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Strengthening all-of-society approaches for disaster resilient societies through competency building: A European research agenda

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Strengthening *all-of-society* approaches for disaster resilient societies through competency building: A European research agenda

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ABSTRACT

The increasing frequency of disasters, alongside the recent COVID-19 pandemic, climate emergency, and ongoing/new crises including conflicts and their disproportionate impacts on many communities, all point towards the cascading, multidimensional, and systemic nature of risks. In

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Climate change adaptation
Vulnerability
Participation
Competency building

the wake of this ever-changing risk landscape, it is paramount to adopt multi-sectoral, multidisciplinary risk reduction, preparedness, and adaptation approaches, which are inclusive and innovative, and which reduce vulnerability. In line with the recent midterm review of the implementation of the Sendai Framework for Disaster Risk Reduction, this calls for nuanced and critical actions at all levels based on strategies to increase risk awareness and vulnerability reduction, which are co-developed and enabled through *all-of-society* engagement and participation.

This paper builds from the research and experience of more than 8 European-funded research projects involving over 100 research and practitioner organisations, which has shown the positive impacts of all-of-society approaches for involving members of the population in areas of disaster risk management (DRM), disaster risk reduction (DRR), and climate change adaptation (CCA). The paper presents evidence-based insights and lessons learnt from these European projects focusing on improving engagement between authorities and citizens and building capacities through inclusive participatory actions. This includes reflections on diverse methodological approaches leading to integrated outcomes. Based on the outcomes of the projects, we propose four key-dimensions of investing in disaster resilient societies: 1) *enhancing the participation* of multiple stakeholders, and 2) *building capacities* in order to 3) *reduce vulnerabilities,* enabled by 4) *organizational change* leading to the adaptability of formal DRM organisations' routines and operating structures.

Key outcomes and recommendations from the projects are provided to guide future research, policy, and practice on all-of-society engagement for strengthening societal resilience to disasters with a specific focus on competency building among populations at-risk.

1. Introduction

It is well understood nowadays that communities globally are increasingly impacted by hazardous events due to factors such as climate change, urbanization, environmental degradation, and socio-economic inequality [1]. The compounding effects of these factors may best be marked by the term *polycrisis*, which refers to the overlapping, interconnected, and systemic nature of crises beyond cause and effect [2]. The frequency and severity of natural hazards like floods, droughts, and wildfires are rising, and we see cascading and compounded risks further exacerbating vulnerabilities. These developments are exposing gaps in the levels of preparedness and the responses of emergency managment organisations and communities. This has been observed for example during the 2021 European floods through the insufficient use of warning messages by authorities and the delayed response by communities [3], as well as during the 2023 Maui wildfires, where there was an absence of adequate preparatory and evacuation measures [4]. Both events cost lives and caused widespread damages.In a similar vein, the COVID-19 pandemic sent shockwaves around the globe as local communities, health and emergency services, businesses, countries, and regions were left both unprepared and struggling to effectively respond to the impacts of the crisis. The pandemic highlighted the critical need for integrating resilience ambitions and knowledge from public health with other sectors such as Disaster Risk Reduction (DRR), Climate Change Adaptation (CCA), and the Sustainable Development Goals (SDGs), into cross-cutting policy frameworks [5].

Indeed, in this multidimensional risk landscape, multi-sectoral, multidisciplinary approaches are needed to create more disaster resilient societies [6]. There is an urgent need for communities exposed to hazards to strengthen their capacities to resist, absorb, accommodate, adapt to, transform, and recover from the effects of hazards in a timely and efficient manner [7]. However, at the moment, there is a continued *response* focus within disaster management efforts. This needs to shift towards critically unpacking why and how risks are created and who is impacted, and to adopting and combining DRR and CCA with risk-informed development processes as fundamental pathways for future resilience [8]. These approaches must also include the analysis of the potential cascading impacts of multiple disasters, and the development of scenarios of events that might impact society as simultaneous or consecutive events, with slow or rapid onsets, leading to compounding or cascading impacts in different sectors of society. This can be done, for instance, by analysing past events in a forensic analysis which form the understanding to co-developing impact chains of possible future events [9].

This way of thinking forms the basis for taking transversal actions towards development, DRR, and CCA which will reduce vulnerabilities, exposure, and risks to hazards and strengthen the capacity of local communities to respond and recover. The concepts have often been critiqued for operating in silos. However, identifying the enabling factors for integration in a contextual manner will provide a basis for breaking silos [10]. In practice, it also requires authorities, citizens, essential businesses, and other stakeholders to adopt risk-informed approaches, which are inclusive and innovative, through pre-defined plans and procedures, as well as through adaptable and flexible capabilities to prepare for, respond to, and recover from crises [11–14].

Since the turn of the century, there is a push for a major shift in the global mindset towards integrating the multi-sectoral, multidisciplinary approaches into actionable recommendations for building more disaster resilient societies [15]. Decision makers and emergency authorities are being urged to adopt disaster *risk* management (DRM)[1] approaches which actively involve communities

[1] Unless highlighted for contextual purposes, in this paper we use the term Disaster Risk Management (DRM) as an umbrella term encompassing related activities within the areas of disaster and emergency management, disaster risk reduction, and climate change adaptation.

and place greater focus on preparedness, adaptation, and prevention activities over traditional response-oriented approaches [6]. These suggested changes have been guided by key international agreements such as the Sendai Framework for Disaster Risk Reduction [7] and Sustainable Development Goals [16], and the Paris Agreement [17], which highlight the importance of *all-of-society* approaches, aimed at strengthening societal inclusion in DRM, including DRR and CCA. The agreements stress broad-based participation and competency building through engagement activities with different stakeholders including formal authorities and response organisations, essential businesses and other private actors, volunteers, and citizens, including those which are marginalised and most vulnerable [18].

However, it is important to recognize that while these frameworks push for community-based approaches, there are still disconnects across them such as the lack of alignments among indicators looking at development within the SDGs and the priorties around DRR in the Sendai Framework [19]. There are also disconnects between the high-level policy rhetoric and acceptance and integration of inclusive DRM, which truly engages with people impacted by disasters. For instance, whereas community-based approaches have been seen as a cornerstone for DRM, competency and capacity development has not featured prominently enough within these discussions and efforts [12,20,21].

While we are still far from *all-inclusive* DRM, European efforts to integrate all-of-society approaches into policies and operations at national and local levels have been guided by forward-looking legislation [22], reports [11], and recommendations and strategies such as the EU Disaster Resilience Goals [23] and Climate Adaptation Strategy [24]. In parallel, EU funded-research programmes (Horizon 2020 and Horizon Europe Secure Societies in particular) and initiatives such as the Community of European Research and Innovation for Security (CERIS) are exploring gaps in societal resilience to disasters and strengthening the impacts of research and dialog on these topics by bringing relevant stakeholders together in projects and events [18,25]. These efforts are moving the bar in their promotition of the importance of participation (in research and practice) of local stakeholders in disaster risk governance and the need for increased engagement among local authorities and citizens.

This paper stems from these initiatives and explores how European research is addressing the all-of-society approach to DRM and proposes policy advice towards building all-inclusive competencies within populations at-risk. In a turn from traditional literature on these topics, the paper takes a unique approach by highlighting and discussing the joined research agendas and outcomes of more than 8 EU-funded Research and Innovation projects.[2] Collectively the projects have spanned 5 years of research and involved over a 100 organisations from different sectors. The projects are defined by grounded, action-based approaches meaning that researchers and DRM practitioners in local communities have been working closely together to identify specific needs and ensure that the science results generated by the projects are actionable and impactful for different groups of stakeholders.

Since 2021, the projects have collaborated as part of a Societal Resilience Cluster (SRC) to produce joined, evidence-based outcomes, including a recent policy brief on *Improving Engagement and Communication among Citizens and Authorities* [18]. The development of the brief has been a significant achievement because it synthesizes learning across multiple risk and governance contexts. Each of the projects was designed with different objectives and approaches for studying societal resilience to disasters and have been engaging in research in different contexts with a diversity of stakeholders from different sectors, disciplines, and geographies, including experts, scientists, practitioners, decision-makers, and citizens. While these projects started with different aims, methodologies, and conceptual and contextual positioning, the results have contributed to shared, evidence-informed outcomes and recommendations towards an all-of-society approach to disaster resilience, with a specific focus on competency building among populations at-risk.

To this aim we first provide a baseline for key concepts which emerge from literature and policy instruments, and their interrelations around disaster resilience. First, we recognize that the concept of resilience is multifaceted, and use the term *disaster resilience* as a general approach for addressing different aspects of individual, community (for example, in the context of localised groups), and broader societal resilience, in relation to coping and adaptation measures towards disaster risks. We underline how enhancing inclusive participation in DRM activities and policies is closely linked to the identification and reduction of risks and vulnerabilities at different levels of society, and how building capacities and competencies of all stakeholders contributes to the all-of-society agendas within DRR, CCA, and other related sectors.

Next, we explain the iterative writing approach we used to generate joined policy recommendations among the projects. Focusing on one section of the policy recommendations around building basic DRM competencies and knowledge in the population through events and education programmes, we apply the Gioia, grounded method [26] to demonstrate how the individual policy priorities and outputs of the cluster projects feed into several common themes underlining their work towards strengthening disaster resilient societies. This includes a focus on enhancing participation of the population, reducing vulnerabilities, investing in capacity building, and recognizing the needs for organisational change and adaptation by DRM authorities.

We then demonstrate how the research activities of the different individual projects contribute to the four thematic areas within the context of capacity and competency building. The results from the projects have demonstrated how community forums, training, workshops, education initiatives, and various other inclusive approaches can facilitate better civil engagement, knowledge exchange, participatory and risk-informed decision making, and the co-creation of preparedness measures at local levels.

Lastly, the paper concludes with critical reflections on areas in which research is still needed to enable DRM competency building among populations at-risk. We argue that, despite the progress which has been made towards strengthening societal resilience to disasters in past years, further participatory and action-oriented research is needed that meaningfully involves populations at-risk and

[2] BuildERS, CORE, DIRECTED, ENGAGE, LINKS, PARATUS, RESILAGE, and RISKPACC projects have contributed directly to the conception of this paper. However, additional SRC projects and invited experts contributed to the joined policy work at the basis of this paper.

which integrates system-thinking to address how the dynamics of risk and vulnerability influence participation in DRM. This also includes holistic capacity building approaches, and greater understanding of the clashes among DRM organisational cultures and calls for change, adaptability, and inclusivity of all stakeholders. While this paper primarily focuses on the policy level, it also points to these research gaps and calls for researchers and authorities to explore innovative approaches for participation and building competencies with non-traditional DRM actors including citizens and volunteers, and to maintain a sense of urgency through these actions even in cold phases. The paper shows the need for further investigation into multi-disciplinary and -sectoral approaches for bridging gaps between science, policy, and practice, particularly for integrating local knowledge into inclusive DRM frameworks. These efforts will ensure that future research outcomes on disaster resilience can be converged into meaningful policies and practices by local communities within Europe and beyond.

2. The all-of-society approach towards disaster resilience

In this section, we highlight the different facets of an all-of-society approach to building disaster resilient communities. This includes situating the paper in relevant literature, concepts, and policy discussions around resilience, hazard risks and vulnerabilities, and inclusive disaster governance, while highlighting needs around DRM competency building among citizens and authorities.

2.1. Resilience

At the most general level, *resilience* is defined as the ability of individuals, households, institutions, communities, countries, systems, and society as a whole, to resist, absorb, accommodate, adapt to, transform, and recover from stresses and shocks [27,28]. Since at least the 1940s the concept has evolved across many fields including physics and engineering, environmental and ecological sciences, neuroscience and mental health, and psychology and sociology [29,30]. This evolution has seen early concepts of bouncing back and absorbing shocks gradually integrating ideas for strengthening and managing adaptive and transformative capacities of people, communities, and societies [29–31].

Today, concepts of individual, community, and societal resilience are interlinked, complex, and even contested. The boundary parameters for the communities and societies in which individuals exist are not fixed but rather dependent on a wide array of contextual factors and variables which, depending on one's objectives, must be considered for defining baselines and progress towards resilience. Hence, critical scholars have argued that resilience is an impossible ontology too complex to find epistemological access [32,33]. For others, resilience became a neo-liberal trick and a means for lobbyists to move responsibilities of the state to individuals and markets [34–36]. Through this neo-liberal lens, local communities are expected to become self-reliant without being provided with proper support and resources.

While these are all relevant aspects and critiques to consider, what is most important in the context of this paper is that resilience at its core is, 1) a crucial concept for understanding and highlighting individual and societal wellbeing [30], 2) an inherently social phenomena that is dependent on the integrated efforts of communities, formal authorities, and other stakeholders, and 3) a concept addressing the adaptive capacity of a complex system [31]. These dimensions become increasingly apparent in the context of disasters, which constitute transversal events affecting interdependent aspects of societies such as operational and political crises involving population safety and security, as well as infrastructure protection and business continuity.

In this paper we acknowledge that understanding resilience in the context of disasters asks for transdisciplinary research that can provide the building blocks for climate (and disaster) resilience capacities among scientists, practitioners, and community members including stewarding capacity in real-world settings (for example, using climate resilience pathways approach to embrace uncertainty, or integrating knowledge on reducing risk creation into development planning), unlocking capacity (such as identifying gaps and lock-ins to overcome them), transforming capacity (for example, through establishing living labs that encourage knowledge co-production, see [37]), and orchestrating capacity (including learning to coordinate multiple stakeholders to integrate innovations) [38].

