz-*

ards include (as mentioned in the Sendai Framework for Disaster Risk Reduction 2015-2030, and listed in alphabetical order) biological, environmental, geological, hydro-meteorological and technological processes and phenomena… They may be natural, anthropogenic or socio-natural in origin" (UNDRR 2020a, p. 53).

Consistently, UNDRR (2020a, p. 53) uses the term "multi-hazard" to describe (1) the selection of multiple major hazards a country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and considering the potential interrelated effects. For example, in the case of natural hazards (e.g., landslides, earthquakes, tsunamis), each hazard can be linked to other hazards or processes, resulting in the use of the term 'multi-hazard', which has a strong link with the term multi-risk in numerous studies (e.g., Marzocchi et al., 2012; Gallina et al., 2016; Terzi et al., 2019).

In order to better define the contours of our research, it is useful to stress that we decided to focus on different (independent) hazards threatening a given (common) area, and we are not investigating the interaction/triggering effects of multiple hazardous events, as this is a more demanding process compared with the independent consideration of different hazards (Liu et al., 2015, p. 60). This approach is in line with the goal of this thematic paper, which is not to provide a multi-risk assessment of the hazard interaction, but rather to extract, from different streams of research, GPs implemented in multi-hazard risk scenarios. Moreover, we are aware of the growing literature dealing with multi-risk assessment (MRA), which provides additional insight on how to address multi-hazard risk scenarios but including also this aspect would ultimately fall outside the scope of the present paper (Marzocchi et al., 2010, p. 705; Selva, 2013, p. 701).

Another term that requires immediate clarification is scenario, in light of the approach adopted by this study. Although scenarios have long been employed in the sphere of disaster (risk) management, it is not possible to identify a single, universally agreed on, definition. The Cambridge Centre for Risk Studies (CCRS, 2020, p. 11) defines scenarios as "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". Although the focus is usually placed on a scenario's ability to investigate the future in order to identify possible gaps, real-life scenarios, based on present disasters and therefore on situations that actually happened, can also be regarded as a useful instrument to analyse lessons learnt and single out good practices. The present thematic paper focuses on GPs in multi-hazard risk (real-life) scenarios with the purpose of shedding light on effective ways to deal with the challenges that arise from complex intersections between the threat multipliers observed worldwide, including the effects of the pandemic onset.

Due to the frequent occurrence of multi-hazard disasters worldwide in recent years, effective multi-hazard scenario analysis is imperative for all the phases of DRM. The multi-hazard disasters have the characteristics of high complexity under the mutual interactions among hazards and the related dynamic evolution of vulnerability, exposure and coping capacity. In addition, DRM and DRR are notably characterised by the involvement of different kinds of actors, who play very different roles: scientists, first-line responders, technical and political decision makers, mass media, judiciary, and citizens, among others (Dolce and Di Bucci, 2014). As such, multi-hazard risk scenario analysis is not only a frontier challenge for scientific research, but also a phenomenon that has a huge impact on national economy, politics and people's lives (Ba et al., 2021, p. 2).

Despite the solid foundation set by the Sendai Framework to include biological hazards in the national and local disaster risk reduction strategies, the COVID-19 still caught the world by surprise in late 2019. The current pandemic is characterised by its rapid spread, differential recovery rate and susceptibility to elderlies and people with weak immune systems (Shaw et al., 2021). The World Health Organization (WHO, 2020a) declared the outbreak a public health emergency of international concern (PHEIC) on 30 January 2020, explicitly calling for an integrated international response (Kelland and Nebehay, 2020). As a result, it is blatant to observe that this is not just a health crisis but also a humanitarian and developmental challenge, which has severely affected the social, economic and environmental progress of all the countries, especially those with high rates of poverty, fragility and conflicts (Ashraf, 2021, p. 2027). In addition to the devastating impact of COVID-19 on low-income countries, we have also witnessed high-income countries being hit by the pandemic resulting in significant loss of lives and economic downturns. The main challenges to simultaneously address multiple disasters are response preparedness and trade-offs, compounded susceptibilities of vulnerable groups, and cooperation with civil society and frontline workers (Ashraf, 2021, p. 2028). There is also a need to revise standard operating procedures (SOPs) and contingency plans to enhance multi-hazard disaster management systems (UNDRR, 2020a). Only a few months after the COVID-19 pandemic was declared, various climate hazards have been reported within the timescale of the pandemic, thus further endangering public health and infrastructure. As the nature of threats varies and such hazards are ubiquitous throughout the world, dealing with them has become a global problem (Ashraf, 2021, p. 2028). As a result, new approaches are required to effectively respond to disasters *while* managing the COVID-19 pandemic.

The impact of COVID-19 has clearly shown the systemic nature of the risk caused by a biological hazard, that is, a public health disaster which quickly turned

into a socio-economic disaster (FAO, 2020, p. 2). COVID-19 as a global health emergency *as well as* a biological disaster has introduced many challenges to disaster management as disasters did not stop striking simultaneously during the pandemic (Chatterjee et al., 2020; Phillips et al., 2020). Improper responses to disasters during the pandemic have increased the spread of COVID-19 and worsened effects resulting in additional human losses and socio-economic damage. For example, emergency response where adequate physical distancing is not observed can result in the spread of COVID-19 in responders, volunteers and other staff members of disaster management. In addition, response to disasters can be inadequate to reduce impact under strict COVID-19 measures (Ashraf 2021, p. 2030). Moreover, in situations where disaster managers are dealing with multiple disasters at once, specific response to one disaster, i.e. the pandemic, can exacerbate another disaster. An example of this is the hindrance to safe evacuations during flooding due to the COVID-19 travel restrictions (UNDRR, 2020b). A further example is provided by the response to wildfires, as COVID-19 requirements focus on social distancing and limiting the exchange between groups and regions, leading to a reduction in sharing of personnel and aviation resources, which may prove to be a major challenge (Stoof et al. 2020, p. 3).

At the same time, there are many potential lessons that the world can learn from such a serious outbreak, which can be applied to create more efficient disaster management systems (Chatterjee et al., 2020; Quigley et al., 2019). For instance, countries with early warning systems for floods such as Nepal used these systems for COVID-19 risk communication with their population (Htoon et al., 2020) (see # 7 in Table 2), an action that helped Nepal to efficiently contain the spread of the virus, comparatively to other South Asian countries such as India, Bangladesh and Pakistan (Htoon et al., 2020; WHO, 2020b). Therefore, this pandemic could and should be seen also as an opportunity to make the world more resilient to multiple hazard disasters by systematically evaluating good practices from the COVID-19 response for disaster risk management.

In order to bridge the gap between decision-makers and scientists, now more than ever disaster risk management needs to be treated in a science-policy context, in the overlapping space of scientific research, political decision-making and public action (De Groeve and Casajus Valles, 2015, pp.1-3). With the purpose to contribute to the ongoing discussion on how to create an efficient disaster management for disasters striking simultaneously, this paper identifies GPs in contexts in which risk management becomes increasingly challenging. In light of the above, the present paper aims at achieving the following, interrelated, goals:

1. enhancing the use of a common and clear terminology concerning multi-hazard risk management;
2. mapping GPs selected through 3 different strands of research: 1) Five different multi-hazard real-life scenarios during the COVID-19 pandemic, 2) Approaches/Strategies of different countries to managing the COVID-19 pandemic, focusing on those GPs that are applicable also in multi-hazard scenarios, 3) Tools/Technologies/Frameworks/Guidelines that have or can be used to improve any DRM phase and/or support recommended strategies;
3. assessing the selected GPs in order to determine the extent to which they have contributed to make the management of multi-hazard disasters more effective.

The paper is structured as follows: section 2 provides some clarifications with regard to both the concepts and the methodology adopted. Section 3 focuses on GPs in multi-hazard risk reduction and management, presenting GPs identified through the three research streams described above. Section 4 offers a discussion of the selected GPs. Section 5 presents some concluding observations.

2. Key Concepts and Methodological Approach

2.1 Good Practices

Good practices (GPs) are generally defined as methods or techniques that are applied to solve existing problems producing effective results and bringing benefits to the users (Trucco et al., 2015). In light of the existence of several options, it is worth explaining why we made the choice to privilege the notion of GP. First, the current literature constantly refers to GPs in the field of DRM (Twigg, 2015). Second, the logic behind using the notion of GPs is that they have proved to be effective in addressing similar problems in the past. We decided not to use the term best practice as for a practice to be claimed to be the best it must be superior to any alternatives, i.e. produce results that are better than those achieved by other means. The notion of "what the best is" is very difficult (or even impossible) to determine, especially when considering different settings and situations. Moreover, in our view the term best practice has a limited scope of application, since it may be possible to identify what would be the best practice in a given context, without assuming, or even suggesting, that the same practice can be implemented elsewhere. An alternative view, which is still not in line with the purpose of this thematic paper, is the use of the term "contextual practice": according to this approach, the notion of "what best is" will vary with the context (Ambler, 2011).

With regard to GPs, practitioners and decision-makers would ideally have access to evidence-based pro-

grammes and strategies, as well as tools to help them select, adapt and apply GPs in their specific contexts (Spencer et al., 2013). However, there are a couple more facts that must be considered:

- The GPs approach is result-oriented, i.e. based on the benefits or the impact of a GP, which consists of five elements (Spencer et al., 2013): effectiveness, reach, feasibility, sustainability, and transferability.
- A GP is proven (to be as such) by collecting evidence about its successful use in a particular context, thus the quality of available evidence should be considered (Spencer et al., 2013).
- GPs are not static instruments, they have to be adjusted as soon as the needs of the users change and/or conditions in the real application field evolve (Trucco et al., 2015).

There have been many efforts to collect and systematise GPs related to different aspects of emergency and disaster management. For instance, *Total Disaster Risk Management: Good Practices* (ADRC, 2005) is a handbook published for the UN World Conference on Disaster Reduction in 2005 in Kobe (Japan) which describes the Total Disaster Risk Management concept and related good practices. *Global Facility for Disaster Reduction and Recovery* Annual Report (GFDRR, 2014), published by the ACP-EU Natural Disaster Risk Reduction Programme, presented a variety of case studies highlighting emerging GPs to support disaster risk assessment, roughly grouped into those focused on: data, modelling; participation, collaboration and communication; those that address the future of risk; and specific risk assessment projects. The Critical Infrastructure Resilience International Network (Trucco et al., 2015) presented an integrated framework for the assessment and comparison of GPs in the Critical Infrastructure Resilience domain, in the perspective of collaborative Emergency Management capacity building. The work also contains a list of 53 GPs used for the framework development and put through the assessment process (Feletti et al., 2021). Even though the concepts of multi-hazard and multi-risk assessment and management have taken central stage in recent years within the European Union (European Union, 2013; European Union 2021), the present thematic paper fills an important gap in the existing literature as, to our knowledge, no study of this kind has been undertaken so far.

2.2 DRM cycle: explanation of the choice to rely on the UNDRR framework and terminology

The present thematic paper predominantly relies on the Report by the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction, formally endorsed by the United Nations General Assembly in 2017 (UNDRR, 2017). According to the Report, the term disaster can be used in relation to "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (UNDRR, 2017). Obviously, many definitions of disaster exist and are employed in various fields. However, there is a widely accepted understanding of disasters as events, which can have different origins, capable of producing negative impacts and/or causing significant injuries or widespread damage. The Sendai Framework (para. 15) has further contributed to better outline the concept of disaster, distinguishing between distinct typologies of events:

- Small-scale disaster: a type of disaster only affecting local communities which require assistance beyond the affected community.
- Large-scale disaster: a type of disaster affecting a society that requires national or international assistance.
- Frequent and infrequent disasters: depend on the probability of occurrence and the return period of a given hazard and its impacts. The impact of frequent disasters could be cumulative, or become chronic for a community or a society.
- Slow-onset disaster: a disaster that emerges gradually over time. Slow-onset disasters could be associated with, e.g., drought, desertification, sea-level rise, epidemic disease.
- Sudden-onset disaster: a disaster triggered by a hazardous event that emerges quickly or unexpectedly. Sudden-onset disasters could be associated with, e.g., earthquakes, volcanic eruptions, flash floods, chemical explosions, critical infrastructure failures, transport accidents.

