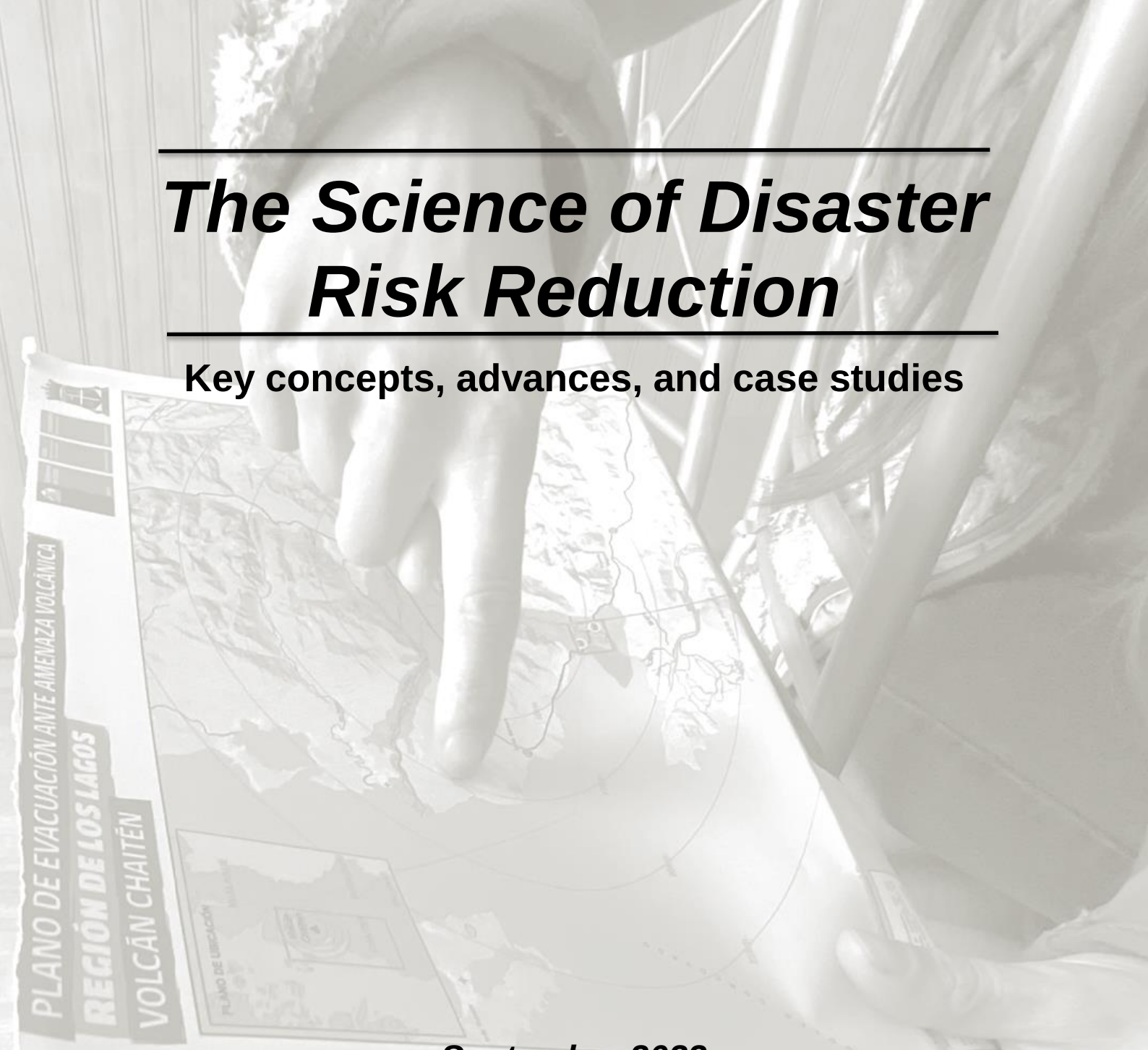
The Science of Disaster Risk Reduction

Key concepts, advances, and case studies



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Cover Image: A resident of Chaitén, Chile, explains to a researcher how she understands the evacuation map of her town in case of a volcanic eruption (November 2021). Courtesy J. Morin/ERC Imagine Project.