2.2. Risk, vulnerability, and inclusive disasters governance

The United Nations Office for Disaster Risk Reduction defines a disaster as "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" [28]. Disasters can be immediate (sudden-onset) or creeping (e.g. drought, climate change), local or spanning across borders and systems, and can cascade into multi-hazard events [39]. The disaster management cycle continues to be widely used to address disasters, despite being heavily critiqued with a response focus [40]. Disasters, know no boundaries and the so-called phases overlap and can look very different in different disasters, including that recovery can take decades [41,42]. In this environment, disaster risk has emerged as a priority in study and practice.

The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period is referred to as disaster risk [28]. Disaster risk depends on several components, such as the frequency and intensity of the hazardous events, their interaction in space and time, and the dynamic nature of exposure, vulnerability and capacity. A multi-hazard risk assessment should identify all possible and relevant hazards, their spatial/temporal interactions and the cascading impacts on various sectors of society [43]. Systemic risks are these multi-hazard risks that threaten the functioning of a system or society [44]. In recent years, concepts around systemic risk and global polycrisis have gained momentum attempting to capture the complex interactions and multiplying impacts of disasters and other crises [45,46]. Here, Lawrence and colleagues [47] have defined global polycrisis as the causal entanglement of crises in multiple global systems in ways that significantly degrade humanity's prospects. In

order to deal with the complexity of systemic risks, an all-of society approach to risk-informed decision making is essential. It requires understanding and integrating knowledge towards reducing risk creation, together with different stakeholders, into transversal development, DRR and CCA approaches [48].

Regardless of the scale, complexity, or duration of disasters, it is now well recognised that they are not "natural" but rather the point in which hazards (natural or anthropogenic) meet with the conditions and capacities of societies, communities, or individuals, such as exposure and vulnerabilities [49–53]. Therefore, a disaster resilient society is one which must recognize and strengthen these conditions and capacities at different levels to minimise disaster risks and cope with (short-term) and adapt to the (long-term) effects of hazards. To effectively minimise risk, research has shown that we must recognize the social and cultural roots of the risks of disaster-affected communities [54–56]. This involves understanding what drives local risk perceptions and awareness of different groups and individuals, and understanding how the characteristics of a person or group may reduce or increase their levels of vulnerability and exposure to hazard risks [57,58].

Connected to this, research also points to the need for understanding the social fabric and ties within communities, and how individuals and groups interact with local and other forms of visible and invisible power structures [30,59–61]. This requires exploring dynamics of both bottom-up and top-town engagement in all disaster phases, among different stakeholder and systems, including citizens, vulnerable and marginalised grounds, volunteers and community/social initiatives and their *informal leaders*, formal authorities, and industry [62,63].

This approach is linked closely with studies on risk and disaster governance, which place emphasis on collaboration and coordination dynamics, in *inclusive spaces* of decision-making, and governance approaches across emergency management organisations, authorities, and civil society based on principles of trust, co-creation of solutions, and learning [64–67]. This, however, should not be taken for granted, as Hagelsteen and Beker [68] pointed out, identifying systemic problems hindering the success of competency/capacity development programmes among DRM professionals calling for capacity to be developed through a flexible, adaptive and locally driven approach to change and learning.

Hence, in the context of systemic risk new forms of governance are needed that bring together national and local governance actors based on systems-thinking [69]. Such a change in governance perspective may pose challenges over leadership and democratic accountability [70] as such 'disaster partnering' [71] also extends to the population, involving spontaneous volunteers and everyday citizens in all phases of DRM [72–74]. The success of these initiatives relies on effective targeted and two-way risk- and crisis-communication processes among authorities and the population, to reach all parts of the society and to set mutual expectations and understandings of which measures can be taken, recognizing both the *diversity and agency* of the population [75,76].

2.3. An all-of-society agenda

What has become clear in the European SRC projects that formed the basis for this paper, is that disaster resilience both in theory and practice is increasingly multidimensional and hence requires collective, inclusive, and holistic participation stemming from different sectors, experts, and parts of the society. It is from this understanding that the concept of *all-of-society* has gained importance as a fundamental component for building disaster resilience at any level. The all-of-society approach refers to broad-based participation in DRM processes through engagement with different stakeholders including scientists, formal authorities including decision makers and response organisations, and volunteers and citizens, including those which are marginalised and most vulnerable [18]. The concept is often used synonymously with the *whole-of-society* governance approach [77] and is linked to participatory and community-based approaches and concepts of localization for DRR, CCA, and development work [78,79]. It encourages decentralisation and emphasises the importance of engaging with citizens in the planning, decision making, and implementation of DRM strategies.

The all-of-society concept pulls away from traditional disaster governance doctrines, which are characterised by a top down, paramilitaristic approach to dealing with disasters [37]. These ways of operation assume that when a disaster occurs, societies may panic and chaos ensues, and therefore procedures must be in place by authorities to "command and control" the situation and to return things to normal [54,80]. Such structures and procedures have their place in the DRM paradigm, but their exclusive nature also leads to knowledge and resources gaps which could be filled through the involvement of other key stakeholders.

While 'managing' key stakeholders (citizens and volunteers in particular) has been considered an organisational challenge by formal disaster management authorities, research from the SRC projects shows that collaboration and collective *learning* processes across different types of stakeholders, can build trust, and strengthen the capacities of formal authorities (and communities) by instilling co-ownership (responsibility and accountability) of decisions, actions, and follow-up actions. On the one hand, this calls for integration of local knowledge, experience, and expertise, through engagement with diverse members of the population including the most vulnerable [57,58,81,82]. On the other hand, it requires the involvement of experts, researchers, solutions providers, and other relevant actors, supported by an all-state institutions approach [6].

To establish an all-of-society inclusive approach the capabilities and skills of current and future DRM professionals need to be expanded, including skills around enabling participation of marginalised groups and multi-stakeholder partnership building [83]. As described in the recent midterm review on the implementation of the Sendai Framework, there is a need for governments to ''develop institutional structures to engage and mobilise the expertise of scientific, academic, private sector, civil society, local and indigenous stakeholders, creating platforms and spaces for such stakeholders to be listened to and exert a meaningful influence over risk-informed decision-making processes'' ([6] p.95). In order for institutions and organisations to facilitate more inclusive disaster governance processes, research also points to the need for greater focus on social learning and change within the organisations [57,58,84,85].

In sum, the all-of-society approach requires the investment in four key-dimensions of disaster resilient societies: 1) enhancing the

participation of multiple stakeholders, 2) building their *capacity* in order to 3) reducing *vulnerabilities* enabled by 4) *organizational change* leading to greater adaptability of formal DRM organisations' routines and operating structures.

3. Merging project results into collective policy recommendations

In a desire to contribute to and further develop all-of-society approaches to DRM, various EU Horizon initiatives and a number of other related programmes, including the Union Civil Protection Knowledge Network (UCPKN) have been forming "clusters" based on shared thematic research areas [86]. The clusters are informal and voluntary, and aim to create a more sustainable and wider impact of results, lessons learned, and progress of the contributing projects. The Societal Resilience Cluster (SRC) was formed in 2021 and now includes over 15 projects, concluded and ongoing. Many of the SRC projects have been funded under annual Disaster Resilient Societies (DRS) calls within the Horizon programmes. Hence, the DRS calls act as a common foundation which connects the projects and from which they build their own unique focuses and research designs towards strengthening societal resilience to disasters.

Over the past five years, a number of interrelations have emerged within and across the SRC projects' research and outcomes in relation to all-of-society approaches to disaster resilience. Through shared dissemination events, discussions, and publications, the projects continue to cross paths on approaches and recommendations towards participatory, inclusive, and innovative DRM. Recognizing these synergies, in 2022 the SRC projects formed a policy working group to assess the potential of creating joined policy outputs for achieving wider impacts of the projects' results for their shared base of stakeholders - in particular disaster management organisations and decision-making authorities at local, regional, and national levels.

The projects collaborated in a series of workshops to first identify the most common and urgent thematic issues amongst them, including any challenges and solutions towards those issues. First, the projects worked independently to identify the core policy priority issues, which the results from their research would address. Collectively the projects then sorted the issues into thematic groups. Four clear thematic groups emerged, with a fifth miscellaneous category for topics which were outside the scope of the other four groups. The four themes included engagement with citizens, improving communication, managing volunteers, and holistic approaches to disaster risk reduction. The first two themes around improving *engagement* and *communication* between citizens and authorities, were selected as the key priority areas for the first policy output. This was done to ensure the scope of the output as manageable, and owing to the interrelation between the two topics.

The projects drafted and consolidated recommendations around the sub-topics under the two themes within a joined structure. For each subtopic and subsequent recommendation(s), considerations were taken towards relevant policy instruments and language at international and national levels, but also for tailoring the recommendations to different target audiences and scales: first at the operational and strategic planning level of disaster management organisations, and second at the policymaking level. This was done to show the interdependencies and conditions needed across the two levels for the effective implementation of the recommendations. Fig. 1 shows the general structure for the shared brief that was followed for the policy themes of 'engaging citizens' and 'improving communication', also with two additional thematic policy areas which could be developed in the future by the cluster using a similar structure.

To illustrate how the conceptual and practical outputs from different projects feed into the policy brief, we use the example of a single sub-topic area of recommendations in the policy brief around *Building basic competence and knowledge around DRM in the population through events and education programmes* [18]. The recommendations are situated under the broader dimension of engaging citizens, and provide suggestions at both operational and policy making levels, which encourage the use of events, workshops, training,

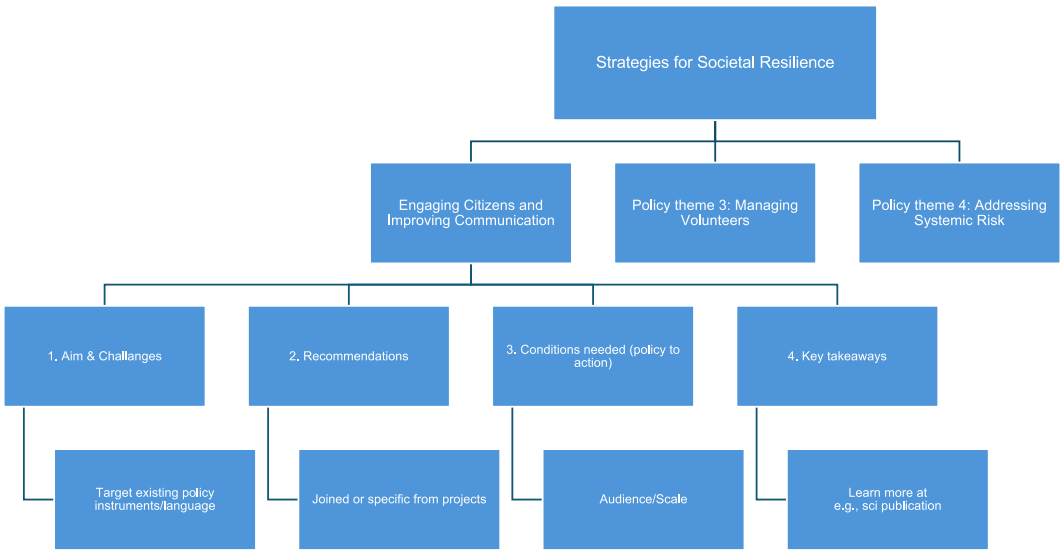


Fig. 1. SRC structure for joined policy outputs.

education and other activities to stimulate civil engagement and participation, and to build DRM competencies and capacities within communities (see Fig. 2).

As noted above, each of the sub-topics identified in the brief were gathered and refined in workshops, meetings, and collective writing assignments to interconnect multi-disciplinary research approaches and outcomes among the projects. The drafted

How to put it into practice?

Build basic competence and knowledge around DRR and DRM in the population through events and education programmes:

Actions for civil protection authorities on strategic and operational levels:

- Organize events such as exercises, training, and workshops involving local authorities, emergency actors, hydromet services, and members of the population.
  - Events should be designed to create learning opportunities for all stakeholders involved, and serve as the basis for establishing mutual trust between citizens and authorities.
  - Events should be used to co-create and develop emergency preparedness plans, to systematically consider vulnerabilities and resilience potentials of diverse societies for various disaster situations, adapt mutual expectations among the different participants, and enable to jointly develop, test and improve procedures and tools.
  - Events should be used to target a better understanding of (local) risks, increase risk awareness, and enhance an understanding of different risk perceptions among different stakeholders.
  - Events should be targeted and consider diversity of members of the population, including cultural minorities and relevant groups with special needs, such as children or people with disabilities.

Actions for policymakers:

- Establish educational programmes around DRR and DRM at municipal and local levels, which enable cooperative action between local authorities and schools, and integrate schools into the planning and implementation phases of emergency response, ensuring they contribute to and benefit from resilience strategies.
  - Schools should be used as the starting place for developing knowledge about disasters, the actions that must be taken, and building basic competences within the population.
  - Courses focused on resilience and preparedness building should also be developed and integrated as part of regular curriculums, based on pedagogical objectives.
- Promote participatory democracy tools and practices in the areas of Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA).
  - Establish participatory requirements for decision and policy-making processes on EU, national, and local levels.
  - Allocate adequate resources for participatory and co-creation processes at local levels to facilitate civic engagement.

