RiskPACC

INTEGRATING RISK PERCEPTION AND ACTION TO ENHANCE CIVIL PROTECTION-CITIZEN INTERACTION

Evaluation and SOTA Summary Report (CPAs)

Deliverable 1.1

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ABOUT RISKPACC

Increasingly complex and interconnected risks globally highlight the need to enhance individual and collective disaster resilience. While there are initiatives to encourage citizen participation in creating a resilient society, these are typically fragmented, do not reach the most vulnerable members of the communities, and can result in unclear responsibilities for building disaster resilience.

New technologies can also support preparedness and response to disasters, however, there is limited understanding on how to implement them effectively. Awareness of risks and levels of preparedness across Europe remain low, with gaps between the risk perceptions and actions of citizens and between the risk perceptions of citizens and Civil Protection Authorities (CPAs).
The RiskPACC project seeks to further understand and close this Risk Perception Action Gap (RPAG). Through its dedicated co-creation approach, RiskPACC will facilitate interaction between citizens and CPAs to jointly identify their needs and develop potential procedural and technical solutions to build enhanced disaster resilience. RiskPACC will provide an understanding of disaster resilience from the perspective of citizens and CPAs, identifying resilience building initiatives and good practices led by both citizens (bottom-up) and CPAs (top-down). Based on this understanding, RiskPACC will facilitate collaboration between citizens, CPAs, Civil Society Organisations, researchers and developers through its seven (7) case studies, to jointly design and prototype novel solutions.

The “RiskPack” toolbox/package of solutions will include a framework and methodology to understand and close the RPAG; a repository of international best practice; and tooled solutions based on new forms of digital and community-centred data and associated training guidance. RiskPACC consortium comprised of CPAs, NGOs, associated organisations, researchers and technical experts will facilitate knowledge sharing and peer-learning to close the RPAG and build disaster resilience.

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Executive Summary

Deliverable 1.1, as the first output of Work Package 1, provides the knowledge base for RiskPACC on the topics of disaster resilience, vulnerability, and risk perception as well as how these terms are operationalized by civil protection authorities. The aim of this work is to explore the following:

1. Review the state of the art of disaster resilience and risk perception concepts and methodologies in research, practice and policy, and investigate how these have evolved.
2. Establish an appropriate working definition of disaster resilience and risk perception and determine how, as concepts, they have been tailored and operationalized in practice through existing resilience, risk management and crisis guidelines, standards, requirements, and approaches

Following the introduction and overview of the deliverable, the report is divided into four sections, with Sections 2-4 focused on resilience, vulnerability, and risk perception and Section 5 exploring how these topics related to the risk perception action gap (RPAG).

In Section 2, disaster resilience is examined from an academic perspective, exploring the different uses across disciplines and the evolution of the term throughout history. The use of resilience in disaster risk management, including the exploration of the term in both literature and practice, is then examined. Building on this base of knowledge, EU-funded projects and defintiions from International Organizations are explored, leading to the following working definition for RiskPACC:

> *The ability of an individual, community, region, or country to resist, adapt to, and recover from the impact of a hazard, either natural or anthropogenic. Enhanced resilience can be embedded in activities in all stages of the disaster cycle, and includes positive transformation that strengthens the ability of current and future generations to adapt to future crises, and to survive and thrive as conditions change.*

Following the development of the definition for RiskPACC, how CPAs have operationalized the term is explored, looking at examples from the UK, Japan, Netherlands, and the US. Issues that have arisen from operationalizing the term are also discussed.

Section 3 explores vulnerability and the use of the term in disaster risk management. This section examines the evolution of the term throughout history, and explores definitions and current uses. From the exploration of definitions, a working definition is created:

> *"[t]he conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.*

Additionally, the interaction between the terms resilience, vulnerability, and risk perception are explored more in-depth.

Following the discussion of the interaction between vulnerability and risk perception, Section 4 focuses on risk perception and how it relates to CPA practices. The evolution of risk perception in literature is explored, including a discussion of the different focuses of risk perception in different disciplines. Different definitions of risk perception and their uses in practice, as well as definitions from previous EU projects and EU Agencies are explored and analysed, leading to the following working definition, taken from the European Environment Agency:

> *Risk perception involves people's beliefs, attitudes, judgements and feelings, as well as the wider social or cultural values that people adopt towards hazards and their benefits. The way in which people perceive risk is vital in the process of assessing and managing risk. Risk perception will be a major determinant in whether a risk is deemed to be "acceptable" and whether the risk management measures imposed are seen to resolve the problem.*

Additionally, the gaps between how experts and lay people in their understanding and perception of risk are explored as well as factors that influence that risk perception. Finally, different CPA activities to increase risk perception are discussed, with examples from Iceland, Costa Rica, and Bangladesh.

Finally, Section 5 ties all of these concepts together and addresses how they relate to the RPAG. The role of CPA-community relationships is emphasized, including the importance of trust in the relationship, and the challenges that can occur with the different understandings of risk that the two possess. Previously developed frameworks are discussed to provide insight into the development of the RiskPACC framework.

The analysis in D1.1 has provided a knowledge base that will support several WPs to come, including WP3, WP4, and WP5. The key findings of the report are as follows:

- Disaster resilience is a contested concept, with a variety of definitions. This lack of consensus in definitions has led to challenges in the operationalization of resilience.
- Vulnerability has been operationalized by many different actors, and the links with risk perception and disaster resilience will be an important factor in the RPAG
- Understanding risk perception among CPAs, and how that differs from community risk perception, and trying to align the two are important to bridging the RPAG. Current top-down techniques may not be sufficient, and a more participatory approach may be needed.

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Glossary and Acronyms

Term	Definition/description
AI	Artificial Intelligence
CPA	Civil Protection Agency
D1.1	Deliverable 1.1
D2.1	Deliverable 2.1
DFID	Department for International Development
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EEA	European Environment Agency
EWS	Early Warning Systems
EU	European Union
FEMA	Federal Emergency Management Agency
HFA	Hyogo Framework for Action
IFRC	International Federation of Red Cross and Red Crescent Societies
IoT	Internet of Things
IRGC	International Risk Governance Council
JRC	Joint Research Council
ML	Machine Learning
RPAG	Risk Perception and Action Gap
SDGs	Sustainable Development Goals
UNDRR	United Nations Office for Disaster Risk Reduction (former UNISDR)
UNISDR	United Nations International Strategy for Disaster Risk Reduction
VGI	Volunteer Geographic Information
WP	Work package

TABLE 1: GLOSSARY AND ACRONYMS

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1. INTRODUCTION

1.1 Overview

This deliverable (D1.1), "Evaluation and SOTA Summary Report (CPAs)", is the output from Task 1.1 in the RiskPACC Description of Action (DoA) and provides appropriate study definitions of disaster resilience and risk perception as well as contextualizing these terms in relation to Civil Protection Authrority (CPA) practices. The task also examines how these terms relate to the importance of human, social, technological, and organizations factors and their general applicability to disaster risk management policies and practices (RiskPACC DoA, 2020 p. 12). This work will highlight the current understanding of disaster resilience and risk perception in both academia and practice. It will develop a better understanding of what is currently being done in practice to address resilience and risk perception, with examples drawn internationally. This is a desk-based task that involves an intensive literature review of academic literature, different national and international standards and guidelines, past and current EU projects, as well as documents relating to current CPA practices. This deliverable will form the background understanding of CPA perspectives of disaster resilience and risk perception that will inform other project activities and tasks.

There are 10 work packages (WP) in RiskPACC, with this deliverable being a part of WP1, which is titled "Understanding good practices and challenges in Civil Protection policy and practice." The overall objective of the WP is to establish the scientific foundations of the study by researching the understanding of disaster resilience from the perspectives of CPAs and identifying good practices that have been implemented by CPAs in terms of disaster resilience and risk perception (RiskPACC DoA, 2020, p. 11). The overall WP has five objectives, the first two of which are relevant to Task 1.1:

- Review the state of the art of disaster resilience and risk perception concepts and methodologies in research, practice and policy, and investigate how these have evolved.
- Establish an appropriate working definition of disaster resilience and risk perception and determine how, as concepts, they have been tailored and operationalized in practice through existing resilience, risk management and crisis guidelines, standards, requirements, and approaches (RiskPACC DoA, 2020, p.11).

This WP, along with WP2, "Engaging citizens to expand understandings of risks, vulnerabilities, and data collection opportunities," will provide the foundational knowledge needed to feed into the other WPs. The outputs and deliverables from WP1 will feed into both the baseline information required for WP3, "Co-creation lab and stakeholder integration," and the development of the framework in WP4, "Framework development," while also forming the baseline understanding of disaster resilience, vulnerability, and risk perception and practice of CPAs that will be used throughout the project.

The work done in this deliverable will provide and understanding of disaster resilience, risk perception, and vulnerability in order to better inform the overall goal of closing the

risk perception action gap. The aim of RiskPACC is to increase citizens risk perception and preparedness for disasters, with a focus on narrowing the risk-perception-action gap (RPAG) to do so. It has been documented that there is a low perception and understanding of risk in Europe among citizens, and it is common for limited action is taken even if risk is understood. There is also a disconnect between how citizens view risk and how civil protection authorities (CPAs) view risk, all of which contributes to the RPAG (Wachinger et al., 2012; Margolis, 1996; Ropeik, 2012). Closing the RPAG should play a role in increase the resilience of the case study areas involved.

These issues will be addressed in RiskPACC through desk based and primary research, as well as co-creation activities and framework creation that will involve both CPAs and citizen groups from the case-study areas. RiskPACC will also draw on different understandings of new technologies and new forms of media used by both CPAs and citizens that have the potential to close the RPAG. Finally, the work of RiskPACC will be combined into "The RiskPACC," which will include a framework and methodology to understand the RPAG in different settings as well as best practices and technological tools that can be used in communities to close the RPAG (RiskPACC, 2020).

The main objective of this document is to explore the current literature surrounding disaster resilience, vulnerability, and risk perception and how these concepts are understood and operationalized by CPAs. While the focus of this report is heavily centred on risk perception and resilience, the importance of vulnerability and how vulnerability relates to these concepts will also be highlighted. This report will include creating working definitons of these concepts for the RiskPACC project.

1.2 Structure of the deliverable

This document includes the following sections:

- Section 2: This section develops an understanding of disaster resilience as it relates to CPAs. It begins by giving an overview and critique of the current state of disaster resilience research, the established standards and guidelines, and how this is related to CPAs and closing the RPAG. It then details the evolution of the term disaster resilience and provides different definitions from the academic literature, practice, and previous EU research done on the topic. It also provides a working definition of disaster resilience for the study. It then examines different factors that relate to resilience, including human, social, organisational, and technological factors. Finally, this section explores current CPA practices relating to resilience.

- Section 3: This section develops an understanding of vulnerability as it relates to CPA practices. It will first provide an overview of the current research and understanding of vulnerability, and then discuss different definitions of vulnerability, in terms of academic research and practice, and different standards and guidelines. It will then provide a working definition of vulnerability and examine different factors that relate to and influence vulnerability. Finally,

it will discuss different CPA practices in relation to vulnerability and how vulnerability relates to the RPAG.

- Section 4: This section examines risk perception definitions and current CPA practices to increase risk perception as well as how CPAs understand and perceive risk. It begins by giving an overview of risk perception research and practice, the current guidelines and standards, and providing a stronger understanding of the RPAG and the role of CPAs in that gap. This section will then detail different definitions of risk perception from academic literature and academic/grey literature on how these have been applied in CPA activities, as well as international and EU definitions, and definitions from different EU projects that have looked at the subject. It then develops the working definition for the RiskPACC project. It also examines different factors that play a role in influencing risk perceptions, such as human, social, political, and technological factors. Finally, this section will more closely examine CPA practices surrounding risk perception and how these practices relate to the RPAG.

- Section 5: This section will bring together all of the previous sections to more closely examine the RPAG and how it relates to CPA activities around disaster resilience, vulnerability, and risk perception. It will determine what actions are currently being pursued to close the gap, as well as potential reasons for the gap and problems caused by it.

The Conclusion of the report with include next steps for the research and how this work will tie into other deliverables.

1.3 Methodology

The aim of this deliverable is to provide a comprehensive understanding of the current literature around disaster resilience, vulnerability, and risk perception and how these definitions have been conceptualized by CPAs in practice. To accomplish this, a desk-based literature review was completed. Information was gathered from four main sources:

1. Academic literature, including research on guidelines and CPA practices
2. UN and other International Organizations work on resilience and risk perception
3. Previous EU funded studies
4. CPA practical guidance documents

Academic literature was gathered using Google Scholar and Web of Science. Literature was gathered using search terms such as “disaster resilience,” “disaster resilience and civil protection authority,” “risk perception,” “risk perception and civil protection authority,” “disaster risk management and resilience” as well as other similar terms. Forward searching of the identified references was also conducted, and additional references were found following consultation with different RiskPACC partners. Academic literature was included if it discussed disaster resilience definitions

and the uses of disaster resilience in practice, or risk perception and how that relates to CPA work. Both historical and more recent scholarship will be examined to understand past and current perspectives.

Current guidelines and standards were found by a search of the databases for terms such as “Sendai Framework” and “European Commission Disaster Management” as well as consultation with RiskPACC partners. Previous EU studies were found by using the following search terms “EU projects disaster resilience” and “EU projects risk perception.” The EU Cordis database was also consulted. This brought up many different projects, some that were applicable and some that were less so. Projects were included if they a) had deliverables that were accessible to the public and b) had deliverables that focused on either disaster resilience or risk perception. Other EU projects funded in the DRS-01 cluster, such as BuildERs, LINKS, and RESILOC, were also accessed. Some project deliverables were included that had a narrower focus on specific aspects of resilience, such as critical infrastructure, but touched on disaster resilience as a whole. Case studies and examples of CPA activities are taken from international and EU example.

2. DISASTER RESILIENCE AND CPAS

This section will focus on disaster resilience, and what that means in terms of CPA activities. It will cover the current state of disaster resilience research, factors of importance in resilience, discuss different definitions of disaster resilience, and then address how these definitions are used and conceptualized by CPAs in practice. While historically vulnerability has been discussed before a discussion of resilience, it will be discussed separately in this report. More information can be found in Section 3.

2.1 The Evolution and Definitions of Disaster Resilience

Resilience as a term is used in many different disciplines, from engineering to psychology. In mechanics and engineering, the term was first used around the 1850s to describe the strength of steel beams. According to Alexander (2013), this was one of the initial uses of resilience that resembles the term as it is known today. Engineers referred to "[a] resilient steel beam [that] survives the application of force by resisting it with strength and absorbing it with deformation" (Alexander, 2013). The reference to resisting and absorbing the application of force is at the heart of modern definitions. Later definitions of resilience in engineering focused on "bouncing back" and how long it takes a linear system to return to equilibrium (Alexander, 2013; Matya & Pelling, 2014). Between the 1940s and 1950s, resilience started to be widely used in psychology, and by the 2000s the term became popular in human ecology and the social sciences. The initial psychology definitions focused on trauma in children and the process of overcoming the negative effects of exposure, while social ecology definitions described resilience as a buffer capacity to make communities safer by limiting poverty and attempting to withstand the impacts of environmental extremes (Alexander, 2013; Matya & Pelling, 2014; Feteke et al., 2014; Manyena, 2006).

While resilience has been used in many different fields, the term has been adopted into the lexicon of disaster studies. Most common definitions of resilience in disaster management stem from the work of Holling (1973) in ecological resilience. In his work, he defines resilience as "[t]he measure of the persistence of systems and of the ability to absorb change and disturbance and still maintain the same relationships between state variables" (p.14). Holling covers three different aspects of resilience: recovery, resistance, and persistence.

- Recovery has developed into the "building back" or "building back better" aspects of resilience definitions in disaster risk management.
- Resistance is understood as buffering the impact of a stressor, which in terms of disaster risk management has become mitigation and preparation aspects of resilience.

- Persistence concerns staying intact as an identifiable object over time (Khilick et al, 2019).

The emphasis on the system derived from this original ecology definition is still widely used today

Following Holling's work, his understanding of resilience became popular in disaster risk management (DRM) and disaster risk reduction (DRR) initiatives and research (Schipper & Langston, 2015). In 2005, the Hyogo framework was created, which expressly highlighted the need to include resilience in DRR activities. While work was done on resilience in DRM prior to this, the Hyogo Framework led to an increase in the use of the term (Schelfaut et al., 2011; Manyena, 2006). Conflicting definitions and arguments over the operationalization of the term in the DRM field started during this time and continue today. The focus of the term resilience in the Hyogo framework was on bouncing back and withstanding stress, with the intended outcome being to maintain vital functions during and after stresses (Mayta & Pelling, 2014). This focus has been criticised by many in the DRM and DRR field who argue that it is a more conservative focus than DRR requires, and that the focus should be directed toward building back better, rather than just building back (Matya & Pelling, 2014; Schelfaut et al., 2011; Sudmeier-Rieux, 2014). This highlights many of the criticisms of Hollings definition for use DRM, where the closed system he studied does not apply to DRM situations, which tend to lack a stable equilibrium. In current uses of resilience, most of the focus and application fall into one of the two camps, either the more conservative definitions that stem from the Hyogo Framework, or the more progressive definitions that further incorporate DRR.

Another core disagreement in the usage of the term resilience lies in whether it signifies the outcome or the process (Manyena, 2006; Abeling et al., 2019). Some research has focused on resilience as the outcome, concentrating primarily on the building back and recovery aspect of resilience. This has been associated with the more conservative thinking of DRM, and has been criticised as taking a more reactive stance (Manyena, 2006; McEntire et al., 2002). Others have focused on resilience more as the process, with a variety of activities across the disaster risk management (DRM) cycle (Matya & Pelling, 2014; Feteke et al., 2014). This allows for more human and social factors to be considered in the resilience process, and views disaster resilience as a characteristic of a system that has gone through the processes of becoming resilient. This disagreement has also been discussed when considering the current focus on resilience to build back better or build forward (Manyena et al, 2019; Manyena, 2006). Those that believe that resilience is an outcome focus less on building back forward, while those that believe it is a process put much more emphasis on these objectives. Additionally, some believe that when discussing resilience, it should be asked resilience to what and at what scale, while others have focused more on resilience as a collection of attributes (Weichselgarten & Kelman, 2015; Zobel, 2011).

There has been a push in recent years from some in the disaster resilience research field to measure or quantify resilience, as well as to close the gap between how the term is used by different stakeholders. There has been disagreement about what should be measured, what type of resilience is the best to measure, what the baseline is, as well as challenges with each system having very different characteristics (Schelfaut et al., 2011). While there is no full consensus on what is considered to be resilience, there has been an overall push to operationalize the term. With resilience being a large focus of various UN guidance and initiatives, this push has intensified and research on operationalization is ongoing.

2.1.1 CURRENT GUIDELINES AND STANDARDS

There are several frameworks that have guided the actions of governments and drm practitioners when looking at resilience and disaster risk reduction globally over the past 20 years. In 2005, the Hyogo Framework for Action 2005-2015: building the resilience of nations and communities to disasters (HFA) was developed through a collaboration between governments, ngos, academics, and private sector stakeholders (UNISDR, 2005). This framework brought resilience into the mainstream and set clear guidelines and priorities to help states reduce disaster risk and damage. This framework set out five priorities to focus on, with priority 3 dedicated specifically to building a culture of safety and resilience (UNISDR, 2007). This framework created rules and responsibilities for all stakeholders involved in and guiding principles for drr activities.

Building upon the work done in the HFA, the Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted as a follow-up to the work that began in 2005. This framework identified gaps in the HFA, namely in addressing the underlying disaster risk factors, the need to create disaster resilience at all levels, and detailing ways to implement resilience (UNISDR, 2015; Aitsi-Selmi et al., 2015). Resilience plays a large role in this framework, with overall goals and expected outcomes aimed at strengthening resilience and two of the four priorities for action mention resilience overtly:

- Priority 3: Investing in disaster risk reduction for resilience, focuses on investing in disaster reduction methods to “enhance the economic, social, health, and cultural resilience of persons, communities, countries and their assets” (UNISDR, 2015). There are many guidelines included in the framework, including building the resilience of schools, critical infrastructure, businesses, and resilience of communities. It also brings together the concepts of risk awareness and risk assessment and how they can help build resilience (UNISDR, 2015).

- Priority 4: Enhancing disaster preparedness for effective response and to “build back better” in recovery, rehabilitation, and reconstruction focuses on one of the major criticisms from the hyogo framework, which was that it did not focus enough on the more progressive drr structures of building back better (Metya & Pelling, 2014). This building

back better concept is a relatively recent one in resilience, but it has gained influence in DRM. Metya and Pelling (2014) argue that this is because societies have the capacity for critical learning, and so they cannot bounce back to the exact same as they were previously. For those that believe in a more progressive definition of resilience, the inclusion of this term in the guidelines shows that the DRM and DRR stakeholders are beginning to move in a more progressive direction.

Priority 4 has guidelines that tie closely to both the concepts of resilience and risk perception. At the national level, the framework proposes guidelines that focus on preparedness, including developing early warning systems and preparing for disaster response (UNDRR, 2015); resilience of critical infrastructure; and building back better in the disaster reconstruction process to increase resilience. The implementation of these guidelines has led to some concrete changes. For example, poland has initiated an agricultural drought monitoring system, urban adaptation plans, the government centre for security alert, and the it system for protection against hazards as a response to the Sendai Framework (Goniewicz & Burkle, 2019). The EU has created the EU Strategy to Implement the Sendai Framework, working on different initiatives such as the development of a Europe wide reserve force for civil protection.

There are other standards and guidelines that concern disaster resilience, with the most commonly referenced being the Sustainable Development Goals, but these two frameworks have underpinned much of the research and practical work that has gone into addressing disaster resilience in the past 20 years.

2.1.2 GAPS IN RESILIENCE RESEARCH

As mentioned previously, there are many criticisms and issues identified in resilience research and practice. First, the definition of resilience has yet to be agreed upon in the academic community and amongst practitioners. With conflicting definitions, the operationalization of resilience and the measuring of resilience has been a major point of contention among academics and has made resilience difficult to implement among practitioners. Several authors have pointed out that without a common definition and way of operationalizing the term, resilience becomes an irrelevant term that is used in too many forms and loses all meaning other than as a piece of jargon (Weichselgarten & Kelman, 2015; Feteke et al., 2014; Cai et al., 2018). While resilience as a common term has benefits, including using it to galvanize the disaster risk reduction field, without consistency in the understanding it, different organizations or stakeholders may not be acting with the same end goals in mind when developing their initiatives.