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ADPC	Asian Disaster Prevention Centre
CBDRR	Community Based Disaster Risk Reduction
CCA	Climate Change Adaptation
DRR	Disaster Risk Reduction
EWS	Early Warning System
FbA	Forecast-based early Action
IPCC	The Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
PAR	Pressure and Release Model
UNDP	United Nations Development Program
VCA	Vulnerability and Capacity Assessment
WFP	World Food Program (United Nations)

Executive summary

This report intends to summarize foundational and contemporary social science disaster risk reduction (DRR) theory, international best practices and guidance for practical DRR. It will also present case studies of relevance for academics, policymakers, and emergency managers involved in the study and management of disaster risk in the Democratic People's Republic of Korea (DPRK).

Drawing from (and providing) a range of academic and institutional resources, the report does not aim to be exhaustive, but rather aims to illustrate some of the key aspects of DRR. It is intended to highlight certain points in order to engage in collaboration that could benefit both the DPRK and the wider scientific community, and form a foundation for future collaborations that could lead to sound theoretical frameworks on DRR.

In particular, it stresses the importance of a comprehensive DRR framework that accounts for the most vulnerable groups – including children - while combining local knowledge and technologies to effectively address risk.

Introduction

Despite decades of efforts to address disaster risk, the impact of disasters around the world continues to increase[1]. The narrow technical approaches of the past - that sought to engineer people out of disasters - have not proved effective, partly because these approaches overlooked the inherently social dimensions of vulnerability. As a result, it is increasingly appreciated that to address disasters, we need to consider the highly complex, interconnected, and holistic nature of disasters. Social sciences can and must make a critical contribution to this effort. The recognition that disasters are not natural and the rejection of the 'natural disaster' misnomer was introduced into the scientific literature over 40 years ago (O'Keefe et al., 1976), and the concepts behind it go back further (Chmutina & Von Meding, 2019). While there has been significant progress made from the social sciences on the topic of disaster risk reduction (DRR) this has not necessarily translated into actions or policies.

Similarly, the notion of "natural risk", extensively used until recently, has progressively become controversial and is now commonly rejected by the scientific community, who instead recognizes that the notion of risk is intrinsically linked to the way human beings develop their societies. While "natural hazards" is still a valid term, climate change might lead us to question the natural origin of hazards more frequently in the future. Critically, risk is social by definition and prominently driven by social factors and processes, and thus social sciences should have a central voice in providing solutions to understand and reduce disasters.

This report presents a concise overview and summary of the social science of DRR and disaster management. It is accompanied by an interconnected database of papers, reports, and resources from international policy, programming, and academia. These resources detail the development and progress that has been achieved to date (both theoretically and in practice), ultimately presenting some of the most critical issues and innovative concepts in DRR today. Throughout this document, practical case studies are presented in separate boxes to contextualise the theoretical discussions.

Therefore, this report acts as a synthesis of current theory and international best practice, as well as foundational social science DRR theory, and guidance for DRR. It is intended to act as the start of a conversion about the social science of disasters. A PDF database of the full versions of the resources and papers that are cited and discussed below is available on request. This collection of literature represents a steppingstone to deeper engagement with these topics.

[1] A synthesis report of the cost of disasters the past two decades is provided by CRED and UNDR (2020).

While this report does not detail the specifics of DRR in the DPRK, the topics chosen were selected firstly for their importance to the field of DRR and secondly for their relevance to the DPRK context and the complex combination of hazards it faces. This is accompanied by a range of case studies from different hazards and geographical contexts. We have also strived to include references of relevance to the DRR context specific to Asia. The choice of topics was also made in line with the policy goals set out in the DPRK National Strategy for Disaster Risk Reduction (2019-2030) so that the information, theory, and case studies provided in this report might contribute to national DRR strategy and programs.