Fig. 2. Policy recommendations for building basic competence and knowledge around DRR and DRM in the population.

recommendations went through various rounds of review and revisions both from experts within and outside the projects.

On a more conceptual level, we applied the Gioia method [26] as a *grounded approach* for demonstrating how the individual and shared outputs of the cluster projects also feed into a number of common themes underlining their work towards strengthening disaster resilient societies as we elaborated on in section 2 on the all-of-society approach. Fig. 3 provides an overview of how key concepts (in the form or recommendations) from the SRC projects around the sub-topic building competencies have been aggregated into shared themes and key dimensions of disaster resilient societies addressed by the cluster projects.

The recommendations under the first order concepts have been derived from the merging of related inputs provided by the empirical research conducted in the individual projects. The appendix provides an overview of how the individual project scopes and objectives are linked to the specific first order concepts. For instance, the recommendation around tailoring communication is directly linked to recommendations from projects BuilDERS, LINKS, and RISKPACC, which had specific project objectives to address risk and crisis communication needs to all parts of the society.

The merging of recommendations and the distillation of second order themes and key dimensions was done manually. In order to reduce researcher bias, we used a process of triangulation engaging multiple researchers in the coding, review, and validation of the results. The initial coding was carried out by researchers at Vrije University Amsterdam (VU), followed by several iterations of review, revisions, and comparison of results among members from VU and University of Copenhagen. Thereafter the authors on the paper from different projects were engaged to ensure that the findings accurately represent their inputs and perspectives.

Based on both the insights from the literature on disaster (risk) management, resilience, and the all-of-society approach as presented in section 2 of this paper, and on the SRC projects' outcomes (adopting Gioia's grounded approach) we can distil that at the highest levels, building DRM competencies in the population involves the following dimensions of disaster resilient societies:

- enhancing participation, based on the actions of informal leaders and spontaneous volunteers. Collaborating with disaster (risk) management practitioners in inclusive spaces,
- reducing vulnerability, enabled by targeted communication recognizing both the diversity and agency of the population,
- building capacity, based on trust, co-creation of outcomes and learning, and
- organisational change based on the adaptive capacity of disaster management organisations and ability to transform their work routines.

It is important to point out that all three levels of analysis (1st order concepts, 2nd order themes and aggregate dimensions) are more interrelated than can be visualised in Fig. 3. For instance, the considerations for targeting communication are equally important for enhancing participation, and building trust can be seen as both an objective and outcome of each of the four identified dimensions. This also explains why the first order concepts oriented around building competencies are not solely connected with the capacity building dimension (as one might assume), but are equally important for, and interrelated to, the other themes and dimensions. Moreover, while the first order concepts are sub-topic specific, the second order themes and four aggregate dimensions derived from the concepts play more static thematic roles across the research in the cluster projects, and indeed within the other recommendations in the brief.

The three levels of analysis proved to be vital in bringing together the various insights and outcomes of the SRC project. Hence, in the next section we will elaborate on how these data layers, in the context of an "all-of-society" approach, are addressed from different perspectives of 8 projects contributing to the SRC, including BuildERS, CORE, DIRECTED, ENGAGE, LINKS, PARATUS, RESILAGE, and RISKPACC. We highlight how specific aims, areas of research, and outcomes from the projects along the feed into the thematic lines and dimensions in Fig. 3, and ultimately into the joined policy recommendations.

4. Project contributions to the dimensions of disaster resilient societies

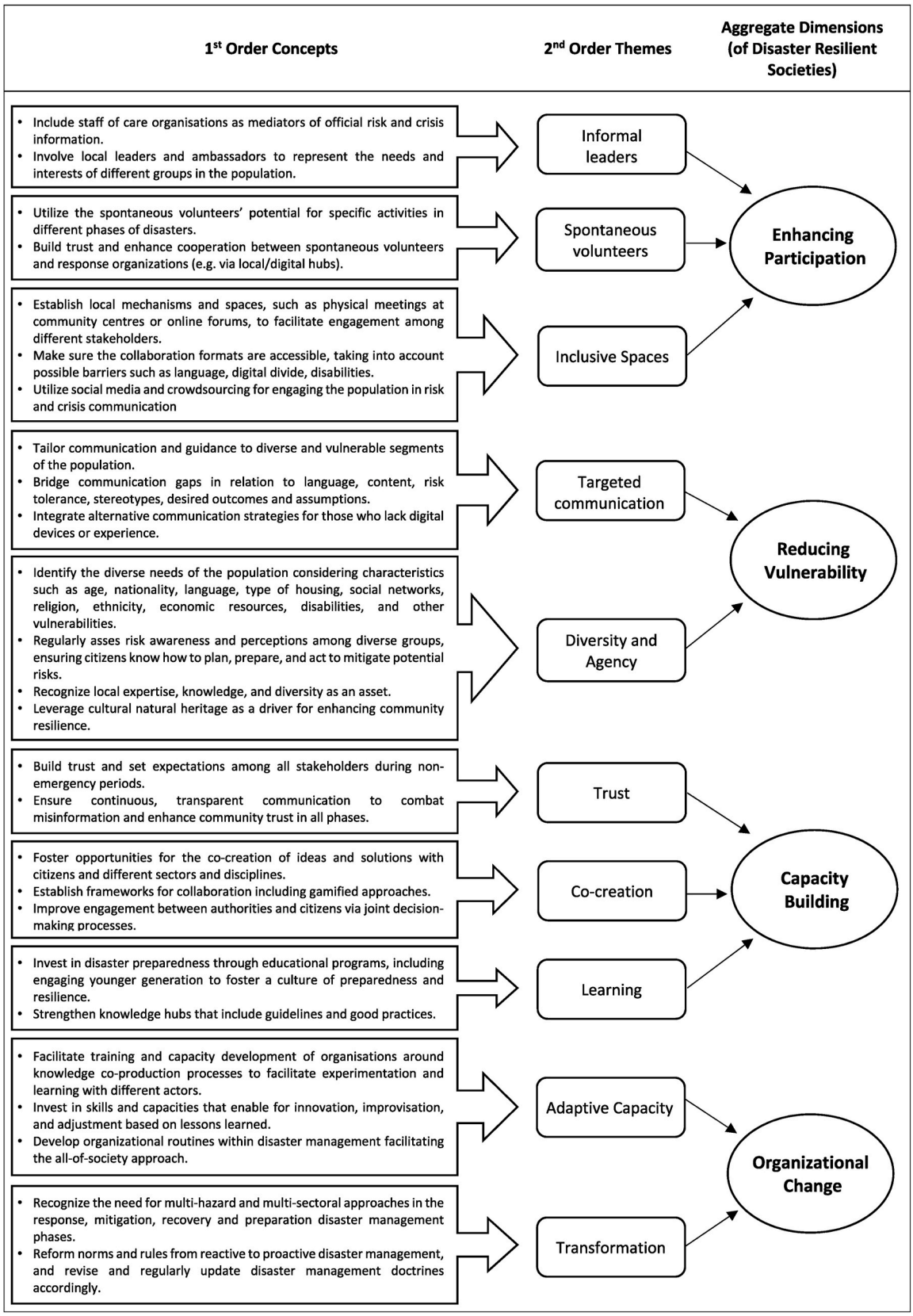
4.1. Enhancing participation

A key theme that emerges across all SRC projects is the focus on enhancing *inclusive participation* in DRM from all parts of the population. Projects such as ENGAGE and LINKS start from the well-known observation in disaster studies that the population does not stay inactive when a disaster strikes or crisis occurs, but often acts in response to and to recover from the event [85,87,88]. Since they are not pre-trained nor professional disaster practitioners nor organised groups, members of the population represent informal actors of disaster management. As some of their actions are seen as a liability rather than as an asset to disaster management activities, to accomplish an all-of-society approach, improvements are required in the interactions between formal (authorities, emergency organisations) and informal actors (individual members of the population, local groups, community and leaders, businesses, and spontaneous volunteers).

The SRC cluster projects have demonstrated and validated in different cases, how such interactions should include involvement in preparedness activities through events and inclusive spaces, enhanced communications, and integration into DRM operations [89–91]. Many of these actions over-lap and are highlighted in detail in the follow sub-sections.

4.2. Reducing vulnerability

Importantly, these interactions require a recognition by authorities of the role diversity and vulnerability play in DRM. This means identifying and *reducing vulnerabilities*, and at the same time leveraging diversity for enhancing resilience within communities [92].



(caption on next page)

Fig. 3. Conceptual data structuring across SRC projects outputs.

Projects such as BuildERS, CORE, LINKS, and RiskPACC have found that this requires recognizing interdependent and intersectional factors that produce socially differentiated impacts depending on the situation-specific and spatial dynamics of vulnerability and diversity [91,93–95]. For instance different risk perceptions and vulnerability factors related to demographic, social, economic, cultural and other characteristics, may impact accessibility (i.e., the possibility to access resources), connectivity (i.e., the capacity to be connected with others), and mobility (i.e., the possibility for people to move) within the population, and ultimately increase the susceptibility of different groups and individuals to the impacts of hazards [57,58,61,92,94–97].

However, empirical research from the projects shows that practitioners and authorities continue to have limited knowledge about how these vulnerabilities can be identified and addressed [89,93,98]. Indeed, this was confirmed by representatives of emergency managers, local and regional authorities, and community organisations in a widely distributed cross-country survey and extensive set of 95 expert interviews by the BuildERS project [93]. The results led to the co-creation of a dynamic scenario-based social vulnerability analysis tool to support authorities in clarifying how the vulnerability factors intersect and overburden certain groups and helps to single out those who need most urgent assistance better targeted disaster planning, response, and risk and crisis communication [99].

The reduction for vulnerability is closely related to the research on inclusive and targeted communication approaches in the cluster projects, both for identifying the diverse needs of the population and the levels of risk awareness, and for harnessing local expertise, knowledge, and culture. LINKS, ENGAGE, BuildERS, and RISKPACC find that targeted and two-way communication strategies, through both digital and other mediums, are key to preparing and leveraging the knowledge and resources within communities [57,58,91,96,100–103]. For instance, in the Netherlands, community forums and workshops were useful to understand levels of risk awareness and to develop roles in risk/crisis communication processes amongst the large industrial chemical plant Chemelot, safety regions, local institutions and organisations such as essential businesses (e.g. (hospitals and care facilities), schools, shops, and surrounding communities [104,105]. This led to the establishment of local, informal leaders in the role of ambassadors, working as *amplifiers* for communication among the Chemical Plant, formal authorities, and diverse and different groups in the neighbouring communities [104].

4.3. Building capacity

Research from the cluster projects has also found that building engagement and communication strategies within communities is important for establishing trust and setting mutual expectations among all stakeholders. Not only the perceptions of authorities and citizens, but also expectations towards each other are often not aligned, i.e. citizens or civil society organisation representing them, may expect support from authorities to an extent that these cannot fulfil, and authorities may expect from citizens a degree of self-preparedness that does not reflect reality [81,98,106–109]. Such misalignment can also be found across disciplines and sectors, increasingly so considering the current multi-hazard risk landscape and the need to share and coordinate risk and crisis science, data, and technologies among different stakeholders.

Where the projects in particular have found common ground is in their focus on developing innovative *co-creation* and *learning* processes among stakeholders, based on the needs and types of stakeholders. This includes the development, testing and validation of different solutions and approaches through social simulations, serious games, table-top exercises, training, workshops and living labs, and education programs aimed at knowledge co-production and capacity building [110]. The projects find that these activities created *inclusive spaces* enabling stakeholders to co-explore and co-design integrated and interoperable technical, governance, and community solutions, that support DRM (including DRR and CCA) and are locally-owned [81,90].

On the more technical end, projects such as BuildERS, DIRECTED, PARATUS and RiskPACC are developing and applying risk assessment and risk management tools, platforms and frameworks through these capacity building activities, to bring together scientific and local experts in hazard risk and impact modelling and governance through knowledge co-production processes [111–116]. The approaches are working to support local/regional stakeholders to identify together the enablers and barriers for governance, risk management, and data modelling, including the visualisation and quantification of disaster impact chains, and identifying affected population groups for context specific hazards and vulnerabilities. Other activities include co-developing digital two-way communication and decision tools to leverage local knowledge from citizens, including data based on crowdsourcing and Volunteered Geographic Information (VGI), and to enhance bi-directional communication between authorities and citizens [117–119].

Overall, the design of capacity building methods and activities by the projects blend the co-creation and co-validation processes around digital tools together with soft solutions. For instance RESILAGE has done this by working together with public authorities, first responders, policy makers, heritage managers, volunteers, vulnerable groups and citizens associations, to take into consideration holistic aspects of cultural heritage, adaptive governance, health and well-being, social interaction and inclusiveness, socio-economic resilience, and active memory in their activities [120,121]. In similar vein, projects such as CORE and LINKS have found that working with authorities, NGOs and schools to co-create educational platforms, materials, and activities can work to instil a culture of disaster preparedness and resilience in younger generations [104,122,123]. For instance, the Learning by Doing: High-School Competition was launched by CORE in 2023 as a competition aimed to empower high school students in Europe to become “sentinels of prevention” in disaster events, and led to the engagement of students in the development of a mobile application (CORE App) [124].