Additionally, there is no consensus on the practical application of resilience. Some believe that it is related to individual aspects of the system, while others say that it is a general characteristic of the system as a whole. If resilience is focused on individual aspects of a system, then building the resilience of one aspect may decrease the resilience of a different aspect, or the entire system, or even a neighbouring system (Mayta & Pelling, 2014). It has also been argued that resilience to an event cannot be achieved unless one is resilient generally. Additionally, there are questions as to whether resilience can be a deliberate process and if we can really make a system

more resilient. That is a question that needs to be researched more, as there is limited research done on resilience applied by practitioners (Feteke et al., 2014; Matya & Pelling, 2014).

There has also been discussion surrounding the recovery and building back aspects of resilience. It has been argued that the desire to build back may be problematic, as it encourages communities to build back in areas that are vulnerable to hazards (Schipper & Langston, 2015; Sudmeier-Rieux, 2014; Feteke et al., 2014). This can become an issue in the long-term development of an area, as even if the build back activities are successful, they may be impacted frequently, eventually decreasing the resilience.

2.1.3 RESILIENCE AND THE RPAG

Risk perception, adaptive action, resilience, and vulnerability are all terms that are linked. This link is discussed more in-depth in section 3.5. In general, addressing risk perceptions, adaptive actions, and vulnerability have the potential to increase resilience. Therefore, increasing disaster resilience of a system, be it a community, region, state, or country will include addressing the existing RPAG. The RPAG will be discussed more in depth in Section 5.

2.2 Defining Disaster Resilience

This section will examine definitions of disaster resilience from a variety of sources, in order to inform the definition that will be used in RiskPACC.

2.2.1 DEFINITIONS FROM ACADEMIA

As mentioned above, resilience as a term has been adopted by DRM and DRR work in the previous 20 years. In the adoption of the term for the field of disaster management, definitions have diverged from those that focus solely on general resilience to have a stronger focus on resilience to disasters. Even among disaster resilience definitions, there is divergence in how the term is used. DARWIN, a previous EU funded project, examined the definitions of resilience for crisis management and found over 300 that were applicable (Woltjer et al., 2015). Although there are a dearth of definitions, there are some similarities between disaster resilience definitions. Within the literature that deals specifically with DRM and definitions of disaster resilience, most references include the ability to bounce back, cope with, withstand, resist, and recover from the impacts of a hazard (Aldunce et al., 2014). In a review of definitions of disaster resilience by Cai et al. (2018) 161 papers were found that defined resilience. The most frequent words used in these definitions were ability, capacity, system, disaster, recover, social, absorb, change and adapt. These words can be found in most, if not all, of the definitions included in this deliverable. Other reviews of disaster resilience definitions have noted that most were related to absorbing and recovering from hazardous events, as opposed to withstanding severe conditions (Lucini, 2014). Table 2 below shows a selection of definitions from the literature, without being exhaustive. These definitions were chosen to highlight the range of definitions, from the simple to the more complex.

Authors	Disaster Resilience Definitions
Feteke et al. (2014)	The **capacity** to **resist** and **recover** from loss (p.4)
Kuhlicke (2013)	The systems **capacity to adapt or respond** to a singular or surprising event (p.62)
Millman and Short (2008)	The ability of a system to maintain upon its **current state** over time (p.758)
Cai et al (2018)	the **capacity** of an individual (or community) **to adapt** (by resisting or changing) in order to reach and maintain its survival and functioning (p.850)
Cai et al (2018)	a set of **capacities** that can be fostered through **interventions and policies**, which in turn help build and enhance a community's ability to **respond and recover** from disasters (p.850)
Bruneau et al. (2003)	The ability of social units (e.g. organisations, communities) to **mitigate hazards**, contain the effects of disasters when they occur, and carry out **recovery** activities in ways that minimise social disruption and mitigate the effects of future earthquakes (p. 735)

TABLE 2: DISASTER RESILIENCE DEFINITIONS FROM ACADEMIA

As can been seen from this small sample of resilience definitions, there is wide variety in the understanding of the term among academics, but the terms capacity or ability, as well as recover and respond, are used in most of the definitions.

2.2.2 DEFINITIONS FROM PRACTICE

Disaster resilience definitions from practitioners involve a stronger focus on standards of living and development practices than academic definitions. For example, the United Kingdom's Department for International Development (DFID) created the following definition: "The abilities of countries, communities and households to manage change, by maintaining and transforming living standards in the face of shocks or stresses-such as earthquakes, droughts or violent conflicts- without compromising their long-term prospects" (Keating et al, 2016, p.78). Other international organizations have developed similar definitions, with the International Federation of the Red Cross/Red Crescent (IFRC) detailing resilience as "the ability of individuals, communities, organizations or countries exposed to disaster, crises, and underlying vulnerabilities to anticipate, prepare for, reduce the impacts of, cope with and recover from the effects of shocks and stresses without compromising their long term prospects" (Keating et al., 2016, p.78). Both definitions have a greater focus on vulnerability and addressed resilience in relation to the long-term development of an area.

Other organizations have developed similar definitions, showing that the definitions created by practitioners focus more on tangible outcomes and development, with both definitions above focusing on not compromising long term prospects. Practical Action, an international development charity, defined resilience as the "ability of a system, community, or society to resist, absorb, cope with and recover from the effects of hazard and to adapt to longer-term changes in a timely and efficient manner without enduring detriment to food security or well-being" (Pasteur, 2011, p.13). This definition also focuses on development and well-being, aspects that are typically missing from academic definitions but are present in most practical ones. Keating et al. (2016) looked at various definitions of disaster resilience in practice, from NGOs and International Organizations focusing on disasters and development, and created their own definition. According to their work, disaster resilience is "the ability of a system, community, or society to pursue its social, ecological and economic development objectives, while managing its disaster risk over time in a mutually reinforcing way" (Keating et al. 2016, p. 80). In practice, resilience seems to be used as a term to increase development goals as opposed to solely responding and adapting to stressors.

The Australian Natural Disaster Resilience Index, developed by Parsons et al (2016) to provide a top-down assessment of resilience to natural hazards in Australia, has defined disaster resilience in the following way: 'the capacity of communities to prepare for, adapt, and recover from natural hazard events, and the capacity of communities to learn, adapt and transform towards resilience' (p.2). This definition includes the major aspects of disaster resilience: preparing for, adapting to, and recovering from hazards and incorporates an area's ability to transform to become more resilient. While not as specifically focused on development, it still recognizes the community's ability to transform to prepare for hazards, making it more practice focused than some of the more academic interpretations. Similarly, the Organization for Economic Cooperation and Development has focused their definition of disaster resilience on transforming to become more resilient. It describes resilience as the 'ability of individuals, communities, and states and their institutions to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long-term changes and uncertainties' (Davies et al., 2015, p. 243). These definitions again highlight that the focus of disaster resilience definitions in practice are centred more on long-term development and changes that can positively impact areas.

2.2.3 CURRENT INTERNATIONAL AND EU DEFINITIONS

The definition developed by the United Nations Office for Disaster Risk Reduction (UNDRR), formerly known as United Nations International Strategy for Disaster Reduction Secretariat (UNISDR) is commonly used in both literature and EU projects. UNDRR describes resilience as "the ability of a system, community, or society exposed to a hazard to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNDRR, 2015). The UNDRR definition is used in the Sendai Framework. The definition of resilience used

in the Hyogo framework was also developed by the UNISDR (2005) and is described as "[t]he capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure." The definition used in the HFA is less comprehensive, not mentioning absorbing or recovering from the effects of the hazard in a timely manner, hence it's replacement by the Sendai definition.

The United States National Academies has worked extensively in the field of resilience, focusing on building a culture of resilience in the nation. The definition that their work centres around details resilience as 'the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions' (National Research Coucil, 2012). This definition includes the most common areas that are addressed in resilience: preparation, adaption and recovery. The European Union defines disaster resilience as "the ability of an individual, a community or a country to cope, adapt and recover quickly from the impact of a disaster, violence or conflict. Resilience covers all stages of a disaster, from prevention (when possible) to adaptation (when necessary), and includes positive transformation that strengthens the ability of current and future generations to meet their needs and withstand crises." (Morsut et al., 2020). This definition is very comprehensive, mentioning that resilience covers all stages of disaster and including violence and conflict in the definition. The definitions developed by the UN and governmental bodies tend to be broader than the practitioner definitions, without the focus on long term development, but typically provide more detail than many of the definitions found in literature. The EU definition is especially detailed in terms of the different stages in the disaster cycle where resilience can occur, and touches on long term developments, most likely because it is also a working definition for EU practitioners.

2.2.3.1 DEFINITIONS FROM EU FUNDED PROJECTS

There have been several past EU funded projects that have focused on and researched the concept of resilience. While some have focused on the overall disaster resilience, several others have narrowed their focus to a more specific factor of resilience, such as critical infrastructure resilience. Most of these past EU studies have defined resilience in one of three ways. Some have taken definitions from disaster resilience research, some have taken definitions from UN organizations or different frameworks that have been developed, and others have created their own definitions. A table of projects and definitions can be found below (Table 3).

EU Project Name	Definitions of Disaster Resilience
RESILOC	**Community Resilience*:** capacities of local communities as complex systems (involving the actions and interactions of local agencies, citizens, the built environment and critical infrastructures) to mitigate, withstand, and recover from the impacts of a disaster or emergency, as well as to adapt or transform themselves to be less vulnerable to future disasters and emergencies

	Disaster Resilience: Sendai Framework definition (Meijer et al., 2020) *While this definition is more related to D2.1, it involves the actions and interactions of local agencies, so it is included here
BuildERS	**BuildERS definition:** processes of proactive and/or reactive patterned adjustment and adaptation and change enacted in everyday life, but particularly in the face of risk, crises, and disasters (Morsut et al., 2020)
DARWIN	No one definition, found over 300 from literature (Woltjer et al., 2015)
DRIVER	Sendai Framework definition (Rigaud, 2017)
IMPROVER	**Resilience:** capacity to bounce-back from external shocks, seeking to secure society from unpredictable systematic shocks by improving the evolutionary capacity, or fitness, of the population **Disaster resilience:** capacity of a system, community or society potentially exposed to a hazard to resist, absorb, accommodate and recover from disasters timely and efficiently (Bram et al., 2016)
ENGAGE	Sendai Framework definition (Sahar et al., 2021)
RESILENS	**RESILENS Resilience definition:** the ability of the system or systems to survive and thrive in the face of a complex, uncertain, and ever-changing future. It is a way of thinking about both short and long-term cycles and long-term trends: minimizing disruptions in the face of shocks and stresses, recovering rapidly when they do occur, and adapting steadily to become better able to thrive as conditions continue to change. Within CI [critical infrastructure], the resilience process offers a cyclical, proactive, and holistic extension of risk management practices (Clarke et al., 2015).
RESOLUTE	**Resilience:** ability to recover from or to resist being affected by some shock, insult, or disturbance (Vurgin et al, 2010) **Resilience:** an emerging process in organisations, which developed through continually dealing with risks, stresses, and strains (Sutcliffe & Vogus, 2003) (Ferriera & Simões, 2016)

TABLE 3: DISASTER RESILIENCE DEFINITIONS FROM EU PROJECTS

As noted in the table, these projects have used many different definitions of resilience within the context of disasters. The most commonly used throughout the projects was the UNISDR definition from the Sendai Framework: "the ability of a system, community, or society exposed to a hazard to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through

the preservation and restoration of its essential basic structures and functions." This is a fairly encompassing definition, giving allowance to the type of system that is becoming resilient, from a system, community, or society.

Most of the definitions used in previous EU research highlight the recovery process, with only one of the study definitions not explicitly mentioning "recover" or "bounce back." This highlights one of the major areas of resilience work, which has focused on recovering quickly, with an increased focus on "building back better." There is a variety of other areas of resilience highlighted in these definitions, with some focusing more on a hazard approach and others just concerned with a general stressor. Another aspect of these definitions that are not congruous is the focus on resisting stress. Some definitions used focus on resisting stress, while others focus on adaptation in the face of stress. While these two phrases seem to signify similar aspects of resilience, there are key differences. Adaptation in the face of stress implies actions prior to or during a stressors impact that can help withstand the worst of the impact, while resisting or absorbing stress implies that factors are already in place when a stressor occurs. Adaptation has been viewed as a more dynamic process (Cutter et al., 2008; Béné et al, 2012).

This report has detailed the many different definitions that have been used in the field. Even among EU projects with similar scopes and goals, it has shown that the definitions have focused on different aspects of resilience. The biggest difference in many of these definitions is the focus. Definitions more routed in practice, like the DFID or IFRC definitions, tend to focus more on the long-term development and resilience as a process to increase, or not reduce, long-term prospects of an area. Other definitions from academia and previous EU projects place the emphasis much more on the ability to bounce back or recover quickly from a hazard, while others focus more on the capacity of a system to react to hazards. These differences show the different strains of thinking in disaster resilience and highlight the issues that have been posed previously in creating a definition that will be usable for all that research and practice resilience.

2.3 Working Definition of Disaster Resilience for RiskPACC

The goal of RiskPACC is to determine different techniques and frameworks that can help CPAs and communities close the risk perception action gap (RPAG), with the aim of increasing resilience in Europe. To accomplish the goals of the project, there needs to be a common understanding of what disaster resilience means. To this end, the following definition of disaster resilience will be used for RiskPACC:

> *The ability of an individual, community, region, or country to resist, adapt to, and recover from the impact of a hazard, either natural or anthropogenic. Enhanced resilience can be embedded in activities in all stages of the disaster cycle, and includes positive transformation that strengthens the ability of current and future generations to adapt to future crises, and to survive and thrive as conditions change.*

This definition takes aspects of several of the definitions mentioned above, namely the UNISDR and EU definitions, as well as the RESILENS definition. The fact that resilience covers all stages of a disaster was taken from the EU definition, as it is important to highlight that resilience is not solely about responding and recovering quickly, but should cover preparedness as well. Also, the emphasis on prevention in the EU definition is important to highlight. The UNISDR definition was used to include all aspects of resilience, from absorbing the impact to recovering from it. For the RISKPACC project, resilience should be viewed as a holistic process that involves all aspects of the disaster cycle and includes long-term development. The RESILENS definition mentioned adapting to future crises and thriving as conditions change, which brings aspects of long-term development into the definition. Resilience can help create communities and areas that can adapt to future hazards and thrive, which is a goal of RiskPACC.

2.4 Factors that Influence Disaster Resilience

When it comes to developing resilience, there are many factors that are related to and can influence the resilience of individuals, communities, regions, and societies. The factors that will be discussed in this section are **human, social, operational, and technical**. More discussion on these factors can be found in Deliverable 2.1, but they have been included in D1.1 as CPAs can address some of these factors in their resilience building activities.

2.4.1 HUMAN FACTORS

Human factors that influence resilience relate to the different skills and abilities humans possess. While there are various human factors that contribute to resilience this section will focus on factors that include people's **health, knowledge, and skills** (Brown et al., 2018). These factors influence the ability to absorb, recover from, and adapt to adverse events (Cutter et al, 2008).

In terms of **health**, this can mean both physical and mental health, including factors such as access to healthcare (Boon, 2014; Lightfoot et al., 2020; Brown et al., 2018; Cutter et al., 2016). If someone has an underlying health condition, they may have a lowered ability to absorb and adapt to adverse events. They may also have more difficulty recovering after a disaster. For example, someone with a disability may have specific needs that cannot be satisfied during a disaster, making them less resilient (Brown et al., 2018). This also applies to mental health. Someone with anxiety may have find it more difficult to recover from disasters, making them less resilient. Following the Horizon Oil Spill in the Gulf Coast of the United States, long term mental health issues made recovery more difficult, lowering resilience in the area (Lightfoot et al., 2020).

Knowledge is an important human factor in resilience. This includes both general education level and specific disaster preparedness and response knowledge (Brown et al., 2018; Cutter et al., 2016). In terms of general education, many studies have detailed that those with lower education levels are less resilient than those with higher education levels (Daria et al., 2020; Cutter et al., 2012; Lightfoot et al., 2020). Education levels are correlated with variables such as employment and income levels.

Additionally, it has been shown that those with lower education levels can more easily misinterpret information and underestimate the seriousness of a situation. It has also been documented that those with lower education levels are more reluctant to evacuate (Daria et al., 2020). All of this leads to lower resilience. For specific disaster education, those that have had regular disaster education and training will have increased resilience (Chou & Wu, 2014). This includes information and education on disaster preparedness, response, and recovery. It has been noted that being prepared for disasters because of previous experience was associated with higher resilience (Lightfoot et al., 2020).

Skill factors include inherent skills and learned skills. These skills can be specifically related to disasters, such as skills needed in disaster preparedness or disaster response (Chou & Wu, 2014; Brown et al., 2018; Cutter et al., 2012). One article specifically mentioned learning rescue skills can increase resilience. In addition to having skills, it has been shown that solely being open to learning new skills increases resilience (Chou & Wu, 2014).

2.4.2 SOCIAL FACTORS

Social factors of resilience fall into two broad categories: **socio-demographic factors and social cohesion factors**. Socio-demographic factors include age, gender, and access to transportation. Social cohesion factors include social networks and social connections, and trust in the community and authorities (Chou & Wu, 2014; Shang & Shinozuka, 2004; Cutter et al., 2010; Brown et al., 2018; Carpenter, 2013; Mathbor, 2007).

There are many different socio-demographic factors that play a role in disaster resilience (Gibson et al., 2013; Shang & Shinozuka, 2004; Cutter et al., 2016). One important factor is **age**. Some research suggests that the elderly have decreased resilience compared to others, as they are less able to adapt and absorb events and may also struggle in the recovery phase (Gibson et al., 2013). This is not always the case, as some research has shown that older adults are more willing to invest in structurally resilient homes and have fewer mental health challenges following disasters (Kwan & Walsh, 2017; Tuohy & Stephens, 2012). Additionally, it has been well documented that **gender** is a factor influencing disaster resilience (Lightfoot et al., 2020; Cutter et al., 2016; Daria et al., 2020). Research highlights different structural and societal factors that accompany gender that can influence a woman's ability to become more resilient. Women typically have lower paying jobs and may be only able to get jobs in certain industries, limiting their income and therefore resilience during recovery (Lightfoot et al., 2020). Additionally, women are typically the caregivers of a family, and some research has argued that the role of the caregiver has led to decreased resilience and can more often lead to death during disasters (Daria et al., 2020). The women's responsibility as a caregiver can also lead to increased stress, decreasing resilience (Lightfoot et al., 2020).

Other socio-demographic factors that play a role in resilience include **income**, and **job opportunities** in the area. Lower income decreases resilience in all stages of the disaster. Those with lower incomes do not have the savings to prepare for disasters, and low income is typically correlated with factors such as poor housing quality, mental

and physical health issues, lack of transportation, and lack of education (Gibson et al., 2013; Cutter et al., 2016). Additionally, those with low incomes tend to live in marginalized communities, which have been documented as having more negative consequences during a disaster and have more trouble recovering, therefore having decreased resilience (Lightfoot et al., 2020). It has been recognized that areas where the majority of jobs are in a single industry, especially an industry that relies on natural resources, have decreased disaster resilience. If jobs in an area rely on natural resources, disasters may ruin the industry and make recovery more difficult (Cutter et al., 2010).

Ethnicity/race is another important factor that impacts resilience. Research has shown that minority ethnicities in the United States, such as Latinos and African Americans, have higher levels of psychological and physical stress during disaster events and have higher death percentages than their white counterparts (Yuan et al, 2021; Bethel et al, 2013; Patel et al., 2018; Perilla et al., 2002). This was shown to be the case during the COVID-19 pandemic, where both African Americans and Latinos in the United States were over-represented in the mortality rate (Gold et al., 2020; Golestaneh et al., 2020). Other research has shown similar results, with African Americans and Latinos being negatively associated with resilience (Cutter et al., 2014). There are also indications that minorities are less prepared for disasters, with Bethel et al. (2013) detailing that African Americans and Latinos are less likely to have a three days' supply of medicine in case of disaster. This reduced resilience among minority ethnicities is due to societal and cultural factors such as lack of resources, less educational opportunities, lack of information available in other languages, and lack of trust in authorities (Cutter et al., 2014; Bethel et al., 2013; Patel et al., 2018). This is not always the case, as it was noted in Patel et al (2018) that the Vietnamese community in New Orleans, while being a racial/ethnic minority, displayed greater resilience than other groups.

In addition to these socio-demographic factors, there are the **social cohesion factors** that also influence resilience. **Social networks** play a role in many stages of DRM, and therefore are significant in developing resilience (Carpenter, 2013; Mathbor, 2007). Those with strong social networks will be able to recover more quickly, as they can rely on others in their community for help (Xu et al., 2020; Cutter et al., 2016). During Hurricane Katrina, the Vietnamese community had higher resilience because of their strong social networks and relationships in the community (Lightfoot et al., 2020). Social networks also include community support, leadership, and the presence of volunteering (Chou & Wu, 2014; Brown et al., 2018; Barasa et al., 2018). **Trust** is another social factor that plays a large role in resilience (Chou & Wu, 2014; Brown et al, 2018; Xu et al., 2020). There are multiple levels of trust that are important, from trust in your neighbours and community, to trust in the authorities. Trust in authorities is vital because when someone trusts the information they are receiving they are more likely to act on it (Xu et al., 2020). This means that those that trust authorities will be more prepared than those that do not, increasing resilience. To achieve this trust, DRM organizations need to have a presence in the community. Trust also applies to trust in community members. Those that trust those around them will be more resilient than those that do not. Social cohesion as a concept is hugely important in increasing

resilience. CPAs can work with communities to increase their social cohesion, and should be considered in CPA practices to reduce the RPAG.

2.4.3 Organizational and Technical Factors

Organizational factors in disaster resilience typically refer to the ability of organizations to respond to emergencies and carry out critical functions, and their ability to absorb challenges and adapt (Jung, 2017; Brown et al., 2018; Chou & Wu, 2014). There are different factors that determine the ability to respond to emergencies. These include things such as **organizational culture, leadership, resources, and political representation**.