The term disaster management, instead, refers to "the organisation, planning and application of measures preparing for, responding to and recovering from disasters", notably the focus is not on completely averting or eliminating the threats, but rather on creating and implementing prevention, preparedness and other plans to decrease the impact of disasters and "build back better" (UNDRR, 2017). The definition is in line with the four priorities identified by the Sendai Framework, namely: (i) Understanding disaster risk; (ii) Strengthening disaster risk governance to manage disaster risk; (iii) Investing in disaster reduction for resilience; and (iv) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

Hence, DRM describes the application of disaster risk reduction policies and strategies to prevent new disaster risks, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses (UNDRR, 2017). The UN relevant agencies, in particular UNDRR, have failed to single out the specific phases of the DRM cycle, whereas other actors, for example the EU Commission's Disaster Risk Management Knowledge Centre (DRMKC), explicitly refer to a DRM cycle made of adaptation, mitigation,

prevention, preparedness, response, recovery and reconstruction (Morsut, 2019). A different taxonomy of the various phases of the DRM cycle is proposed by the Swiss Red Cross (SRC), which applies an integrated multi-sector approach to DRM, in line with the Sendai Framework. According to said approach, DRM is understood as a cyclical and comprehensive process carried out within an overall framework that comprises the core areas of: disaster management, recovery and reduction. In this thematic paper we adopted the approach of the DRMKC, making reference, when appropriate, to the seven phases of the DRM cycle singled out at the EU level.

To complete the terminology overview, it is worth stressing that DRR "is known as the policy objective of DRM, and its goals are defined in DRR strategies and plans" (UNDRR, 2017). DRR aims at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and, therefore, to the achievement of sustainable development (UNDRR, 2017). Given how DRM and DRR are intrinsically entwined, with the latter representing a substantial and essential element of the former, the present thematic paper will focus on GPs that belong to both, referring to specific phases of the DRM cycle when relevant/applicable and explaining how each GP contributes to building towards disaster-resilient communities and thus fits under the Sendai Framework 2015-2030. Finally, a further caveat is needed in relation to the use of the terms risk and resilience as they are consistently associated with DRM and DRR. The concepts of risk and resilience represent distinct approaches to address the threat of unexpected societal and economic impacts and losses from disasters. More in detail, DRM addresses specific risks, and primarily (although not exclusively) attempts to mitigate or alleviate disasters before they occur; while resilience refers to "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UNDRR, 2017).

Ultimately, the choice to rely on the approach adopted at the UN level and on the UN lexicon is mainly based on two considerations. First, the UN is the most representative international organisation operating in the field of DRM and DRR, and the UNDRR, the UN focal point for disaster risk reduction, operates in all regions of the globe, bringing together a multitude of different stakeholders, from governments to civil society organisations. Second, the UNDRR oversees the implementation of the Sendai Framework 2015-2030, supporting countries in its implementation, monitoring and sharing what works in reducing existing risk and preventing the creation of new risk. Through the Sendai Framework, all countries in the world have been provided with a roadmap for how to make communities safer and more resilient and therefore it represents a sort of universal benchmark to assess the good practices identified in the present study. Finally, the current EU Civil Protection Mechanism also refers to the Sendai Framework: "The Commission shall strengthen cooperation on training, and promote the sharing of knowledge and experience, between the [Union Civil Protection Knowledge] Network and international organisations and third countries, in particular in order to contribute to meeting international commitments, particularly those in the Sendai Framework for Disaster Risk Reduction 2015-2030" (European Union, 2013).

2.3 An overview of the approach adopted in the thematic paper

Despite a significant increase in DRM and DRR research funded by the EU research programmes and by national research agencies, the literature on research methodology that focuses on disasters is still scant (Stallings, 2006; Njå and Rake, 2008; Faber et al., 2014). The lack of attention devoted to the issue of developing an ad hoc methodology ultimately results in the employment of research methods that are widely used in other fields, without taking into due consideration the uniqueness of the disaster context (Witt and Lill, 2018, pp. 971-972). Moreover, research on disasters represents an interdisciplinary field which brings together a wide range of experts, academics and practitioners, from different backgrounds and therefore with different research traditions. Several authors (Amaratunga et al., 2002, p. 23) have already noted that, in interdisciplinary research, the clear understanding of the research problem, terminology and choice of appropriate research methods becomes especially challenging, as "... fundamental issues pertaining to different types of research typologies will affect the whole research process, as the success of a research project will be largely dependent on the robustness of this strategy".

As reported in the ROADMAP second bulletin (ROADMAP Second Periodical Bulletin, 2021, p. 3), we point out that "by analysing the data, it appears evident that current practices in managing multiple hazards are mostly focused on one hazard at a time, which may not be sufficient for addressing challenges of multi-hazard management", especially when a global pandemic amplifies disaster vulnerability and hampers disaster resilience. The know-how acquired during the two years of pandemic led to extensive discussions on how to further improve preparedness and emergency management by all the actors involved in DRM and DRR. As a result, several reports, scientific publications and webinars have been dedicated to the experiences from the management of the emergencies that occurred during the pandemic. It will not be possible to make reference to all the material produced so far, however the present thematic paper will try to offer a comprehensive overview of the existing sources, focusing on the GPs identified and extracted from the three different streams of research proposed in 1.2.

In light of these general considerations, in the process of drafting the present thematic paper we first set a specific goal and then developed the methodology to adopt. Once again, the Sendai Framework provided important guidance, since it specifically calls for "multi-hazard and solution-driven research in disaster risk management to address gaps, obstacles, interdependencies and social, economic, educational and environmental challenges and disaster risks" (p. 14). The ROADMAP project and this first thematic paper, sharing the Sendai Framework's perspective, follow a bottom-up approach based on the collection of selected experiences, GPs and solutions already implemented by EU Member States and/or states beyond the EU borders. This approach is perfectly in line with the main goal of the ROADMAP project, which aims at establishing a European Doctrine on disaster risk and crisis management funded on the mutual cooperation between scientific communities and DRM authorities.

We applied the desk research methodology, collecting data from external and internal resources. External sources consist of up-to-date scientific literature, international and national projects and institutional websites. Internal sources come from the ROADMAP consortium and Advisory Group as well as the ROADMAP periodical bulletins, which present a selection of GPs through a systematic review of past and ongoing national/international projects and initiatives dealing with DRM. More specifically, for the first strand of research (the five real-life multi-hazard risk scenarios) we surveyed the leading scientific journals, reports by international organisations and NGOs and the ROADMAP periodic bulletins. For the second strand of research (national and regional strategies to deal with COVID-19), we mainly consulted institutional websites and we collected useful information from the members of the ROADMAP consortium and the Advisory Group who, in some instances, contributed also to shape the measures adopted at the State level. For the third strand of research (tools/technologies/frameworks that have or can be used to improve any DRM phase) we focused predominantly on the outcomes of relevant research projects as presented in the dedicated websites. We decided to focus our study on natural disasters which have not ceased to happen during the pandemic, leaving aside other typologies of concurrent events. These include, for example, armed conflicts, protracted violence and turmoil, large-scale migration flows. With regard to the latter, which is a phenomenon that affects several countries, we are aware that during the COVID-19 outbreak the presence and movements of migrants has influenced fundamental demographic, social, cultural and economic dynamics, shaping the local contexts that the pandemic was and is affecting and modifying the overall vulnerability, exposure and coping capacity of States (Banulescu-Bogdan et al., 2020). As a result, it is logical to affirm that accounting for migrants in national efforts to deal with COVID-19 will affect the pandemic's trajectories as well as States' responses (Guadagno, 2020, p.1). Given the specific focus of this thematic paper, however, we could not delve into the many complex issues related to large-scale migration flows, although we did include under the third stream of research some GPs focussed on enhancing communication for the whole population, including migrants and refugees.

In order to summarise the findings of the present study, we included at the end of section 3 a table that contains an overview of all the GPs collected. This table is made of 6 columns: "GP short title", "Country/region/organisation", "DRM phase", "GP type", "Sendai Priority/Target" and "References", which serve the purpose of categorising the 25 good practices extracted from the three streams of research. The same table is also used as the starting point for the discussion carried out in section 4. The table serves multiples purposes: it helps the reader by providing an overview of all the main GPs at once; it represents the natural input for the discussion; and it highlights the connection between the research carried out in the present thematic paper and the Sendai Framework.

3. Good Practices In Multi-Hazard Risk Starting From a Pandemic Scenario

3.1 Multi-hazard risk in the context of a pandemic

As introduced in the previous sections, multiple-hazard events are disaster events of natural or anthropogenic origin, including those of biologic origin (e.g. an infectious disease such as COVID-19), that overlap in time and space. The occurrence of two or more of these events (e.g. an earthquake during COVID-19 pandemic) is referred to as a multi-hazard scenario, a.k.a. "concurrent hazards", "compound hazards", "superposed hazards" (Figure 1) or "coinciding hazards" (EC, 2011; Kappes et al., 2012; Quigley et al., 2020; Hariri-Ardebili and Lall, 2021). Hazards that are triggered by preceding hazards are referred to as cascading hazards (Quigley et al., 2020) or cascading events. Whilst prior to COVID-19 in many countries DDR and DRM strategies devoted limited attention to the management of biological hazards and emergencies and focused largely on natural hazards, the global pandemic provided an unexpected opportunity to rethink how to deal with multi-hazard risks.

3.2 GPs stemming from real-life multi-hazard scenarios (disaster event + pandemic)

This first strand of research focuses on GPs stemming from real-life multi-hazard scenarios, as defined in section 1. Each of the five selected scenarios depicts how DRM has been implemented in one or more contexts

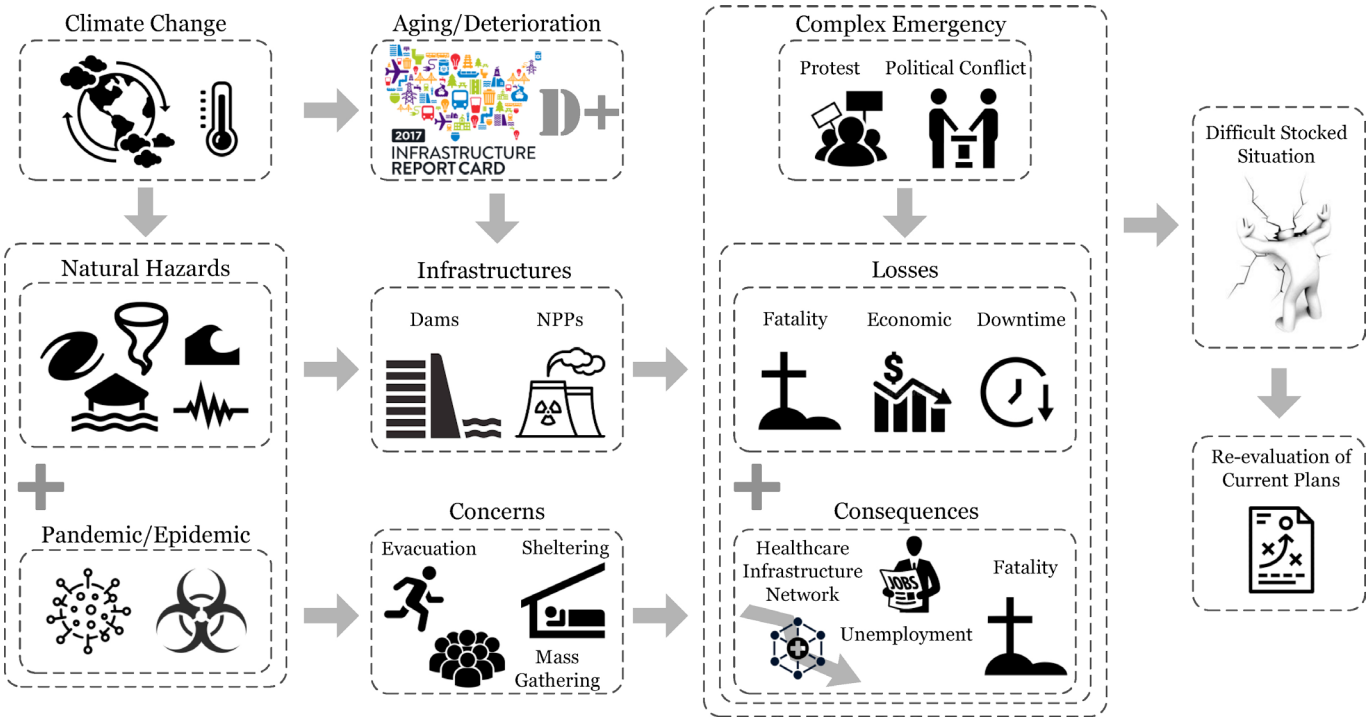

Figure 1: Illustration of superposed natural hazards and pandemics (adapted from Hariri-Ardebili and Lall, 2021).

where a disaster event hit a given area at the same time as the COVID-19 pandemic. The disaster events have been identified based on a number of factors, especially their frequency over the past two years and the damage caused or likely to be caused. As mentioned before, in selecting the multi-hazard scenarios, we decided to consider one or more natural disasters combined with the pandemic, leaving aside other types of events (for example armed conflicts, protracted violence and political instability, and the phenomenon of large-scale migration flows) that have affected several countries over the past two years. Moreover, in describing the different real-life scenarios we are aware that the level of information and details provided is not uniform, but this depends on the available sources, including the existing literature.