4.4. Organizational change

Over the past 5 years, and through different case scenarios and contexts, the research from the cluster projects has shown that participatory, inclusive, capacity-strengthening activities in DRM feeds into improved transdisciplinary collaboration, systems-thinking, creativity, reflexivity, knowledge integration and advocacy, preparedness, and indeed competency building within the population and within the organisations of formal authorities [111,115]. This last point is of particular importance. Underlying all of the issues and solutions identified by the projects in this chapter, is the need for building resilience not only at the levels of individuals and communities, but also of the DRM organisations. For co-creation and learning processes to be truly effective, the processes and lessons learned must be integrated in ways which facilitate change and transformation within organisations [125].

For example, during the LINKS project it became clear that for authorities to effectively apply social media and crowdsourcing (SMCS) solutions in their work, they first needed to understand their own organisational capacities for doing so [126]. To meet this challenge, researchers, municipalities, fire departments, and other authorities in Denmark, worked to develop a "Resilience Wheel" as a flexible assessment tool to support and evaluate their uses and needs for integrating SMCS into communication strategies and operational routines [127]. Such discussions and organisational adjustments led to better planning, development, and adoption of targeted solutions for engaging with and building competencies within local communities, as well as within their own organisations [125,127].

While the cluster projects differ in terms of their objectives and scopes, their work and outcomes have indeed fed into the four key-dimensions of enhancing participation, reducing vulnerability, capacity building, and organisational change. Ultimately, their work, individually and collectively, strives to strengthen all-of-society approaches to build disaster resilient societies. The examples in the above section are but short illustrative instances of these efforts from the cluster projects. More detailed descriptions of the specific objectives and outcomes of the cluster projects in relation to how their work contributes to the all-of-society approach to resilience are provided in the appendix of this document for reference. In the next section we reflect on areas in relation to the four dimensions, in which research and funding mechanisms still need to address for creating disaster resilient societies.

5. Discussion and conclusion

In this section, reflecting on themes and dimensions identified above, we bring together a few pressing issues identified across the different research projects in relation to building disaster resilient societies. While significant progress has been made in each of these respective areas, we argue that DRM in Europe needs to continuously engage and push for larger transformations in four key areas.

5.1. Towards an inclusive approach for disaster risk management

Disasters are socio-political problems with multiple stakeholders engaged in various aspects of DRM. The all-of-society approach to DRM has been recognised for quite some time now as a way to recognize the potential of the inclusion of heterogeneous actors, both formal and informal, in all phases of DRM. However, very often people affected by disasters are not considered as having agency but rather passive victims or the affected. As a result, there is a huge untapped potential in involving for instance local leaders, representatives of those in vulnerable situations [57,58], and volunteers for various DRM activities, especially in areas of risk reduction [128].

Based on the outcomes of the SRC projects, we argue that given the ever-changing disaster landscape, DRM frameworks must emphasize dialog and participation with sectors beyond traditional DRM communities. This entails system-thinking on ways to identify, inform, and involve policymakers, businesses, and civil society actors in disaster resilience proactively [129]. Such processes can be supported by establishing more conceptual clarity on policy expectations for the roles of specific groups, which encompass a wide range of stakeholders with different contributions to a community's disaster resilience (e.g. care facilities, insurances, local shop owners). As Jordan and Shaw [14] argue, "this vagueness obscures how the policy is translated to assure businesses' own continuity as well as the resilience of their external environment." The same argument can be made for other stakeholder groups, which often get lumped together under a blanket categorization of "vulnerable" in both policy and practice, which misses the diverse needs and capabilities of specific actors vis-a-vis their preparedness towards different risk characteristics.

In this paper we have argued that participation - and risk communication for that matter - is inherently a multiple-way street. On the one hand, it involves creating inclusive spaces and opportunities to engage, learn, and co-develop solutions within communities. On the other hand, it requires a recognition and better understanding by authorities of how communities already engage, organise, resist risk creation and pursue risk reduction at local levels, as these efforts still get very little attention. Overall, we propose that meaningful participation entails responsibility and prioritization of resilience actions by all stakeholders even in cold phases, to maintain momentum during "peacetime" and avoid a return to "business as usual". The institutionalization of participation mechanisms plays an important role here, for sustaining urgency and inclusivity in DRM activities even in non-crisis times.

5.2. Engaging with vulnerability

As the research from the SRC projects has shown that vulnerability is intersectional - people have different socio-economic backgrounds, identities, needs and priorities that are not static, communities have capacities and agency [12]. This makes the effective implementation of all parts of the society into participatory DRM a complex task. As noted above, the SRC projects have highlighted the need to increase our understanding (both research, policy, and practice) of and engagement with vulnerability and

vulnerable groups vis a vis specific hazards, risks, and various other factors.

Innovative and adaptive socio-technical systems and multidisciplinary research offer significant potential to address vulnerabilities comprehensively, particularly by integrating intersectional data into risk and impact assessments [130–132]. For example, solutions toward inclusive disaster resilient societies should be a matter of overcoming barriers to risk and crisis communication to different parts of the population [94,96,133]. Innovative socio-technical systems (for example social media) have the potential to improve risk communication to consider all vulnerable aspects such as language, culture, gender, etc. (Nielsen et al., 2023). As does the integration of detailed risk and impact assessment data which identifies, integrates, and addresses specific considerations for vulnerabilities at local levels.

At the same time, blindly using new technologies is not a solution for vulnerability reduction. As we have learned from the COVID-19 pandemic, we have to move away from the obsession with numbers and risk metrics [41]. The pandemic revealed layers of how vulnerability unfolds and hence the need to recognize vulnerable populations [57,58,81]. In order to understand the underlying socio-economic and political mechanisms to vulnerability, this must be addressed also as a diversity question [41,42,92]. Yet, Europe has not completely engaged and recognised these insights. Given the increasing impacts of climate change and other risks this is a missed opportunity as vulnerability contributes to both visible and invisible, tangible and intangible aspects of loss and damage [134].

5.3. Capacity building for all

Importantly, the SRC projects have found that taking vulnerability into account for DRM (including DRR and CCA) is only the first step. Next, there is a need to develop and implement strategies to harness the diversity, knowledge, and capacities which exist within different parts of the populations.

For instance, EU DRM initiatives must prioritize institutionalized education programs that include disaster preparedness as an essential component, similar to practices observed in Finland [129,135], and in Europe [124]. Children continue to be seen as passive victims and not considered for active participation in DRM [136]. Greater prioritising is needed, including the incorporation for lessons from outside Europe (for example Japan), on integrating disaster preparedness into curriculums and education programmes. The projects also find that capacity building takes testing and investing in adaptable approaches for knowledge development and co-creation across disciplines and communities. This must surpass the rhetoric around participation and inclusion, and include deeper research and investment into multi-sectoral and multidisciplinary learning processes, which ultimately feed into the harmonization and bridging of science to policy and action gaps, and help communities integrate holistic DRM approaches.

5.4. Investing in resilient disaster management organisations

Last and certainly not least, to engage with change, organisations and institutions working with DRM need more serious thinking on how they approach disaster resilience. Resilience, thought carefully, may serve as a tool to challenge global dogma and leverage it to change disaster governance [137]. However, competence building in this regard has been primarily inward looking within organisations. For effective engagement and participation among all stakeholders, and to address vulnerability and diversity in a meaningful way, organisations must be equipped with the right competencies and capacities to do so.

As noted above, *co-creation* has been recommended often as a new pathway for finding DRM solutions. But co-creation must not become yet another buzzword and European institutions must find ways of truly building competencies within DRM organisations at national, regional, and local levels to support multidisciplinary co-creation, knowledge co-production, and decision-making processes for change. This requires more research into the structures and cultures of DRM institutions, and indeed adaptation and reform of DRM norms and doctrines where needed. As crises are increasingly boundary spanning, it entails a deeper understanding and the complexities and challenges of coordination and collaboration dynamics across organisations and stakeholders, which raise issues around leadership, legitimacy, and accountability within DRM structures [70,138,139].

Transdisciplinary projects, like those funded by the European Horizon programme in the DRS cluster, offer opportunities to study and build these areas of competencies by including DRM practitioners/organisations as equal project partners and enabling learning by-doing (e.g. establishing partnerships and engaging citizens, applying new participatory methods and tools). These processes facilitate wider exchange of scientific and local knowledge, between individuals involved from science, policy and practice, having a ripple effect towards partner organisations' staff. Organizational change takes time, dedication, and willingness to reach outside the "usual" ways of working. The joined-competence building efforts of DRS projects help to open these pathways and simultaneously support long-term planning and preparedness thinking across sectors during cold phases [140].

5.5. Elevating the all-of-society agenda for inclusive disaster resilient societies

While the roots of studying all-of-society approaches in disasters go back as early as the 1970s [54], it is only over the past decade that more robust research agendas and funding mechanisms have been established to support holistic, multi-disciplinary research on these topics. Similarly, the integration of all-of-society approaches into international policy frameworks dealing with disaster resilience emerged only recently, and namely in the context of the Hyogo Framework for Action and its predecessor the Sendai Framework for Disaster Risk Reduction. Hence, the implementation of these approaches in practice remains scattered and largely un-systematised across countries and communities. Research has also identified a resilience implementation gap between ambitious high-level policy and rhetoric and on-the-ground action [141].

Nevertheless, this paper has demonstrated how European research involving diverse groups of stakeholders and coming from

different directions is converging around common understandings for the conditions needed for establishing all-of-society resilience. At the most basic level, we have demonstrated that building disaster resilient societies requires scientists, practitioners, policymakers, and citizens to broker and integrate knowledge across multiple disciplines, sectors, and geographies, and EU Research and Innovation projects have the opportunity to build and sustain this interfacing capacity among partners across science, policy, and practice. While far more research is needed in this domain to ensure that these initiatives are effectively operationalized, such joined efforts are already providing a strong basis for holistic, impactful, evidence-informed, policy agendas which can be implemented at different levels to develop and strengthen existing and emerging all-of-society approaches and solutions.

Moving forward, the emerging research supporting policy-to-practice coming from DRS projects, and indeed the wider landscapes of development, disaster, and climate studies in the EU and beyond, should aim to converge objectives, conceptual understandings, and outcomes into an overall inclusive framework towards the operationalization of disaster resilience approaches and their impacts. Research towards such a framework can be supported by methodologies coming from the DRS projects, for multi-disciplinary research and knowledge sharing and should include adjacent research areas, such as development and humanitarian (including conflict) studies. As highlighted above, it should support policy advice that is actionable at local levels and address the root causes of disasters – that is vulnerability and disaster risk. The work must be grounded and aligned across research and practice to depart from all-of-society lip service, and to concretely support complex system-thinking addressing dynamic interplays among cultures, contexts, risk characteristics e.g. (exposure and vulnerabilities, impacts and probability), and practical guidance on how to build local disaster resilience capabilities that are cognisant of an all-of-society approach.

CRediT authorship contribution statement

Nathan Clark: Writing – original draft, Data curation, Conceptualization. **Kees Boersma:** Writing – original draft, Data curation, Conceptualization. **Emmanuel Raju:** Writing – original draft, Data curation, Conceptualization. **Antonio Opromolla:** Writing – original draft, Data curation, Conceptualization. **Kati Orru:** Writing – original draft, Data curation, Conceptualization. **Sten Hansson:** Writing – original draft, Data curation, Conceptualization. **Raffaella Russo:** Writing – original draft, Data curation, Conceptualization. **Maria Vittoria Gargiulo:** Writing – original draft, Data curation, Conceptualization. **Gabriella Duca:** Writing – original draft, Data curation, Conceptualization. **Paolo Capuano:** Writing – original draft, Data curation, Conceptualization. **Pia-Johanna Schweizer:** Writing – original draft, Data curation, Conceptualization. **Lydia Cumiskey:** Writing – original draft, Data curation, Conceptualization. **Max Steinhausen:** Writing – original draft, Data curation, Conceptualization. **Matthieu Branlat:** Writing – original draft, Data curation, Conceptualization. **Alexandra Olson:** Writing – original draft, Data curation, Conceptualization. **Nina Blom Andersen:** Writing – original draft, Data curation, Conceptualization. **Robert Larruina:** Writing – original draft, Data curation, Conceptualization. **Funda Atun:** Writing – original draft, Data curation, Conceptualization. **Cees van Westen:** Writing – original draft, Data curation, Conceptualization. **Rosa Tamborrino:** Writing – original draft, Data curation, Conceptualization. **Maike Vollmer:** Writing – original draft, Data curation, Conceptualization.

Declaration of competing interest

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

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Appendix

This appendix has been provided to give more context to how societal resilience to disasters, in the context of an "all -of-society" approach, is being addressed from different project perspectives. The projects below have provided a condensed overview of their project objectives and approaches (conceptual and methodological) which address the all-of-society approach, also in relation to the policy brief subtopic areas of *Building basic competence and knowledge around DRM in the population*. They also highlight relevant results such as conceptual outcomes and methods, empirical outcomes from e.g. cases, and solutions and tools. Lastly, for context a few examples of recommendations are provided for each project which fed into the policy brief subtopic areas of building competencies.