Organizational culture is an influential factor in resilience. Typically, organizations that have more distributed control rather than the traditional top-down structure are more resilient. This organizational structure allows for more flexibility and better response to change, both significant factors in responding to disasters. It also allows for the opinions of those that are closest to the disaster to be heard (Barasa et al, 2018; Son et al, 2020; Jung, 2017; Kapucu et al., 2010; Waugh, 2003; Waugh & Streib, 2006). Many CPA and DRM organizations, as well as governments, still work in the top-down command and control structure. In Korea, the emergency management system is very top-down, and therefore suggestions that they work more on disaster preparedness and mitigation have been ignored to focus more on disaster response (Jung, 2017). Top-down disaster management can be seen in much of the COVID-19 response, where command and control structures were established through the public health, government, and military response and continue to be utilized (Kalkman, 2020). Other aspects of organizational culture include how the organization views challenges. If they view challenges as an opportunity to learn and grow, they are typically more resilient.

Resources available are also a key organizational factor, as limited material and financial resources impede the resilience of many organizations. If resources are available to avoid negative consequences of disasters, resilience increases (Barasa et al., 2018). **Leadership** is another organizational factor that influences resilience. Resilience will be stronger if there is decisive, effective, and proactive leadership (Barasa et al, 2018; Brown et al., 2018). For example, following Typhoon Yolanda in the Philippines, entrenched leaders were not viewed as legitimate or accountable, which was a factor in the dissatisfaction of the recovery efforts (Eadie, 2019). Leadership in disasters can be improved if different stakeholders are involved in the planning phase. In Japan, they are beginning to have community input in disaster reconstruction and preparedness, leading to better resilience (Mabon, 2019). **Political representation** can also impact resilience. For those that lack political representation, resilience may be lower, as they will be less involved in the process and may be forgotten or intentionally ignored during all phases of DRM, from preparedness to recovery and response. For example, during Hurricane Andrew in Florida, those that lacked political representation, namely illegal immigrants and the homeless, were left out of the response and recovery efforts. Homeless people were not allowed into FEMA tents during the event, and illegal immigrants were scared that they would be

arrested if they went to emergency shelters (Kapucu, 2012). For both groups, the lack of political representation was a factor in their lack of resilience.

Technical resilience refers to how well physical systems perform during disasters. Technical factors that are related to resilience include **information sharing and critical infrastructure.** The degree to which information can be shared, and the way it is shared can be vitally important to improving resilience (Gibson et al., 2013; Shang & Shinozuka, 2004). This sharing of information should occur between CPAs and citizens as well as between citizens. Technical factors of information sharing include the physical structures for communicating, such as the internet and power systems. If these are functioning, it is easier to share information, therefore increasing resilience (Cutter et al., 2016; Son et al., 2020). At the same time, there are many interactions between technical and social factors when it comes to information sharing. People who are older tend to have a harder time accessing information because they are not as technically literate and cannot access the internet (Gibson et al., 2013). Designing effective information sharing platforms for all citizens can greatly increase resilience.

Finally, **critical infrastructure** is key to resilience. Research has shown that many rural areas are less resilient than urban areas (Cutter et al., 2016). There are many reasons for this, but one of the major factors is that critical infrastructure is not as prevalent in the area. Government functions are limited under normal circumstances, and when disasters occur is it very difficult to rebuild (Cutter et al., 2016). The lack of investment in infrastructure reduces resilience in this case. Additionally, if a system has redundancy or physical attributes built with the ability to withstand anticipated disasters, it will be more resilient.

2.5 Operationalization of Disaster Resilience

As mentioned above, resilience has become jargon in the DRM field, and has now become a major focus of government initiatives across the globe. While there has been a push to increase disaster resilience throughout national response programs, this effort has encountered several challenges. Notably, there is a lack of consensus among academics and practitioners about the definition of resilience. There are between 85 and 300 different definitions of resilience, and without consensus being reached, it is difficult to operationalize the term with any consistency (Woltjer et al., 2015; Wiig & MCrea, 2019). While this vagueness can have benefits, especially in the breadth of activities and the different scales that can be brought under the term, there is concern that this lack of definition can present challenges in consistent implementation and operationalization (Coaffee and Clarke, 2015; Rice & Jahn, 2020; Manyena et al., 2019; Wiig & MacRea, 2019). For example, some agencies have highlighted the focus on diversity, redundancy, and interdependency as ways to address resilience, whilst others have been more focused on the tenet of “building back better” as the best way to focus on resilience (Rice and Jahn, 2020), or have focused on either preparedness or on response and recovery operations as the best way to address resilience (Wiig & MacRea, 2019).

Because of this lack of standardization and consistency of understanding, different agencies have operationalized resilience in different ways in relation to disasters. One

study in Australia showed that there were three different resilience structures that were at play at the same time among different CPAs (Aldunce et al., 2014). *First* was the *mechanistic understanding*, where the influence is placed on government agencies and practitioners, with little input from the community. This is the more top-down approach, where physical infrastructure is emphasised, and environmental control is the focus. These approaches include activities such as designing risk assessments, improving zoning plans, and building and strengthening infrastructure (Aldunce et al., 2014; Rice & Jahn, 2020). *Second*, at the same time, different CPAs are more focused on bottom-up, *community-centred resilience* approaches. Such approaches became more popular starting in the 1990s, although still not used as prevalently as top-down approaches (Aldunce et al., 2014; Rice & Jahn, 2020). Community-centred approaches embrace the role of the community in DRM activities and understand that resilience cannot be managed with engineering resilience alone. Other factors, such as the social and economic factors mentioned in section 2.4 are related to resilience, and these must be addressed (de Brujin et al., 2017). Such community-centred approaches often focused on enhancing *communication between CPAs and the community,* with the aim to make communities more self-sufficient and more responsible for their own resilience (Dufty, 2012; Rice & Jahn, 2020). *Third*, other CPAs have concluded that a *combination of the two approaches* is best, where agencies and practitioners design resilience projects, and get communities involved in these activities so they better understand and can take control of these systems (Aldunce et al., 2014).

In terms of organizational structure and the progressive shift from disaster government to disaster governance, there are competing ideologies that dominate the operationalization of disaster resilience. For many decades Governments and institutions have concerned themselves with planning for the risk of disruption, but in the current century preparation for such disasters have become a central focus of government action, driving specific policy measures and generating a push for new and better coordinated governance, commonly under the banner of enhancing resilience and emergency measures to an array of civil contingencies. Whilst there is a long-held normative recognition within emergency management scholarship that a set of well-defined institutional structures, response networks, command chains and detailed planning should be advanced to prepare for multiple types of shock, how these are operationalised in practice varies between and across different territories (Coaffee, 2021).

In most countries that have operationalised disaster resilience policies such approaches have been premised on a top-down approach from central government and have been actualised through meta-strategies linked to national security or emergency management. The aim here has been to transform the conventional and often outdated ways in which such institutions operate. A number of examples can be given from the UK, Japan, Brazil, The Netherlands and the United States to showcase this strategic command-and-control operation of disaster resilience.

In the UK, disaster resilience consists of a robust governance structure, which although being mostly top-down driven, involves a significant bottom-up, community-

centred dimension. This structure begins with the National Security Risk Assessment (NSRA), a process overseen by the Civil Contingencies Secretariat within the Cabinet Office that is undertaken every two years, with the last one in 2019 identifying approximately 130 *'serious malicious and non-malicious, chronic and acute, international and domestic threats and hazards facing the UK and its interests overseas'* (House of Lords, 2021, p.15). The communication of risk information to the public is performed through the National Risk Register (NRR) (a public facing version of the NSRA) and provides an overview of the most imminent risks the UK faces, while also identifying the types of emergencies that could occur because of these risks and the mitigation practices the government are employing against them, and is produced every two years (House of Lords, 2021). There is also a Local Version of the NRR that is advanced by municipal or sub-regional authorities

Although the Cabinet Office in the UK is responsible for civil protection, local coordination of risk is carried out by the Local Resilience Forums (LRFs) (Chmutina and Bosher, 2017). Established in 2004 by the Civil Contingencies Act (Cabinet Office, 2004), the LRFs can be understood as multi-agency partnerships that consist of representatives from local public services, including the emergency services, local authorities, the NHS and arms-length statutory bodies such as the Environment Agency (Cabinet Office, 2013). Emergency response is divided into two categories (Category 1 and Category 2), with Category 1 including the core organisations for emergency response (i.e. National Health Service) and Category 2 mostly consisting of 'cooperating bodies' with lesser set of duties. The LRFs are generally tasked with developing strategic plans for preparing for and responding to a variety of disruptive incidents, in an attempt to systematise disaster risk governance at the local level, with a view to foresight planning and futureproofing, with activities such as horizon-scanning and capability reviews (Coaffee, 2019).

In Japan, the triple disaster on the Eastern seaboard following the devastating Tohoku earthquake of March 2011 exposed the tensions between traditional top-down, centralised and command and control power structures and more organic bottom-up governance configurations where the importance of tacit community knowledge were increasingly important. Historically in Japan, disaster management and planning have a highly technocratic and centralist *modus operandi*, with ingrained conventions where 'official' narratives remained unquestioned. In the wake of 3/11 this prevailing governance culture collided with a re-invigorated *Machizukuri* approach (community planning) and led to conflicting redevelopment aspirations and ultimately a reframing of disaster reconstruction as a resilience building programme, not only in the affected localities but for the nation as a whole in attempt to overcome intergovernmental friction (Aldrich, 2019; Coaffee and Lee, 2016).

Similarly, in Brazil disaster resilience governance is entirely designed following a linear top-down approach. The federal structure of the country's administration in conjunction with the lack of resources and a rich tradition of national and local state-driven policy making (Marchezini, 2019; Wisner et al., 2020) has enabled this structure to emerge. The fundamental institution for the disaster risk governance structure in Brazil is the National Centre for Monitoring and Early Warning of Natural Disasters (CEMADEN). Situated in the state city of São José dos Campos, in the state of São Paulo,

CEMADEN was established in the aftermath of the 2011 flash floods in the mountainous areas of the state of Rio de Janeiro, where 916 people died and a further 35,000 were displaced. This tragic event catalysed several political shifts towards the creation of a national apparatus for disaster risk governance and the institutionalisation of formal instruments - such as policies, plans, laws and protocols – to confront the impact of natural hazards (Horita et al., 2017). CEMADEN is tasked with developing and operating information systems that monitor environmental variables (e.g., volume of rainfall or water level in riverbeds), as well as issuing warnings of imminent natural hazards to the National Centre for Disaster Risk Management (CENAD), who is later responsible for mobilising different national and local agencies to respond to the potential event, through a process of local mobilisation (Tkacz et al., 2021). In other words, CEMADEN is the central hub for disaster risk forecasting and early warning, but the mobilisation of emergency response mechanisms lies with local authorities at the state or (less frequently) at the municipal level. As far as community involvement is concerned, such initiatives can be sporadically met in some states but they are not an outcome of a central systematized process, but rather emerge as by-products of local, hyper-local or international collaborations.

By contrast, the Netherlands has a very robust emergency planning and response apparatus along with a rich history of effectively managing crises and disasters stemming from natural hazards both at the national and at the regional level, combining top-down and bottom-up approaches. An interesting example of such a practice is the Safety Regions Act published in October 2010 and revised in January 2013 (Dutch Ministry of Security and Justice, 2013). Based on the Safety Regions Act, territorial Netherlands was divided to 25 distinct public bodies called Safety Regions (veiligheidsregios), in an attempt to facilitate local cooperation for crisis management and emergency response and ensure efficient coordination of civil protection agencies and local communities. Safety regional managers have the responsibility for designing joint policies and regulations for crisis management as well as for administering the emergency response services and civil protection authorities in their respective regions (Dutch Ministry of Security and Justice, 2013).This Act also specifies that as a common rule, safety regions must be structured on the same scale as the police regions, and the fundamental argument behind their establishment is that *'dividing the territory into equal regions creates an essential basis for multidisciplinary action in the event of a disaster or crisis'* (PreventionWeb, 2013). The Safety Regions Act lays the legislative and organisational foundations for the effective disaster risk and crisis management for Dutch CPAs, implementing in action ideas around the devolution of power and responsibility and subsidiarity as expressed prior to its publication, albeit with a strong centralised focus.

Finally, in the United States, FEMA, the United States' disaster response agency, has taken an approach to disaster resilience that frames it as 'everyone's business and is a shared responsibility among citizens, the private sector, and government' (National Research Council, 2012). The development of this new disaster response governance system was driven by US National Academies *Disaster Resilience: A National Imperative* that set out on a new path that focused on the value of building a culture of resilience across individuals, households, communities and the nation overall, as a

way of lessening the impact of disasters and their impacts before they occur. The driving force behind this framework was not only to enhance preparedness for impending disaster, but also to reduce disaster cost. As FEMA note:

> FEMA Resilience aims to build a culture of preparedness through insurance, mitigation, continuity, preparedness programs and grants. FEMA Resilience works to fulfill FEMA's vision of ***a prepared and resilient nation*** through its programs and partnerships (FEMA, 2020).

Centrally, disaster resilience was seen as a strategic and holistic activity and as 'the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions' (National Research Coucil, 2012), whilst at the same time placing much of the responsibility for resilience on the local community, and emphasizes self-sufficiency as a tool to increase resilience (Rice & Jahn, 2020).

As noted above, whilst many CPA systems still operate in a more top-down structure, there has progressively been a move to involve communities and individuals in a more bottom-up approach that allows for greater input and information sharing between CPAs and communities. Here the challenge – and one central to RiskPACC – is to better align the strategic actions of CPA with the experiential understandings of communities (see a detailed discussion in Deliverable 2.1).

More generally, research on the way that tenets of resilience in academia can be transferred to CPA practice in order to enhance resilience also suggests a combination of the top-down and bottom-up approaches discussed above. De Brujin et al (2017) suggest 5 key principles

- The first is adapting a systems approach, where the whole system is understood so that effective measures can be tailored to the system. This requires an understanding of the whole system of events from threats of eminent weather to the recovery process.
- The second principle is to look beyond the design events. This means that CPAs must be aware of all possible events, not just the ones that are deemed most likely. This principle is meant as an opportunity for CPAs to take a more resilient approach to risk assessment.
- The third principle is to prepare infrastructure to remain functioning. While infrastructure has become critical to the functioning of society, CPAs need to make sure that infrastructure failures are not catastrophic.
- The fourth principle is to increase recovery capacity by focusing on social capital. Activities to focus on social capital include basic poverty alleviation practices, as well as a specific focus on community education and training on disasters during the preparedness phase.
- The fifth principle of resilience in practice is to remain resilient into the future. Organizations and communities may need to adapt their resilience activities, due to climate change and stressors on the community. Flexible and adaptive policies and strategies are required to make sure that resilience is maintained. This is one example of operationalizing resilience and developing real guidelines for CPAs.

2.5.1 CPA USE OF TECHNOLOGY AND DISASTER RESILIENCE

There has been a recent effort in the field of DRM to embrace technology in disaster resilience practices and use that technology to enhance current activities. The Sendai framework has emphasized the need to 'strengthen technical and scientific capacity'

(UNISDR, 2015) in all areas of disaster resilience. The realisation that systematic disaster management cannot be achieved by exclusively focusing on the physical factors that influence the occurrence of hazard events has led to a more process-driven approach of understanding the environmental and socio-economic drivers of exposure and vulnerability that turn hazards into disasters and dictate the resilience capability of a community (Kankanamge et al., 2019). As technologies emerge and advance, CPAs have begun using them more often to increase resilience. One example of this is the **use of social media**. In Australia, CPAs have been using social media to explain disaster risk and engage with communities to manage that risk (Dufty, 2012). Social media can build emergency management communities aligned with a particular disaster and share information with community managers and first responders. Grasso & Crisci (2016) analysed the use of codified hashtags on **Twitter** of regions in Italy expecting severe rainfall and found that tagged tweets contained useful information about citizen perceptions; those tweets were also used to update official data. Therefore, CPAs and emergency agencies could implement codified hashtags for improved information dissemination and retrieval.

Early Warning Systems (EWS) offer a way to utilise citizen-generated data during pre-disaster stages. Volunteered local knowledge helps CPAs to understand individual- and community-level exposure and vulnerability to imminent risks that are instrumental in the operationalisation of preparedness, mitigation and response strategies (Haworth & Bruce, 2015). Conversely, volunteer geographic information (VGI) can capture local knowledge about the extent, severity, impacts and coping strategies of past disaster occurrences, and provide insight into local vulnerabilities that existing EWS do not consider (Adams, 2013). The goal is to formulate a risk management framework based on local knowledge of the vulnerability, by understanding the risk perceptions, needs, experience, capabilities, susceptibilities of all stakeholders (including citizens), and based on this understanding communicate this information to relevant audiences during each stage of a disaster lifecycle (Harrison et al., 2020). The British Geological Survey exemplified such integration of collectively generated information by feeding multimedia tweets into the National Landslide Database to model hazard impacts (Harrison et al., 2020). See D2.1 for a more comprehensive discussion of VGI and how technology can increase community resilience.

Developments in disruptive technology applications, such as robotics, drone technology, machine learning (ML), big data analytics, artificial intelligence (AI) and blockchain are having significant implications for research across the disaster lifecycle. For example, the Internet of Things (IoT) has contributed to real-time bi-directional communication between CPAs and citizens during pre-disaster stages. Developments in cloud computing, data analytics and software and hardware engineering sensors have led to the emergence of real-time, connected sensors referred to as IoT. IoT sensors are used to monitor hazards levels and alert CPAs and citizens alike about potentially hazardous situations, thereby facilitating information dissemination and reception by allowing CPAs to probe citizens about hazard levels in their respective locations, and to disseminate relief measures for those already impacted and mitigation strategies for the yet to be impacted citizens (ITU, 2019).

AI technologies are used to facilitate emergency calls, as call centres are often overwhelmed during and after a crisis. In addition to voice calls, emergencies are reported by text messages aided by AI-powered chatbots and speech-to-text functionalities. These technologies can interact with and interpret natural language, handle requests and quickly respond with relevant updates during an emergency. Hence, reducing communication and information vertical (between CPA and citizens) gaps, assisting CPAs to gather analytics about vulnerability status, quicken response time and preserving human resources by eliminating the need for human agents (Tsai et al., 2021).

3. VULNERABILITY AND CPAS

This section will discuss the concept of vulnerability in disaster management, definitions of vulnerability, and how the concept is applied to CPA activities

3.1 Vulnerability Definitions

The understanding of vulnerability as a determinant of disaster risk is a development that took place over the last century. Traditionally, disasters such as famine, plagues or natural hazards were characterised as *Acts of God* with the implication that nothing could be done about their occurrence. The rise of Enlightenment, secularism, and science changed people's perception of disaster, being characterised more as *Acts of Nature*. Although the origin of disasters was now conceptualised differently, it was believed that their occurrence was *natural* and thus not to be influenced or prevented. In the 20th century, the interplay between disasters and social change were analysed (Prince, 1968) and the understanding slowly shifted towards the framing that hazards are Acts of God but that "losses are largely acts of man" (White, 1945, p. 2). Respective thoughts were formalised and more widely discussed during the 1980s that disasters began to be understood as socially constructed or *Acts of Men and Women* (Hewitt, 1983, p. 3). With respect to natural hazards it was recognised that due to political, social or economic forces, certain parts of the society in question were placed in a more perilous position than others. In other words, it was acknowledged that similar hazards can lead to very different harms and losses in different settings.

Since then, a range of definitions and conceptualisations aiming to describe (and assess) these forces, mechanisms and their implications on disaster risk have been developed by different scholars. Most prominently, concepts of vulnerability have emerged from three main schools encompassing:

i. Geographic development and poverty research
ii. Hazards and disaster risk reduction research
iii. Climate change sciences including research on adaptation (Birkmann, 2013, 12 ff)

Depending on scholarly background, different aspects of vulnerability were put into the focus of definition and analysis. For example, food availability and entitlement rights played a major role in *development and poverty research* (Bohle, 2009; Sen, 1981). These discussions were driven by impacts of droughts in the Sahel during the 1970s and the root causes of famine and hunger linked with a decline in food availability. Chambers (1989, p. 1) defined two sides of vulnerability: "an external side of shocks and stress to which an individual or household is subject; and an internal side which is defencelessness meaning a lack of means to cope without damaging loss." Research thereby mainly focused on developing countries and slow-onset hazards such as droughts (Birkmann, 2013, p. 13).

In the *hazards and disaster risk reduction research* field, the move from hazards research as the main driver of disasters towards a deeper understanding of dynamic pressures and root causes of vulnerability (Blaikie et al., 1994) were important aspects

in “taking the naturalness out of natural disasters" (O'Keefe et al., 1976) during the 1980s. Hewitt (1983) argued for example that disaster situation, losses and relief processes could not be sufficiently understood by focusing on the hazards only but that disasters and ineffective social response have to be understood in their socio-economic context. “The formula used today, that risk has to be seen as a function of hazard and vulnerability: Risk = Hazard x Vulnerability was already embedded in this early work” (Birkmann, 2013, p. 14). Politically, these developments were accompanied by the International Decade for Natural Disaster Reduction (IDNDR) during the 1990s as declared by the United Nations General Assembly, the creation of the United Nations Office for Disaster Risk Reduction (UNDRR, former UNISDR), the Hyogo Framework for Action (2005-2015) and its successor the Sendai Framework for Disaster Risk Reduction (2015-2030).

Finally, in the *climate change research community*, the discourse shifted from a greenhouse gas emission focus towards the inclusion of climate change adaptation needs, specifically for countries and people who are highly vulnerable to climate change and its variability. Initial framings of vulnerability focused very much on the impact dimension of climate change, concentrating on its consequences for social and biological systems, among others (e.g IPCC, 2007). Later definitions developed for example in the context of the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) “underscores that vulnerability is considered to be […] independent of the physical event, meaning that vulnerability should […] focus on the social context that makes people and societies prone to facing harm and loss” (Birkmann, 2013 based on IPCC, 2012, p. 33).

All schools and efforts have resulted in different aspects and definitions of vulnerability. Birkmann (2013) for example identified 30 different definitions, each with a slightly different focus. Frequently, overlaps exist with related concepts such as resilience, susceptibility, or coping capacity.