3.2.1 Wildfires and Pandemic

A survey completed by 443 individuals active in wildland fire management from over 38 countries around the world (Stoof et al., 2020) has shown a significant impact of COVID-19 on the operation of the respondents' organisations and fire management, mainly related to:

- Availability of support services (e.g. logistics and supply, catering, aviation maintenance and supply, accommodation, transportation) and to some degree of specialist services (e.g. meteorology, air quality, remote sensing);
- Ability to share resources and services with other regions or countries in need;
- Reduction/cancellation of various risk reduction activities, such as training and pre-season community engagement.

To facilitate the sharing and receiving of resources during this pandemic, simple checklists (see # 3 in Table 2) have been developed, e.g. by the National Multi-Agency Coordinating Group (2020) in the United States (see Figure 2).

Different countries, jurisdictions and agencies have found ways to cope with these impediments. For example, in Australia firefighting staff reside at home while in the USA staff are housed in large camps, which involves different risks of COVID-19 transmission (Moore et al., 2020). The data shows that in a large number of cases, the number of staff per vehicle is reduced as a result of COVID-19 requirements, leading to less staff at the fire scene (usually not enough space for many vehicles) and firefighters driving when exhausted (among 'the most frequent killers in the business') (Moore et al., 2020).

3.2.2 Severe Weather Events and Pandemic

In 2020, many Asian countries were impacted by large-scale disasters amid the COVID-19 pandemic. Potut-

ORDERING UNIT -- Provide the following information in "Special Instructions" in resource order

		Yes	No
1	Confirm Best Management Practices are in place to mitigate COVID-19.		
2	Description of any additional supply/equipment needs (self-sufficient, food, water, extended camping equipment, etc.)		
3	There is a medical plan in place with identified care facilities for COVID-19 patients.		
4	Describe the level of COVID-19 outbreak in the county where the fire is located from the following website: https://coronavirus.jhu.edu/us-map		

SENDING UNIT – Is the following met?

		Yes	No
1	All individuals filling the order have been screened using the MPHAT Wildland Fire Screening Tool or their employing agency's equivalent.		
2	The resource is equipped with PPE and supplies required to adhere to COVID-19 mitigation protocols during mobilization and for at least three operational periods.		
3	The resource is prepared to be self-sufficient regarding food and water for at least the first three operational periods if driving.		
4	The resource can meet any additional supply/equipment needs identified in the Special Instructions section of the resource order.		
5	There is an isolation/quarantine plan in place to use upon return to the home unit that can be implemented if deemed necessary.		

Figure 2: Interagency Checklist for Mobilization of Resources in a COVID-19 Environment, developed by the National Multi-Agency Coordinating Group (NMAC, source) (adapted from Stoof et al., 2020).

an and Arakida (2021) have analysed reports presented by the member countries of Asian Disaster Reduction Center (ADRC) and highlighted the good disaster response practices during the COVID-19 pandemic. Various organisations across the world have been forced to strengthen disaster management systems by modifying their approaches to respond to disasters under the COVID-19 pandemic (Ishiwatari et al., 2020). They are also named "evolving practices" (Potutan and Arakida, 2021) since they resulted from the adaptation to concurrent crises.

- **Digitalisation of some aspects of disaster response** (see # 4 in Table 2) - Many DRM agencies in Asia have accelerated the utilisation of digital technologies for disaster early warning, surveillance, and impact assessment to adapt to movement restrictions imposed during the pandemic. In addition, training activities on disaster response are also increasingly done online. For instance, the Singapore Civil Defence Force (SCDF) reported using virtual reality in disaster response training (Understanding Risk, 2021). Likewise, the Ministry of the Interior and Safety (MOIS) of the Republic of Korea reported to have accelerated its online disaster response training, and lessened the conduct of face-to-face training (MOIS, 2021).
- **Dispersed evacuation** (see # 5 in Table 2) - To adapt to social distancing measures, the conventional evacuation practice evolves towards *dispersed evacuation*, enforcing the minimum physical distance between individuals (usually 1.5-2 m). The implications of dispersed evacuation include the need to designate **more evacuation centres**, identify **isolation facilities** for infected individuals, and implement **additional health measures**, including stockpiling of additional emergency supplies (e.g., facemasks, disinfectants, and thermometers).
- **Remote psychological first aid** (see # 6 in Table 2) - To disaster-impacted individuals who are already experiencing anxieties from the pandemic.

3.2.3 Earthquakes and Pandemic

Amidst the COVID-19 pandemic, the City of Zagreb (Croatia) was hit by two severe earthquakes that occurred on 6:24 and 7:04 AM, on 22 March 2020 (Richter magnitude 5.5 and 5.0, respectively). At the time, most positive cases of COVID-19 of Croatia were identified in Zagreb. A substantial number of citizens attempted to leave the city in fear of further earthquakes. Most of them were successfully stopped but many managed to relocate (sometimes to relatives), which led to concerns of spreading

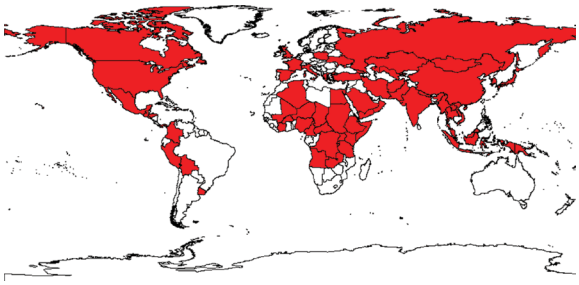

Figure 3: Countries with flood events occurred during the pandemic (after detection of the first COVID-19 case), by the end of September 2020 (adapted from Simonović et al., 2021).

the disease into disease-free communities and breaking down previously quite successful epidemiologic chains of disease contact monitoring. Effective epidemiological surveillance (see # 1 in Table 2) was continued, proposing strict self-isolation criteria and quarantine measures for COVID-19 positive patients and their contacts, but the number of screening tests had not been increased. The earthquake severely disrupted health care and civil services, and thousands of people remained in close (involuntary) contact over a period of several days. Despite that, the earthquake did not exacerbate the disease spread since the number of COVID-19 cases remained stable through the subsequent 14-day incubation period. Still, the other impacts of the earthquake had implications on the COVID-19 response measures, which included bringing many "non-essential" workers back to work in the recovery process (e.g. construction workers). Additionally, serious damage to major hospitals put additional pressure on the health care system and urged a need for reorganisation of already adopted pandemic mitigation and response procedures and strategies (adapted from Ćurković et al., 2021).

3.2.4 Floods and Pandemic

There have been 70 countries in the world with flood events occurring after detection of the country's first COVID-19 case, and hundreds of thousands of people have been evacuated (Simonović et al., 2021; see Figure 3). Floods hit 22 countries in Africa, 25 in Asia, 8 in Europe, 2 in Oceania, 8 in North America, and 6 in South America. The evidence gathered by the Flood Observatory (FO, 2021) at the University of Colorado shows that every few days people are adversely impacted by floods somewhere in the world.

In Europe, there were floods for example in the United Kingdom during 15-19 February 2020 and in the south of Poland in late June 2020, but the most notable one took place in July 2021, when several European countries were affected by severe floods. The disaster started with heavy rain in the United Kingdom between 12 and 15 July 2021, which then spread across western Germany, the Netherlands, Belgium, and Luxembourg. The floods affected several river basins across Europe including Austria, Belgium, Croatia, Germany, Italy, Luxembourg, the Netherlands, and Switzerland (BBC, 2021), causing deaths and widespread damage.

In many cases, the flooding impact was exacerbated due to the pandemic restrictions and preventive measures, e.g. in the City of Ottawa and the province of Manitoba in Canada (Manitoba 2020; Ottawa 2020). Ottawa City established a separate team to deal with flooding as the city responded to the COVID-19 pandemic. Manitoba province issued a high-water response activity guide for COVID-19 adaptation (Manitoba, 2020). Another example is the hindrance to safe evacuations during flooding due to the COVID-19 travel restrictions (UNDRR, 2020c). The flood disaster in Japan caused by Typhoon Hagibis hit across the country in October 2019 and activated numerous landslides. There was a shortage of volunteers in the early recovery process (Ishiwatari et al., 2020), but also the local governments suspended receiving volunteers in February 2020 as a measure to prevent spreading COVID-19 (NCSW, 2020). Over 7 million citizens had to be evacuated, and in some regions the population was asked to stay home to avoid crowding evacuees at evacuation centres, or to stay at friends' houses instead of evacuation centres (Kamogawa City, 2020). Some countries with Early Warning Systems (EWS) for floods used these systems for COVID-19 risk communication with their population (see # 7 in Table 2), which helped to efficiently contain the spread of the virus (Ashraf, 2021).

3.2.5 Volcanic Eruptions and Pandemic

According to the Global Volcanism Program of the Smithsonian Institution (SI, 2021), overall, 46 volcanoes were in continuing eruption status as of 9 December 2021. An eruption marked as continuing does not always mean persistent daily activity but indicates at least intermittent eruptive events without a break of 3 months or more. Detailed statistics are not kept on daily activity, but generally there are around 20 volcanoes actively erupting on any particular day. There are about 1500 potentially active volcanoes worldwide. When volcanoes erupt, they can spew hot, dangerous gases, ash, lava and rock that can cause disastrous loss of life and property, especially in heavily populated areas. Volcanic erup-

tions can also cause secondary events, such as floods, landslides (in turn potentially causing tsunamis, as in Stromboli Island in 2002) and mudslides, if there is accompanying rain, snow or melting ice. Erupted materials can also start wildfires, and ashes in the atmosphere can have an impact on air traffic (e.g., in the case of the Eyjafjallajökull eruptions in 2010).