BuildERS

Objectives and approach:

To improve the overall resilience of people, communities and thereby all-of-society, the EU Horizon 2020 research project "Building European Communities' Resilience and Social Capital (BuildERS)" scrutinized existing approaches, strategies, technologies

and tools to measure and reduce disaster vulnerability in Europe. Our cross-country comparative study based on document analysis and 95 semi-structured expert interviews with representatives of emergency managers, local and regional authorities and community organisations looked into measures engaging members of the public and handling vulnerabilities. In our cross-country survey, we focused on the crisis coping mechanisms of the less studied segment of society and interviewed 320 representatives of the socially or economically least engaged, such as migrants and homeless population.

Vulnerability should be understood as a result of interdependent and intersectional factors that produce socially differentiated impacts depending on the situation-specific and spatial dynamics of vulnerability.[3] Our empirical research demonstrated that the authorities plan their crisis management and communication around pre-determined vulnerable groups (e.g. elderly, individuals with chronic diseases), thus disregarding the place- and hazard-specific contextual drivers of vulnerability.[4] The practitioners engaged in the study also admitted their limited knowledge about how vulnerabilities could be identified. To address this lacuna, in collaboration with hundreds of practitioners and academic experts we created a dynamic scenario-based social vulnerability analysis tool to support better targeted disaster planning, response, and risk and crisis communication.[5] Rather than focusing on certain groups as vulnerable, the tool takes an all-of -society approach to clarify how the vulnerability factors intersect and overburden certain groups, and helps to single out those who need most urgent assistance.

Relevant results:

The results of the BuildERS project suggest that from an all-of-society perspective, it is useful to think of risk and crisis communication not merely in terms of information dissemination activities (e.g., awareness campaigns) that DRM authorities typically undertake but to seek a more broad understanding – including via education programmes – of the various barriers to communication that may make people vulnerable to disasters and that should be overcome to save lives.[6] Specifically, social vulnerability to disasters may emerge due to barriers occurring in the three stages of communication[7]:

1. *Accessing* information about risks, e.g., individuals or organisations having no or limited access to channels of communication needed to call for help or receive warnings,
2. *Understanding* of risk and crisis messages, e.g., warnings may be issued in languages not understood by some groups in society, and
3. *Reacting* to risk and crisis information, e.g., people not trusting official sources of information or having no resources to react adequately to warnings.

From an all-of-society perspective, anyone's understanding of risk and crisis information may be potentially adversely affected by exposure to false or misleading messages. During crises, false and harmful information comes in various forms, all of which should be monitored and addressed.[8] The results of the project show that people may be exposed to messages that discourage the adoption of appropriate risk behaviour that is recommended by the authorities, encourage potentially harmful behaviour, and distort the ways in which people interpret risks.[9] It is also important to protect people who may fall victim of crisis-related scams or harassment.

A key insight from the project is that people do not always engage in adequate protective action after having received information about a hazard or a disaster that could affect them. Their inability or unwillingness to change their behaviour may be rooted in disadvantageous socio-economic circumstances and previous experiences. How people react to information depends on whether or not they trust its source.[10]

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[7] Ibid. 6

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BuildERS study on the homeless and care clients in Europe revealed significant variability in disaster coping strategies and outcomes depending on the living arrangements and the related issues of trust and communication habits of these marginalised groups.[11] People living on the street or under temporary arrangements have lower trust in government crisis information, but their primary trusted information source is social worker. This group have thought less about preventive actions, are less likely to believe that the risks like COVID-19 virus causes them notable harm.[12] Comparatively, care recipients living in their own homes exhibited higher levels of risk awareness, and higher levels of trust in the risk and crisis information provided by the authorities. This reveals an under-recognised potential of social workers at day centres, soup kitchens, and social housing who carry official risk and crisis information to the most marginalised segments of society, mitigating rumours and unnecessary fear.[13] Social care organisations representing the needs of the most marginalised have a great potential for tailoring more inclusive disaster management and communication measures.[14]

Relevant recommendations:

- The representatives of care organisations need to be involved in official crisis management planning and in tailoring response measures for the interventions to reflect the needs of their clientele and other vulnerable segments of the population
- The staff of care organisations need to be recognised as the mediators/interpreters of official risk and crisis information for their clientele, including marginalised individuals. Their communication and guidance are essential sources of motivation for alignment with safety measures.
- To increase risk awareness and levels of trust, governments and authorities should tailor their communication strategies to different audiences, including the most marginalised, their preferences, and their needs.

CORE

Objectives and approach:

The CORE project was aimed to enhance societal resilience by fostering a unified approach to crisis management through interdisciplinary collaboration in environmental and social sciences. Emphasizing an all-of-society approach, the project established common metrics for various disaster scenarios and assesses their impacts on populations, with a particular focus on vulnerability mechanisms. CORE focused on vulnerability mechanisms, and the analysis of specific needs of all citizens whose personal characteristics or state related to physical, mental, social, economic, and environmental factors increase the susceptibility to the impacts of hazards. Vulnerabilities' assessment was central to CORE's analysis, drawing on lessons from past events to understand mechanisms affecting social ties and societal resilience.[15] Drawing insights from Japan, known for its high-risk awareness due to frequent seismic, volcanic, and tsunami threats, CORE identified and applied best practices in disaster risk reduction (DRR) and disaster risk management (DRM). This included the direct involvement of schools in educational initiatives, aimed to build basic competence and knowledge around DRR and DRM among the population.

Relevant results:

1. Mechanisms and Role of Trust in Community Resilience: The project investigated how trust in authorities influences community resilience. A web survey targeting the general population was translated into several languages i.e. Italian, English, French, Tagalog, Hebrew, and German. The survey underscored the importance of collaborative approaches in managing critical events, involving local citizens, practitioners, policymakers, and decision-makers. It further emphasized the need to empower citizens with essential information and address psychological impacts. Activities involving citizens should consider geographical context, socio-economic, cultural, and generational differences, and vulnerabilities, focusing on creating customized, context-specific strategies rather than replicable ones. While older adults resulted to be better prepared, they were more susceptible to misinformation, underscoring the need for clear, transparent information and anti-misinformation tools. Continuous, tailored communication from experts is crucial, particularly for rare events, and overcoming language and cultural barriers. Policymakers and practitioners must collaborate on multi-level, citizen-focused activities to enhance community resilience through clear, transparent information and

[11] T.-O. Nævestad, K. Orru, K. Nero, A. Schieffelers, A. Olson, Alexandra, J. Ludvigsen, C. Morsut, M. Airola, L. Savadori, P. de los Rios, A. Daniel, M. Krüger, M. Schobert, I.S. Hesjevoll, L.E. Egner, C.H. A. Kuran, Christian Henrik Alexander, Psychological impacts for socially marginalised groups in the COVID-19 pandemic: a study from eight European Countries, *PLOS ONE*, 2024. https://doi.org/10.3886/E192421V2.

[12] K. Nero, K. Orru, T.-O. Nævestad, A. Olson, M. Airola, L. Savadori, A. Kazemekaityte, G. Lovasz, Mechanisms behind COVID-19 scepticism among socially marginalised individuals in Europe, *Journal of Risk Research 26*(6) (2023) 675–696. https://doi.org/10.1080/13669877.2023.2208119.

[13] K. Nero, K. Orru, T.-O. Nævestad, A. Olson, M. Schobert, P. Windsheimer, J. Keränen, P. Jukarainen, J. Kajganovic, 2023. Care organisations role as intermediaries between the authorities and the marginalised in crisis management. *International Journal of Disaster Risk Reduction 86*, 103516. https://doi.org/10.1016/j.ijdrr.2022.103516.

[14] K. Orru, K. Nero, T. Nævestad, A. Schieffelers, A. Olson, M. Airola, A. Kazemekaityte, G. Lovasz, G. Scurci, J. Ludvigsen, D.A. de los Rios Pérez, D. A., Resilience in care organisations: challenges in maintaining support for vulnerable people in Europe during the Covid-19 pandemic. *Disasters, 45*(S1) (2021) S48-S75. https://doi.org/10.1111/disa.12526.

[15] CORE [95]. D5.1 "Human centeredness and safety culture measurement toolkit". CORE project.

coordinated actions. Effective strategies should start locally, promoting participation in emergency guidelines and fostering a co-creation approach with differentiated activities for diverse groups. Addressing challenges in timely practical solutions was found crucial to minimise inconvenience and social isolation, as seen in the 2011 Japan earthquake/tsunami disaster recovery.[16] Psychological, experiential, and cultural factors resulted vital, necessitating further investigation for comprehensive solutions.[17]

2. Safety Culture Modelling and Comparative Analysis: CORE defined a tailored Safety Culture concept for DRS context, building on its broad application in various contexts.[18] The project created a three-step methodology to measure Safety Culture in local communities, using unique indicators and combining qualitative and quantitative techniques, in toolkit including a large-scale survey, semi-structured interviews, and focus groups. All tools were released in three customized version for citizens, practitioners, and public servants indirectly involved in prevention and preparedness. The toolkit was validated through a campaign comparing Safety Culture across European regions (NUTS2), each focusing on specific event like wildfires, floods, earthquakes, and terrorist attacks. The comparative analysis of safety culture provided evidence-based inputs for policy making recommendations,[19] such as:
   - Create conditions for successfully utilizing volunteers in DRM activities in practice
   - Create, on a national level, an authoritative and trusted dedicated crisis communication/information channel
   - Effort should be devoted to harmonizing with other organisations (national and international) that has coinciding goals and objectives when designing regulations and work procedures/instructions
   - When designing DRM measures, or regulations for citizens, the local cultural characteristics need to be considered to a greater extent, as the citizen groups showed more significant local cultural variations.
   - Regionally evaluate (relevant organizational level will vary depending on country) public's risk awareness of local and regional risks, and knowledge of how citizens should plan, prepare and act to minimise consequences from potential risks, can be improved
3. Learning by Doing: High-School Competition: CORE promoted activities involving schools[20], thanks to a competition aimed to empower high school students in Europe to become "sentinels of prevention" in disaster events by engaging them in developing a mobile application (CORE App) promoting disaster preparedness and resilience. The competition was designed to foster a culture of risk awareness and community resilience among the younger generation. The participating schools were selected through outreach to schools across Europe, ensuring a broad representation by involving technical and non-technical high schools from diverse socio-economic backgrounds. The competition was structured into two lines: CORE App Content Development and CORE App Prototype. For a full year the schools were engaged in training and brainstorming activities for the competition that covered topics such as disaster preparedness guidelines, case study phenomenology, and app development instructions. These activities aimed to equip teachers and students with the knowledge and skills to create effective disaster preparedness tools, fostering a proactive and resilient mindset among the younger generation. The winning App for the App prototype line of competition "Safe Rescue" is dedicated to fires risk. After a brief introduction, players choose a level from the initial screen. Each level consists of several sub-levels, or rooms, where the objective is to extinguish a fire by selecting one of two options. Correct choices are followed by explanations and progression to the next sub-level, while incorrect choices include error explanations and retries. Completing all sub-levels allows players to advance to the next level. Collectibles can be unlocked throughout the game. The application has been developed using the Unity graphics engine (version 2022.3.16f1) with C#. The game is designed for ages 7/8 and above and supports all Android devices newer than the Samsung Galaxy S8.

Relevant recommendations:

- Utilize Volunteers in DRM: Establish frameworks to effectively incorporate volunteers in disaster risk management activities.
- Promoting preparedness through comprehensive analysis of lessons learned: at the local level, identify potential risks by reviewing past events to avoid pitfalls and develop solutions. Gather best practices and share them with regions facing similar risks.
- Harmonization with Other Organisations: Align goals and regulations with national and international organisations to ensure coherent DRM strategies.
- Cultural Considerations in DRM: Tailor DRM measures to local cultural characteristics to improve their effectiveness.

[16] I. Gagné, Dislocation, Social Isolation, and the Politics of Recovery in Post-Disaster Japan. Transcult Psychiatry. 2020 Oct; 57(5):710–723. https://doi.org/10.1177/1363461520920348. Epub 2020 Sep 9. PMID: 32903157; PMCID: PMC7583447.

[17] CORE (2024b)). D6.2 "Decision making and resilience". Core Project.

[18] G. Duca, G. Gugg, Safety Culture in the Disaster-Resilient Society Context: A Conceptual Exploration. Sustainability 2023, 15, 12236; CORE [95]. D5.1 "Human centeredness and safety culture measurement toolkit". CORE project.

[19] CORE (2024) D5.2 Report on Human centred disaster preparedness, emergency management and safety culture diversity among European countries + UK, Israel and social groups.

[20] M.V. Gargiulo, F. Napolitano, O. Amoroso, R. Russo, P. Capuano, A didactic experience for educating the youngest generations on seismic risk using an escape room, Front. Commun. - Disaster Communications 9 (2024a). oi: 10.3389/fcomm.2024.1386674. ; M.V. Gargiulo, G. Woo, R. Russo, P. Capuano, A role game to learn about risk perception via downward counterfactual thinking. International Journal of Disaster Risk Reduction (2024b).; M.V. Gargiulo, R. Russo, G. Gugg, O. Amoroso, P. Capuano, Engaging Youth in the creation of tools for Disaster Preparedness: The CORE App Competition International Journal of Disaster Risk Reduction (2024c).