3.2 Factors and Key Components of Vulnerability

Overall, vulnerability concepts and assessment approaches can be differentiated into (a) *core factors* that describe different components of vulnerability and (b) different *thematic dimensions*. The core factors encompass for example susceptibility and coping or adaptive capacities. The thematic dimensions can define the aspect under consideration and relate for example to *social*, *environmental*, *economic* or *institutional vulnerability*. The social dimension can thereby relate to issues such as poverty, marginalisation, demography, social networks, education, health but also risk perception and subsequent self-protection (e.g. Birkmann, 2013, 26 ff). The considered aspects may vary with the selected scale, which can for example be the individual or household level or also regional or national level. Similarly, economic vulnerability could relate to livelihood patterns or assets of a household or the financial (lack) of capacity at state level. Environmental vulnerability usually refers to ecosystem services and their role in socio-ecological systems. More precisely, the vulnerability of ecosystems can be tightly coupled with exposure patterns (for example in case of coastal degradation) but also with social vulnerability patterns, e.g. impacting (rural) livelihoods. Finally, institutional vulnerability could include the impact of institutions or regulation on vulnerability of people. [9]

Overall, it needs to acknowledged that a sectoral analysis of vulnerability neglects the fact that sectors usually overlap. For example, ecological vulnerability may be the result of institutional vulnerability, due to the inability of institutions to take action to safeguard the environment. An alternative way of braking down vulnerability was for example presented in Alexander (1997), as also detailed in Figure 1 below.

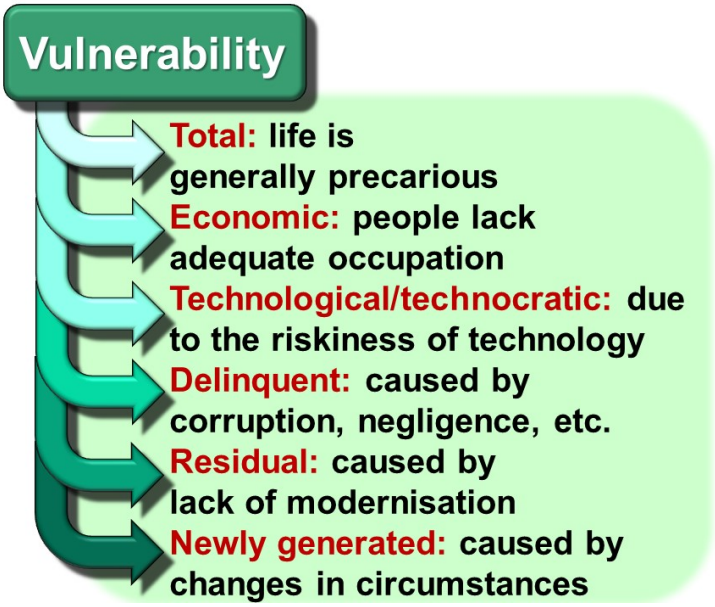

FIGURE 1: OVERLAP IN VULNERABILITY FACTORS (DEVELOPED FROM ALEXANDER, 1997)

3.3 Operationalization of Vulnerability

Different aspects and dimensions of vulnerability can be analysed and assessed by applying different quantitative or qualitative approaches and methodologies at multiple scales. When it comes to the broader conceptualisation and operationalisation, vulnerability is usually considered as one component in **risk assessments.** For example, the IPCC 5th Assessment Report on Impacts, Adaptation and Vulnerability suggested the following concept:

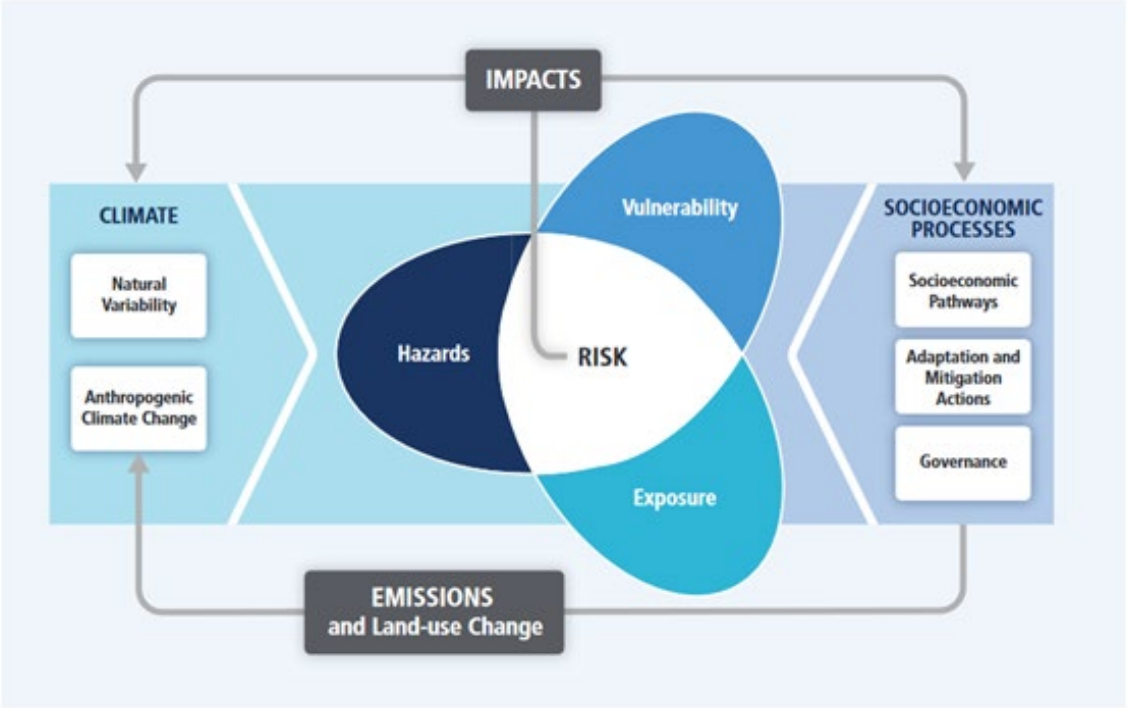

FIGURE 2: IPPC RISK ASSESSMENT CONCEPT (SOURCE: IPCC (2014): SUMMARY FOR POLICY MAKERS, HTTPS://WWW.IPCC.CH/REPORT/AR5/WG2/ (24.1.2021), P. 3)

Potentially less widely known but more encompassing with respect to the different dimensions (or sectors) and also integrating aspects of resilience and anticipation as well as multiple temporal and spatial scales is the MOVE[1] framework detailed in Figure 3 below.

Both frameworks however do not include aspects of conflict or disease as well as cascading effects including infrastructure failure.

1 The MOVE (Methods for the improvement of vulnerability assessment in Europe) Project was an FP7 project funded by the European Commission, see Final Report Summary - MOVE (Methods for the improvement of vulnerability assessment in Europe) | FP7 | CORDIS | European Commission (europa.eu)

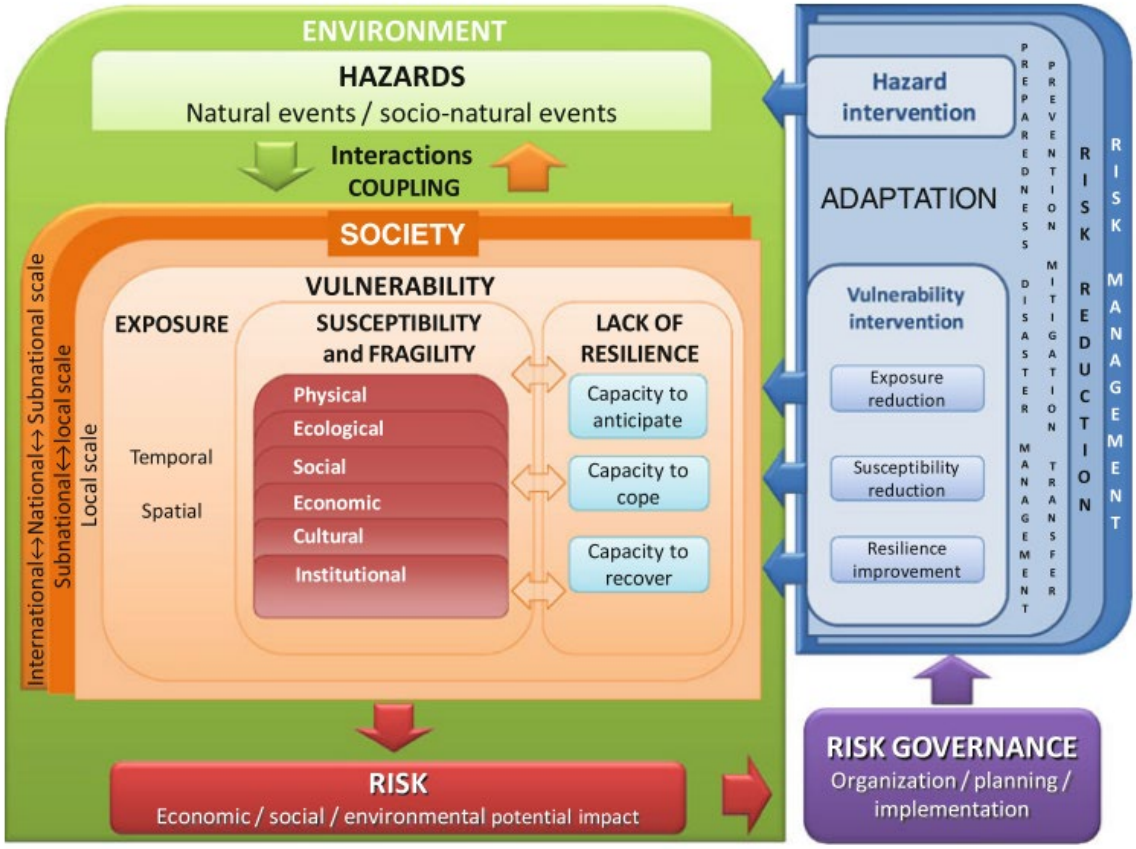

FIGURE 3: THE MOVE FRAMEWORK (SOURCE: BIRKMANN ET AL., 2013, P. 199)

3.3.1 VULNERABILITY AT THE NATIONAL AND INTERNATIONAL LEVEL

The implementation of risk assessments had been identified as a key indicator for determining progress and challenges in disaster risk reduction[10] at international level. At the EU level, all Member States shall develop risk assessments at national or appropriate sub-national level to promote an effective and coherent approach to prevention of and preparedness for disasters according to Decision 1313/2013/EU on a Union Civil Protection Mechanism.[11] The legal basis does thereby not make any specification with respect to the risk components to be assessed. With respect to infrastructure, the European Program for Critical Infrastructure places a heavy emphasis on assessing the vulnerability of critical infrastructure in Europe, with reducing vulnerability being a separate work stream and a report on vulnerability filed every two years (Fekete et al., 2014).

3.3.2 INDICES

At the international level, several indices operationalize aspects of vulnerability. For example, the INFORM Index by the Joint Research Centre (JRC) differentiates "**socio-economic vulnerability** and **vulnerable groups**. The indicators used in each category are different in time variability and the social groups considered in each category are the target of different humanitarian organizations. If the first category refers more to the demography of a country in general, the vulnerable group category captures social groups with limited access to social and health care systems."[12]

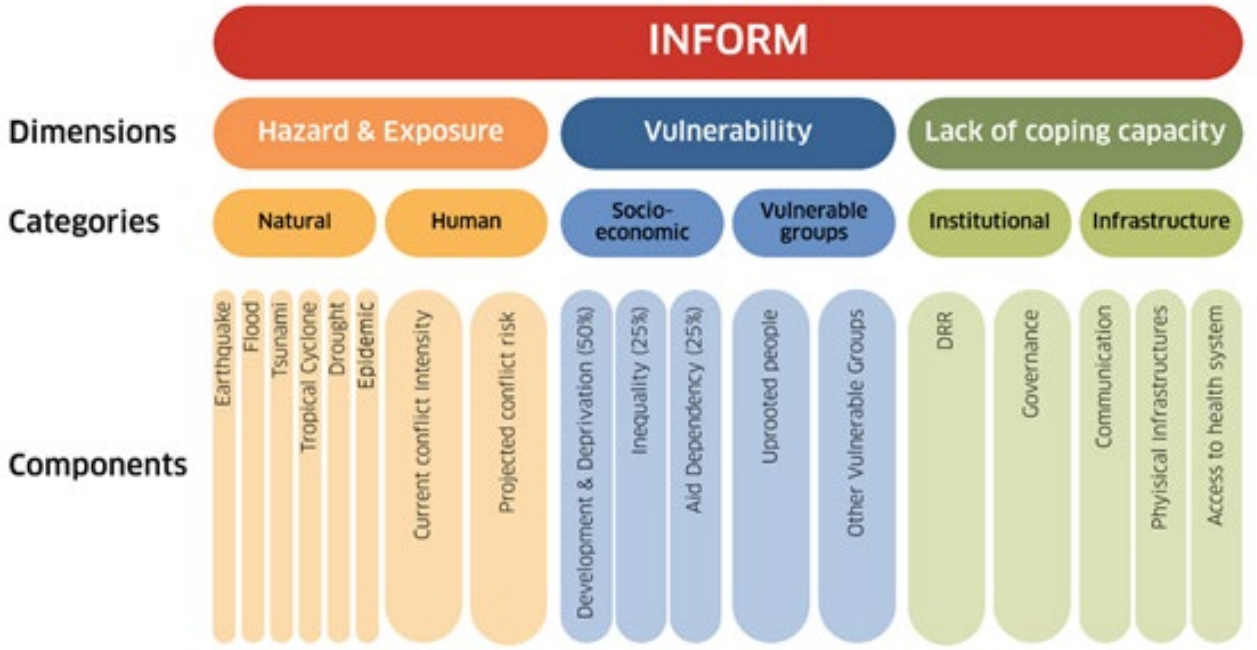

FIGURE 4 INFORM INDEX OF VULNERABILITY(SOURCE: HTTPS://DRMKC.JRC.EC.EUROPA.EU/INFORM-INDEX/INFORM-RISK/METHODOLOGY#INLINE-NAV-6)

The World Risk Index calculates vulnerability along the three dimensions susceptibility, coping and adaptive capacity. "It refers to social, physical, economic, and environmental factors that make people or systems vulnerable to the effects of natural hazards, the negative impacts of climate change, or other processes of change. Vulnerability also considers the capacities of people or systems to cope with and adapt to adverse impacts of natural hazards."[13]

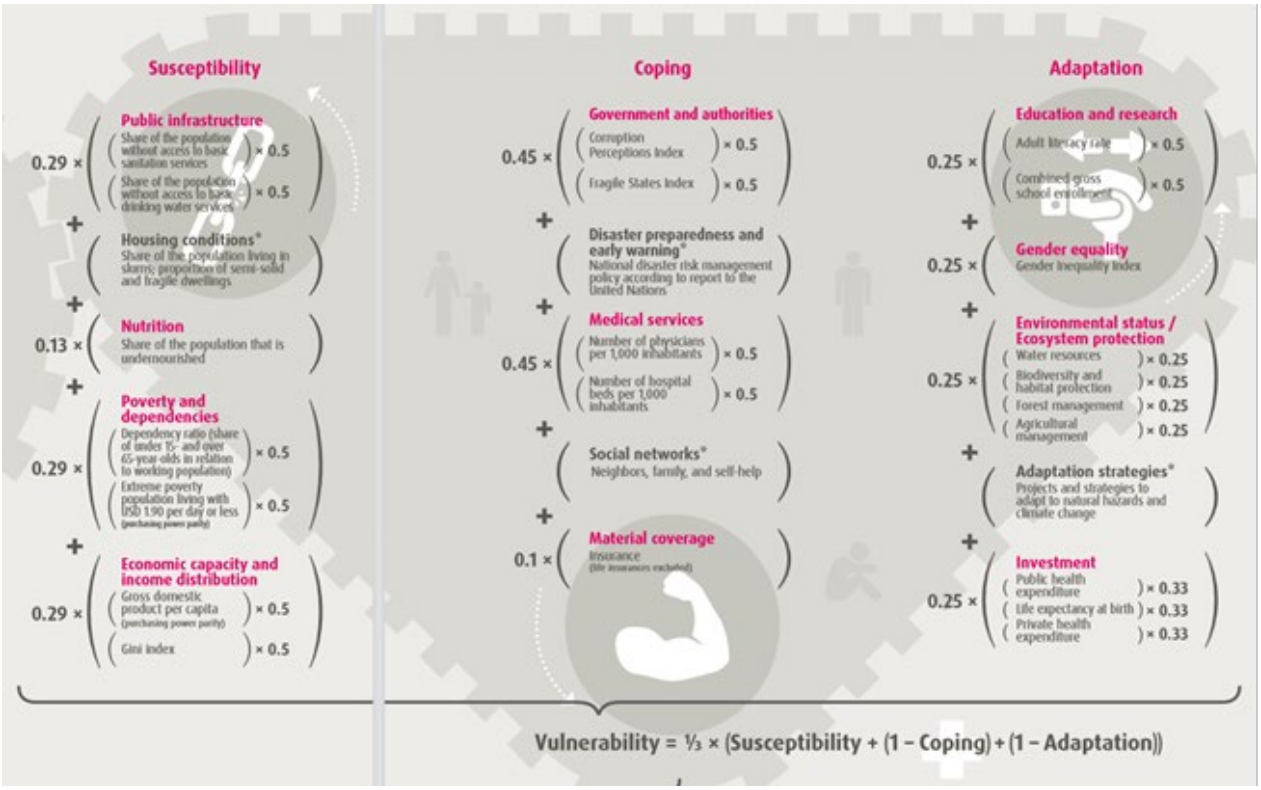

FIGURE 5 WORLD BANK VULNERABILITY INDEX (SOURCE: HTTPS://WELTRISIKOBERICHT.DE/WP-CONTENT/UPLOADS/2021/09/WORLDRISKREPORT_2021_ONLINE.PDF P. 44-45.)

Overall, it needs to be stressed that all indices contain deficiencies. These are linked with the necessary reduction of complexity and cause-effect relationships related with the selection of indicators or limitations in data bases requiring the selection of proxy indicators. However, indices can be a useful informative comparative tool. They can be used to inform the public about risk and its underlying causes and indirectly to also derive funding.

3.4 Links with Concepts of Resilience and Risk Perception

For resilience, the number of research articles including and analysing the concept of vulnerability has grown enormously. Consequently, several authors have analysed, reviewed and compared the work on definitions and concepts of vulnerability and of resilience, and also on the relations of the two concepts (e.g. Fekete et al., 2014; Hosseini et al., 2016; Meerow et al., 2016; Melkunaite, 2016; Radianti, 2016; Vollmer et al., 2016; Vollmer & Walther, 2018).

As already noted by Miller et al. (2010), the more recent meta analyses have also shown that coherence is missing regarding

- different definitions of resilience,
- different definitions of vulnerability,
- theoretical work and practical implementation of the concepts, and
- the relationship of vulnerability to resilience.

Some of the literature reviews on resilience have been conducted in the context of EU H2020 projects that were funded under the call topic DRS-07-2014 "Crisis and disaster

resilience – operationalizing resilience concepts", i.e. the projects IMPROVER[2], DARWIN[3], RESILENS[4], RESOLUTE[5], and SMR[6]. The reviews of IMPROVER and SMR also specifically address the relation of resilience to vulnerability. The understandings of how the concepts relate to each other differ, mainly as a result of the use of different definitions of the two terms. In some cases, vulnerability and resilience are treated as positive and negative poles of the same continuum, i.e. being highly vulnerable would mean a low level of resilience, and being resilient would mean that the vulnerability is very low. However, many authors see vulnerability and resilience as two completely different concepts, while they can partly overlap (Melkunaite, 2016; Rankin & Bång, 2016; Vollmer & Walther, 2018). In case of the latter understanding, the two concepts have common elements, which include – depending on the specific definitions – for example abilities to prepare for, to cope with, or to adapt to impacts of a hazard event. RiskPACC has taken the approach adopted in the MOVE framework (Figure 3), in which resilience and vulnerability are influenced by each other. Factors relating to resilience such as capacity to adapt or capacity to recover can influence different vulnerabilities, such as social and economic, which in turn can also influence ones' capacity to adapt, cope, and respond (Birkmann et al., 2013).

Both vulnerability and resilience can be influenced by people's risk perception. As described below, risk perception can be seen as a component of vulnerability, i.e. it can lead people to take preventive or preparatory actions, which decreases their vulnerability. In turn, if people experience a disaster, and they are affected e.g. in a very vulnerable state, this potentially changes their risk perception. An increased risk perception can also help – through an increased preparedness – to better cope, recover or adapt to stresses or disaster events. However, if and in how far risk perception actually leads people to take concrete action, is determined by the RPAG, which will be further analysed in the course of RiskPACC.

3.5 Key Similarities and Working Definition of Vulnerability

The common ground across the vulnerability definitions is the assumption that disaster risk is socially constructed and hence influenced by a number of factors that can increase or lower vulnerability. A well know and widely-used definition of vulnerability was developed by the United Nations Office for Disaster Risk Reduction (UNDRR) which we therefore suggest for the use as the RiskPACC **working definition.** The United Nations Office for Disaster Risk Reduction (UNDRR) defines vulnerability as:

[2] IMPROVER – Improved risk evaluation and implementation of resilience con-cepts to critical infrastructure (June 2015 – Mai 2018), http://improverproject.eu

[3] DARWIN – Expecting the unexpected and know how to respond, (June 2015 – May 2018), http://www.h2020darwin.eu/

[4] Realising European ReSILiencE for Critical INfraStructure, (May 2015 – April 2018), http://resilens.eu/

[5] RESilience management guidelines and Operationalization appLied to Urban Transport Environment, (May 2015 – April 2018), http://www.resolute-eu.org/

[6] Smart Mature Resilience (June 2015 – May 2018), http://smr-project.eu/home/

"[t]he conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.
Annotation: For positive factors which increase the ability of people to cope with hazards, see also the definitions of "Capacity" and "Coping capacity"[8]

4. RISK PERCEPTION AND CPAS

This section will highlight current trends and definitions in disaster risk perception research, discuss factors that influence risk perception, and examine how risk perception is understood and operationalized by CPAs in different contexts. A complementary review of risk perception is being produced as a part of D2.1, which focuses on risk perception from the viewpoint of community.