The eruption of Cumbre Vieja volcano on the Canary Island of La Palma (Spain) began on 19 September 2021. Lava has burned through homes, roads and farmlands causing mass destruction on the west part of the island forcing authorities to evacuate nearly 8000 people, placing them inside hotels and empty apartment buildings (Lerche, 2021). In response to the eruption, the Copernicus Emergency Management Service (EC, 2021) (see # 8 in Table 2) was activated (See Figure 4). Satellite imagery has helped authorities and local teams to monitor and manage the ongoing crisis. The fleet of Copernicus Sentinel satellites carries different instruments which have been providing crucial information, such as images of the rivers of lava, measurements of gas emissions and environmental impact assessment (ESA, 2021). The emergency teams had also realised a group of dogs had been stranded by lava from a volcano's prolonged eruption. Drones had been used to drop food and water for the animals, while a cargo drone mission had been prepared to airlift them, as it was impossible to fly helicopters (due to ash and pyroclastic rocks in the air) and too risky to attempt by foot (Chappell, 2021). However, by the time the mission was ready and special flight permits were approved, dogs were already rescued by a mysterious A Team (Chappell, 2021). In general, drones are already extensively used in DRM for i) mapping or damage assessment; ii) search and rescue; iii) transportation; and iv) training (Daud et al., 2022) (see # 9 in Table 2).

GPs related to the DRR and DRM strategies put in place to prepare and respond to volcanic eruptions while dealing at same time with the current pandemic (see # 1 in Table 2) have been identified in different countries:

- **Emergency communication campaign** (see # 23 in Table 2): On 9 April 2021, La Soufrière volcano in Saint Vincent and the Grenadines started a series of explosive eruptions that prompted significant ashfall and pyroclastic flows, with consequent damages and destruction. The advent of heavy rains on 29 April 2021 caused subsequent flooding, landslips, and mudflows, which increased the impacts on persons, infrastructure, and agriculture. A research project[1] has been funded by the EU-Caribbean RRB in order to strengthen the National Emergency Management Organisation's (NEMO) operational framework for disaster management by revising its National Disaster Response Plan in light of the ongoing volcanic eruption and COVID-19 pandemic and providing capacity-building opportunities. The main output of the project was the development of an emergency communications campaign, carried out during the days following the first eruption, to build awareness of the potential harmful impacts of volcanic ash. Public service announcements video and

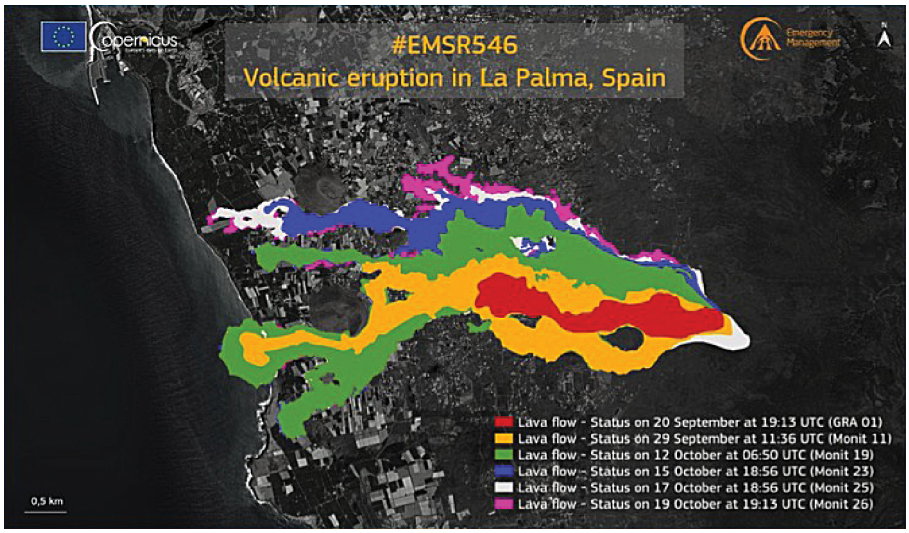

Figure 4: Copernicus EMS mapping of the volcano eruption in La Palma, Spain.

[1] https://www.gfdrr.org/en/saint-vincent-and-grenadines-preparing-compounding-emergencies-covid-19-volcanic-eruption-and

social media contents, including three videos, were rapidly produced to provide useful tips on ways to safely interact with ash and protect children, homes, and vehicles. These were disseminated by NEMO, the CDEMA, the World Bank/GFDRR, and local media via television, radio, and social media channels.

- **Improve the management of the evacuation centres** (see # 1 in Table 2)**:** the National Disaster Risk Reduction and Management Council has enhanced the monitoring of the evacuation centres in the aftermath of the Taal Volcano (Philippines) eruption in 2020 and 2021 to make sure that the following measures are implemented:
  - Providing technical assistance for assessing and isolating suspect COVID19 cases identified in the evacuation centres;
  - Increasing the number of staff and medical supplies in anticipation of possible influx of patients;
  - Continuous coordination with provincial health offices (PHO) regarding hospital's surge capacity and bed availability for COVID and non-COVID patients;
  - Conduct ocular visit to the activated and prepared evacuation centre to ensure that COVID-19 safety and health protocols are implemented and to provide concrete guidance as well as conduct rapid damages and needs assessment.

3.3 GPs from strategies to deal with the COVID-19 pandemic and concurring disasters

The GPs described in this subsection have been extracted from the second strand of research of the present study: strategies that have been implemented at the national or regional level in order to deal with the COVID-19 pandemic alone or, in some cases, with other disaster events simultaneously. We are aware that these national strategies do not represent GPs per se, but we can formulate some conclusions around these and their potential applicability in multi-hazard scenarios as well. The selection of the states and regions surveyed has been based on practical considerations, in the first place the availability of the information collected (retrieved from institutional websites, published academic articles or first-hand information shared by the members of the ROADMAP consortium and its Advisory Group).

3.3.1 Norway

A full evaluation of Norway's response and management of COVID-19 done by a committee of leading scientists, practitioners, and decision-makers states as the main finding: *"In its preparedness work, the Government has not considered how risk in one sector depends on the risk in other sectors. A preparedness system based on each sector assessing its own risk and vulnerability fails when no one has taken responsibility for assessing the sum of the consequences for society as a whole. There is a need to develop a cross-sectoral system that captures how the risks in the various sectors interact with each other. This is a learning point for emergency preparedness in general"* (Gonzalez, 2021).

In Norway, the likelihood of a pandemic was considered high with a high impact on the population (DSB, 2019), but relatively little had been done to build specific capacities to deal with a pandemic. The Norwegian authorities had delegated the responsibility for the preparation to the regional health systems, which had problems building up robust emergency preparedness. Over 20% of the local municipalities did not have an operational plan for infection control and training was lacking (Christensen and Lægreid, 2020). However, the decision-making process when the crisis unfolded was fast and carried out in close collaboration of the national government with the Norwegian Directorate of Health (NDH) and the Norwegian Institute of Public Health (NIPH). Even though the political leadership sometimes opted for more radical measures compared to the advice it was given, the professional experts' opinion was highly respected. This consensus-based and collaborative approach is typical in Norway, based on high mutual trust relations between political and administrative executives and expert bodies. The Norwegian approach has proven to work well, also in comparison to the relaxed Swedish approach to its public health responses and soft mitigation strategy, and the US' slow response, with no national lockdown, lack of trust in government, and confrontational policy style (Hall and Battaglio, 2020).

In general, the Norwegian crisis management in response to the COVID-19 pandemic can be considered an example of rather effective decision-making, handling, and making sense of the situation, also thanks to the cooperation among authorities and the public (Christensen and Lægreid, 2020). The Norwegian healthcare system is very good with abundant resources, and still, the medicine reserves and infection control equipment were insufficient at the beginning of the response. Despite this, when the crisis struck, the Norwegian health care capacity was shown to be robust and strong in most other respects, mainly supported by the strong economy, the efficient revision of the budget and the quick restock of the key resources (see # 10 in Table 2).

The Norwegian approach was top-down and based on collaboration between political, administrative, and professional central authorities. The main decision-making style and handling of the outbreak was consensual and based on a pragmatic collaborative approach combining argumentation and feedback, given that there was a lack of evidence-based knowledge and much uncertainty regarding the efficacy of measures to fight the pandemic (Ansell and Boin, 2019). In summary, the Norwegian governance capacity was overall good when it came to delivery, regulation and coordination, but the analytical capacity was weaker, especially regarding preparedness for a pandemic (Christensen and Lægreid, 2020).

From the Norwegian case, we can formulate the following GPs (adapted from lessons learned in Christensen and Lægreid, 2020):

- Use of a suppression strategy (the government managed to control the pandemic rather quickly and effectively) followed by a control strategy, based on a collaborative and pragmatic decision-making style, successful communication with the public, mainly thanks to a high level of citizens' trust in the government (see # 2 in Table 2).
- Establishment of trade-offs between protecting citizens from the pandemic and protecting the economy (see # 11 in Table 2). Successful management of a pandemic needs to give priority to protecting citizens from becoming infected, but this also needs to be followed up by measures to reduce the negative economic side effects of radical measures.
- Establishment of multi-level collaboration between policy areas (and also with other countries) and administrative levels and between political authorities and professional expert bodies is necessary. This cooperation actually concerns several types of hazards and risks as well (see # 12 in Table 2).

From the statement of the committee above, we can assume that a GP can be:

- Establishment of a cross-sectoral system of collaboration among different bodies, agencies at different levels to consider how risk in one sector can influence risk in another sector (see # 13 in Table 2).

3.3.2 South Korea

Korea's national response framework covers 41 types of disasters and has three components: a) the Standard Risk Management Manual, b) the Working-Level Manual for Risk Response, and c) the Manual for Actions-at-Scene. The Standard Manual is developed for each type of disaster by the responsible agency and finalised through interagency consultations. It defines the basic principle for responding to a specific disaster and describes the roles and responsibilities of the relevant response institutions. The Working-Level Manual is developed by related support agencies to enhance the Standard Manual and must be approved by the Disaster Management Supervision Agency. The Action Manual is developed by on-site response agencies, such as local government authorities (Kim et al., 2021). The national manual system is regularly updated so that the manuals can be executed for any disaster. For example, infectious disease manuals include (as per 30 April 2021) 1 standard manual, 17 working manuals, and 276 action manuals, which have been improved based on the experience and knowledge gained through dealing with SARS (2003), H1NI (2009), and MERS (2015).

Korea's response to COVID-19 has shown the need to better understand the features of systemic risks and that the established plans need to be adapted in the face of new or unknown risks which emerge through multi-sectoral collaboration. The key findings from the study of the risk triggered by COVID-19 and the impact of Korean response countermeasures call for the enhancement of the national response framework and risk assessment tools by considering the response managerial challenges caused by the systemic risk. More specifically (Kim et al., 2021):

- The government should take actions immediately, even with the lack of complete information and knowledge about the new type of risk, since delayed action is highly likely to amplify the disaster risk;
- A multi-sectoral response should be prepared to cope with systemic risk. For example, establishing a coordinating centre with health and non-health response pillars during the early stage of the pandemic;

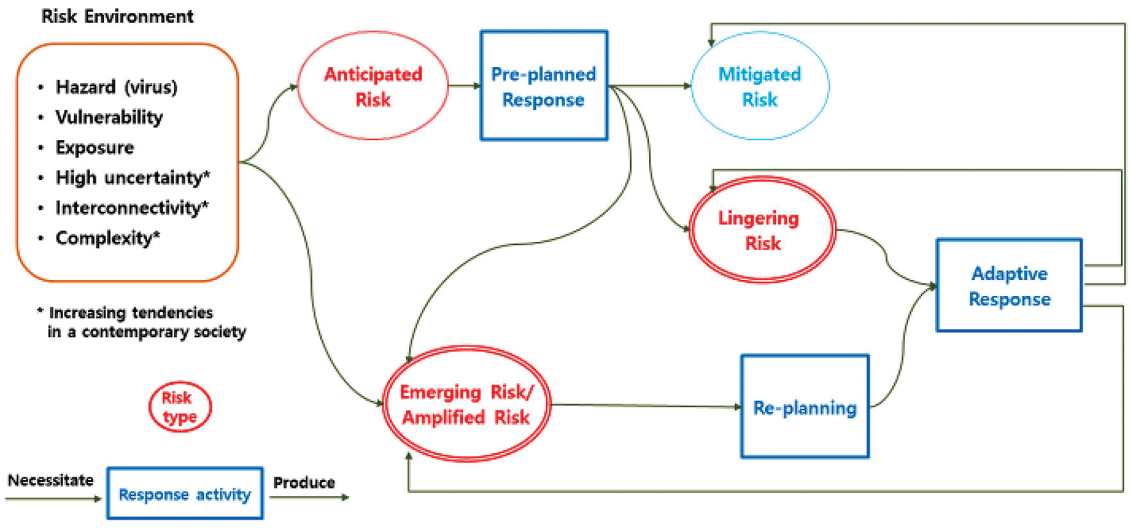

Figure 5: Risk management flow (adapted from Kim et al., 2021).