The target audience of this report is scientists, policymakers, experts, academics, and specialists involved in DRR in the DPRK. It is also intended to extend to those who have a professional relation to the topic or who have an interest, such as those working for national ministries, committees, and strategists. This scope is deliberately broad in order to mirror the call for the 'mainstreaming' (the widespread inclusion into other domains) of DRR in the DPRK national strategy. Consequently, no previous understanding of DRR is assumed or required, and this report provides background definitions and context in order to be easily understandable to as wide a relevant audience as possible.

The report is divided into ten key sections that are intended to build a picture of the social science of disasters, beginning with definitions of key terms (section 1) and a short history of DRR paradigms over time (section 2). The report then presents six key theories (section 3); this is a small subset of the theories that exist, but these six are important and influential concepts that converge on our current best understanding of disasters. The following five sections present key themes of disaster social science including:

- Community-based disaster risk reduction: putting communities at the centre *(section 4)*,
- Inclusive disaster risk reduction *(section 5)*,
- Assessing and addressing vulnerability and resilience *(section 6)*,
- Integration of climate change adaptation in DRR *(section 7)*,
- Communicating to and with communities *(section 8)*.

These are presented in this order to first cover the main theoretical directions of the field (towards community-based and inclusive approaches) before setting out the practical approaches and methods to achieve this.

The report then provides brief conclusions with a discussion of potential for future work (section 9) and collaborations on the social science of disasters in DPRK and finally the report presents a list of the references included, as well as further resources and references sorted by topic (section 10). A summary of the key points presented in sections five to eight are delivered in bullet-points at the end of each chapter and key materials are also highlighted throughout the report in **bold.**

1. Key definitions

1.1 Disaster

The United Nations Office for Disaster Risk Reduction (UNDRR)[2], defines a disaster as *"a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts"*. The debates around this definition are considerable, but the core concept of most definitions is that disasters are produced by a combination of hazard and vulnerability that results in a reduction of the ability of people to cope.

1.2 Hazard

Hazards can be defined as *"a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation"*. It is important to recognise that this definition specifies that hazards may emerge from natural or human sources, and these are dynamic over both space and time (Kelman, 2018b). Hazards are often characterized by categories of origin (geophysical, meteorological, etc.), intensity and/or magnitude, duration, and frequency or probability of occurrence.

1.3 Vulnerability

Many definitions exist for vulnerability and interpretations of the concept vary (for example see Manyena, 2006; Weichselgartner, 2001). One of the most popular definitions refers to the properties or behaviour of a person, group or society that produces potential for harm or damage as a result of hazards (Wisner et al., 2003). The UNDRR defines vulnerability as *"the 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"*. This definition is a considerable improvement on early definitions that suggested vulnerability was both calculable and quantifiable, contrary to foundational disaster studies literature that showed vulnerability has many qualitative, intangible, and chronic elements (Hewitt, 1983; Lewis, 1979).

[2] The most up-to-date UNDRR definitions are only available online but a technical review of the terminology is included in the references as UNDRR (2015), and also see Kelman (2018b) for an academic discussion of disaster terminology.

1.4 Resilience

The UNDRR defines resilience as "*the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management*". Instilling and ensuring resilience has become a predominant priority in disaster management policies around the world, partly because of the perceived positivity of building up the capacity of resilience rather than addressing vulnerability. Yet, resilience as a concept is identified as often being problematic, since there is no consensus on its exact definition or how to assess resilience. The idea of resilience is also often applied in a top-down way (often by government or people who are external to the community; see section 3.4) since its use as a goal and the definition of success of that goal are not often shared by the communities (Cannon & Müller-Mahn, 2010). Both resilience and vulnerability can exist simultaneously and equally, it should not be assumed that resilience is the inverse property of vulnerability, as resilience differs in its focus on addressing the coping capacity and capabilities in the ways people deal with disasters (Gaillard, 2010).