4.1 Risk Perception: Current Research and Definitions

There is an abundance of risk perception literature, as it has been a major field of research for over 60 years (Morsut et al., 2021). While there are many different definitions of risk perception depending on which field the research is conducted in, it is generally referred to as 'the subjective, intuitive and contextual mental constructs about risk, based on cognitive and affective factors' (ibid., p. 6). There are several fields that have contributed to risk perception research, but much of the major work has been done in psychology, sociology, and anthropology (Morsut et al., 2020). These fields have agreed that risk perception is 'a mental construct or model, which is subjective, intuitive, and contextual, and has been built through interactions and experience' (ibid., p. 47). Disagreements arise in the extent to which risk perception occurs at the individual or group level, and which factors play the largest part in determining risk perception, whether it be individual cognitive processes, cultural understandings and world views, or social norms and understanding (Scolobig et al., 2012).

Research on risk perception has remained predominantly in the domain of psychological sciences, however risk perception also conforms with issues in human or socio-economic geography, which Lechowska (2018: 1342) suggests 'emphasises not only a sociological aspect of the phenomenon but its economic and spatial dimensions as well'. In Lechowska's paper on flood risk perception, Bubeck et al., (2012) and Becker et al., (2013)'s definition is used: 'risk perception is defined as an assessment of the probability of hazard and the probability of the results (most often—the negative consequences) perceived by the society' (Lechowska, 2018: 1342). Wilson et al's. (2019) definition contradicted this, arguing that 'decades of research identify risk perception as a largely intuitive and affective construct, in contrast to the more deliberative assessments of probability and consequences that form the foundation of risk assessment' (Wilson et al., 2019: 1).

To understand risk perception, the concept of risk, and how it is understood by different stakeholders, must be explored. Foucault (1991) detailed governments control of risk, where 'individuals are expected to cope with social risks and insecurities, [and] to measure and calculate them' (Lemke, 2016, p.47) and that governments could use fear to influence how certain risks are perceived. Beck (1992) similarly believes that risk is at least partially constructed by decisions taken by governments and are therefore 'politically reflexive' (p. 183). These constructs represent a top-down narrative of how risks are perceived and illustrate how risks can be influenced by governments and risk management. Others have detailed different approaches to

understanding risk. Lloyd and Hicks (2021) describe three different ways that risk is understood:

- Techno-scientific approach: risk understood in terms of measurements and probability
- Cognitive psychological approach: risk studied in terms of rational human response to danger
- Socio-cultural approach: risk studied in terms of the social and cultural context that shape understanding of hazards (p.3)

Generally, CPA and governments understand risk using the techno-scientific approach, while individuals will take a more cognitive or socio-cultural approach. According to Slovic (2000), when experts judge risk they correlate highly with technical measurements, while lay peoples' judgement of risk is skewed by other factors. Understanding the different interpretations of risk between CPAs and lay people, and working to better align these perceptions, will be key to closing the RPAG.

4.1.1 Risk Perception and its Importance in DRM

In the field of DRM, risk perception has gained in importance due to the influence it has on preparedness, vulnerability, and resilience. Many of the theories in other fields have been combined in looking at risk perception in DRM, as cognitive, social, and cultural factors all play a role in risk perception for hazards (Wachinger et al., 2010). In terms of preparedness, the general understanding is if individual and community risk perceptions are low there tends be a lack of preparedness for hazards (Scolobig et al., 2012). Risk perceptions can also lead to individuals partaking in riskier behaviour than necessary, for example following 9/11 in the United States, the perceived risk of flying was high, therefore more people drove, which has a much higher risk of injury (Deonandan & Backwell, 2011). Risk perception generally influences DRM, with accurate understanding of risk typically determining whether DRM activities will be successful (Bubeck et al., 2012). With the strong influence that risk perception can have in DRM activities, it is important to understand risk perception better and learn how it can be used in practice. Additionally, even if risk perception is high it does not necessarily translate to preparedness and action, resulting in the risk perception action gap (RPAG). Closing this RPAG is the main goal of RiskPACC.

4.1.2 Risk Perception and Current Standards and Practices

Due to the importance of risk perception in many of the concepts that encompass DRM work, such as preparedness and resilience, there are several current standards and frameworks that incorporate risk perception. The Sendai framework (European Commission, 2016) is a voluntary action plan whose "recommendations are based on existing EU disaster risk management policies and programmes" (p. 1). This has been discussed in a previous section, but many of the priorities and standards discussed are relevant to risk perception as well.

Within the **first priority,** 'understanding disaster risk', former practices in "[r]isk assessment and mapping requirements" (ibid., p. 6) are particularly relevant to risk perception. If risk is better understood, it can be communicated to the public.

Communicating this information should increase risk perception and lead to better trust in the information provided. This priority will mean increasing the use of citizen generated data to better understand risk. A relevant example is the "Social media image analysis in the immediate aftermath of the 2020 Beirut blast" (Joint Research Centre, 2021), where openly accessible pictures on the social media platform Twitter were used to create a disaster heat map after the Beirut explosions (ibid.). The other priorities in the framework are also influenced by risk perception but will not be discussed in depth.

The 2030 Agenda for Sustainable Development, developed in 2015, expressed the need for a need to better align disaster governance and development by combining priorities of the Sendai Framework and the Sustainable Development Goals (SDGs) (Raikes et al., 2019). This highlights the importance of risk perception and disaster risk reduction on human development, and vice versa (Raikes et al., 2019; Collins, 2019). For example, the SGD of improving education can be directly tied to risk perception. A lack of education can lead to a reduced risk perception, so there is the potential for this SDG to increase risk perception among those with limited access to education (Collins, 2019). Additional SGDs, especially those focused on gender equality, reducing inequalities, and poverty influence risk perception.

The **first SDG, 'poverty'**, seeks to end poverty in all its forms (cf. UN[b]). The first goal includes to "[b]y 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters" (ibid.). The goal to reduce vulnerability and build resilience to events will be influenced by risk perceptions. Research has shown that improved risk perception can increase preparedness, and therefore lead to increased resilience (Bodoque et al., 2019). Similarly relevant to risk perception is the goal to "strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters" (UN[d]). There is a link between risk perception and climate change adaptation, as most with higher risk perceptions regarding climate change will be more likely to take adaptive measures (Lai et al., 2021). The **fifth goal** addresses **'gender equality'** (UN[g]), while almost all the SDGs are linked to gender inequalities. Most risks seem to have more severe impacts on girls and women, than on boys and men. Disasters highly affect girls' and women's inferior standing in "health[,] […] security and social protection" (UN[g]). Therefore, the risk perception of women and girls is typically higher than of men and boys (Rana et al., 2020; Xue et al., 2021). The female workforce could also fall back into "unpaid care and domestic work" (UN[g]), an issue that has been discussed earlier in the report as decreasing the resilience of women, and an issue that can lead to higher risk perception.

The relationship between these current initiatives and risk perception highlight some of the factors that unpin risk perception in individuals, and how these perceptions can impact actions. This will be a major focus of RiskPACC going forward.

4.1.3 DEFINITIONS IN LITERATURE

As mentioned previously, much of the research on risk perception comes from the following disciplines: phsychology, sociology, and anthropology, although while research on risk is in general evenly split between these disciplines, risk perception has traditionally been overwhelpingly dominated by the field of phsychology. These disciplines have slightly different focuses in defining and conceptualizing risk perception, and all three have played a part in developing definitions of risk percepton that are used in DRM.

Psychology

Psychological definitions concern mainly congnitive and individual understanding of risk. These theories suggest that an individual's risk perception is based on mental hueristics, biases, and other chanractersitics. A typical definiton of risk perceptions using the phsycological perspective was created by Slovic (1987). His research posited that risk perception is an intuitive judgement on which citizens rely upon in making decisions about risk. The psychometric paradigm has been used to understand psychological risk perception (Sjoberg, 2000). This paradigm states that individuals perceive hazards based on characteristics such as catastrophic potential and controlability (Sjoberg, 2000; Paek & Hove, 2017).

Sociology

Defintions and thinking of risk perception that are routed in sociology are much more focused on social influences, such as social networks and cultural, economic, and political factors. Rather than taking an individual view on risk perception, sociology takes into account the environment that the individual finds themselves in and how that will influence perceptions. A defintion rooted in sociology would be as follows: "An understanding of risk based on experiences, background, beliefs and attitudes" (Morsut et al., 2020, p.48)

Anthropology

Defiitions and thinking of risk perception that are routed in anthropology take a view that culture has the largest influence over the perception of risk. Douglas and Wildavsky (1982) determined that risk perception is the result of cultural factors influencing individual risk understanding. This theory relies heavily on the belief that individuals will strive to maintain standing in the culture and therefore cultural norms and understandings will have a large inflence over their understanding and perception of risk (Douglas & Wildavsky, 1982). Definitions of risk perception using the anthropologic understanding include the following: risk perception is the result of a process of social communication (Luhmann, 1986). Social and cultural factors combine to amplify risk. The anthropology perspective understands that experiences, background and beliefs influence risk perception.

Application of these definitions for DRM

While these three overarching theories and disciplines have driven much of the risk perception research for the past 60 years, definitions that are more focused on risk perception in relation to disasters have emerged in research recently. Table 3 below gives examples of different definitions that can be found in hazard and disaster research:

Authors	Risk Perception Definitions
Khan et al. (2020)	'The subjective valuation of the likelihood of a specific type of disaster occurring and how concerned one is about the consequences' (p.90)
Ricci et al (2013)	How people view their risk from hazard including their understanding of likelihood (p.3)
Rana et al. (2020)	'A complex psychological phenomenon, which can be influenced by numerous unexplainable, unquantifiable factors' (p.8)
Geirlach et al. (2010)	'An inherently psychosocial construct, risk perception is the subjective judgement about the feeling of the likelihood of encountering hazards' (p.1539)
Rühlemann and Jordan (2021)	'The subjective judgement that people make about the severity and characteristics of risk' (p.425)
Khan et al. (2020)	'The subjective valuation of the likelihood of a specific type of disaster occurring and how concerned one is about the consequences' (p.90)

TABLE 4: RISK PERCEPTION DEFINITIONS FROM ACADEMIA

While there are many different defintions here, and many others that are not displayed, the overall theme of many of these definitions is the idea that risk perception is a subjective judgement of the risk faced by individuals. Many factors can influence this judgement, and for some it not necessarily rooted in objective facts about the risk.

4.1.4 RISK PECEPTION DEFINITIONS IN PRACTICE

The UNDRR defines disaster risk management as the 'organization, planning and application of measures preparing for, responding to and recovering from disasters' (UNDRR, 2020). Emergency management is also used, sometimes interchangeably, with disaster management, often in the context of biological and technological hazards and health emergencies (UNDRR, 2020). Risk perception plays an important role in disaster risk management (Mañez et al., 2016). According to Bubeck et al., (2012) and Mañez et al., (2016), literature has shown that risk perception largely influences risk management (action) which as a result, determines whether risk management is successful in reducing vulnerability. This is reiterated by Cori et al., (2020) who state that risk perception within the emergency and disaster management sector has become increasingly recognized as important with the recognition of 'beliefs, knowledge, values, and attitudes which influence not only decisions but also behaviours' (Cori et al., 2020: 2). Historically, risk communication has been seen by CPAs as the action that will raise the understanding of risk and encourage people to

prepare for hazards, but research has shown that because perception on risk will be different among different people and this perception will influence behaviours, other techniques may be needed (Bubeck et al., 2012). Further details on CPA practices regarding risk perception can be found in section 4.3.

4.1.5 INTERNATIONAL AND EU DEFINITIONS

Unlike resilience, which has been defined by multiple UN and International organizations, risk perception has fewer definitions available outside of academia. The International Risk Governance Council (IRGC), while not explicitly defining risk perception, has detailed risk perception as people responding to risk based on their own risk constructs and images. One important role of risk perception highlighted by the IRGC is that it details the contextual aspects that risk managers need to consider in designing risk reduction measures (Renn & Graham, 2005). These contextual aspects include 'the interplay of different actors dealing with risk, [and] how these actors may differently perceive risk' (p. 11). Other organizations such as the IPPC and OEDC, while also not defining risk perception, have it featuring in different documents concerning risk (Cordona et al., 2012; Rodgers and Pearce, 2013). For example, OEDC has detailed that risk perception highlights the understanding that risk means different things to different people, and that the perception is based on different factors that are constantly changing.

In contrast to other international organizations, The European Environmental Agency does have a fully developed definition of risk perception. It defines risk perception as follows:

> "Risk perception involves people's beliefs, attitudes, judgements and feelings, as well as the wider social or cultural values that people adopt towards hazards and their benefits. The way in which people perceive risk is vital in the process of assessing and managing risk. Risk perception will be a major determinant in whether a risk is deemed to be "acceptable" and whether the risk management measures imposed are seen to resolve the problem" (EEA, 2019).

This definition not only involves the individual, social and cultural aspects of risk perception, but it brings risk management practitioners' actions in, which makes it one of the more holistic of the available definitions.

EU project Definitions:

There are several previous and current EU projects that research risk perception, for example the DRIVER, ENHANCE, TACTIC, and BuildERs projects. Many have not directly discussed a specific definition, instead they have discussed factors of risk perception and the different schools of thought that lead to these definitions. The BuildERs project discusses risk perception in terms of psychology, anthropology and sociology, together with its implications for DRM. Several definitions are mentioned from different disciplines, including the following:

- "The subjective assessment of risk and the extent to which we are worried about its consequences in form of accidents, crises, or disasters" (Engen et al, 2006)
- "A process of collecting, selecting, and interpreting signals about uncertain impacts of threats and crises" (Wachinger et al., 2013)

Other projects such as ENHANCE and DRIVER do not give a definition of risk perception, but discuss how the concept has been applied to DRM and different risks. ENHANCE explains that risk management approaches are highly influenced by what both risk managers and citizens perceive as risky (Mañez et al., 2016). ENHANCE also makes the point that there is a connection between preparedness and risk perception. They documented cases that areas that have erected physical barriers as preparedness measures typically have lower levels of risk perception. DRIVER also highlights that different people perceive risk differently, where risk perception means the subjective probability as well as the consequences of a negative outcome (Hofer, 2014). TACTIC, another EU funded project, describes risk perception and preparedness activities in different hazard scenarios. It gives a general overview of different factors effect risk perception, including a critique of the psychological view of risk perception (Shreve et al., 2014). While the EU projects have slightly different focus, they all give an overview of risk perception and how risk perception relates to preparedness, vulnerability, and DRM in general.

4.2 CPA Understanding Risk and Relevant Factors Impacting Risk Perception

This section will delve into how CPAs perceive risk, and the differences with how citizens perceive risk. It will then examine how different factors can influence risk perception and how these factors can be used to address the RPAG.

4.2.1 CPA and Citizen Understanding of Risk

One of the most challenging issues for CPAs in addressing risk has been that risk management experts and citizens typically have a different understanding of risk and therefore perceive risks differently, leading to misunderstandings and communication breakdowns between the two groups (Ardaya & Ribbe, 2012; Samamdipour et al., 2019; Xu et al., 2016; Bradford et al., 2012). This can quickly lead to a lack of trust, which can then decrease risk perception in the area (Bradford et al., 2012; Antrionico et al., 2020). CPAs typically have a more technical understanding of risk (Sjoberg, 2002; Brown, 2014). Among experts, risk is typically understood using some variation of this formula:

$$Risk=hazard*vulnerability/capacity$$

This is a more analytical approach to determining risk, which includes looking at patterns and normative rules, and produces a statistical understanding (Samamdipour et al., 2019; Bradford et al., 2012; Botterill & Mazur, 2004). It also involves the integration of uncertainty into the perception of risk. CPAs typically have a good understanding of how uncertainty is integrated into the calculations of risk, and what that means for the probability of events. While

this gives an accurate and extensive understanding of risk for CPAs, much of the analytical work does not translate well to citizens understanding (Wachinger et al., 2013).

Risk is commonly understood by CPAs as the statistical probability that an event will occur, and the damage that the event would cause (Heinrich et al., 2015). This is typically expressed using return periods and damage. An example of this expression is:

> *"A flood event with flood depths of 4 metres will occurs once every 500 years on average"*

While experts in the field will understand the meaning of the above expression of risk and have a uniform understanding of risk perception from this phrase, a citizen may not understand this meaning, and from it, different perceptions of the risk may emerge (Bradford et al., 2012). Research has been done showing that different people will interpret risk expression like this very differently (Heinrich et al., 2015). Decreasing the time intervals and putting it into the perspective of a human lifecycle may help increase the understanding. Even when CPAs try to simplify these expressions and use words such as possible or likely, they run into similar problems, where they will be understood differently by citizens (Theil, 2002).

Turning to the way communities understand risk, we note that while CPAs take an analytical approach to the understanding of risk, citizens tend to take a more experimental view, including their previous experiences, cultural and social factors, and intuition into risk perceptions of different hazards (Wachinger et al., 2013; Ardaya & Ribbe, 2012; Xu et al., 2016; Khan et al, 2017). Because CPAs do not take these factors into account in their risk calculations and understanding of risk perception, there is usually a wide variation in understanding. When asked to rank risks, it has been showed that CPAs and citizens rank risks differently and have a different understanding for the magnitude of risk (Sattar & Cheung, 2019; Sjoberg, 1999). Additionally, while CPAs tend to have a good understanding of uncertainty, citizens tend to have a different understanding. This can lead to miscommunication and result in a lack of trust in risk perceptions that are communicated by CPAs, which in turn can affect risk perception (Wachinger et al., 2013; Antrinico et al, 2020). See Deliverable 2.1 for a more detailed account of how communities perceive risk.

4.2.2 Factors Influencing Risk Perception

As mentioned above, citizens tend to include different factors into their perception of risk, and each person may have a different understanding of risk based on their past experiences, sociodemographic characteristics, and many other factors (Lechowska, 2018; Kahn et al., 2020; Rana et al., 2020). Figure 6 below gives a good overview of one understanding of the factors that relate to risk perception, including human, social, and cultural. These factors are important for CPAs to understand as they try to increase risk perception and action among citizens.

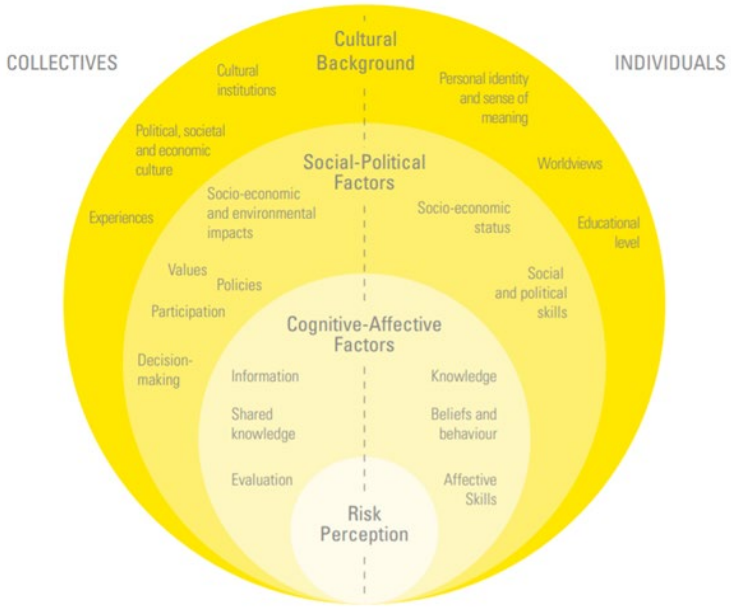

FIGURE 6 FACTORS IMPACTING RISK PERCEPTION (SOURCE MANEZ ET AL, 2016, P.54)

The most prominent factors mentioned in the literature reviewed, as well as the conflicting impact they seem to have on risk perception will be addressed in the section.

4.2.2.1 HUMAN FACTORS

There is general agreement among academics that personal psychological factors play a role in how individuals understand their disaster risk. These factors include what will be termed here as human factors, such as feelings and understanding gleaned from **previous hazard experiences**, **fear** of a hazard, **awareness** of potential impacts, **education** on how a hazard occurs and what to do if it does, the **uncertainty** of a hazard and its impacts, and **trust** (Khan et al., 2020; Lechowska, 2018; Sullivan-Wiley & Gionatti, 2017; Martin et al., 2009). These factors are important for CPAs to understand fully, because they can influence not only risk perception but citizen action.

Some researchers posit that **previous experience** with a hazard leads to a better understanding of the risk, therefore increasing risk perception of those individuals (Cui & Han, 2018). Others maintain that experiencing a hazard leads to higher risk perception in the short term, but that risk perception decreases if the interval between a hazard is long (Rana et al., 2020). Still others say that experiencing a hazard has the opposite effect, lowering risk perception (Rühlemann & Jordan, 2021). Understanding how previous experience influences risk perception in the area will be necessary in any attempts to increase risk perception. **Fear of a hazard** also needs to be understood, as it indicates a person's feeling of lack of control, dread, disastrous consequences, and inequal consequences (Paek & Hove, 2017). A person who has high levels of fear may either have high risk perception and act upon those perceptions, or may be too afraid to act (Martin et al., 2009). Understanding this fear will be crucial for addressing the RPAG and understand what might influence someone to action.

One of the most important factors to consider for RiskPACC is **trust**. This factor is strongly influenced by social, cultural, and organizational factors and includes both trust in authorities and trust in community (Botzen et al., 2009; Sullivan-Wiley & Gionnati, 2017). There are many instances of individuals and communities lacking trust in the disaster management authorities, and because of that lack of trust, they do not participate in education campaigns (Lechowska, 2018; Khan et al., 2020; Xue et al., 2020). Trust in community members also plays a role in risk perception. If there is no trust established within these communities, information is less likely to be shared and less likely to be believed (Lechowska, 2018). Trust will be essential when looking at solutions to close the RPAG.

4.2.2.2 SOCIAL FACTORS

There have been mixed results when examining how sociodemographic factors influence risk perception. Many researchers have found that old **age** leads to higher risk perception, because older individuals are more risk averse and have more experience with hazards, although this has not been found in every case (Lechowska, 2018; Khan et al., 2020; Sullivan-Wiley & Gionnati, 2017). **Gender** also plays a role in risk perception, with the majority of research has found that women have higher risk perceptions than men (Rana et al., 2020; Xue et al., 2021). **Ethnicity** has also been found to play a role, with studies showing that white men had the lowest risk perception, significantly lower than white women, and non-white males and females (Geirlach et al., 2010). **Education** is also seen as an important factor, with less educated tending to have lower risk perception (Botzen et al., 2009).