- The government should impose transparency, inclusive risk governance, and extensive use of innovative technologies from the initial response stage against risks with high uncertainty and novelty.

All of the listed practices have enabled a more effective response to systemic risks.

Another crucial aspect is understanding the risk management flow (see Figure 5: Risk management flow (adapted from Kim et al., 2021)). (see # 14 in Table 2) for the enhancement of the disaster response management system. COVID-19 has triggered various risks, which have been changed through the intervention implemented by the authorities and through the intersection between response measures and risk triggering factors.

Within the risk management flow, understanding the features of different categories of risk plays a critical role in enhancing the response system.

3.3.3 Italy

Measures to contrast the COVID-19 outbreak and propagation have been adopted by Italian public authorities since the end of January 2020. In addition to the measures adopted at the central level, it is worth noting that each of the 20 regional authorities has adopted its own regulations and legislative acts; the same happened for municipalities. Italy is often referred to as a "regionalised country", in particular since the constitutional reform of 2001 and the fiscal federalism law of 2009, which granted greater autonomy to the regions. In addition, Italy has an asymmetric decentralisation, with fifteen ordinary-status regions (RSO) and five special status regions (RSS) enjoying even more legislative and financial autonomy (Aosta Valley, Friuli-Venezia Giulia, Sardinia, Sicily and Trentino-Alto Adige/Südtirol). In light of Italy's fragmented legislative landscape, it is of course not feasible to survey all the actions and the measures enacted at the different levels to respond to the pandemic; we will focus on one specific document, the Civil Protection's operative measures (OM) issued by the Presidency of the Council of Ministers on 31 January 2020 (ICPD, 2020).

The goal of the operative measures was to provide additional guidance to the Civil Protection system, which operates at all levels (from the central state to the municipalities), in dealing with one or more hazards in the course of the pandemic (see #2 in Table 2). In particular, the OM identify the actions that must be undertaken in order to prevent the spread of COVID-19 across first responders as well as among the civilian population in the occurrence of a disaster event. The document explicitly mentions the types of events that are more likely to happen in Italy (and that in fact took place in 2020-2021), i.e. extreme weather events and earthquakes (ICPD, 2020, pp. 2-3). Due to the fact that Italy has a three-tier system of subnational governments, comprising the regions, the provinces and the municipalities, the document addresses the different levels specifying for each of them which are the actors involved and those in charge. At the same time, the OM present an overview of the actions that must be implemented at all levels, which include:

- The modalities to carry out a survey of the building damage in the aftermath of an earthquake, as well as the related inspections (ICPD, 2020, Annex I);
- The list of preventative measures that must be implemented by volunteers (as spelt out also in a separate document called Operative Measures for the Civil Protection's voluntary work in the course of the COVID-19 pandemic, 2020);
- The revision of the parameters to set up emergency areas in compliance with anti-Covid measures.

3.3.4 Singapore and New Zealand

In the evaluation of the strategies and policies of various countries against the COVID-19, Singapore's approach has been rated as effective as it managed to keep both the infection rates low and the economy strong (Fakhruddin et al., 2020). The key lesson was the detrimental role of the bureaucratic structure in handling fluid and unprecedented situations, so the Singapore government has led a well-coordinated, multi-stakeholder response and recovery, which has been praised by other countries. Still, Singapore overlooked huge numbers of migrants living in crowded dorms where a series of COVID-19 outbreaks hit, and are still affected by the pandemic (Marsh, 2021).

The key success factor has been assigned to the fact that Singapore has learned from their recent pandemics experience – hand-foot-mouth disease (in 2000), SARS (in 2003) and H1N1 (in 2009). A good practice from Singapore is, thus, to use the experience from other types of outbreaks to cope with the COVID-19 pandemic (see # 15 in Table 2).

Countries such as South Korea, Taiwan and Vietnam used their experiences of previous epidemics to: (1) build their information systems; (2) allow for complementary laws and guidelines to work around data privacy and trust issues; (3) integrate databases such as immigration and health insurance records for ease of determination of travel history of patients; (4) immediately recognize the threat early on and closing borders; and, (5) create necessary systems and applications to facilitate contact-tracing and stop the transmission of disease (Tabuga et al., 2020) (see # 15 in Table 2).

New Zealand's success factors are believed to be their strong leadership, bold and strong actions early in the pandemic outbreak that prevented COVID-19 transmission and widespread (see # 16 in Table 2). This approach significantly limited the number of infected citizens, who were extensively tested, their contact was traced, and they were isolated.

3.3.5 United Kingdom

Hilton and Baylon (2020) have sought opportunities to improve the UK's preparedness for future disasters based on experiences with COVID-19. There were nu-

merous challenges and shortcomings in the response to COVID-19, including plans not being sufficiently flexible and not regularly updated, a lack of systems thinking, underestimating emerging infectious diseases beyond influenza ("preparing to fight the last war") and limited use of external expertise. Nonetheless, Hilton and Baylon (2020) have identified good practices, coming from both the public and private sectors, which the UK government might use to improve its risk management practices.

- **A "three lines of defence"** approach to risk governance, which is common in the private sector (see # 17 in Table 2).
  1) Firm-wide risk planning and risk mitigation where risk ownership is spread across the business.
  2) Adoption of Chief Risk Officer (CRO), a board-level executive with responsibility for risk management policies and for the risk assessment process. The CRO provides an oversight function and a strong senior-level voice to ensure that all parts of a firm are acting to address risks.
  3) An audit function that has a degree of independence from the day-to-day work reports to the board and acts to ensure that risk management is working effectively.
- **Worst-case scenarios to compare risks and highlight residual acceptable risk** - i.e. two sets of scenarios (see # 18 in Table 2).
  - The first set illustrates the scale of the risk and expected damage pre-mitigation – this allows risks to be compared.
  - The second set illustrates the level of residual risk and damage expected after mitigation – this highlights for executives the level of risk and damage they are still willing to accept and the cut-off point at which further mitigation is deemed too costly.
- **Vulnerability Assessments** - an approach that primarily assesses risks in terms of both their scale and the level of vulnerability of the business with regard to them. This highlights the gaps that need to be closed in the current system and supports flexible risk planning.
- **Seeking expert and public feedback on risk assessments** - as done by The Swiss government and Norwegian government.
- **The publication of quantifiable predictions** - which allows an organisation to learn from its errors and to improve and be accountable for its mistake.

3.4 GPs from tools and technologies supporting operational activities and strategic approaches implementation

The third stream of research from which GPs have been extracted is represented by tools, technologies, approaches and frameworks developed to enhance any phase of the DRM cycle or to support recommended strategies adopted at the national, regional or international level. These GPs are implemented to overcome many of the challenges met by the different stakeholders. They have not been necessarily designed or developed with a multi-hazard situation in mind, yet they can, and should, be taken into account also in contexts where two or more disasters occur at the same time. In order to categorise the different examples collected, we divided them into two groups: 1) Software tools and technologies; and 2) Strategic tools/solutions (frameworks, standards, guidelines, approaches, methods, techniques, etc.)

3.4.1 Software tools and technologies

The **Resilience Diagnostic Tool** (Wardekker et al., 2020) (see # 19 in Table 2) is a practical web tool that helps diagnose choices made in resilience-building, making them transparent and explicit. By focusing on making decisions based on resilience principles, rather than resilience assessment, enables informed choices for the local experts and their stakeholders. The Resilience Diagnostic Tool is process-based, with guiding questions. The three steps and their elements (see Figure 6) are developed based on resilience assessment tools and governance/planning support tools.

Step 1 reflects on the goals of resilience-building. The scope of the analysis is determined - resilience for who, where, what, when and why, and the key data is gathered. Step 2 explores choices made, i.e. which aspects/principles of resilience are emphasised, both for the current situation and the desired one (plans, measures, policies for resilience-building). Step 3 reflects on the consequences of the choices, do the interventions match the goals set in Step 1, and possible side effects. Lastly, a follow-up is considered, such as gathering more input data for more detailed sectoral or geographical analysis or revising resilience plans that do not match the established goals. The Multi-layered set of resilience principles is available in Wardekker et al. (2020).

Economic Recovery Dashboard (WSDC, 2021) (see # 20 in Table 2) is a web tool implemented to track economic recovery and resiliency in the state of Washington (US). The tool (Figure 7) uses a variety of data sources and displays the latest available data on employment, businesses, government assistance programs and consumer behaviour, helping monitor the economic impact of COVID-19 across the state. With the emphasis on driving a sustainable and equitable recovery across populations, regions, and industries, the tool aims to:

1) Provide a consolidated economic dashboard to:
   - Monitor recovery progress, and identify implications for ongoing planning.
     - Employment/unemployment across regions and industries.
     - Impacts on disadvantaged populations.
     - Business income, trade, and investments.
     - Consumer behaviour.
   - Inform critical policy decisions with a holistic, data-based view of the economy.
   - Enable and support public behaviour needed for safe, accelerated recovery by externalising data.

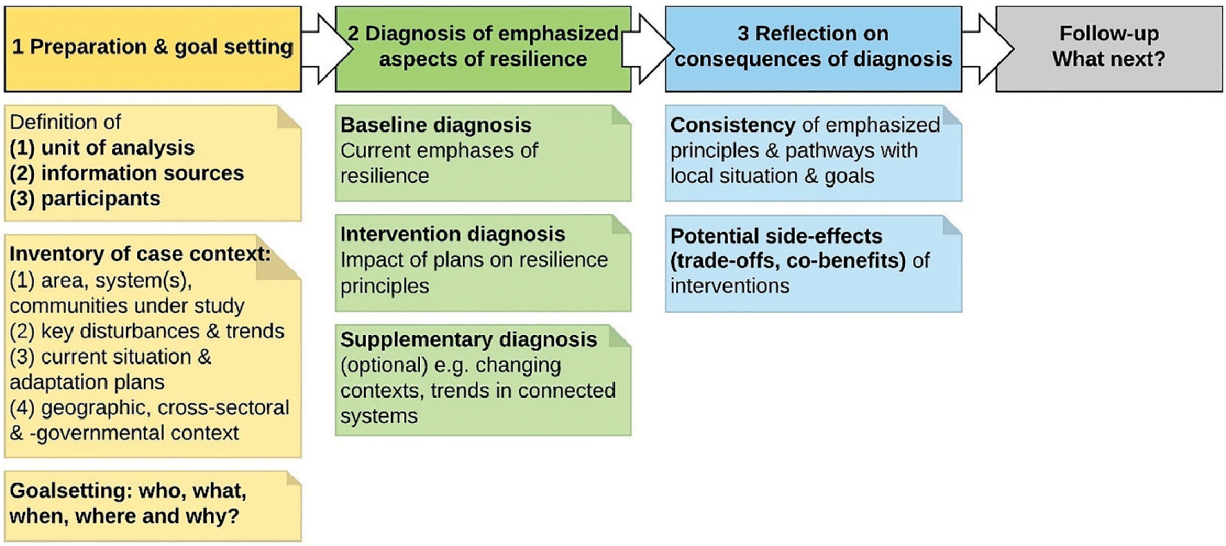

Figure 6: Steps of the Resilience Diagnostic Tool (Wardekker et al., 2020).