1.5 Disaster Risk Reduction (DRR)

UNDRR defines DRR as aiming to "*preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development*". There are several interrelated (but differentiated) terms to DRR that were previously positioned alongside DRR within the umbrella term of disaster management. This included disaster mitigation, disaster prevention, disaster preparedness and disaster risk management (DRM), as well as specific terms for post disaster work including disaster response and relief, and emergency management. DRR has since separated and become disassociated with disaster management, while DRM has been adopted as the operational component of DRR (which is the orientating policy objective of Sendai Framework for Disaster Risk Reduction 2015–2030). DRR is the more widely used both in a policy and program contexts and thus is adopted here.

2. The development of disaster risk reduction paradigms over time

This section aims to summarise the progression of DRR and disaster management over time and across various paradigms. The definitions and use of the terms defined above have undergone a complex development and these are not static concepts. Their various uses tell an important story regarding how the causes of disasters have been approached over time and the progress made (and still to make) regarding the management of disasters and disaster risk.

The oldest and most widely applied conceptualisation of the cause of disasters is the "extreme" paradigm. It is based on a hazard-centred approach that sees hazards as the primary (or sole) cause of disasters. In the early 20th century, technocratic approaches were dominant in disaster management in the global North. This also presented disasters as straightforward technical challenges that could be addressed or controlled by engineering, structural measures or by monitoring hazards. An assumption behind this approach was that scientific and technical advances could engineer countries out of disaster entirely. This approach was shown not to be a complete solution as the impacts and number of disasters continued to rise in the 20th century. Yet, while effectively disproved, the assumption of technology or wealth being at the heart of solutions to disasters is largely still present.

Within this conceptualization of disaster, the vulnerability of people is explained by a misperception of threats, which are seen as external to societies (Gilbert, 2007). Individuals with the highest perception of risk are seen to be the best prepared to face it (Kates, 1971). Understanding risk perception is therefore essential for scientists trying to understand the behaviour of populations in the face of hazards. This approach is still strongly embedded in risk management policies (Vinet, 2017). However, there is growing evidence that having a high-risk perception is not necessarily a good predictor of whether someone will take action in the event of a disaster (Wachinger et al., 2013).

The extreme paradigm is challenged by another paradigm, described as 'radical' (Gaillard, 2019), according to which disasters simply prolong pre-existing everyday emergencies for victims (Dibben & Chester, 1999; Gaillard, 2019; Gaillard et al., 2010; Hewitt, 1983; Maskrey, 1989; O'Keefe et al., 1976; Wisner et al., 2003; Wisner & Luce, 1993). This approach recognises that disasters are the result of underlying structural constraints (social, economic, political, historical, cultural, and environmental), which disasters tend to reveal and accentuate. The degree of development in the places where disasters strike is thus one of the root causes of disasters, and it explains their frequency, scale, and territorial distribution. In this paradigm, the responses of individuals to

threats are induced by their state of vulnerability. Reducing risk and improving responses therefore requires reducing vulnerabilities and increasing local capacity through development projects.

Assuming that risk cannot be entirely eliminated, a third paradigm, 'disaster preparedness', emerged in the 2000s (Metzger et al., 2014). It emphasises the fundamental importance of crisis management preparedness in risk management, based on the adoption of operational tools such as early warning systems, emergency planning, or simulation exercises (Revet, 2020; Revet & Langumier, 2015). The concept of resilience is then imposed, emphasising the capacities of societies to cope with disasters. The use and operational relevance of this notion of resilience is the subject of much debate (Reghezza-Zitt et al., 2012). In risk management programmes, prevention activities are gradually being replaced by crisis preparedness activities (NRC, 2006).

However, **these three paradigms are not contradictory: the whole point of DRR is to equip society to cope with disasters** (capacity building as a means of reducing vulnerability and vice versa). Risk management, described above, is part of this, as is effective crisis management.