Socioeconomic factors also play a role in risk perception, but again, there is not consensus on how these factors influence perception (Marshall, 2020). Socioeconomic factors include variables such as **income** and **home ownership**. Different research has indicated different ways in which these factors influence risk perception. Some have suggested that those that have lower income have higher risk perception than others (Ullah et al., 2015; Mamen et al., 2014). Those with high income may not have high risk perception because they believe that even if they are at risk, they will have an easier time replacing damaged items because of their access to the resources to rebuild (Rana et al., 2020). Homeownership is important, as research has indicated that those that own their property are much more aware of the potential risks than those that are renting (Ullah et al., 2015). These social factors are important to understand, as they may help CPAs understand who to target with risk information to close the RPAG. Besides sociodemographic and socioeconomic factors, there are other social factors that influence risk perception. These include things such as social capital, social networks, and a sense of place. These factors will be addressed more in-depth in D2.1

4.2.2.3 CULTURAL FACTORS

There is general agreement that culture has an influence on risk perception, but less consensus on the degree of influence (Oltedal et al., 2004; Geirlach et al., 2010). Cultural theory posits that culture plays a role in understanding of nature and people's interactions with the natural world. While culture plays a part in risk perception, it has been shown to account for a very small variation in risk perception (Oltedal & Rundmo, 2007; Sjoberg, 2000). Other researchers have developed different theories surrounding cultural factors and their influence on risk perception. Rühlemann and

Jordan (2021) have described how many other factors from human to social and organizational all operate under the wider context of society and culture, and that these cultures may influence other factors across social and spatial scales. Culture underpins many of the human factors, in dictating what people should be afraid of and what they should focus on. This can drastically impact risk perception, where if a culture believes something is important it will take precedent over something that may be more dangerous. Cultural narrative is difficult to change, and therefore the culture has influenced much of the activities around risk and risk perception in these areas. Lacroix and Gifford (2017) showed that even if risk perception is high, cultural aspects and cultural narratives may hinder response. Culture should be considered when developing solutions in RiskPACC, as they may inhibit desired change if ignored.

4.2.2.4 ORGANIZATIONAL AND TECHNICAL FACTORS

Organizational factors tie directly into the trust that individuals have in organizations, and therefore strongly influence risk perception. Organizational factors include things such as **organizational culture**, **interactions with the community**, and **risk communication**. Interactions with communities, and the nature of these interactions is very important to building trust. If communities see organizations as only responding to disasters and not preparing for them, they may lose trust. This is especially true if the response to the disaster is not handled properly (Khan et al., 2020). Interaction that occurs constantly, not just after a disaster, can lead to better risk perception in areas. Risk communication is also a vitally important organizational factor in increasing risk perception (Marshall, 2020). Because organizations and individuals tend to understand risk different, much of the communication is ineffective. If this gap can be bridged, the risk communication may be more effective. Effective risk communication can go a long way in increasing understanding of risk and hazard, raising risk perception and closing the RPAG.

Technical factors include physical structures such as **critical infrastructure**. These play a surprisingly large role in risk perception (Botzen et al., 2009). Research has shown that where physical barriers are constructed, risk perception of a hazard decreases, despite the risk of physical barriers being overwhelmed. This happens in both CPA and individual risk perception, where those that are behind barriers are considered safe (Botzen et al., 2009; Bradford et al., 2012). low risk perception can lead to increased vulnerabilities if people are not aware of risk and do nothing to mitigate it and this needs to be considered in the RPAG.

4.3 Operationalization of Risk Perception

This section will dive deeper into how CPAs understand risk perception and the strategies they use to increase risk perception among the populations that they serve.

There are two different approaches taken when it comes to DRM activities surrounding risk perception. On the one hand, there are top-down centred activities, where different CPAs and authorities will create emergency plans and conduct other disaster related planning, and then relay this information to communities through workshops and discussions (Ardaya & Ribbe, 2012). This is the traditional approach to enhancing risk perception in an area. This traditional approach

can sometimes be problematic due to the different understandings and perceptions of risk between CPAs and citizens discussed above. On the other hand, some areas have started using more participatory methods (Wachinger et al, 2013; Botterill & Mazur, 2004). The goal of these new techniques is to involve the community from the beginning of the risk management process, to understand their needs and concerns, and hopefully build a disaster response system that works for everyone (Wachinger et al, 2013). This has been shown to increase risk perception, as it gets more local people involved and includes an understanding of their risk as well. This section will discuss both top-down and participatory strategies. It will touch on participatory strategies and community centred approaches, but they will be discussed more in-depth in D2.1.

Top-down strategies:

Top-down strategies for addressing risk perception within populations that work with CPAs include general education initiatives, more targeted disaster risk courses, and preparedness and response trainings. These approaches require CPAs to inform the public about risks and how to address them, with little to no input from the community. These strategies typically include one-way communication with few opportunities for citizen engagement. There are strengths and weaknesses to these approaches that will be discussed below, but in research done so far, there has been a varying degree of success in impacting risk perception in the areas they were working. There has also been a wide range of satisfaction in these activities, from communities that did not even show up to participate to others that showed high levels of satisfaction (e.g. 75%) (Sattar & Cheung, 2019; Xu et al, 2016). Below are some of the most common activities when it comes to addressing risk perception.

1. General education campaigns

General education campaigns are used frequently by different CPAs to help citizens understand what their risks are and how to prepare (Jóhannesdóttir & Gísladóttir, 2010; Mammen, 2014). These include things like putting information on a state, city, or CPA organization's website to direct people to the information they need (Ricci et al., 2013). These are examples of one-way communication that limit opportunity for community engagement. This has proven challenging in areas that do not have proper access to the internet. Other examples include posting fliers in areas at risk and sending brochures to households (Xu et al, 2016). For example, Iran has distributed posters, brochures, and leaflets to educate the population on earthquake risk (Izadkhah & Hosseini, 2010). Other techniques for general hazard and risk education are used, but previous research has shown that these education campaigns have varying effectiveness. In a town in China that is at high risk of landslides, fliers were spread in the areas at greatest risk. Despite this, only 19% had been exposed to information (Xu et al., 2016). Other areas have seen similar uptake in general education campaigns. In Iceland, CPA distributed brochure on the risk of volcanic eruption, but in interviews most households said they had thrown them away before reading them (Jóhannesdóttir & Gísladóttir, 2010). While general

education is important, there is an issue of reaching the public with the information, and it is very difficult to reach those that are not actively seeking out the information.

2. Courses and Workshops

Aside from general education campaigns, CPAs usually provide courses and workshops on different hazards in the area to help people understand their risk and increase risk perception and action. These can include activities such as workshops on understanding and preparing for flooding in the area, courses to help understand how landslides happen and which areas are at greatest risk, and teaching mitigation measures. While these courses and workshops are very important in terms of communicating about risk and giving people practical mitigation and preparedness activities to improve resilience, there is research showing that they may not be effective (Arbaya & Ribbe, 2017). The largest hurdle in the effectiveness of these workshops is getting community members to participate. If risk perception is low, or if previous experience has led to a lack of trust in CPAs, the community will not engage in these workshops. Working towards a more participatory model of addressing risk perception may help better engage citizens in these workshops.

3. Training and drills

The last of the most common techniques used to increase risk perception by CPAs is to hold trainings and drills on what would happen in an emergency to increase understanding of emergency plans and educate citizens on risks in the area, increasing risk perception. The structure and format of these drills and trainings can differ (Xu et al., 2016; Jóhannesdóttir & Gísladóttir, 2010; Ricci et al., 2013). Some CPAs run drills on disaster response, including rescues. Others will run drills with school children, including disaster response drills. In Iran, the government has developed educational trainings in schools on how to act during an earthquake, including drills that are conducted in every primary school in the country (Izadkhah & Hosseini, 2010). Knowledge from these drills is meant to be communicated from children to households, therefore increasing risk perception of larger parts of the community (Wachinger et al., 2013). Other activities include evacuation drills, which involve the community in how a disaster response would work. While more effective in most cases than general information campaigns, there is still an issue with these drills in getting attendance. One community in China has made an effort to increase landslide risk perception in the area using simulations and drills. Despite the push, only 38% of the community had attended these drills (Xu et al, 2016). While attendance will always be an issue for these activities, research has shown that these activities can be useful. They promote self-efficacy and spread risk information to increase risk perception. In a small town in Italy, those that had done the drills had a much better understanding of the risk and disaster response. After the drill, 56% of the population knew that the town had an emergency plan and had looked at the plan (Ricci et al, 2013). This was a large increase from prior to the workshop.

Examples of CPAs implementing these activities have been documented in multiple cases in the literature, and this report will examine activities used to address risks such

as volcanic eruptions and cyclones (Jóhannesdóttir & Gísladóttir, 2010; van Mamen, 2014; Sattar & Cheung, 2019). In Iceland, CPAs believed that the risk to communities of a volcanic eruption was quite high, but there was low risk perception in the areas most at risk. To address this, the initial plan consisted of educating children using evacuation drills and general education, as well as distributing brochures with information to the community. This did not lead to any meaningful increase in risk perception. There were several issues with these initial attempts, mainly due to the fact that there was a disconnect between the risk perception of CPAs and community members, which meant that there was a lack of meaningful communication (Jóhannesdóttir & Gísladóttir, 2010). Because of the low risk perception in the areas and the failure of previous ideas, other activities were designed. This included creating a "Volcano Day" on the day of a previous eruption that gave information about the volcano to residents of the towns at risk. CPAs also conducted a town wide evacuation drill. This led to both better education of residents and more resident input in the plans. This participatory work led to better overall risk perception, and better preparedness in the community (Jóhannesdóttir & Gísladóttir, 2010). While not perfect, it was a step in the right direction.

Similarly, in Costa Rica there have been DRR and risk education plans in areas at risk of volcanic eruptions in place since the 1980s (van Mamen, 2014). These have involved physical education as well as access to online information. There were several issues with the CPA's approach that have led to a lack of risk perception in the area. First, the education campaign did not address many of the factors that influence risk perception, such as culture, demographics, and economics. Additionally, many of the education materials were online, and over 50% did not have access to the internet (van Mamen, 2014). Due to these disconnects, over 35% of community members did not know they were at risk and did not know what to do to prepare. Local authorities had organized emergency committees in the community and had created and shared evacuation plans, but because of a lack of trust in the government and authorities, this information was not absorbed, and risk perception remained low. This example illustrates the need to address the factors such as culture and economics when designing these programs, and highlights the need for RiskPACC activities to include those that may not be connected to technology.

In Bangladesh there has been a large effort to increase the disaster response and risk perception in the country to reduce losses from cyclones (Sattar & Cheung, 2019). Activities to increase the risk perception of the population included cyclone early warning system trainings as well as trainings on search and rescue and providing relief. These trainings were given to volunteers, practitioners, and community members. The activities have been mostly successful, with 75% of the respondents of a relevant survey being at least moderately satisfied with CPA activities, and community members having a higher risk perception than CPAs anticipated they would (Sattar & Cheung, 2019). Despite the general level of satisfaction, there was still a feeling of a lack of input in the planning, and many did not agree with government planning. Additionally, despite the success of the trainings, risk perception in the community did not correlate with actual risk. Factors such as gender, education level, and previous experience play a large role in risk perception, so more targeted training

may be necessary. While risk perception may not be correlated with actual risk, the fatalities from cyclones has been decreasing in Bangladesh (Sattar & Cheung, 2019). The CPA activities to make people aware of their risk and how to respond may be having an effect.

As illustrated by these examples, there are shortfalls in many of the common techniques that are traditionally used by CPAs to influence risk perception. It has been difficult to increase participation, and therefore the messages do not penetrate most communities. Another major issue for increasing perception is the lack of communication with community members. If CPAs do not understand the community where these activities are taking place, then it is difficult to plan and communicate effectively. For example, in designing evacuation plans in Iceland, the CPAs created a system to let people know by phone and radio that they need to evacuate (Jóhannesdóttir & Gísladóttir, 2010). This created a lack of trust in the community because most farmers, who are in their fields all day, would not have access to either phone or radio to receive the evacuation call. With this trust broken, many in the community stopped participating in trainings and did not receive the risk information necessary to be more knowledgeable in risk perception. This is where the more participatory and bottom-up approaches may provide some insight that other approaches do not.

Participatory and bottom-up strategies:

Most CPA activities to spread awareness and increase risk perception have been top-down in nature, but there are new techniques emerging that allow citizens to take a more active role in disaster management, which has shown to increase risk perception (Wachinger et al., 2013). More participatory strategies have included things such as including community members in the planning of evacuation routes (Jóhannesdóttir & Gísladóttir, 2010; Ricci et al, 2013; Wachinger et al., 2013). When citizens become involved in planning for disaster management, then CPAs have the ability to better explain their risk perception and hear about the risk perception of citizens. The goal of the participatory work is to create a dialogue between CPAs and citizens, so that each other's perceptions can be better understood.

Research has shown that people are more aware of flooding and the risks, as well as more willing to participate in preparedness activities, if they have already been involved in exercises (Arbaya & Ribbe, 2012). These types of exercises include getting people involved in testing and developing emergency plans. Initiatives such as these that heavily involve community members and households can also increase trust between CPAs and individuals. Many studies have proposed that trust in authorities is one of the hurdles to proper risk perception amongst individuals, so if CPAs can establish that trust it will help increase risk perception. More information on participatory methods and community risk perception can be found in D2.1.

4.4 Working Definition of Risk Perception

Of the definitions discussed above, most concern the subjective understanding of risk and how individuals process risk based on psychological and socio-cultural factors. Risk perception also plays a major role in assessing and acting upon risk. To that end, the definition that has been developed by the European Environment Agency definition covers many of the aspects that are important for risk perception and will be the working definitions for RiskPACC. The definition can be found below:

> *"Risk perception involves people's beliefs, attitudes, judgements and feelings, as well as the wider social or cultural values that people adopt towards hazards and their benefits. The way in which people perceive risk is vital in the process of assessing and managing risk. Risk perception will be a major determinant in whether a risk is deemed to be "acceptable" and whether the risk management measures imposed are seen to resolve the problem" (EEA, 2019).*

This definition covers beliefs, attitudes, and judgements which covers the more psychological side of disaster risk perception, but also mentions the sociological and anthropological aspects in terms of wider cultural and social values. Besides bringing in aspects of all of the traditional fields of study for risk perception, this definition also incorporates more practical aspects of risk perception into DRM. It brings more attention to perceived risks as an important part of DRM, which is the practical side that will be important as RiskPACC activities go forward.

5. RISK PERCEPTION, RESILIENCE, VULNERABILITY AND THE RPAG

All three terms discussed in detail above, disaster resilience, vulnerability, and risk perception play a role in the RPAG, and understanding these concepts will assist in closing the gaps that currently exist in our case study areas. Research has shown that resilience heavily depends on how effectively CPAs and citizens interact and understand each other, and the implementation of risk management that comes from these interactions (Le Roux & Van Neikerk, 2019). If there is a break-down in the understanding of risk perceptions and CPAs and citizens lack communication and trust, resilience in an area could decrease. To add to the difficulties in CPA and citizen interaction, as detailed above, there is a divergence in the way that citizens and CPAs perceive and understand risk (Birkholtz at al., 2014; Bradford et al., 2012), as well as a lack of two-way communication. Factors discussed above that influence risk perception, resilience, and vulnerability also need to be considered to reduce the RPAG and decrease vulnerability. For example, the research details that risk perception is high in women, but women typically have lower resilience. Targeting women in closing the RPAG may lead to solutions that transfer the high risk perception into higher resilience.

In terms of closing the RPAG, the literature over a significant period of time tells us that risk perception is a necessary but not sufficient part of the problem that we face. Understanding individual psychology and how it affects intention to act and actual behaviour must be set in wider social contexts. This takes us from psychological, through psychosocial to sociological and cultural approaches and methods: none alone can solve our problem. There may be many other factors which influence one's propensity to act. We know from many psychological and behavioural studies that prior experience of disasters has an impact on individuals' risk perception (Rana et al., 2020) but there is not a straight line causal relationship that links that perception to personal action; and that includes the risk perceptions of both citizens and Civil Protection Authorities. Beyond the individual, it is important to situate people in their socio-political/community context which would include understanding the demographics of the location, such as the age profile, as well as recent change such as in or out-migration, because that also contributes to the resources available to people to act. All of these factors also apply to understanding the vulnerabilities present in the community. Having a better understanding of the context of the area, both in terms of vulnerabilities and factors that will relate to risk perception, may help reduce the RPAG.

It is also important to understand the relationship between Civil Protection Authorities and the citizens they serve. Trust is known to influence the degree to which citizens will believe (and act upon) communications from CPAs; if there have been past failures to respond or deliver what citizens expect from CPAs, then this can colour how, and to what extent, citizens will engage (Lechowska, 2018; Khan et al., 2020; Xue et al., 2020). The ways (tools and methods) that CPAs engage with citizens can also affect

the level of response. As demonstrated above, many of the top-down engagement techniques have had limited success in the past. If CPAs are constrained by resource availability and by institutional culture to communicate in particular ways, then some citizens may be excluded or dissatisfied. Methods such as developing a constructive dialogue and participatory ethos can bridge some of these gaps, as research has shown that typically risk perception and action both increase if participatory methods are used effectively (Wachinger et al., 2013). Additionally, a strong understanding of factors that impact risk perception should be considered when designing these participatory methods, so that they can be better tailored to individuals and communities.

In future RiskPACC activities, these concepts will be used to understand differences in risk perceptions and actions in case-study areas. This will be done with the goal to create solutions that will take into account the risk reduction relationship and the contributing factors to the RPAG to close that gap and increase resilience. Previous frameworks have integrated the concepts of risk perception and vulnerability into risk governance, to try and lead stakeholders to a better understanding of risk and to create policies that will include an understanding of these factors. The IRGC (2017) is a good example of steps that can be taken to attempt to give priority to different stakeholder understanding and perception of risk and create risk policies once these have been understood. According to the framework, involving stakeholders 'improves the knowledge about risk and its management and can thus increase the effectiveness, the fairness and the acceptability of the decisions that are made' (p. 30). RiskPACC is attempting to do something similar, using knowledge from different stakeholders to understand risk perception and vulnerability in the local context, to then present solutions that are acceptable to all involved and work to close the RPAG and increase resilience.

6. CONCLUSION

In this document we have described in depth the concepts of disaster resilience, risk perception, and vulnerability, as well as how those terms are operationalization by CPAs. All of this led to discussing the RPAG and how all three of these concepts should be considered when designing ways to close this gap. As there are many factors that influence these concepts in practice, these factors were highlighted and discussed in terms of closing the RPAG.

In Section 2 we have shown how disaster resilience has evolved as a term, from its early uses in the 1800's to its adoption into disaster research. We also examined the differences in use between academia and practice, and how CPAs operationalize the term. Definitions were explored from not only academia, but previous EU projects and organizations that work in the resilience field. The vagueness and lack of consensus in definitions was examined, both from an academic and practical perspective, highlighting the difficulties for CPAs in operationalizing the definitions. We have also discussed the important factors that can influence resilience, and ways to address these influences. Additionally, specific examples of CPA activities to address resilience have been discussed. These examples highlighted the different resilient approaches taken by different countries, from top-down approaches to more citizen based resilience practice. A working definition of disaster resilience for RiskPACC was developed:

> *the ability of an individual, community, region, or country to resist, adapt to, and recover from the impact of a hazard, either natural or anthropogenic. Enhanced resilience can be embedded into activities in all phases of the disaster cycle, and includes positive transformation that strengthens the ability of current and future generations to adapt to future crises, and survive and thrive as conditions change.*

In Section 3 we have shown how vulnerability is understood by CPAs and international organizations, factors that influence vulnerability, and some frameworks and actions that have been taken to address vulnerability. The definition of vulnerability that will be used in RiskPACC can be found here:

> *"[t]he conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.*

In Section 4 we have shown how risk perception is understood in academia, practice, and in previous EU funded projects. Factors influencing risk perception were discussed to show the difficulties in understanding individual and community risk perception, and finally examples of CPA activities were included to show how current techniques used were less than successful in closing the RPAG. This led to a discussion on new techniques that are being using, including more participatory actions that more heavily involve the community in planning. This is one area to explore in attempts to close the RPAG, as getting input from the community will help

better align the risk perceptions and understanding between CPAs and communities. The working definition for risk perception, that was developed in conjuncture with D2.1, can be found below:

> *"Risk perception involves people's beliefs, attitudes, judgements and feelings, as well as the wider social or cultural values that people adopt towards hazards and their benefits. The way in which people perceive risk is vital in the process of assessing and managing risk. Risk perception will be a major determinant in whether a risk is deemed to be "acceptable" and whether the risk management measures imposed are seen to resolve the problem"*

Finally, it is worth highlighting how all these concepts have a place in understanding the RPAG, and in creating news ways to address that gap. Section 5 discussed this relationship in-depth, providing some ideas of areas to focus on going forward. This chapter highlighted the importance of aligning the risk perceptions between CPAs and communities, as well as establishing a trusting relationship between the groups. It also emphasizes the importance of context in understanding the community.

6.1 Future Work and Next Steps

This work, along with work done in D2.1, will form the basis of understanding for these concepts, how they relate to the RPAG, and how RiskPACC can understand these concepts to address the RPAG. The next steps will be accomplished in D1.2 and D2.2, where primary research will be undertaken to better understand how these terms are operationalized in practice in our case study areas. Interviews will be conducted to understand how CPAs and Community Groups understand resilience and risk, how they communicate with each other, and how they respond to risk and hazards. D1.2 will focus on consulting CPAs and examining their current best practices, interactions with communities, and resilience building techniques. This will give us a better understanding of issues that need to be addressed to close the RPAG in each case study. This work will also be used for the gap analysis that will be completed as part of Deliverable 1.3. This gap analysis will examine gaps in the current operationalization of disaster resilience in the case study areas and produce a roadmap for key actions to advance activities. A similar analysis will be done for D2.3.

In addition to future WP1 and WP2 activities, the research done in this deliverable will provide some of the research and evidence for WP4 and will be used to develop the RiskPACC framework. This framework will assist in understanding risk perceptions, communications between CPAs and communities, and other factors that may be behind the RPAG in different settings. The framework will then lead into the work that is done with communities and CPAs in WP3, including the co-creation labs.