- Local and Regional Risk Awareness: Regularly assess and enhance public awareness of local and regional risks, ensuring citizens know how to plan, prepare, and act to mitigate potential risks.
- Educational Initiatives: Promote disaster preparedness through educational programs and competitions, engaging the younger generation to foster a culture of resilience.
- Build trust during non-emergency periods: Ensure continuous, transparent communication from experts to combat misinformation and enhance community trust, beginning during times of calm

DIRECTED

Objectives and approach:

DIRECTED aims to increase disaster resilience for extreme climate events by improving the interoperability of risk data, models, communication and governance. Disciplinary silos, lack of collaboration and the fractured landscapes of academia, decision-making, practice, financing and policy pose significant challenges on the way towards more disaster resilient societies. To overcome these challenges and integrate *all-of-society* in DRM and CCA the project collaborates with four European Real World Labs (RWLs) (Capital Region of Denmark, Emilia-Romagna region in Italy, Danube region, and Rhine-Erft region in Germany) that drive research and innovation to address their resilience challenges. The RWLs are hosted by project partners and involve local/regional authorities, water boards, first and second responders, relevant actors from the private sector, as well as volunteers and citizens. Through an iterative process of experimentation and learning with the RWLs DIRECTED aims to develop and test the "Risk-Tandem Framework" to facilitate knowledge co-production to enable integrated governance and interoperable technical solutions through the "Data-Fabric".[21]

The Risk-Tandem Framework combines existing risk governance frameworks[22] with the knowledge co-production and capacity building approach of the TANDEM framework.[23] The Risk-Tandem Framework supports the four RWLs to identify their most pressing DRM and CCA challenges, connect the relevant societal stakeholders and co-produce governance solutions that foster resilience.[24] To promote interoperability for data, information and models, DIRECTED co-develops the Data-Fabric with the RWLs. This co-development process is linked to the Risk-Tandem Framework to tailor the digital infrastructure to the real-world challenges of our four RWLs. With these close collaborations, the project aims to integrate many of the currently disjointed risk models that the research and commercial community provides. These models are made interoperable through adherence to open data and API standards. The resulting interoperable risk models and technical solutions will inform more integrated governance and communication processes of local/regional authorities and civil protection, as well as the development of local/regional/national policy for disaster risk management and climate adaptation.

Relevant results:

The application of the Risk-Tandem Framework in each of the Real World Labs is demonstrating the importance of facilitating knowledge co-production processes among a diverse group of scientific, practice and civil society actors who collectively want to enable disaster resilience in their regions. The approach supports local/regional partners to identify the enablers and barriers for governance, communication and data/modelling together with the stakeholders for the context specific climate hazards and vulnerabilities. This knowledge enables them to co-explore and co-design integrated and interoperable technical and governance solutions that support DRR and CCA and are locally-owned. Applying the Risk-Tandem Framework is flexible and tailored in each RWL, guided by knowledge co-production training to strengthen RWL hosts' competencies and skills.[25] The Emilia-Romagna RWL led by the Regional Agency for Prevention, Environment and Energy (ARPAE) and Regional Agency for Territorial Safety and Civil Protection, with support from local technical partner GECOSistema organised the Flood Exercise in Rimini, June 2024. This involved simulating an extreme climate event including flood and storm surge risks, supported by visualisations in the SaferPlaces Platform and RIM2D modelling, testing the communication procedures between all coordinating agencies (virtually) and engaging volunteers in-person to directly implement preparedness measures, including sandbags and dike protection tarpaulin. Post-exercise reflections demonstrated

[21] J. Parviainen, S. Hochrainer-Stigler, L. Cumiskey, S. Bharwani, P. Schweizer, B. Hofauer and D. Cubie. Risk-Tandem: an iterative framework for combining risk governance and knowledge co-production toward integrated disaster risk management and climate change adaptation. International Journal for Disaster Risk Reduction. [in Issue – details to be confirmed]; Schweizer et al. (2024) Deliverable 3.1 Framework Development - Introducing the Risk-Tandem Framework. DIRECTED project.

[22] IRGC, International Risk Governance Council. (2005). *Risk Governance: Towards an Integrative Approach*. White Paper No. 1, Author O. Renn with an Annex by P. Graham. Geneva: IRGC; K. C. Lauta, K. Albris, G. Zuccaro, G. Grandjean, (Eds.) ESPREssO Enhancing Risk Management Capabilities Guidelines. 2018, available at: www.espressoproject.eu; S. Hochrainer-Stigler, K. Reiter, Risk-Layering for Indirect Effects. *Int J Disaster Risk Sci* **12**, 770–778 (2021). https://doi.org/10.1007/s13753-021-00366-2.

[23] S. Bharwani, A. Gerger Swartling, K. André, T. Santos Santos, A, Salamanca, N. Biskupska, T. Takama, L. Järnberg, A. Lui, Insights and Updates from Three Diverse Case Studies Using the Tandem Framework to Co-Design Climate Services. 2024 https://doi.org/10.2139/ssrn.4626369; E. Daniels, AS. Bharwani, Å. Gerger Swartling, G. Vulturius, K. Brandon, Refocusing the climate services lens: Introducing a framework for co-designing "transdisciplinary knowledge integration processes" to build climate resilience. 2020, Clim. Serv. 19, 100181. https://doi.org/10.1016/j.cliser.2020.100181.

[24] Ibid, 22.

[25] L. Cumiskey, J. Parviainen, S. Bharwani, P. Schweizer, B. Hofauer, S. Hochrainer-Stigler, S. Bagli, P. Mazzoli, J. Lohrlein, M. Steinhausen. (2024) Capacity development for locally-led knowledge co-production processes in Real World Labs for managing climate and disaster risk. International Journal for Disaster Risk Reduction. [in Issue – details to be confirmed].

how the exercises helped to build competencies in the civil protection and municipal authorities to reflect on procedural, communication and technical gaps in how they engage with volunteers and civil society. For example, identifying the need to engage civil society beyond the large civil protection volunteer network to enhance their capacity to prepare for and respond to warning alert levels, and to develop more interoperable digital tools to improve communication between authorities, volunteers and citizens and access to real-time information.[26]

Relevant recommendations:

- Facilitate/support training and capacity development of local/regional organisations around knowledge co-production processes to facilitate experimentation and learning with relevant climate adaptation and disaster risk management actors to jointly identify and overcome governance and technical barriers for strengthening societal resilience.
- Promote interoperability across data, models and tools to support integration of emerging technologies with local and regional organisational systems for disaster and climate risk assessment and management.

ENGAGE

Objectives and approach:

ENGAGE starts from the well-known observation that the population does not stay inactive when a disaster strikes or crisis occurs, but often acts in response to and to recover from the event. As individuals or organised groups, members of the population therefore represent informal actors of disaster management. As some actions might put them in danger or be misguided, and to accomplish an all-of-society approach, improvements are required in the interactions between formal (authorities, emergency organisations) and informal actors (individual members of the population, local groups, businesses). Interactions include involvement in preparedness activities, communications with, or integration in operations.

We investigated the contribution of the population to disaster-type situations through a detailed analysis of recent events (e.g., 2011 Utøya attack, 2009 earthquake in L'Aquila) based on document analysis and interviews. International surveys were also conducted to understand the perception of the contribution of the population from the public, as well as from the formal actors. Such knowledge led to the development of a model of societal resilience.

A second observation is that many solutions (tools, methods, strategies, guidelines, etc.) have already been proposed and successfully implemented to improve such interactions. The project therefore aimed to accomplish two things: (1) making such solutions more visible and known, especially through developing a Catalogue of Solutions (CoS); and (2) facilitating their uptake by recognizing the conditions for their successful implementation in a specific location with specific characteristics. Existing solutions were identified and described in depth in the CoS through literature analysis and workshops complemented when possible, by interviews.

Relevant results:

The ENGAGE policy recommendations related to communicating with citizens and the role of spontaneous volunteers in disaster management were key results of the project and were formulated in order to propose methods and strategies for improving the interactions between formal and informal actors. The development of these recommendations built upon an analysis of factors that may, in their current state, inhibit an "all-of-society approach" to be taken within disaster risk management and disaster risk reduction. For example, the ENGAGE recommendations advocate for those with local or regional responsibility to find ways to further develop trust and connections within the community, since trust plays a role in the ways that messages are received and interpreted.

Furthermore, ENGAGE urges authorities to develop creative ways to communicate risk to citizens that are the most relevant to them by engaging with communities, hearing their concerns, and gaining a better understanding of their reactions in terms of emergencies (Wales & Olson, 2023).[27] The ENGAGE recommendations also advocate for a more refined approach to be adopted in terms of how professionals within the field of disaster management perceive spontaneous volunteers. For instance, recognizing that volunteers contribute to the disaster management cycle in myriad ways and gaining a better understanding of how to minimise restrictions that may serve to make volunteering less accessible [102].[28]

Relevant recommendations

- Bridge the communication gaps between professionals and citizens. For example, in relation to language (terminology), content, risk tolerance, stereotypes, desired outcomes/priorities, and assumptions.
- Design consistent messaging and communication that is inclusive and adaptable to specific needs.
- Use technology to strategically enhance the volunteer experience and contributions.
- Strengthen learning structures to advance the contributions of volunteers.

[26] Ibid. 25

[27] D. Wales, A. Olson, A voice for citizens in emergencies and disasters: the policy recommendations of the ENGAGE project. https://eena.org/blog/a-voice-for-citizens-in emergencies-and-disasters-the-policy-recommendations-of-the-engage-project/, 2023.

[28] D. Wales, Policy Brief: The involvement of spontaneous volunteers in disaster management. https://www.project-engage.eu/wp-content/uploads/2023/04/Involvement-of-spontaneous-volunteers-policy-brief1.pdf, 2023.

LINKS

Objectives and approach:

LINKS aims at strengthening societal resilience through a comprehensive study on how social media and crowdsourcing (SMCS) could be better integrated into disaster risk management (DRM). In line with an *all-of-society* approach, the project sees SMCS as a bridging mechanism between authorities, citizens, and other key stakeholders in all phases of disasters. When applied correctly it can facilitate targeted and inclusive communication processes which flow both ways between stakeholders.[29] For this to be effective, social, institutional, and technical factors need to be addressed for building competencies around SMCS use, both within populations and by authorities. On the one hand, this includes building technical competencies and routines around SMCS use within DRM organisations.[30] On the other, it requires authorities to have a better understanding of how to leverage, target, and involve diversities within populations in their communication strategies. This means recognizing how different risk perceptions and vulnerability factors related to demographic, social, economic, cultural and other characteristics, may impact accessibility (i.e., the possibility to access resources), connectivity (i.e., the capacity to be connected with others), and mobility (i.e., the possibility for people to move) to communication technologies within the population.[31] The awareness and harnessing of these diversity characteristics by authorities can strengthen community resilience by including a new range of capabilities, skills, knowledge, and information access within DRM processes.[32]

With this conceptual underpinning, LINKS research takes place within a variety of case scenarios concerning different hazards and locations including earthquakes (Italy), industrial hazards (Netherlands), droughts (Germany), terror (Germany), and cloudbursts (Denmark).[33] *Deep dive* assessments are made in the cases over a 3 year period, working closely with local stakeholders (e.g. municipalities, fire departments, civil protection, NGOs, business, etc.) to understand how better to integrate and build competencies around SMCS use considering the different characteristics of the communities, local disaster management principles, and matureness in the use of communication technologies. These studies include surveys, interviews, and workshops investigating how communities perceive a hazard, identify vulnerable groups, reach communities and vulnerable groups through both digital and analogue communication channels, and build competencies within those communities.

For instance in the Italian case, we recognize that SMCS tools can be integrated into the preparedness education and curricula for minors, by working together with schools, local civil protection, and expert intermediaries such as Save the Children Italy.[34] In the Netherlands, community forums and workshops have been useful to understand levels of risk awareness and to develop roles in risk/crisis communication processes among the large industrial chemical plant Chemelot, safety regions, and local institutions and organisations such as businesses and schools.[35] This has led to the establishment of local ambassadors as *amplifiers* for sharing communication within diverse groups.[36] And in Denmark we see the need to focus on elderly populations, who are often less digital than the

[29] N. Andersen, A.B. Nielsen, E. Raju, T. Patil, Policy Brief: Targeting communication in disasters, LINKS project. https://cloud.links.communitycenter.eu/index.php/s/boiypANyHPn7ZQF, 2023; C. Froio, O. Nardini, N. Clark, T. Patil, T., Policy Brief: Accessibility for all: fostering inclusive use of social media in disaster communication, LINKS project. https://cloud.links.communitycenter.eu/index.php/s/BScJyP62LcatSwY, 2023 (accessed 31/07/2024).

[30] A. B. Nielsen, E. Raju, D.R. Landwehr, J.É. Nicolaï, T. Patil, N.B. Andersen, Leveraging social media and crowdsourcing in disaster management processes in Europe. https://www.preventionweb.net/publication/leveraging-social-media-and-crowdsourcing-disaster-risk-management-processes-europe, 2023.

[31] S. Bonati, Disaster vulnerability knowledge base – A consolidated understanding of disaster vulnerability in social media and crowdsourcing. Deliverable 2.1 of LINKS: Strengthening links between technologies and society for European disaster resilience, funded by the European Union's Horizon 2020 Research and Innovation Programme (No. 883490). http://links-project.eu/deliverables/, 2020; S. Morelli, V. Pazzi, O. Nardini, S. Bonati, Framing Disaster Risk Perception and Vulnerability in Social Media Communication: A Literature Review, Sustainability 14, no. 15: 9148. 2022, https://doi.org/10.3390/su14159148.