2) Support economic recovery planning
   - Capture key goals for the state economic recovery
   - Identify potential investment ideas to support economic recovery and evaluate on common criteria
     - e.g., jobs, long-term impact, equity, climate
   - Understand trade-offs across ideas on common dimensions to inform decision-makers

Strategyfinder (see #21 in Table 2) is a collaborative software to elicit and collect wisdom, experience, and knowledge from interdisciplinary experts in a structured way.

The extension of the risk systemic methods to the pandemic system-of-systems poses several major challenges (Gonzalez et al., 2021):

1) Increase in the number of risks and the interrelations among the risks, which.
2) Induces an even larger increase in the number and impact of the vicious cycles, which.
3) Causes a significant increase in the complexity of the risk scenarios, which in turn.
4) Increases the challenge to identify powerful portfolios of strategies to disable the most potent risks.

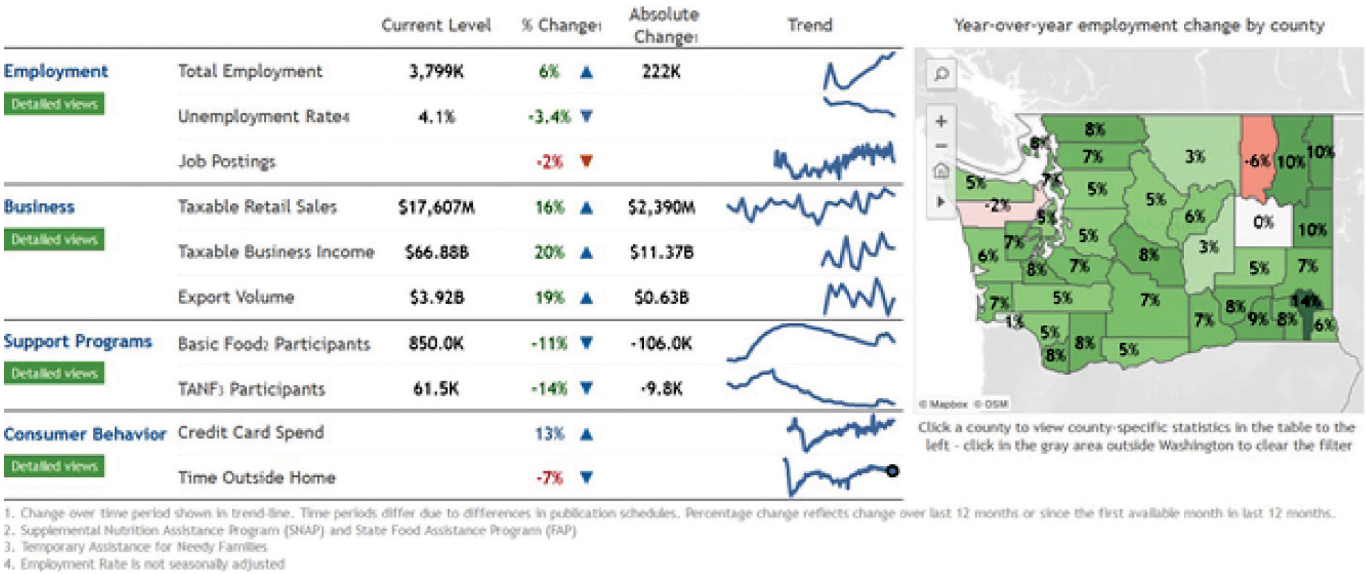

Figure 7: The Washington State Economic Dashboard (screenshot by Authors).

The Systemic Pandemic Risk Management approach involves (Gonzalez, 2021):

- **Identifying and selecting appropriate experts for the risk systemicity workshops**, since the development of effective strategies for risk mitigation must involve interdisciplinary thinking and strategy implementation – working across traditional silos.
- **Workshops to construct a risk systemicity model with scenarios**, used to elicit risks, their interdependencies and develop scenarios.
- **Back-room analysis to identify priorities for risk mitigation**, by finding risks and their causal links. The mitigation of risk with the biggest impact in terms of the number of vicious cycles becomes the focus of strategy development.
- **Devising workshops for developing effective mitigation strategies**, evaluated by their potential impact and practicality to finally select a portfolio of strategies focused on mitigating the high priority risks and causal links.

Strategyfinder allows the participants to jointly work on a causal map of the interconnected risks which leads to discovering feedback loops (vicious and virtuous cycles, and balancing/controlling feedback loops). The system of risks presented in a causal map format (a form similar to a 'cognitive map') allows participants to explore and validate a prepared generic map of the system of risks in their location and selected time horizon, and to develop impactful strategies that are practical.

3.4.2 Strategic tools/solutions

Sphere Standard (see # 22 in Table 2): the Sphere Association (https://spherestandards.org/) provided the guidance of applying humanitarian standards in response to COVID-19 (Sphere, 2020). The Sphere Handbook, in particular, covers the approaches of promoting hygiene measures, establishing health systems and controlling communicable diseases and is widely accepted as general guidance for humanitarian responses (Sphere Association, 2018). Beyond technical advice, the standard provides additional guidance on relevant principles (Sphere, 2020):

- *Information*: People have the right to understand what is happening and to trust that the measures taken are in their own and the community's best interest. People have the right to clear, transparent and understandable information concerning the outbreak, the actual danger and what is expected of them.
- *Dignity*: Respecting their human dignity is the basis for your response. People who are living with conditions associated with stigma or indeed those who fear they may be stigmatised for having the virus can be driven to hide the illness to avoid discrimination. It is important therefore to provide supportive messaging and care.
- *Community engagement*. If you want to build trust, share information transparently, involve and include communities directly, listen to them and understand perceptions, social norms and beliefs to avoid the spread of rumours and misinformation.
- *Other needs and others*. Focusing on preventing the spread of the Coronavirus should not make us forget affected people's other needs, nor the long-term needs of the wider population.

The list of collected case studies for applying humanitarian standard to COVID-19 response is available at the Sphere website (Sphere, 2021), ranging from community-led response in Indonesia, over complex emergencies in the Middle-East and North Africa, to palliative care for refugees in Bangladesh and human mobility in South America.

Enhancing communication strategies for the whole population (adapted from OECD, 2020) (see # 23 in Table 2): equal access to official information related to the pandemic for all parts of the population, including refugees and migrants, is essential for countries' ability to limit the spread of COVID-19. It is thus in the best interest of governments to ensure the timely translation of communication materials on the pandemic as well as on public health measures and the access to medical services and treatment. At the same time, the crisis context poses specific challenges, as countries may not have the resources and procedures for timely translation in place. Communication content also needs to be continuously adapted both to rapid changes in the development of the pandemic and to evolving policy responses. The information also needs to be culturally appropriate and conveyed in formats that are adapted to specific needs, such as for persons with disabilities, children or older persons. To this end, measures adopted thus far included:

- **Dedicated multilingual websites:** they allow governments to provide one single source of reliable and up-to-date information for all of the resident population. The campaign "Unite against COVID-19" launched by the government of New Zealand is an example of an extensive effort to provide equal access to information to the general public and specific migrant communities alike. It includes information on the national COVID-19 alert system, border restrictions, medical services and employment. The website provides all official information in 22 languages in addition to English, Maori and New Zealand sign language. In Sweden, the National Public Health Agency follows a similar approach by providing official information on COVID-19 on its multilingual website to both the general public and migrants, complemented by a dedicated telephone hotline operating in 13 languages. In France, information on COVID-19, including medical issues, is available to migrants in nine languages on the Ministry of Interior's website, while this information has separately been provided to the general public on other websites. Similar-

ly, the German Ministry of Interior has established a dedicated website for migrants in 20 languages. It is complemented by a second website dedicated to migrants run by the Ethno-Medical Center e.V. and the Federal Ministry of Health, providing health information related to COVID-19 in 34 languages.

- **Enhancing opportunities to communicate with migrants via personal interaction during the pandemic:** in Portugal, it has been possible to maintain face-to-face service at the National Support Centers for the Integration of Migrants (CNAIM) for urgent situations. In-person support by translators has also been guaranteed, as well as the reinforcement of STT service (Telephone Translation Service) and the extension of opening hours, as well as STT's collaboration to directly support translations of Linha Saúde 24, the telephone and digital service of the National Health Service. In Italy, in the scope of a national action plan to tackle labour exploitation in agriculture coordinated by the Ministry of Labour and Social Policies, NGO's workers and mediators met asylum seekers, refugees and migrants living in informal settlements in the countryside. They promoted health literacy about the COVID-19 pandemic and gave information about a regularisation scheme issued by the government.
- **Tackling misinformation (and stigmatisation against migrants) on social media:** the German Federal Antidiscrimination Agency created a webpage to inform about cases of racist and anti-Semitic discrimination related to COVID-19 reported to the agency since the beginning of the pandemic, with the number of overall cases having increased in past months. The page also provides information on how victims can get help and shares its content on social media. Another example of a communication campaign aiming to tackle misinformation on social media is the digital campaign "We stop this virus together", launched by the Spanish Government in May 2020. The campaign uses the official Twitter account of the Ministry of Social Inclusion and Migration to publish short videos and tweets informing about the important positive contributions that migrants make to the Spanish economy and society. A comparable effort was made by the Italian Government through the portal "Integrazione migranti", which aims to fight misinformation and negative stereotypes on migrants by publishing official data and testimonials that highlight the positive contributions of migrants to the Italian society. This portal also informs and supports migrants and refugees in the country by providing online multilingual tools and content, such as a map showing available migration and integration services in all regions of the country, and quarantine procedures.

The Framework for Recovery and Renewal (Shaw et al., 2021) (see # 24 in Table 2): it has the purpose to support the development of recovery strategies and renewal initiatives. Even though it is not COVID-19 specific, the framework is developed in the context of the present challenges and conversations of the pandemic. It aims to help "in articulating a vision for recovery; defining a strategy; prioritising actions; fine-tuning planning; and providing guidance on financing, implementing, and monitoring the recovery" (GFDRR, 2015). The framework is practice-oriented and builds on the critical learning captured over the first 18 months of the COVID-19 pandemic, which has revealed significant gaps in understanding and implementation of post-disaster recovery and renewal.

The framework has been developed with extensive consultation across the sector, including desk-based research, empirical research and practice testing. The framework (*Table 1*) is organised according to six overlapping and interdependent themes, which represent key impact and recovery and renewal action areas pertaining to disaster-affected communities, the economy, infrastructure, health, environment, and governance. Populating the themes are specific sub-category action areas covering vital recovery issues.

Among the numerous potential applications of the framework, three areas stand out:

- **Assessing impacts/needs** – provides a checklist to consider whether assessments encompass the key issues that recovery and renewal may need to address, and ensures their dimensions are fully understood.
- **Learning lessons** – to make sure the lessons have been generated on each of the framework themes and sub-categories and that the entire system has been represented in the process.
- **Strategy delivery** – to deliver positive results recovery strategies and renewal initiatives need to be implemented effectively, so appropriate governance arrangements are critical. The framework can help ensure that all aspects of governance are addressed. Different themes and sub-category action areas will have different relevance in different disaster scenarios and locations, so the framework should be adapted to better fit different circumstances. This can be achieved through the co-creation with local communities of the vision, principles, proposed outcomes, actions, and monitoring indicators for a successful recovery.

In the specific context of COVID-19, which is expected to last for years, the impacts are such that multi-stakeholder recovery partnerships and associated resourcing should endure in the long term.

Framework for assessing the economic losses (see # 25 in Table 2): Ranger et al. (2021) proposed this framework associated with compounding climate, economic, and pandemic shocks (Figure 8).