7. REFERENCES

Abeling, T., Huq, N., Chang-Seng, D., Birkmann, J., Wolfertz, J., Renaud, F., & Garschagen, M. (2019). Understanding Disaster Resilience: The emBRACE Approach. In H. Deeming, M. Fordham, C. Kuhlicke, L. Pedoth, S. Scneiderbauer, & C. Shreve, *Framing Community Disaster Resilience: Resources, Capacities, Learning, and Action.* John Wiley & Sons Ltd. https://doi.org/10.1002/9781119166047.ch2

Adams, D. (2013). Volunteered Geographic Information: Potential Implications for Participatory Planning. In *Planning Practice and Research* (Vol. 28, Issue 4, pp. 464–469). https://doi.org/10.1080/02697459.2012.725549

Aitsi-Selmi, A., Egawa, S., Sasaki, H., Wannous, C., & Murray, V. (2015). The Sendai Framework for Disaster Risk Reduction: Renewing the Global Commitment to People's Resilience, Health, and Well-being. *International Journal of Disaster Risk Science, 6*, 164-176. https://doi.org/10.1007/s13753-015-0050-9

Aldrich, D.P. (2019). Challenges to coordination: Understanding intergovernmental friction during disasters. *International Journal of Disaster Risk Science, 10*, 306–316. https://doi.org/10.1007/s13753-019-00225-1

Aldunce, P., Beilin, R., Handmer, J., & Howden, M. (2014). Framing disaster resilience: The implications of the diverse conceptualisations of "bouncing back". *Disaster Prevention and Management, 23*(3), 252-270. https://doi.org/10.1108/DPM-07-2013-0130

Alexander, D. (2013). Resilience and disaster risk reduction: an etymological journey. *Natural Hazards and Earth Science Systems, 13*, 2707-2716. https://doi.org/10.5194/nhess-13-2707-2013

Amaratunga, C. (2014). Building community disaster resilience through a virtual community of practice (VCOP). *International Journal of Disaster Resilience in the Built Environment, 5*(1), 66-78. https://doi.org/10.1108/IJDRBE-05-2012-0012

Amir, S., & Kant, V. (2018). Sociotechnical Resilience: A Preliminary Concept. *Risk Analysis, 38*(1). https://doi.org/10.1111/risa.12816

Antronico, L., De Pascale, F., Coscarelli, R., & Gulla, G. (2020). Landslide risk perception, social vulnerability and community resilience: The case study of Maierato (Calabria, southern Italy). *International Journal of Disaster Risk Reduction, 46*. https://doi.org/10.1016/j.ijdrr.2020.101529

Ardaya, A., Evers, M., & Ribbe, L. (2017). What influences disaster risk perception? Intervention measures, flood and landslide risk perception of the population living in flood risk areas in Rio de Janiero state, Brazil. *International Journal of Disaster Risk Reduction, 25*, 227-237. https://doi.org/10.1016/j.ijdrr.2017.09.006

Barasa, E., Mbau, R., & Gilson, L. (2018). What Is Resilience and How Can It Be Nurtured? A Systematic Review of Empirical Literature on Organizational Resilience. *International Journal of Health Policy and Management, 7*(6), 491-503. https://doi.org/ 10.15171/IJHPM.2018.06

Beck, U. (1992), Risk society: Towards a new modernity, London: SAGE Publications.

Béné, C., Wood, R. G., Newsham, A., & Davies, M. (2012). Resilience: New utopia or new tyranny? Reflections on the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. *Institute of Development Studies: IDS Working Paper 405.* https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/2291/IDS%20Working%20Paper%20405.pdf?sequence=1&isAllowed=yBethel, J. W., Burke, S. C., Britt, A. F. (2013). Disparity in disaster preparedness between racial/ethnic groups. *Disaster Health, 1*(2), 110-116. http://dx.doi.org/10.4161/dish.27085

Bickerstaff, K. (2004). Risk perception research: socio-cultural perspectives on the public experience of air pollution. *Environment International, 30*, 827-840. https://doi.org/ 10.1016/j.envint.2003.12.001

Birkholtz, S., Muro, M., Jeffery, P., & Smith, H. (2014). Rethinking the relationship between flood risk perception and flood management. *Science of the Total Environment, 478*, 12-20. https://doi.org/10.1016/j.scitotenv.2014.01.061

Birkmann, J. (2013). Measuring vulnerability to promote disaster-resilient societies and to enhance adaptation: conceptual frameworks and definitions. En J. Birkmann (Ed.), *Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies* (2ª ed., pp. 9–79). United Nations University Press.

Blaikie, P., Cannon, T., Davis, I. & Wisner, B. (Eds.). (1994). *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Routledge.

Bodoque, J., Díez-Herrero, A., Amerigo, M., García, J., & Olcina, J. (2019). Enhancing flash flood risk perception and awareness of mitigation actions through risk communication: A pre-post survey design. *Journal of Hydrology, 568*, 769-779. https://doi.org/10.1016/j.jhydrol.2018.11.007

Bohle, H.-G. (2009). Sustainable Livelihood Security. Evolution and Application. En H. G.

Boon, H. (2014). Disaster resilience in a flood-impacted rural Australian town. *Natural Hazards, 71*, 683-701.https://doi.org/ 10.1007/s11069-013-0935-0

Botterill, L., & Mazur, N. (2004). *Risk & risk perception: A literature review.* Rural Industries Research and Development Corportation. https://www.agrifutures.com.au/wp-content/uploads/publications/04-043.pdf

Botzen, W., Aerts, J., & van der Bergh, J. (2009). Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water Resources Research, 45*, W10440. https://doi.org/10.1029/2009WR007743

Bradford, R., O'Sullivan, J., van der Craats, I., Krywkow, J., Rotko, P., Aaltonen, J., . . . Schelfaut, K. (2012). Risk perception- issues for flood management in Europe. *Natural Hazards and Earth Systems, 12*, 2299-2309. https://doi.org/10.5194/nhess-12-2299-2012

Bram, S., Degerman, H., Melkunaite, L., Urth, T., & Carriera, E. (2016). *D4.3: Organisational resilience concepts applied to critical infrastructure.* IMPROVER: Improved Risk Evaluation and Implementation of Resilience Concepts to Critical Infrastructure.

Brauch, Ú. O. Spring, J. Grin, C. Mesjasz, P. Kameri-Mbote, N. C. Behera, B. Chourou & H. Krummenacher (Eds.), *Facing Global Environmental Change: Environmental, Human, Energy, Food, Health and Water Security Concepts* (pp. 521–528). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-68488-6_36

Brown , V. (2014). Risk perception: It's personal. *Environmental Health Perspectives, 122*(10). https://doi.org/ 10.1289/ehp.122-A276

Brown, N., Orchiston, C., Rovins, J., Feldmann-Jensen, S., & Johnston, D. (2018). An integrative framework for investigating disaster resilience within the hotel sector. *Journal of Hospitality and Tourism Management, 36*, 67-75. https://doi.org/10.1016/j.jhtm.2018.07.004

Bruneau, M., Chang, S., Eguchi, R., Lee, G. C., O'Rourke, T. D., Reinhorn, A., Shinozuka, M., Tierney, K., Wallace, W., & von Winterfeld, D. (2003). The framework to quanitatively assess and enhance the seismic resilience of communities. Earthquake Spectra, 19(4), 733-752. https://doi.org/ 10.1193/1.1623497

Bubeck, P., Botzen, W., & Aerts, J. (2012). A review of risk perception and other factors that influence flood mitigation behavior. *Risk Analysis, 32*(9), 1481-1495. https://doi.org/ 10.1111/j.1539-6924.2011.01783.x

Bündnis Entwicklung Hilft. (2021). *WorldRiskReprt 2021*. https://weltrisikobericht.de/wp-content/uploads/2021/09/WorldRiskReport_2021_Online.pdf

Burns, W. (2007). *Risk perception: A review.* Center for Risk and Economic Analysis of Terrorism Events: University of Southern California. http://research.create.usc.edu/published_papers/155

Cabinet Office. (2013). *The role of Local Resilience Forums*. Accessed from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/62277/The_role_of_Local_Resilience_Forums-_A_reference_document_v2_July_2013.pdf (accessed 12.5.21).

Cabinet Office. (2004). *Civil Contingencies Act.*

Cai, H., Lam, N. S., Qiang, Y., Zou, L., Correll, R. M., & Mihunov, V. (2018). A synthesis of disaster resilience meansurement methods and indices. *International Journal of Disaster Risk Reduction, 31*, 844-855. https://doi.org/10.1016/j.ijdrr.2018.07.015

Cardona, O.-D., van Aalst, M., Birkmann, J., Fordham, M., McGregor, G., Perez, R., . . . Sinh, B. (2012). Determinants of risk: exposure and vulnerability. In C. V.-K. Field, *Managing the Risk of Extreme Events and Disasters to Advance Climate Change Adaptation* (pp. 65-108). Cambridge, UK and New York, NY, USA: Cambridge University Press.

Chambers, R. (1989). Editorial Introduction: Vulnerability, Coping and Policy. *IDS Bulletin*, *20*(2), 1–7. https://doi.org/10.1111/j.1759-5436.1989.mp20002001.x

Chang, S., & Shinozuka, M. (2004). Measuring Improvements in the Disaster Resilience of Communities. *Earthquake Spectra, 20*(3), 739-755. https://doi.org/10.1193/1.1775796

Chou, J., & Wu, J. (2014). Success factors of enhanced disaster resilience in urban community. *Natural Hazards, 74*, 661-686. https://doi.org/10.1007/s11069-014-1206-4

Chmutina, K. & Bosher, L.. (2017). Managing Disaster Risk and Resilience in the UK, in: Chandler, D., Coaffee, J. (Eds.), *The Routledge Handbook of International Resilience*. Routledge, New York, pp. 267–278.

Clarke, J., Coaffee, J., Rowlands, R., Finger, J., Hasenstein, S., & Siebold, U. (2015). *D1.1: Resilience Evaluation and SOTA Summary Report.* RESILENS: Realising European Resilience for Critical Infrastructure. http://resilens.eu/wp-content/uploads/2016/08/D1.1-Resilience-Evaluation-and-SOTA-Summary-Report.pdf

Coaffee, J. (2021). Futureproofing against shock: Institutional responses to terrorist risk in London, 1990–2020. *Applied Geography, 133,* 102493. https://doi.org/https://doi.org/10.1016/j.apgeog.2021.102493

Coaffee, J. (2019). Futureproof: How to Build Resilience in an Uncertain World, First. ed. Yale University Press, New Haven, CT.

Coaffee, J. & Clarke, J. (2015) On securing the generational challenge of urban resilience, *Town Planning Review*, *86*(3), 249-55

Coaffee, J. & Lee, P. (2016). Urban Resilience: Planning for Risk, Crisis and Uncertainty. PALGRAVE, New York, NY, USA.

Collins, A. E. (2018). Advancing the disaster and development paradigm. *International Journal of Disaster Risk Science, 9*, 486-495. https://doi.org/10.1007/s13753-018-0206-5

Cui, K., & Han, Z. (2019). Association between disaster experience and quality of life: The mediating role of disaster risk perception. *Quality of Life Research, 28*, 509-513. https://doi.org/10.1007/s11136-018-2011-4

Cutter, S., Ash, K., & Emrich, C. (2016). Urban–Rural Differences in Disaster Resilience. *Annals of the American Association of Geographers, 106*(6), 1236-1252. https://doi.org/10.1080/24694452.2016.1194740

Cutter, S., Ash, K., Emrich, C. (2014). The geographies of community disaster resilience. *Global Environmental Change, 29,* 65-77. http://dx.doi.org/10.1016/j.gloenvcha.2014.08.005

Cutter, S., Burton, C., & Emrich, C. (2010). Disaster Resilience Indicators for Benchmarking Baseline Conditions. *Journal of Homeland Security and Emergency Management, 7*(1). https://doi.org/10.2202/1547-7355.1732

Daria, A., Channad, P., Lee, Y., & Asce, A. (2020). Evaluating implications of flood vulnerability factors with respect to income levels for building long-term disaster resilience of low-income communities. *International Journal of Disaster Risk Reduction, 48*. https://doi.org/10.1016/j.ijdrr.2020.101608

Davies, T., Beaven, S., Conradson, D., Densmore, A., Gaillard, J., Johnston, D., . . . Wilson, T. (2015). Towards disaster resilience: A scenario-based approach to co-producing and integrating hazard and risk knowledge. *International Journal of Disaster Risk Reduction, 13*, 242-247. http://dx.doi.org/10.1016/j.ijdrr.2015.05.009

de Bruijin, K., Buurman, J., Mens, M., Dahm, R., & Klijn, F. (2017). Resilience in practice: Five principles to enable societies to cope with extreme weather events. *Envionmental Science and Policy, 70*, 21-30. https://doi.org/10.1016/j.envsci.2017.02.001

Deonandan, R., & Backwell, A. (2011). Driving deaths and injuries post-9/11. *International Journal of General Medicine*, 4, 803-807. https://doi.org/10.2147/IJGM.S27049

Douglas, M., & Wildavsky, A. (1982). *Risk and Culture.* Berkeley; Los Angeles; London: University of California Press.

Dufty, N. (2012). Using social media to build community disaster resilience. *The Australian Journal of Emergency Management, 27*(1). https://www.researchgate.net/publication/279861590_Using_Social_Media_to_Build_Community_Disaster_Resilience

Dutch Ministry of Security and Justice. (2013). Safety Regions Act. Amsterdam.

Eadie, P. (2019). Typhoon Yolanda and post-disaster resilience: Problems and challenges. *Asia Pacific Viewpoint, 60*(1), 94-107. https://doi.org/ 10.1111/apv.12215

EC. (n.a.). *INFORM Index - Methodology.* Joint Reasearch Cnetre (JRC), Disaster Risk Management Knowledge Centre (DRMKC). https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Risk/Methodology#inline-nav-6

EEA (2019). Introduction to Risk Assessment Concepts. https://www.eea.europa.eu/publications/GH-07-97-595-EN-C2/chapter1h.html

European Commission (2016). Commission Staff Working Document. Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030. A disaster risk-informed approach for all EU policies. Brussels, Belgium: European Commission. Retrievable at https://ec.europa.eu/echo/sites/default/files/sendai_swd_2016_205_0.pdf

Ferriera, P., & Simões, A. (2016). *D2.1-State of the Art Review.* RESOLUTE: Resilience management guidelines and operationalization applied to urban transport environment. http://www.resolute-eu.org/files/RESOLUTE_D2.1_SotA_v18.pdf

Feteke, A., Hufschmidt, G., & Kruse, S. (2014). Benefits and Challenges of Resilience and Vulnerability for Disaster Risk Management. *International Journal of Disaster Risk Science, 5*, 3-20. https://doi.org/10.1007/s13753-014-0008-3

FEMA. (2020, Nov. 3). *Resilience*. Retrieved from https://www.fema.gov/about/offices/resilience

Gibson, M., Gutman, G., Hirst, S., Fitzgerald, K., Fisher, R., & Roush, R. (2013). Chapter 5 Expanding the Technology Safety Envelope for Older Adults to Include Disaster Resilience. In A. Sixsmith, & G. Gutman, *International Perspectives on Aging.* New York: Springer Science and Business Media. https://doi.org/ 10.1007/978-1-4419-8348-0_5

Gierlich, E., Belsher, B., & Beutler, L. (2010). Cross-Cultural Differences in Risk Perceptions of Disasters. *Risk Analysis, 30*(10). https://doi.org/ 10.1111/j.1539-6924.2010.01451.x

Gold, J., Rossen, L., Ahmed, F., Sutton, P., Li, Z., Salvatore, P., . . . Jackson, B. (2020). *Race, Ethnicity, and Age Trends in Persons Who Died from COVID-19 — United States, May–August 2020.* Center for Disease Control and Prevention - Morbitity and Mortality Weekly Report. *https://www.cdc.gov/mmwr*

Golestaneh, L., Neugarten, J., Fisher, M., Billett, H. H., Gil, M. R., Johns, T., . . . Bellin, E. (2020). The association of race and COVID-19 mortality. *Emergency Clinical Medicine, 25*. https://doi.org/10.1016/j.eclinm.2020.100455

Goniewicz, K., & Burkle Jr., F. (2019). Challenges in Implementing Sendai Framework for Disaster Risk Reduction in Poland. *International Journal of Environmental Research and Public Health, 16*. https://doi.org/10.3390/ijerph16142574

Grasso, V., & Crisci, A. (2016). Codified hashtags for weather warning on twitter: An Italian case study. *PLoS Currents*, *8*(Disasters), 2021. https://doi.org/10.1371/currents.dis.967e71514ecb92402eca3bdc9b789529

Harrison, S., Potter, S., Prasanna, R., H Doyle, E. E., & Johnston, D. (2020). Volunteered Geographic Information for people-centred severe weather early warning: A literature review. *Australasian Journal of Disaster and Trauma Studies*.

Haworth, B., & Bruce, E. (2015). A Review of Volunteered Geographic Information for Disaster Management. *Geography Compass*, *9*(5), 237–250. https://doi.org/10.1111/gec3.12213

Henrich, L., McClure, J., & Crozier, M. (2015). Effects of risk framing on earthquake risk perception: Life-time frequencies enhance recognition of life. *International Journal of Disaster Risk Reduction, 13*, 145-150. https://doi.org/10.1016/j.ijdrr.2015.05.003

Hewitt, K. (Ed.). (1983). *Interpretations of Calamity: From the Viewpoint of Human Ecology*. Allen & Unwin.

Hofer, J. (2014). *D32.1: Report on risk perception.* DRIVER Project.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecological System, 4*(1), 1-23. https://www.annualreviews.org/doi/pdf/10.1146/annurev.es.04.110173.000245

Hosseini, S., Barker, K. & Ramirez-Marquez, J. E. (2016). A review of definitions and measures of system resilience. *Reliability Engineering & System Safety*, *145*, 47–61. https://doi.org/10.1016/j.ress.2015.08.006

Horita, F.E.A., de Albuquerque, J.P., Marchezini, V., & Mendiondo, E.M. (2017). Bridging the gap between decision-making and emerging big data sources: An application of a model-based framework to disaster management in Brazil. *Decision Support Systems, 97*, 12–22. https://doi.org/10.1016/j.dss.2017.03.001

House of Lords. (2021). Preparing for Extreme Risks: Building a Resilient Sociery. London.

IPCC. (2007). *Climate Change 2007. Impacts, Adaptation and Vulnerabilty.* Cambridge University Press (CUP).

IPCC. (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: A Special Report of Working Group I and II of the IPCC*. Cambridge University Press (CUP).

IPCC. (2014). *AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability: Summary for Policymakers*. https://www.ipcc.ch/report/ar5/wg2/

IRGC. (2017). I*ntroduction to the IRGC Risk Governance Framework, revised version*. Lausanne: EPFL International Risk Governance Center. https://doi.org/10.5075/epfl-irgc-233739

ITU. (2019). Disruptive technologies and their use in disaster risk reduction and management. *International Telecommunication Union*, 1–39. https://www.itu.int/en/ITU-D/Emergency-Telecommunications/Documents/2019/GET_2019/Disruptive-Technologies.pdf

Izadkhah, Y., & Hosseini, K. (2010). An Evaluation of disaster preparedness in four major earthquakes in Iran. *Journal of Seismology and Earthquake Engineering, 12*(1). http://www.iiees.ac.ir/jsee

Jóhannesdóttir, G., & Gísladóttir, G. (2010). People living under threat of volcanic hazard in southern Iceland: vulnerability and risk perception. *Natural Hazards and Earth System Sciences, 10*, 407-420. https://doi.org/10.5194/nhess-10-407-2010

Joint Research Centre (2021). *Social media image analysis in the immediate aftermath of the 2020 Beirut blast. Exploratory activity for enhancement of Copernicus emergency management services.* Brussels, Belgium: European Commission. Retrievable at https://op.europa.eu/en/publication-detail/-/publication/7be1d445-8ac5-11eb-b85c-01aa75ed71a1/language-en, last accessed 19/11/2021.

Jung, K. (2017). Sources of Organizational Resilience for Sustainable Communities: An Institutional Collective Action Perspective. *Sustainability, 9*(1141). https://doi.org/10.3390/su9071141

Kalkman, J. (2021). Military crisis responses to COVID-19. *Journal of Contingencies and Crisis Management, 29*, 99-103. https://doi.org/ 10.1111/1468-5973.12328

Kankanamge, N., Yigitcanlar, T., Goonetilleke, A., & Kamruzzaman, M. (2019). Can volunteer crowdsourcing reduce disaster risk? A systematic review of the literature. In *International Journal of Disaster Risk Reduction* (Vol. 35). Elsevier Ltd. https://doi.org/10.1016/j.ijdrr.2019.101097

Kapucu, N. (2012). Disaster resilience and adaptive capacity in Central Florida, US, and in Eastern Marmara Region, Turkey. *Journal of Comparative Policy Analysis, 14*(3), 202-216. https://doi.org/10.1080/13876988.2012.687620

Kapucu, N., Arslan, T., & Demiroz, F. (2010). Collaborative emergency management and national emergency management network. *Disaster Prevention and Management, 19*(4), 452-468. https://doi.org/ 10.1108/09653561011070376

Keating, A., Campbell, K., Mechler, R., Magnuszewski, P., Mochizuki, J., Liu, W., . . . McQuistan, C. (2017). Disaster resilience: what it is and how it can engender a meaningful change in development policy. *Development Policy Review, 35*(1), 65-91. https://doi.org/10.1111/dpr.12201

Khan, A., Rana, I., & Nawaz, A. (2020). Gender-based approach for assessing risk perception in a multi-hazard environment: A study of high schools of Gilgit, Pakistan. *International Journal of Disaster Risk Reduction, 44*. https://doi.org/10.1016/j.ijdrr.2019.101427

Khan, M., Johar, F., & Baba, A. (2017). Disaster management risk perception of local communities. *Jurnal Kemanusiaan*, 87-94. http://eprints.utm.my/id/eprint/80337/1/FoziahJohar2017_DisasterManagementRiskPerception.pdf

Kuhlicke, C. (2013). Resilience: a capacity and a myth: findings from an in-depth case study in disaster management research. *Natural Hazards, 61*, 61-76. https://doi.org/10.1007/s11069-010-9646-y

Kuhlicke, C., Masson, T., Kienzler, S., Seig, T., Theiken, A., & Kreibich, H. (2020). Multiple Flood Experiences and Social Resilience: Findings from Three Surveys on Households and Companies Exposed to the 2013 Flood in Germany. *Weather, Climate, and Society, 12*(1), 63-88. https://doi.org/ 10.1175/WCAS-D-18-0069.1

Kwan, C., & Walsh, C. A. (2017). Seniors' disaster resilience: A scoping review of the literature. *International Journal of Disaster Risk Reduction, 25*, 259-273. http://dx.doi.org/10.1016/j.ijdrr.2017.09.010

LaCroix, K. & Gifford, R. (2017). Psychological barriers to energy conservation behavior: The role of world views and climate change risk perception. *Environment and Behavior, 50*(7), 749-780. https://doi.org/o0r.g1/107.171/0770/10301931961561571771155296

Lai, C., Liao, P., Chen, S., Wang, Y., Cheng, C., & Wu, C. (2021). Risk perception and adaptation of climate change: An assessment of community resilience in Rural Taiwan. *Sustainability, 13*(3651). https://doi.org/10.3390/su13073651

Lechowska, E. (2018). What determines flood risk perception? A review of factors of flood risk perception and relations between its basic elements. *Natural Hazards, 94*, 1341-1366. https://doi.org/10.1007/s11069-018-3480-z

Lee, D. (2019). Local government's disaster management capacity and disaster resilience. *Local Government Studies, 45*(6), 803-826. https://doi.org/10.1080/03003930.2019.1653284

Lemke, T. (2016). *Foucault, Governmentality, and Critique.* New York: Routledge Publishing.