[32] S. Bonati, V. Pazzi, F. Graziani, F., First DRPV-Methodology for the LINKS Framework and the case assessment. Deliverable 2.3 of LINKS: Strengthening links between technologies and society for European disaster resilience, funded by the European Union's Horizon 2020 Research and Innovation Programme (No. 883490). http://links-project.eu/deliverables/, 2021.

[33] N. Clark, C. Fonio, R. Lüke, S. Bonati, O. Nardini, F. Graziani, M. Claessens, L. Rijkx, N. Andersen, J. Thayssen, S. Rammert, A. Hammachers, N. Hingmann, First LINKS Case Report. Deliverable 6.4 of LINKS: Strengthening links between technologies and society for European disaster resilience, funded by the European Union's Horizon 2020 Research and Innovation Programme (No. 883490). (2022) http://links-project.eu/deliverables/.

[34] R. Larruina, N. E. Clark, F. Graziani, C. Froio, E. Roeloffs, R. Luke, N. Blom Andersen, L. Stolpe Meyer, N. Hingmann, A. Hamchers, Final report on the LINKS Framework application in a broader context. Deliverable 6.6 of LINKS: Strengthening Links Between Technologies and Society for European Disaster Resilience, funded by the European Union's Horizon 2020 Research and Innovation Programme (No. 883490). http://links-project.eu/deliverables/, 2023.

[35] Ibid, 34.

[36] F.K. Boersma, N.E. Clark, R. Larruina, E. Roeloffs, Utilizing social media and crowdsourcing for crisis management and communication: proposing an integrative framework, in: B. Penkert, B. Hellingrath, M. Rode, A. Widera, M. Middelhoff, K. Boersma, & M. Kalthoner (Eds.), Proceedings of the 21st ISCRAM Conference (Vol. 21, pp. 1–11). Information Systems for Crisis Response and Management, ISCRAM, 2024. https://ojs.iscram.org/index.php/Proceedings/article/view/47.

younger ones.[37] Here a specific focus is given to the potentials of applying the principles of 'social listening', which implies crowd-sourcing and applying the results to reply to and answer the questions from the public'[38] – to understand how insights in a community and the meaningful wisdom in the crowd can support and strengthen DRM operations. The result is that in many cases, it is relevant to apply digital platforms, like social media, and in other cases communicating, learning from, and building competencies within the vulnerable groups in the community needs to be analogue.

These practices, while promising, are still not fully understood and applied by professional DRM authorities. Too often authorities lack the experience to involve and engage citizens and members in a community using SMCS, as well as concrete insights, methods, and tools to how this can be done. A key solution in LINKS which emerged to support these processes was the development of a SMCS 'Resilience wheel'. It became clear during the lifetime of the project that for authorities to effectively apply SMCS they first needed to understand their own organisational capacities.[39] Guided by municipalities, fire departments, and other authorities in Denmark, the Resilience Wheel was developed as a flexible assessment tool to support authorities to evaluate their uses and needed integrations of SMCS into communication strategies and operational routines. Such discussions and organisational adjustments led to better planning, development, and adoption of targeted solutions for engaging with and building competencies within local communities (as well as within their own organisations).[40]

For example, the need to identify and engage diverse groups by authorities in the Italian, Dutch and Danish cases led to the development of an *Including Citizens Handbook,* which provides a set of e-learning modules for inclusive communication and engagement with citizens in different phases of a disaster cycle. This includes concrete steps authorities can integrate into their emergency planning for communicating risks, making information accessible, and mobilising citizens and spontaneous volunteers.[41] Guided by Save the Children Italy, authorities and primary schools in the Italian and Dutch cases also developed the *Feel Safe* educational platform to assist them with strengthening the preparedness of minors and intergenerational participatory actions in DRM. The materials in Feel safe are now being used by educators to increase children's awareness of risks' and promote good practices they can adopt for disaster prevention and preparedness.[42]

Relevant recommendations

- Identify the diverse needs of different groups of citizens including socio-demographic characteristics such as age, nationality, language, type of housing, characterization of household members, social networks, religion, ethnicity, economic resources, disabilities, and other vulnerabilities, which can often define, and influence individual needs for information.
- Promote and fund educational activities for improving digital skills of individuals who have different levels of familiarity with technological devices such as smartphones or struggle with basic functions of social media.
- Promote programmes with teaching activities on strengthening digital capacities, addressing the needs of both assistive technology experts and people with physical and sensory accessibility issues.
- Work together with local representatives in the community for people with different cultural backgrounds to understand their needs, and tailor your communication strategies and messages accordingly.
- Use alternative communication strategies for those who lack digital devices, for instance relying on trained outreach personnel to spread risk information or to alert communities with emergency sirens and alarms systems, via landline phone trees, or by reaching people at home or at other in-person community spaces.
- Establish physical and virtual meeting spaces, e.g. at a community centre or an online forum, to facilitate engagement among disaster management organisations, local community representatives, and other relevant actors to ensure that people coming from different cultural backgrounds are both heard and informed.

PARATUS

Objectives and approach:

The PARATUS project aims at increasing the preparedness of first and second responders in the face of multi-hazard events and reducing the risks related to multi-hazard impacts on various sectors that result from complex interactions of elements during disasters. The main outcome is a cloud-based online service platform that offers support in reducing dynamic risk scenarios and systemic vulnerability caused by multi-hazard disasters. The project aims to perform in-depth assessments of complex hazard interactions and their resulting impacts and study how future scenarios could change impacts.

The intensity and extent of the challenges make clear that achieving resilient cities is everybody's business. Scientists, stakeholders

[37] A. B. Nielsen, E. Raju, D.R. Landwehr, J.É. Nicolaï, T. Patil, N.B. Andersen, Leveraging social media and crowdsourcing in disaster management processes in Europe. https://www.preventionweb.net/publication/leveraging-social-media-and-crowdsourcing-disaster-risk-management-processes-europe, 2023 (accessed 31/07/2024).

[38] H. Marynissen, M. Lauder, Stakeholder-focused communication strategy during crisis: a case study based on the Brussels terror attacks, International Journal of Business Communication 57(2) (2020) 176–193. https://doi.org/10.1177/232948841988273.

[39] Ibid, 38.

[40] Ibid, 38.

[41] See https://links.communitycenter.eu/index.php/Including_Citizens_Handbook.

[42] See https://feelsafe.savethechildren.it/en.

and citizens are faced with the challenge to adapt their disaster risk reduction plans but lack the understanding and tools to account for the cross-sectoral impacts and dynamic nature of the risks involved. Therefore, in PARATUS the overall objective is to co-design the dynamic risk scenarios together with stakeholders starting from in four case study areas (including the Caribbean Island countries of Saint Vincent and Sint Maarten, Bucharest in Romania, Istanbul in Türkiye, and the Brenner Corridor in the Alps).

PARATUS project has four main dimensions. First, we learn from the past for a better understanding of low frequency and high magnitude events. Direct involvement of stakeholders from various sectors support learning about the trends in the development of the dynamic and interactive conditions of risk. Additionally, we improve historical datasets with the support of satellite remote sensing data and artificial intelligence to be exploited for providing risk components for systemic risk assessment. Second, we look at the future to co-develop scenarios for future changes including climate change effects for multi-hazard risk assessment and potential changes of exposure, vulnerability and resilience. Third, we co-assess the existing approaches for Disaster Risk Reduction and Climate Resilience for a better adaption to changes and co-developing context-specific decision-making tools for risk reduction. Fourth, we co-develop a cloud-based user-centred simulation and information service for first and second responders and other stakeholders to evaluate the impact chains of multi-hazard events with particular emphasis on cross-border and cascading impacts.

Relevant Results

We started the project by defining our impact strategy.[43] Stakeholder involvement is the key in the project and their engagement can be in 5 different levels: inform, consult, involve, collaborate and empower.

Then, we organized workshops in the case study areas to fulfil the tasks in the first dimension of the project. In the workshops together with stakeholders we co-designed impact chains for the past events.[44] The key lesson learned was that the learning happened multi-dimensional, between academics and practitioners and among practitioners as they come from various sectors.

We developed PARATUS forensic analysis by combining four forensic methods.[45] With the support of forensic analysis we are currently working on defining the quantifiable components to improve the impact-chains.[46] By involving and collaborating with stakeholders in various workshop settings help us to tailor information on dynamic risk drivers to the specific users.

Another result is the improved historical datasets from remote sensing time series analysis, crowd sourcing and Artificial Intelligence on hazard events and exposure datasets. We are currently working on co-developing guidelines for improving historical disaster databases to include multi-hazard impact chain.

The next steps are about co-developing future scenarios based on changes in causes and co-develop planning alternatives and selection of optimal risk reduction options. Guidelines and tools will help us for the quantification of uncertainty in the risk components and the inclusion of uncertainty in the estimation of systemic risk for specific events and sectors, i.e. health, cultural heritage, environment, key economic sectors.

Regarding the third dimension, we compiled a toolbox of approaches with the support of our practice partners.[47] We are currently working on the development of two serious games for the evaluation of optimal adaptation/mitigation measures for risk reduction under "What if?" scenarios to simulate the decision-making process. Besides, we will apply a stress test method during the workshops for short- and long-term decision making and planning processes for different sectors.

Within the fourth dimension, we have been co-developing the first version of the platform.[48] The very initial idea was to co-develop exclusively with and for the PARATUS stakeholders,[49] however, the current platform is aimed at all stakeholders and brings together results from European funded projects dealing with Societal Resilience Societies in the SRC cluster of projects, in order to promote its sustainability. Therefore, we call the platform "Disaster Risk Stakeholder Hub", and is hosted on the CMINE (Crisis Management Innovation Network in Europe). The platform has two interrelated blocks: an information service that provides static hazard and disaster information for stakeholders (or regularly updated information) and simulation service, which is a dynamic component where stakeholders can interactively work with the tools in the platform. We are currently working on developing a user-centred methodology to test the tool together with various stakeholders.

To sum, by developing an online and open-source platform for dynamic compounding risk scenarios, PARATUS supports

[43] D5.1 PARATUS impact strategy. Draft version. PARATUS project funded by the European Union Horizon Europe research and innovation programme (No. 101073954) https://www.paratus-project.eu/project-library/public-deliverables/.

[44] D1.1 Impact chains for the application case studies. PARATUS project funded by the European Union Horizon Europe research and innovation programme (No. 101073954) https://www.paratus-project.eu/project-library/public-deliverables/.

[45] F. Atun, R. Sliuzas, F. Romagnoli, I. Armas, R. Mocanu, S. Kundak, Forensic Analysis of Historical Disasters to Develop Quantifiable Multi-hazard Impact Chains Models. 2024, In: Erberik, M.A., Askan, A., Kockar, M.K. (eds) Proceedings of the 7th International Conference on Earthquake Engineering and Seismology. ICEES 2023. Lecture Notes in Civil Engineering, vol 401. Springer, Cham. https://doi.org/10.1007/978-3-031-57357-6_40.

[46] D1.2 Report on virtual participatory workshops in learning and application case study sites, including impact chain diagram. PARATUS project funded by the European Union Horizon Europe research and innovation programme (No. 101073954) https://www.paratus-project.eu/project-library/public-deliverables/.

[47] D3.1 Virtual compilation of toolbox. Please follow the link to access the virtual toolbox https://www.cmine.eu/topics/35391/page/d31-toolbox.

[48] The Disaster Stakeholder Hub and the various tools are accessible via: http://drs-hub.eu.

[49] C. van Westen, et al. (2024). Development of a Platform for the Generation, Visualisation and Quantification of Disaster Impact Chains. In: M.A. Erberik, A. Askan, M.K. Kockar, (eds) Proceedings of the 7th International Conference on Earthquake Engineering and Seismology. ICEES 2023. Lecture Notes in Civil Engineering, vol 401. Springer, Cham. https://doi.org/10.1007/978-3-031-57357-6_39.

authorities from Europe and beyond in developing more adequate and efficient policies to reduce risk and avoid maladaptive actions that increase risk. Risk assessments most often fail to account for the evolution of risk because they use information that represents risk factors at a single time point in the past, and do not include projections of those data into the future.

PARATUS methodology will contribute to one more of EC's priorities "to promote scientific excellence" in Europe. The project also contributes to "Promoting the European way of life" by addressing the safety of the most vulnerable groups and considering the implications of the EU's migration policy. PARATUS will provide significant policy impact on solutions to reduce the negative consequences of global challenges that involve not only first and second responders but reaches the ultimate stakeholders: the citizens. Additionally, the project contributes to reducing or preventing the adverse impact of the current or expected future climate, or the risks of such adverse impact, in accordance with relevant Union law and the Sendai Framework for Disaster Risk Reduction 2015–2030, in particular, Priority 1 (Understanding disaster risk), Priority 2 (Strengthening disaster risk governance to manage disaster risk). PARATUS's results will provide insight into legislation and national practice.