Communities	Economic	Infrastructure
▪ Vulnerable people ▪ Volunteers ▪ Community participation ▪ Public protection ▪ Emergency housing (incl. homelessness) ▪ Welfare (incl. social care) ▪ Education and skills ▪ Cultural	▪ Economic strategy (national & local) ▪ Business regeneration/ rejuvenation ▪ Public sector support mechanisms ▪ Voluntary, community and social enterprise sector ▪ Personal finance ▪ Innovation ▪ Labour and workforce	▪ Infrastructure providers ▪ Infrastructure customers ▪ Energy (utilities) ▪ Telecommunications (incl. digital) ▪ Urban & rural infrastructure ▪ Transport ▪ Waste management ▪ Supply chain & logistics
Environment	**Health**	**Governance**
▪ Spatial planning (incl. public spaces) ▪ Environmental health ▪ Living sustainably ▪ Resilience to climate change	▪ Healthcare ▪ Public health and wellbeing (incl. psycho-social supports) ▪ Excess death management ▪ Connectivity between health and the wider system	▪ Legislation, policy, guidance ▪ Information & data ▪ Resourcing & financial frameworks ▪ Partnerships & coordination ▪ (national, subnational, local) ▪ Strategic communications ▪ Governance of delivering Recovery and Renewal

Table 1: Recovery and Renewal Framework (Shaw et al., 2021).

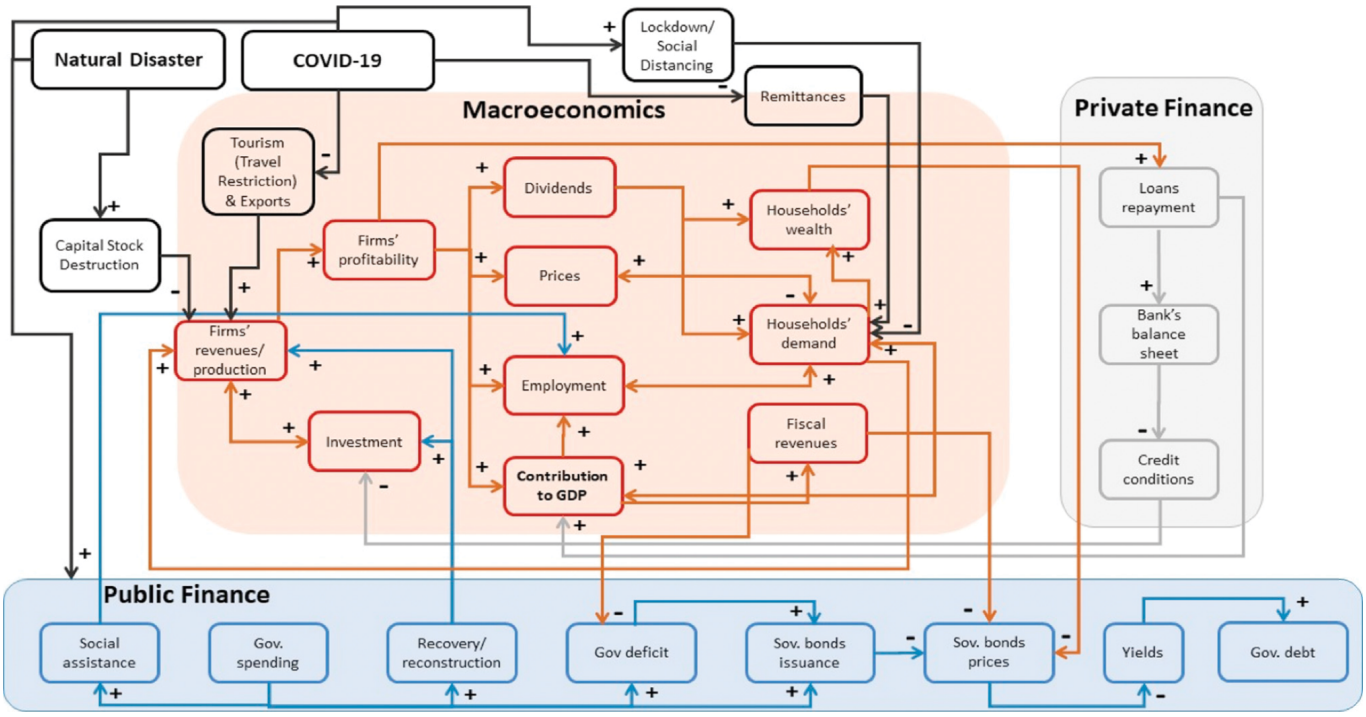

Figure 8: Compound risk transmission channels through the real economy (red), public (blue), and private finance (grey), with positive and negative feedback (adapted from Ranger et al., 2021).

This initial attempt to better understand the fiscal and economic impact of compound shocks analysis has also raised many questions about the policy responses and role of financial instruments in managing those risks. For example, how to consider them within the climate change financial risk assessment and in resilience investment decision-making, how to better design climate-resilient financial instruments (e.g., insurance; Ranger et al., 2021).

Financial protection against disasters: Mahul and Signer (2020) suggested the following core principles as good practices in designing.

- Governments need appropriate risk information, based on data and analytics, to make informed financial decisions in allocating public resources.
- Since not all resources are needed at once, the timeliness of funding matters – rapid mobilisation of funds is needed for relief and early recovery, while funds for reconstruction are mobilised with more time available.
- An efficient financial protection strategy uses risk layering - financial instruments are combined to match funding needs for various risks (with different frequency and severity).
- Governments require dedicated mechanisms and expertise to effectively allocate, disburse, and monitor spending.

In Table 2: Summary of the main good practices analysed in this thematic paper below, we have summarised the GPs whose descriptions can be find across the document. Some GPs, the same or similar, have been used in different places and we list some examples of the countries with the available information. The source reference is provided for each practice as a direction for additional information. The GPs are also characterised by the DRM phase of their main application and contribution and according to the Sendai Framework's priorities and targets they meet.

Sendai Framework Priorities: *(i) Understanding disaster risk; (ii) Strengthening disaster risk governance to manage disaster risk; (iii) Investing in disaster reduction for resilience and; (iv) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.*

Sendai Framework Targets: *Target (a): Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020-2030 compared to the period 2005-2015; Target (b): Substantially reduce the number of people affected globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020-2030 compared to the period 2005- 2015; Target (c): Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030; Target (d): Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030; Target (e): Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020; Target (f): Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030; Target (g): Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.*

#	GP Short title	Country / Region / Organisation	DRM phase	GP type	Sendai Priority / Target	References
1	Unified health emergency (COVID-19) and disaster response system	Various countries (e.g. New Zealand, Croatia, Indonesia, Philippines)	Response	Strategy / Approach	P. (ii) and T. (d)	Potutan and Arakida (2021)
2	Whole-of-Government Approach	Various countries, (e.g. UK, Italy)	All	Strategy / Approach	P. (ii) and T. (d)	Potutan and Arakida (2021); WHO (2021); ICPD (2020)
3	Facilitated sharing and receiving of resources	USA	Response	Checklist	P. (iv) and T. (c)	NMCG (2020)
4	Digitalisation of some aspects of disaster response / Extensive use of	Various countries (e.g.	Preparedness Response	Strategy / Approach	P. (iv) and T. (g)	Understanding Risk (2021); MOIS (2021); Kim et al. (2021); Ćurković et al. (2021)

#	GP Short title	Country / Region / Organisation	DRM phase	GP type	Sendai Priority / Target	References
	innovative technologies/surveillance	Singapore, South Korea, Croatia)				
5	Dispersed Evacuation	Various countries (e.g. Philippines, Japan)	Response	Strategy / Approach	P. (ii) T. (b)	Potutan and Arakida (2021)
6	Remote Psychological First Aid	Various countries (e.g. India, South Korea)	Response Recovery	Strategy / Approach	P. (iv) and T. (b)	Potutan and Arakida (2021)
7	Using floods Early Warning System (EWS) for COVID-19 risk communication to population	Various countries	Response	Strategy / Approach	P. (iv) and T. (g)	Ashraf (2021)
8	Copernicus Emergency Management Service	EU	All	Satellite system service in support of European EM/DRM (provides imagery and other geospatial data)	P. (i) and T. (g)	EC (2021)
9	Unmanned aerial vehicles - UAVs (Drones) use in DRM	Worldwide	All	Used in mapping, search and rescue, transportation and training	P. (i) and T. (g)	Daud et al. (2022)
10	The efficient revision of the budget and the quick restock of the key resources	Norway	Response Recovery	Strategy / Approach	P. (ii) and T.(c)	Christensen and Lægreid (2020)
11	Matching radical citizen protection measures (to prevent infections) with adequate measures to reduce the negative economic side effects	Norway	Response Recovery	Strategy / Approach	P. (iv) and T.(c)	Christensen and Lægreid (2020)
12	Transboundary collaboration	Norway	All	Strategy / Approach	P. (i) and T. (e)	Christensen and Lægreid (2020); Fakhruddin et al. (2020)
13	Decision-making in close collaboration between political, administrative, and professional central authorities / Multi-level and multi-sectoral response	Various countries (e.g. Norway, Italy, South Korea, Singapore)	Response Recovery	Strategy / Approach	P. (ii) and T. (d)	Christensen and Lægreid (2020); Kim et al. (2021); Fakhruddin et al. (2020); Italy Civil Protection's Operative Measures (2020)
14	Understanding the risk management flow	South Korea	Mitigation PreparednesResponse	Strategy / Approach	P. (i) and T. (d)	Kim et al., (2021)
15	Using experiences from previous pandemics/outbreaks to better prepare	Various countries (e.g. Singapore, South Korea,	Mitigation PreparednesResponse	Strategy / Approach	P. (iv) and T. (g)	Fakhruddin et al. (2020) Tabuga et al. (2020)

#	GP Short title	Country / Region / Organisation	DRM phase	GP type	Sendai Priority / Target	References
		Taiwan, Vietnam)				
16	Immediate actions (even bold and strong)	Various countries (e.g. South Korea, New Zealand)	Response	Strategy / Approach	P. (ii) and T. (b)	Kim et al., (2021); Fakhruddin et al. (2020)
17	"Three lines of defence" approach	United Kingdom	Mitigation Preparedness	Strategy / Approach	P. (ii) and T. (d)	Hilton and Baylon (2020)
18	Worst-case scenarios to compare risks and highlight residual acceptable risk	United Kingdom	Mitigation Preparedness	Strategy / Approach	P. (i) and T. (g)	Hilton and Baylon (2020)
19	Resilience Diagnostic Tool	N/A	Preparedness	Practical process-based tool for resilience building	P. (iii) and T. (d)	Wardekker et al. (2020)
20	Economic Recovery Dashboard	Washington state (USA)	Recovery	Online tool to track economic recovery and resiliency	P. (iv) and T. (c)	WSDC (2021)
21	StrategyFinder	N/A	Mitigation Preparedness	Collaborative software	P. (i) and T. (e)	Gonzalez et al. (2021)
22	Sphere Standard	Sphere	Response	Guidance for applying humanitarian standards and principles	P. (i) and T. (e)	Sphere (2020)
23	Enhancing communication and tackling misinformation (in the context of Covid-19)/communication campaigns	Various countries	Mitigation Response Recovery	Strategy / Approach	P. (iii) and T. (g)	OECD (2020)
24	Framework for Recovery and Renewal	N/A	Recovery	Practice-oriented framework	P. (iv) and T. (d)	Shaw et al. (2021)
25	Framework for economic losses assessment	N/A	Recovery	Framework for assessing economic losses in compound disasters	P. (iv) and T. (c)	Ranger et al. (2021)

Table 2: Summary of the main good practices analysed in this thematic paper.