Lightfoot, E., Lesen, A., & Ferreira, R. (2020). Gender and resilience in Gulf Coast communities: Risk and protective factors following a technological disaster. *International Journal of Disaster Risk Reduction, 50*. https://doi.org/10.1016/j.ijdrr.2020.101716

Lloyd, A. and Hicks, A., (2021). Contextualising risk: the unfolding information work and practices of people during the COVID-19 pandemic. *Journal of Documentation*. Pp. 1-26

Lucini, B. (2014). Chapter 3: What is resilience? The state of the art. In B. Lucini, *Disaster Resilience from a Sociological Perspective: Humanitarian Solutions in the 21st Century* (pp. 31-53). Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-04738-6_3

Lupton, D. (2013), *Risk*, London: Routledge. pp. 1-280

Mabon, L. (2019). Enhancing post-disaster resilience by 'building back greener': Evaluating the contribution of nature-based solutions to recovery planning in Futaba County, Fukushima Prefecture, Japan. *Landscape and Urban Planning, 187*, 105-118. https://doi.org/10.1016/j.landurbplan.2019.03.013

MacAskill, K., & Guthrie, P. (2014). Multiple interpretations of resilience in disaster risk management. *4th International Conference on Building Resilience, Building Resilience 2014, 8-10 September 2014* (pp. 667-674). Salford Quays, United Kingdon: Procedia Economics and Finance. https://doi.org/10.1016/S2212-5671(14)00989-7

Macias, T. (2016). Environmental risk perception among racial and ethnic groups in the United States. *Ethnicities, 16*(1), 111-129. https://doi.org/ 10.1177/1468796815575382

Macrae, C., & Wiig, S. (2019). Resilience: From Practice to Theory and Back Again. In S. Wiig, & B. Fahlbruch, *Exploring Resilience: A Scientific Journey from Practice to Theory.* Springer Open. https://doi.org/10.1007/978-3-030-03189-3_15

Mañez, M., Carmona, M., Haro, D., & Hanger, S. (2016). *Risk perception. In: Novel Multi-Sector Partnerships in Disaster Risk Management. Results of the ENHANCE project*. Eds. Aerts, Jeroen & Mysiak, Jaroslav, pp. 51-67 Brussels, Belgium: EU FP7 project ENHANCE. pp. 52-66.

Manyena, B., Machingura, F., & O'Keefe, P. (2019). Disaster Resilience Integrated Framework for Transformation (DRIFT): A new approach to theorising and operationalising resilience. *World Development, 123*. https://doi.org/10.1016/j.worlddev.2019.06.011

Manyena, S. (2006). The concept of resilience revisited. *Disasters, 30*(4), 433-450. https://doi.org/10.1111/j.0361-3666.2006.00331.x

Marchezini, V. (2019). The power of localism during the long-term disaster recovery process. *Disaster Prevention and Management An International Journal, 28*, 143–152. https://doi.org/10.1108/DPM-05-2018-0150

Margolis H. (1996) Dealing with Risk: Why the Public and the Experts Disagree on Environmental Issues. Chicago: University of Chicago Press.

Marshall, T. (2020). Risk perception and safety culture: Tools for improving the implementation of disaster risk reduction strategies. *International Journal of Disaster Risk Reduction, 47*. https://doi.org/10.1016/j.ijdrr.2020.101557

Martin, W., Martin, I., & Kent, B. (2009). The role of risk perceptions in the risk mitigation process: The case of wildfire in high risk communities. *Journal of Environmental Management, 91*, 489-498. https://doi.org/10.1016/j.jenvman.2009.09.007

Mathbor, G. (2007). Enhancement of community preparedness for natural disasters: The role of social work in building social capital for sustainable disaster relief and management. *International Social Work, 50*(3), 357-369. https://doi.org/10.1177/0020872807076049

Matyas, D., & Pelling, M. (2014). Positioning resilience for 2015: the role of resistance, incremental adjustment and transformation in disaster risk management policy. *Disasters, 39*(S1), S1-S18. https://doi.org/10.1111/disa.12107

McEntire, D., Fuller, C., Johnston, C., & Weber, R. (2002). A Comparison of Disaster Paradigms: The Search for a Holistic Policy Guide. *Public Administration Review, 62*(3). https://doi.org/10.1111/1540-6210.00178

Meerow, S., Newell, J. P. & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011

Meijer, S., Hall, J., Erdelyiova, R., Sabanes, M., Onencan, A., & Junge, K. (2020). *D2.6: Analysis of different approaches to resilience also outside EU.* RESILOC: Resilient Europe and Societies by Innovating Local Communities.

Melkunaite, I. (Ed.). (2016). *IMPROVER – Improved Risk Evaluation and Implementation of Resilience Concepts to Critical Infrastructure. D1.1 International Survey.*

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., van der Leeuw, S., Rockström, J., Hinkel, J., Downing, T., Folke, C. & Nelson, D. (2010). Resilience and Vulnerability: Complementary or Conflicting Concepts? *Ecology and Society*, *15*(3). https://doi.org/10.5751/ES-03378-150311

Milman, A. & Short, A. (2008). Incorporating resilience into sustainability indicators: an example for the urban water sector. *Global Environmental Change, 18*(4), pp.758–767.

Morsut, C., Kuran, C., Kruke, B., Orru, K., & Hansson, S. (2021). Linking resilience, vulnerability, social capital and risk awareness for crisis and disaster research. *Journal of Contingencies and Crisis Management*, 1-11.

Morsut, C., Kuran, C., Kruke, B., Schobert, M., Gabel, F., Kruger, M., . . . Bairampa, E. (2020). *D1.2: Final report of the unified theoretical framework on the concepts of risk awareness, social capital, vulnerability, resilience and their interdependencies.* BuildERS EU H2020.

National Research Council. (2012). *Disaster Resilience: A National Imperative*. Washington, DC: The National Academies Press.https://doi.org/10.17226/13457.

O'Keefe, P., Westgate, K. & Wisner, B. (1976). Taking the naturalness out of natural disasters. *Nature*, *260*(5552), 566–567. https://doi.org/10.1038/260566a0

Oltedal, S., & Rundmo, T. (2007). Using cluster analysis to test the cultural theory of risk perception. https://doi.org/10.1016/j.trf.2006.10.003

Oltedal, S., Moen, B., Klempe, H., & Rundmo, T. (2004). *Explaining risk perception: An evaluation of cultural theory.* Norwegian Research Council Risk and Safety in Transportation Program.st

Paek, H., & Hove, T. (2017). *Risk Perception and Risk Characteristics.* Oxford Research Encyclopedias: Communication. https://doi.org/10.1093/acrefore/9780190228613.013.283

Parsons, M., Glavac, S., Hastings, P., Marshall, G., McGregor, J., McNeill, J., . . . Stayner, R. (2016). Top-down assessment of disaster resilience: A conceptual framework using coping and adaptive capacities. *International Journal of Disaster Risk Reduction, 19*, 1-11. http://dx.doi.org/10.1016/j.ijdrr.2016.07.005

Pasteur, K. (2011). *From Vulnerability to Resilience*. Reading: Practical Action Publishing. http://repo.floodalliance.net/jspui/bitstream/44111/1443/1/From%20Vulnerability%20to%20Resilience,%20a%20framework%20for%20analysis%20and%20action%20to%20build%20community%20resilience.pdf

Patel, M. M., Saltzman, L., Y., Ferriera, R. T., & Lesen, A. E. (2018). Resilience: Examining the impacts of the Deepwater Horizon Oil Spill on the Guld Coast Vietnamese American community. S*ocial Sciences, 7*(203). https://doi.org/ 10.3390/socsci7100203

Perilla, J. L., Norris, F. H., & LaVizzo, E. A. (2002). Ethnicity, culture, and disaster response: Indentifying and explaining ethnic differences in PTSD six months after Hurricane Andrew. *Journal of Social and Clinical Psychology, 21*(1), 20-45. https://doi.org/10.1521/jscp.21.1.20.22404

PreventionWeb. (2013). Netherlands: Safety Regions Act [WWW Document]. Dutch Minist. Secur. Justice. Accessible from: https://www.preventionweb.net/publication/netherlands-safety-regions-act

Rühlemann, A., & Jordan, J. (2021). Risk perception and culture: implications for vulnerability and adaptation to climate change. *Disasters, 45*(2), 424-452. https://doi.org/10.1111/disa.12429

Radianti, J. (2016). *SMR – Smart Mature Resilience. D1.2 Survey Report on EU-Sectoral Approaches*. http://smr-project.eu/fileadmin/user_upload/Documents/Resources/WP_1/SMR_D1_2_EU-SECTORAL-APPROACH_Revisedv01.pdf

Raikes, J., Smith, T., Jacobson, C., & Baldwin, C. (2019). Pre-disaster planning and preparedness for floods and droughts: A systematic review. *International Journal of Disaster Risk Reduction, 38*. https://doi.org/10.1016/j.ijdrr.2019.101207

Rana, I., Jamshed, A., Younas, Z., & Bhatti, S. (2020). Characterizing flood risk perception in urban communities of Pakistan. *International Journal of Disaster Risk Reduction, 46*. https://doi.org/10.1016/j.ijdrr.2020.101624

Rankin, A. & Bång, M. (2016). *SMR – Smart Mature Resilience. D1.1 Survey Report on Worldwide Approaches*. http://smr-project.eu/fileadmin/user_upload/Documents/Resources/WP_1/D1.1.SMR_Final.pdf

Renn, O., & Graham, P. (2005). *Risk Governance: Towards an Integrative Report.* Interntional Risk Governance Council. https://irgc.org/wp-content/uploads/2018/09/IRGC_WP_No_1_Risk_Governance__reprinted_version_3.pdf

Ricci, T., Nave, R., & Barberi, F. (2013). Vesuvio civil protection exercise MESIMEX: survey on volcanic risk perception. *Annals of Geophysics, 56*(4), S0452-6. https://doi.org/10.4401/ag-6458

Rice, R., & Jahn, J. (2020). Disaster resilience as communication practice: remembering and forgetting lessons from past disasters through practices that prepare for the next one. *Journal of Applied Communication Research, 48*(1), 136-155. https://doi.org/10.1080/00909882.2019.1704830

Rigaud, E. (2017). *D34.1 – Conceptual Approach to resilience of local governments.* DRIVER: Driving Innovation in Crisis Management for European Resilience.

RiskPACC. (2020). *RiskPACC: Integrating risk perception and action to enhance civil protection-citizen interaction,* Research and Innovation Grant Agreement Number 101019707

RiskPACC DoA. (2020) ANNEX 1. Research and Innovation action number 101019707. Brussels, European Commision.

Rodgers, M., & Pearce, J. (2013). Chapter 6: Risk communication, risk perception and behavior as foundations of effective National Security practices. In B. Akjar, & S. Yates, *Strategic Intelligence Management: National Security Imperatives and Information and Communication Technologies* (pp. 66-74). Butterworth-Heinemann.

Ropeik, D. (2012). The Perception Gap: Recognizing and managing the risks that arise when we get risk wrong. *Food and Chemical Toxicology, 50*(5) 1222-25

Sahar, E., Leire, L., Marcos, B., & Hernantes, J. (2021). *Deliverable 2.1 – Expectations and needs to improve societal resilience.* ENGAGE.

Samamdipour, E., Seyedin, H., & Ravaghi, H. (2019). Roles, responsibilities, and strategy for enhancing disaster risk perception: A quantitative study. *Journal of Education and Health Promotion, 8*(9). https://doi.org/ 10.4103/jehp.jehp_185_18

Sattar, M., & Cheung, K. (2019). Tropical cyclone risk perception and risk reduction analysis for coastal Bangladesh: Household and expert perspectives. *International Journal of Disaster Risk Reduction, 41*. https://doi.org/10.1016/j.ijdrr.2019.101283

Schelfaut, K., Pannemans, B., van der Craats, I., Krywkow, J., Mysiak, J., & Cools, J. (2011). Bringing flood resilience into practice: the FREEMAN project. *Environmental Science and Policy, 14*, 825-833. https://doi.org/10.1016/j.envsci.2011.02.009

Schipper, E., & Langston, L. (2015). *A comparative overview of resilience measurement frameworks: Analysing indicators and approaches.* Overseas Development Institute. https://cdn.odi.org/media/documents/9754.pdf

Scolobig, A., De Marchi, B., & Borga, M. (2012). The missing link between flood risk awareness and preparedness: finding from case studies in an Alpine Region. *Natural Hazards, 63*, 499-520. https://doi.org/10.1007/s11069-012-0161-1

Sen, A. (Ed.). (1981). *Poverty and Famines An Essay on Entitlement and Deprivation$ Users without a subscription are not able to see the full content. Poverty and Famines: An Essay on Entitlement and Deprivation*. Clarendon Press.

Shreve, C., Fordham, M., Anson, S., Watson, H., Hagen, K., Wadhwa, K., . . . Karanci, N. (2014). *Report on risk perception and preparedness.* TACTIC Project.

Sjoberg, L. (1999). Risk perception by the public and by experts: A dilemma in risk management. *Human Ecology Review, 6*(2), 1-9. https://www.jstor.org/stable/24707052

Sjoberg, L. (2002). The allegedly simple structure of experts' risk perception: An urban legend in risk research. *Science, Technology, and Human Values, 27*(4), 443-459. https://doi.org/10.1177/016224302236176

Slovic, P. (1987). Perception of Risk. *Science, 236*, 280-285. https://doi.org/10.1126/science.356350

Son, C., Sasangohar, F., Neville, T., Camille Peres, S., & Moon, J. (2020). Investigating resilience in emergency management: An integrative review of literature. *Applied Ergonomics, 87*. https://doi.org/10.1016/j.apergo.2020.103114

Song, Z., Zhang, H., & Dolan, C. (2020). Promoting Disaster Resilience: Operation Mechanisms and Self-Organizing Processes of Crowdsourcing. *Sustainability, 12*(1862). https://doi.org/10.3390/su12051862

Stolero, N., Bodas, M., Peleg, K., & Adini, B. (2021). *D1.3: Communication, Social Media, and Societal Resilience Among Citizens.* ENGAGE.

Sudmeier-Rieux, K. (2014). Resilience – an emerging paradigm of danger or of hope? *Disaster Prevention and Management, 23*(1), 67-80. https://doi.org/10.1108/DPM-12-2012-0143

Sullivan-Wiley, K., & Gianotti, A. (2017). Risk perception in a multi-hazard environment. *World Development, 97*, 138-152. https://doi.org/10.1016/j.worlddev.2017.04.002

Tkacz, N., da Mata Martins, M., de Albuquerque, J.P., Horita, F., & Dolif Neto, G.(2021). Data diaries: A situated approach to the study of data. *Big Data and Society,* 1–16.

Tsai, M. H., Chan, H. Y., Chan, Y. L., Shen, H. K., Lin, P. Y., & Hsu, C. W. (2021). A chatbot system to support mine safety procedures during natural disasters. *Sustainability (Switzerland)*, *13*(2), 1–19. https://doi.org/10.3390/su13020654

Tuohy, R. & Stephens, C. (2012). Older adults' narratives about flood disaster: resilience, coherence, and personal identity. Journal of Aging Studies, 26, 26-34. https://doi.org/ 10.1016/j.jaging.2011.06.002

Ullah, R., Shivakoti, G., & Ali, G. (2015). Factors effecting farmers' risk attitude and risk perceptions: The case of Khyber Pakhtunkhwa, Pakistan. *International Journal of Disaster Risk Reduction, 13*, 151-157. https://doi.org/ 10.1016/j.ijdrr.2015.05.005

UN[a] (United Nations). *Sustainable Development Goals*. Retrievable at https://www.un.org/sustainabledevelopment/

UN[b] (United Nations). *Goal 1: End poverty in all its forms everywhere*. Retrievable at https://www.un.org/sustainabledevelopment/poverty/

UN[d] (United Nations). *Goal 2: Zero Hunger*. Retrievable at https://www.un.org/sustainabledevelopment/hunger/

UN[g] (United Nations). *Goal 5: Achieve gender equality and empower all women and girls*. Retrievable at https://www.un.org/sustainabledevelopment/gender-equality/

UNISDR. (2005). *Hyogo Framework for Action 2005-2015: ISDR International Strategy for Disaster Reduction International Strategy for Disaster Reduction.* United Nations.

UNISDR. (2007). *Words Into Action: A Guide for Implementing the Hyogo Framework*. United Nations.

UNISDR. (2014). *Progress and challenges in disaster risk reduction: a contribution towards the development of policy indicators for the post-2015 framework for disaster risk reduction.* https://www.undrr.org/publication/progress-and-challenges-disaster-risk-reduction-contribution-towards-development-policy

UNISDR (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030*, available via: https://www.unisdr.org/we/inform/publications/43291

van Mamen, S. (2014). Hazard and risk perception at Turrialba volcano (Costa Rica); implications for disaster risk management. *Applied Geography, 50*, 63-73. https://doi.org/10.1016/j.apgeog.2014.02.004

Vollmer, M. & Walther, G. (2018). How to Demarcate Resilience? A Reflection on Reviews in Disaster Resilience Research. En A. Fekete & F. Fiedrich (Eds.), *The Urban Book Series. Urban disaster resilience and security: Addressing risks in societies* (Vol. 38, pp. 413–427). Springer International Publishing; Springer. https://doi.org/10.1007/978-3-319-68606-6_24

Vollmer, M., Walther, G., Jovanović, A., Schmid, N., Øien, K., Grøtan, T. O., Choudhary, A., Kokejl, R., Buhr, K., Karlsson, A. & Egloff, R. (2016). *SmartResilience D1.1: Initial Framework for Resilience Assessment*

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The Risk Perception Paradox—Implications for Governance and Communication of Natural Hazards. *Risk Analysis, 33*(6), 1049-1065.

Waugh, W. (2003). Terrorism, Homeland Security and the National Emergency Management Network. *Public Organization Review: A Global Journal, 3*, 373-385.

Waugh, W., & Streib, G. (2006). Collaboration and leadership for effective emergency management. *Public Administration Review*.

Weichselgartner, J., & Kelman, I. (2015). Geographies of resilience: Challenges and opportunities of a descriptive concept. *Progress in Human Geography, 39*(3), 249-267. https://doi.org/10.1177/0309132513518834

Wilkinson , C. (2012). Urban Resilience: What Does it Mean in Planning Practice? *Planning, Theory, and Practice, 13*(2), 299-333.

Wilson, R.S., Zwickle, A. and Walpole, H., (2019). Developing a broadly applicable measure of risk perception. *Risk Analysis*, *39*(4), pp.777-791.

Wisner, B., Brenes, A. & Marchezini, V. (2020). *Non-Governmental Organizations and Natural Hazard Governance in Latin America and the Caribbean*, in: : : Oxford Research Encyclopedia of Natural Hazard Science. Oxford University Press, Oxford, UK, pp. 1–40. https://doi.org/10.1093/acrefore/9780199389407.013.333

Woltjer, R., Nevhage, B., Nilsson, S., Oskarsson, P., Hermelin, J., Trnka, J., . . . Cedrini, V. (2015). *D1.1 – Consolidation of resilience concepts and practices for crisis management.* DARWIN. https://h2020darwin.eu/wp-content/uploads/2017/10/DARWIN_D1.1_Consolidate_resilience_concepts_and_practices_for_crisis_management.pdf

Xu, D., Peng, L., Su, C., Liu, S., Wang, X., & Chen, T. (2016). Influences of mass monitoring and mass prevention systems on peasant households' disaster risk perception in the landslide threatened Three Gorges Reservoir area, China. *Habitat International, 58*, 23-33. https://doi.org/10.1016/j.habitatint.2016.09.003

Xu, W., Xiang, L., Proverbs, D., & Xiong, S. (2020). The Influence of COVID-19 on Community Disaster Resilience. *International Journal of Environmental Research and Public Health, 18*(88). https://doi.org/10.3390/ijerph18010088

Xue, K., Gou, S., Liu, S., & Xu, D. (2021). Social Networks, Trust, and Disaster-Risk Perceptions of Rural Residents in a Multi-Disaster Environment: Evidence from Sichuan, China. *International Journal of Environmental Research and Public Health, 18*(2106). https://doi.org/10.3390/ijerph18042106

Yuan, F., Li, M., Liu, R., Zhai, W., & Qi, B. (2021). Social media for enhanced understanding of disaster resilience during Hurricane Florence. *International Journal of Information Management, 57*. https://doi.org/10.1016/j.ijinfomgt.2020.102289

Zinn, J. (2009), Introduction: The contribution of sociology to the discourse on risk and Uncertainty, In: Zinn, J. (Ed.) *Social theories of risk and uncertainty: An introduction*. New York: John Wiley & Sons, pp.1-17

Zobel, C. W. (2011). Representing the multidimensional nature of disaster resilience. *Proceedings of the 8th International ISCRAM Conference – Lisbon, Portugal, May 2011.* http://idl.iscram.org/files/zobel/2011/1165_Zobel2011.pdf

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FIGURE 7: THE RISKPACC CONSORTIUM