Recommendations

To influence decisions about built environment, i.e. building restrictions, regulating the construction of new houses and/or economic activities, PARATUS suggests policy makers to:

- Highlight long-term, cost-effective options for risk reduction measures;
- Promote social simulations and serious games for improving the disaster risk reduction decisions;
- Enhance resilience by considering economic development trends at the local, regional and national levels;
- Provide tools with higher-resolution topography and exposure data to make better disaster risk reduction decisions;
- Investigate past disasters by considering not only what went wrong but also what went well;
- Enhance disaster risk management plans by considering the future trends in population movement and urbanization;
- Promote multi-hazard risk approach.

RESILIAGE

Objectives and approach:

In front of the pressure of climate crisis and continuous disaster events, RESILIAGE's aim is to improve all-of-society preparedness as well as mitigate the effects of these events by framing community resilience and heritage drivers as a resource of local communities. Literature has observed the relevance of community resilience in DRR[50] and understood it as an emergent property of human-environment interactions. However, the lack of empirical evidence of this emergent property has also been highlighted by showcasing its dynamics in some socio-ecological systems.[51]

RESILIAGE embeds its vision in the perspective of a sustainable society with more effective access to information, strong connectivity, supported by digital innovation and conceiving innovative strategies where communities play a role at the grassroots level. For this purpose, it aims to advance the understanding of community resilience by capitalising on the complex network of socio-cultural-economic-environmental interactions developed throughout history within local communities that also represent how they have been preparing and reacting to crises in certain places. Local knowledge, cultural practices and local cultural expressions, 'sense of place' and cultural natural heritage include relevant information, which the project aims to more adequately consider both in policy frameworks and in points of intervention to secure desired protective behaviours of citizens. For this purpose, it considers especially relevant engaging local communities in identifying cultural practices.

Inspired by the 2030 Agenda for Sustainable Development on the role of culture as an enabler of sustainable development, RESILIAGE analyses effective interactions among formal and informal disaster management stakeholders together with their local cultural and natural heritage understandings in multi-hazard endangered sites. They identify COmmunity REsilience laboratories (CORE labs) where networks – including public authorities, first responders, policy makers, heritage managers, volunteers, vulnerable groups and various kind of citizens associations – develop analysis and knowledge exchange by co-creating and co-validating both digital tools and soft solutions where heritage is also activated as a powerful driver of community resilience.

Designed activities deepen relevant aspects of societal resilience by a Systemic Resilience Innovation framework (SyRI) to highlight variations in society in consideration of: adaptive governance, health and well-being, social interaction and inclusiveness, socio-economic resilience, and active memory. Tools and methodologies are conceived to enable local communities to identify valuable information in the framework for DRR and support the improvement of preparedness by plans and training. A digital hub, conceived as an open data-driven web platform of integrated tools, provides a set of tools supporting online engagement for systemic community resilience, a kit for analytical monitoring its implementation, and a toolbox for replicating the RESILIAGE approach. Co-created with/in CORE labs they are available for engaging more citizens in leveraging heritage-driven community resilience.

Through community based collaborative methodologies, RESILIAGE generates actionable knowledge rooted at the local level with the aim of fostering bottom-up processes for building public awareness on DRR and resilience at all levels (local, regional, European

[50] K. Maclean, M. Cuthill, and H. Ross. 2014. Six attributes of social resilience. Journal of Environmental Planning and Management 54(1): 144–156. https://doi.org/10.1080/0964056 8.2013.763774.

[51] L. Faulkner, K. Brown, T. Quinn. Analyzing Community Resilience as an Emergent Property of Dynamic Social-Ecological Systems. Ecology and Society 23, no. 1 (2018). https://www.jstor.org/stable/26799048.

and beyond). In this aim, capitalising on RESILIAGE knowledge and lessons learned in the first year, it organizes a comprehensive capacity-building strategy including regional workshops, virtual events, open calls for joining the project both via summer school for ESR and other targeted groups, and for CORE Associated labs to enable replication of the solutions under different social and cultural contexts and to upscale RESILIAGE efforts in the EU and beyond.

Relevant results:

The research has created local networks for knowledge exchange and an open digital hub for the improvement of public awareness on DRR and all-of-society collaboration for DRM. It provides an actionable bottom-up methodology and tools to identify gaps and enhance community resilience and preparedness plans. At the same time, research activities and digital tools foster structured exchanges across the five networks of local communities, extended by mentoring and peer learning activities with CORE-associated labs. A Call for joining the project as Associated CORE labs has been launched.[52] The CORE digital network tool enables local and cross-CORE communities interactions.

By its approach, the project has created a huge collaborative engagement of different expressions and groups of society in five community resilience labs. Focus groups, collaborative surveys and workshops exploring communication gaps and user needs, co-mapping cultural practices, new opportunities to enhance preparedness plans, and experiments on psychological reactions have fostered a large citizen engagement. RESILIAGE partners have acted as facilitators by dealing with all activities and communication materials in local languages. The SyRI makes it possible to verify and validate scalable results such as the prioritization of indicators.

Moreover, the project has developed a range of capacity building on-site and online activities targeting different groups. It supports and encourages peer learning activities and exchanges organised by local communities. Summer schools for ECR interacting with the CORE labs have focused on "Heritage-driven community resilience in large scale cultural natural areas"[53] and on "SHEroes Empowering women in Disaster Risk Reduction through heritage".[54] Partners and qualified speakers, also including women with relevant roles in National Civil Protection of European countries and in UNESCO culture and heritage sectors have produced outcomes (ongoing publication).

Moreover, public virtual events have been organised as well. They have provided an introduction to RESILIAGE approach to leverage natural and cultural heritage for enhancing community resilience, especially targeting some regions (Latin America).[55] A specific webinar has been organised for timely crucial exploration of the intersection between gender, heritage, and resilience-building strategies in the face of disasters by bringing together experts from various disciplines to discuss groundbreaking approaches with a particular focus on highlighting the significance of inclusivity and gender equality and the pivotal contributions of women in science and their indispensable role in bridging the gender gap within the field of DRR.[56]

Relevant recommendations:

- Leverage cultural natural heritage as a driver for enhancing community resilience
- Foster collaborative community-based methodologies for engaging local
- Establish and connect local hubs for collaborative knowledge exchange and fostering bottom-up processes
- Support and monitor communication and collaboration among all formal and informal actors of disaster risk management including public authorities, first responders, volunteers, citizen associations
- Provide communication materials and engagement activities in local languages
- Enhance preparedness plans through digital tools and non-digital solutions validated by formal and informal actors of disaster risk management

RISKPACC

Objectives and approach:

The RiskPACC project aimed at strengthening citizens' risk awareness and preparedness, as well as communication between

[52] RESILIAGE CORE Associated labs Call for applications, organised by UNESCO, https://www.unesco.org/en/articles/call-applications-join-resiliage-project-build-heritage-driven-disaster-resilient-community.

[53] "RESILIAGE Heritage-driven community resilience in large scale cultural natural sites Summer School", Cultural Heritage in Context: Digital Technologies for the Humanities Politecnico di Torino-UCLA, Cotsen Institute of archaeology Joint Summer School Program, organised by Politecnico di Torino and UNESCO, Politecnico di Torino-Castello del Valentino, Turin, June 25th - July 1st, 2023. https://www.dist.polito.it/news/(idnews)/20441.

[54] "RESILIAGE SHEroes Empowering women in Disaster Risk Reduction through heritage Summer School", Cultural Heritage in Context: Digital Technologies for the Humanities Politecnico di Torino-UCLA, Cotsen Institute of archaeology Joint Summer School Program, organised by Politecnico di Torino and UNESCO, Politecnico di Torino-Castello del Valentino, Turin, June 22–29th 2024 https://resiliage.eu/dissemination-outcomes/.

[55] "Empowering communities: Leveraging Heritage for Disaster Risk reduction", RESILIAGE Webinar, organised by UNESCO and VOLIES Voluntariado y Estrategia, 16 July 2024 https://resiliage.eu/recap-of-our-webinar-empowering-communities-leveraging-heritage-for-disaster-risk-reduction/.

[56] "Empowering Women in Disaster Risk Reduction through Heritage", RESILIAGE Webinar, organised by UNESCO and Politecnico di Torino, 10th April 2024. https://resiliage.eu/webinar-on-empowering-women-in-disaster-risk-reduction-through-heritage/.

citizens and civil protection authorities (CPAs). It has been observed that there is often a mismatch between risk perception and subsequent actions, on self-preparedness in particular. Further, risk perception differs among different societal groups, and more specifically among citizens and CPAs. Not only perceptions, but also expectations towards each other are often not aligned, i.e. citizens may expect support from CPAs to an extent that these cannot fulfil, and CPAs may expect from citizens a degree of self-preparedness that does not reflect reality. These mismatches present, in sum, the "Risk Perception-Action Gap" (RPAG).

RiskPACC has focussed on narrowing down this RPAG, by developing strategic, technical and conceptual solutions that facilitate engagement and two-way communication between citizens and civil protection authorities. They consider diverse perspectives and needs of different societal groups, including most vulnerable or marginalised ones. To the extent possible, the solutions are accessible to everyone, considering possible barriers such as specific socioeconomic conditions, disabilities, etc. In addition, a dedicated collaborative framework aims to guide citizens and civil protection authorities in closer collaboration.

The project's solutions have been developed in a co-creative manner, involving CPAs, volunteers, different citizen groups and other stakeholders. A suitable co-creation methodology has been developed,[57] and implemented in a series of co-creation workshops in the project's case studies involving CPAs and different citizen groups. The first phase of the workshop series was dedicated to "rapid prototyping", which included collecting user requirements, proposing and discussing possible tools or functionalities, and collecting respective feedback. The second phase of the workshop series was dedicated to "refining", i.e. iteratively refining technological and conceptual solutions.

The project's solutions, co-creatively developed in close collaboration with the case studies, have then been transferred to new environments. Six associated cities and regions implemented and tested the solutions in their specific context, evaluated in dedicated events. These evaluation events again involved different stakeholder groups, including CPAs and citizens.

Relevant results:

The RiskPACC collaborative framework has been developed for closing the RPAG.[58] It provides guidance on how professionals and citizens can relate to each other, in order to develop the shared understanding needed to build effective risk communication tools and strategies. The framework is structured along (a) Understanding the context (of risk and of the community), (b) Sharing (of knowledge, risk perceptions, and expectations), (c) Relating (developing relationships of trust), and (d) Building (of collaborative solutions to enhance communication).

The "Building" module of the RiskPACC collaborative framework includes co-creation approaches, such as the RiskPACC co-creation methodology. RiskPACC's co-creation methodology applied in the case studies' workshop series includes four main phases: The introduction phase (define and explain the main goal), conceptual phase (choose and explain the specific methodology), collaboration phase (discuss, test and evaluate) and continuation phase (enable follow-up communication).[59] A careful selection of stakeholders according to the objective to be addressed is the basis for target-oriented results. This includes the identification and involvement of minorities and vulnerable groups, and all of them need to have an equal voice during the co-creation process. Specific workshop methodologies, such as participatory mapping, storyboard user stories, or a risk communication exercise, serve to enhance mutual understanding among the different groups.

During events, gamified approaches can motivate engagement, help exchanging perspectives and ideas, and support mutual understanding and collaboration among different stakeholders and citizen groups. The RiskPACC board game can be used in dedicated events on local level, involving stakeholders (including citizens) relevant for disaster risk management in a municipality. It aims to support bringing the different groups together, facilitate discussion and mutual understanding, identify most relevant issues in the specific municipality as well as possible suitable solutions, as well as requirements for their implementation.

Digital two-way communication tools, developed applying the co-creation methodology, take advantage of crowd-sourcing and volunteered geographical information (VGI) technologies, while acknowledging and addressing related challenges (e.g. digital divide). For example, the Aeolian AR mobile app enables dissemination of timely bi-directional information between citizens and CPAs, supporting preparedness against and response to natural and man-made hazard events. This crowdsourcing solution is a user-friendly tool that enhances inclusivity, knowledge generation and exchange. It also supports properly designed trainings. HERMES is a social-network-like web-application where different communities of citizens can be created (e.g. volunteer groups; specific vulnerable groups), to send and receive pertinent emergency and preparedness[60] information.[61]

[57] J. Anniés, Lab Methodology and Glossary. In: RiskPACC – Integrating Risk Perception and Action to enhance Civil protection-Citizen interaction. 2022. https://doi.org/10.5281/zenodo.7801826.

[58] F. Mulder, M. Fordham, D. Alexander, S. Dryhurst (forthcoming). RiskPACC Collaborative Framework. Deliverable 4.4 of RiskPACC: Integrating Risk Perception and Action to enhance Civil protection-Citizen interaction, funded by the European Union's Horizon 2020 Research and Innovation Programme (GA No. 101019707).

[59] Ibid, 51.

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Recommendations

- Support collaboration (e.g. via platforms, tools and events) of all stakeholders involved in disaster risk management, including civil protection authorities, first responders, critical infrastructure providers, citizens and volunteers.
- Make sure the collaboration formats are accessible, taking into account possible barriers such as language, digital divide, disabilities.
- Foster co-creation and collaborative governance
- Strengthen knowledge hubs that include guidelines and good practices
- Provide funding for co-creative, multistakeholder initiatives
- Establish the use of digital two-way communication tools
- Establish frameworks for collaboration and stakeholder engagement, including gamified approaches

Data availability

Data will be made available on request.

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