4. Discussion

In the fields of DRM and DRR, practices before the COVID-19 pandemic were mainly reactive and focused on single hazards (Simonović et al., 2021; Forman and Mossialos, 2021). The pandemic has given a boost to the need of revising this existing approach and of focusing more on multiple hazards. The analysis of multi-hazard risks, in fact, cannot simply be regarded as the sum of single hazard risk examinations (Kappes et al., 2012). The static nature of risk as a measure (independent of time) and its inability to simultaneously consider different consequences of different and evolving hazard scenarios makes it an insufficient tool for addressing the challenges of multi-hazard scenarios (Simonović et al., 2021). Global trends, including rapid population growth and migrations, climate change, and land-use exploitation, are directly affecting the complexity and uncertainty of current and future disaster risk management problems (Simonović et al., 2021). In addition, the COVID-19 pandemic has showed that, although the Sendai Framework also covers risks from biological hazards with the focus on public health, it does not consider the cascading impact of biological and oth-

er hazards in a systematic risk management approach (Fakhruddin et al., 2020). Indeed, biological hazards are not yet fully integrated in the DRM systems, and the "traditional" single-hazard approach so far has hindered the capacity of DRM systems to integrate response measures adequate to deal with a pandemic (Potutan and Arakida, 2021). This means in practice that, when a disaster strikes during a pandemic emergency, DRM can be less efficient if it maintains a single-hazard approach. However, a multi-hazards risk approach requires adaptation of DRM in all its phases, both strategically and operationally, and at all levels (international, national, regional and local). For instance, a multi-hazard risk emergency plan should be made flexible enough in its design in order to be adapted to the circumstances as the scenarios evolve (Alexander, 2020). In addition, when two or more different types of hazards occur simultaneously, they influence the overall impact and the respective activities, which then must be changed and tailored for specific scenarios. In the case of the pandemic, strategic adjustments may include management options (Moore et al., 2020) that, alternatively: 1) are no longer viable under COVID-19; 2) can be applied but are constrained in some ways; 3) have to be prioritised; 4) are new or have never been used before, meaning that they may have not been selected or seriously considered in the past. Operational aspects include those changes that have implications on staff, its transport, equipment used, handling and transfer, mobilisation and demobilisation, adjusting techniques and practices, and so on (Moore et al., 2020). This underlines the role of dynamic resilience as a support for planning and real time disaster risk management as a continuous process rather than a predefined activity (Simonović et al., 2021).

The COVID-19 crisis demonstrates that the extent of a disaster can also be worldwide and that, in such cases, individual national responses are not enough, especially in certain contexts, but must instead be mounted in cooperation with other countries and regions. Although stronger cooperation, especially towards low-income countries, was recommended by several actors, from the UN to regional organisations, since the inception of the pandemic, the reality is that states have been focussing mainly on their national responses. However, practical considerations should also be taken into account as international collaboration can be more difficult to implement during a global pandemic that imposes the adoption of very restrictive measures. As a result, national and local actors need to be reinforced to effectively face complex disasters. The reliance on local actors requires preparedness strategies where local actors are empowered to coordinate the response and make decisions (UNDRR, 2020c).

We have seen that the main identified GPs extracted from the three streams of research as described above have been summarised in Table 2. In general, the approach adopted with the GPs collected in this paper is result-oriented. The key aspect is gathering evidence about their practical benefits, which is not an easy endeavour. Nonetheless, we can argue that Table 2 represents a gathering of good practices that have been effective in addressing relevant problems of a certain domain in the past. In addition, the GPs in Table 2 do not represent ready-made solutions, but they contribute to the pool of empirical knowledge that can be reused and exploited.

One of the limitations of this paper is surely the different level of detail and evidence in the covered cases, which varies due to the amount of publicly available material. For instance, the GPs concerning the strategies implemented at national and regional level mostly concern the COVID-19 pandemic and we hypothesize but do not have evidence that these GPs can be applicable in multi-hazard risk scenarios. The limited information available at this point makes it also difficult to analyse GPs jointly in order to compare the outcomes of different practices or benchmark the cases and identify common approaches.

We are aware that the list presented is not exhaustive and that, although in general different types of disasters (e.g., natural or anthropogenic vs biological) share many common activities in response and recovery, there are still many specificities and significant differences in the way some of those activities are carried out. For instance, the management of a pandemic is mainly done in a sectoral way, since it is provided by the health service, while the risk management concerning natural of anthropogenic disasters is based on the use of cross-functional resources, where the stakeholders hold very different expectations and interests. In addition, disaster risk management is usually locally to nationally based, while the management of the COVID-19 pandemic has followed top-down guidelines at the world scale, established for example by the WHO, and was supported by global benchmarks and validation instruments.

An analysis of Table 2 shows that, firstly, out of the 25 selected GPs, 10 deal with only one of the 7 phases of the DRM cycle as described above. More in detail, 6 GPs focus only on response, 3 on recovery, and 1 on preparedness. Of the remaining 15, 4 GPs focus on all the phases at the same time, whilst 11 address two or more phases of the DRM cycle. A closer look shows that the 11 GPs that have a multi-phase approach are divided as follows: 1 tackles preparedness and response, 1 focuses on mitigation, response and recovery, 2 deal with mitigation, preparedness and response, 3 concern mitigation and preparedness, 4 address at the same time response and recovery. None of them deal with prevention.

Secondly, with regard to the geographical scope of the selected GPs, it is interesting to observe that 12 out of 25 have been implemented in more than one country, not necessarily belonging to the same region. In relation to the typology of GP implemented, most of them, 16 out of 25, can be described as strategies/approaches.

Thirdly, as far as the priorities and targets identified by the Sendai Framework are concerned, it is possible to highlight the following aspects: priorities (ii) (Strengthening disaster risk governance to manage disaster risk) and (iv) (Enhancing disaster preparedness for effective

response, and to Build Back Better in recovery, rehabilitation and reconstruction) are the most represented, as they are reflected in, respectively, 7 and 9 GPs; target (d) (Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030) is potentially met by 7 GPs. While all 4 priorities appear in the table, the same cannot be said with regard to the targets. Target (a) (Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020-2030 compared to the period 2005-2015) cannot be assessed in relation to the selected GPs, and target (f) (Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030) was not met, nor pursued, by any of the GPs.

In many countries the public health emergency response system is separate from the disaster response system. In situations of disasters that have occurred during the pandemic, in many cases the health agency led the COVID-19 response while the DRM agency led the disaster response. These parallel response systems operated separately, in silos, and, as observed in practice, created administrative and logistic bottlenecks, including issues concerning leadership, mandates, and coordination (Potutan and Arakida, 2021). A unified COVID-19 and disaster response system (see # 1 in Table 2), led by the DRM agency, is believed to minimise bottlenecks of intragovernmental coordination (Potutan and Arakida, 2021). One of the mechanisms that might be insightful in improving intra-governmental coordination is the Whole-of-Government (WOG) approach (see # 2 in Table 2), where a diverse set of governmental institutions work across portfolio boundaries to develop a common solution to a common problem (Shergold, 2004; WHO, 2021).

The key findings on GPs in multi-hazard risk scenarios can tell us what we currently have and in which directions we are (or should be) moving. It can be summarised as follows:

- DRM systems should be adapted to incorporate health-related emergencies - health and DRM agencies must operate in close collaboration, breaking silos and removing bottlenecks that hinder DRM – GP #1;
- Use of a multi-hazard approach in risk modelling and assessment must be considered, in order to address the challenges of simultaneously occurring hazards, the potential consequences (including time dimension) and interdependencies – e.g. GPs #14, #17, #18, #19. #21, #24;
- Inter-organisational collaboration and information-sharing (cross-sector, cross-border) must be enhanced in all DRM phases, involving as many stakeholders as possible (multi-actor and multiscale approach). Joint plans must be flexible and collaboratively adapted to the developments of scenarios – GPs #2, #3, #12, #13, #16;
- Extensive use of innovative technologies can bring benefits in all DRM phases (such as satellite imagery, use of drones, Digitalisation disaster response, ICT tools for remote collaboration and training, etc.) – GPs #4, #6, #8, #9, #20;
- Communication with communities should be enhanced, as it improves their preparedness, helps them understand the DRM strategy and principles to adapt their actions in the recovery and ensure their wellbeing – e.g. GPs #22, #23;
- Existing GPs can be used in alternative ways or adjusted to fit the scenario at hand – e.g. GPs #5, #7;
- Financial planning is needed to ensure the economic resilience of a state or region, along with a comprehensive risk management strategy to ensure economic protection (such as analysing trade-offs between different DRM strategies, mechanisms for efficient resource allocation, monitoring the economic impact of disasters and targeting assistance programmes, etc.) – e.g. GPs #10, #11, #20, #25;
- Improving based on experiences, lessons learned and good practices is a GP itself – e.g. GP #15.

The GPs presented in this paper are applied to different levels, in terms of governance, activities and stakeholders. This implies that operational GPs might be used to support other GPs that follow specific tactical and strategic approaches in other levels. Developing a framework for clustering GPs that contribute to the same goals, across different levels, can be a way for a significant progress towards a better understanding and application of these GPs. Another framework for clustering GPs can follow the classification of GPs according to their features and compatibility: this would allow practitioners to quickly understand alternatives with their trade-offs and pick solutions on this basis. In addition, clustering GPs could serve as a knowledge base to be taken into account in the definition of future national and local risk assessments and DRM strategies, as well as to support local stakeholders in developing needed resilience capacities to withstand disasters.

When considering policy developments in multi-hazard risks scenarios, GPs could follow the same lines as other evidence-based recommendations, as the findings by Ishiwatari et al. (2020) suggest:

- Policies to strengthen the protection and empowerment of all people;
- Priority on protecting human life at evacuation centres and of disaster management staff;
- Focus on the vulnerable groups;
- Involvement of local organisations and communities;
- Risk communication based on scientific knowledge;
- Coordination with multiple sectors.

There are initiatives, at global level, that go in this direction. For instance, the pandemic has shown that, to better align prevention and response efforts of health

and DRM authorities, there is the need to integrate health planning into DRM planning and vice versa. The UNDRR has therefore called for the establishment of multi-sectoral DRM committees that include health officials and seek to strengthen the integration of biological hazards into multi-hazard DRM (UNDRR, 2020c). This includes the revision of standard operating procedures (SOPs) and contingency plans to incorporate containment measures for COVID-19. Multi-sector planning can significantly improve preparedness for complex chains of decisions and consequences. In addition, to implement the Sendai Framework (SFDRR, 2015), the World Health Organization (WHO) put together a Health Emergency and Disaster Risk Management Framework (H-EDRM) to promote a multi-hazard approach and bring together diverse stakeholders (WHO, 2021). The H-EDRM could complement and enhance the responses to the COVID-19 pandemic by providing scientific knowledge in understanding risks, strengthening risk governance and enhancing community-based activities (Djalante et al., 2020). These initiatives are in their nascent phase and only time will show which kind of good practices they will be able to generate.

5. Conclusions

This first ROADMAP thematic paper emphasises the importance of GPs in multi-hazard risk scenarios for DRM and DRR by presenting selected examples of GPs. The collection of GPs included in this thematic paper is obviously not comprehensive, as only compound hazards including the pandemic have been dealt with, although all across the globe. Still, the paper offers an overview of common issues and current developments through the representative sample of identified GPs. We are confident that it will stimulate further research, turning practice into knowledge and, vice-versa, scientific knowledge into practice. For instance, research can raise awareness around the dynamic interactions between the physical and the social environment, which increase complexity and uncertainty and, at the same time, the likelihood of multiple hazards (Simonović et al., 2021). In this regard, multi-hazard risk scenarios require an evolution in DRM approaches, which need to analyse and manage not only one risk, but also the interactions and interdependencies among risks, including possible reinforcing (escalating) impacts and consequences. This, in turn, calls for inter-organisational (including cross-border) collaboration with an involvement of as many stakeholders as possible across all phases of DRM. Furthermore, by collecting GPs implemented during the pandemic and showing their relevance vis-a-vis the Sendai Framework targets and priorities, this first thematic paper is expected to boost the debate among academics, researchers, practitioners and all the actors involved in DRM and DRR on how to fully implement the Sendai Framework. Finally, re-using GPs in different contexts is an important issue that still needs to be explored: how to choose a suitable GPs when resorting to the GP pool? Since GPs are dependent on the context, this process requires a deeper understanding of the logic behind each GP, its applicability and possible adaptation or customisation, classifying GPs' features and limitations. A significant research effort in characterising GPs has to be planned and carried out to make their choice easier for practitioners and civil protection decision-makers.

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