3. Key theories

In addition to the key terms defined above, several concepts are critical to understanding modern DRR and have played a considerable role in its development over time. This section will highlight some of these concepts (in approximate chronological order) and briefly provide a summary of their development, use, and critique.

3.1 The risk equation

Within DRR efforts, it is important to define risk, because the term holds different meanings for different groups. One of the early attempts in disaster management was a simple equation stating that risk is the likelihood of an event occurring multiplied by the consequences of that event if it were to happen:

Risk = Likelihood x Consequence

This concept was built on by Blaikie et al. (1994)[3] who argued that the risk of disaster (as opposed to risk more generally) is a compound function of a hazard (natural or otherwise), and the number of people who are exposed, who are characterised by their varying degrees of vulnerability:

Disaster risk = hazard x vulnerability (P. Blaikie et al., 1994)

This simple equation became a highly influential way to think about disaster risk, and was added to and modified over time by various authors (for an overview see Aven, 2012) including adding additional elements and concepts to the equation such as coping capacity:

$$\textit{Disaster risk} = \frac{\textit{hazard x exposure x vulnerability}}{\textit{coping capacity}}$$

While this equation is a simplistic representation of the component parts of a disaster, perhaps its most important contribution has been to highlight and remind us that disaster occurs when *vulnerable* people experience a hazard and suffer severe damage and/or disruption to their livelihood system. Therefore disaster risk can only be adequately addressed if DRR considers vulnerability in all its aspects (including social and cultural), not just hazards (Wisner et al., 2003). Conversely, perhaps the biggest criticism of the use of equations as a way of representing disaster risk is that it implies that the components of these equations are simply knowable and quantifiable, and that the solution to disaster risk is purely a matter of missing knowledge. Social science disaster research aims to correct this view by showing **the chronic, intangible and systemic nature of disaster vulnerability** (Hewitt, 1983). **Vulnerability (and by extension disaster risk) is a result of the decisions,**

[3] This reference is not provided in the literature database attached to this report, instead the second edition updated by Wisner et al. (2003) is provided.

attitudes, values, and activities that form society. These factors are routinely concealed, hidden, or overlooked (both inadvertently and deliberately) in service of certain agendas and priorities. Consequently, **disasters are rarely a simple product of a dearth of knowledge**, and individuals are rarely fully responsible for their own vulnerability. Rather it is more important to ask how knowledge and resources that exist might be most effectively used to reduce hazards and vulnerability. This has led some to use the phase Disaster Risk Creation (DRC) to acknowledge that it is often only through human actions (and inactions) that disasters occur.

3.2 The pressure and release model (PAR)

In their Pressure and Release Model (PAR), Blaikie et al. (1994; then Wisner et al. in a revised edition, 2003) underline the necessity of studying the deep causes of vulnerability to better understand how these are channelled by social and economic mechanisms into unsafe conditions for a population. Those **deep-seated 'root' causes, combined with dynamic pressures (historical, political, institutional, social, economic, cultural, environmental) make it possible for an ordinary event to become a disaster**. In other words, reducing the risk of disaster essentially means making deep structural changes in society that will help address root causes and release the pressures to lead to safer conditions. While allowing a systematic understanding of the progression of vulnerability, the PAR helps to envision solutions to favour the progression of safety.

The PAR applies to any sort of context and hazard, as illustrated by Wisner et al. (2003) with examples from the Irish Potato Famine during the 19th century (see case study 13), flood hazards with an emphasis on Bangladesh, tropical cyclones[4] in Andhra Pradesh in 1977 and in Mozambique in 1979, and earthquake in Mexico City in 1985.

To avoid any confusion, note that PAR also refers to "Participatory Action Research" in the literature on DRR (McCall & Peters-Guarin, 2012). A potential confusion might also arise with the PRA (Participatory Rural Appraisal), which implies similar methods but represents a different specific approach (Chambers, 1994).

[4] Typhoon and hurricane are both regionally specific terms for tropical cyclones, all of which are used in this report for each of their corresponding contexts.

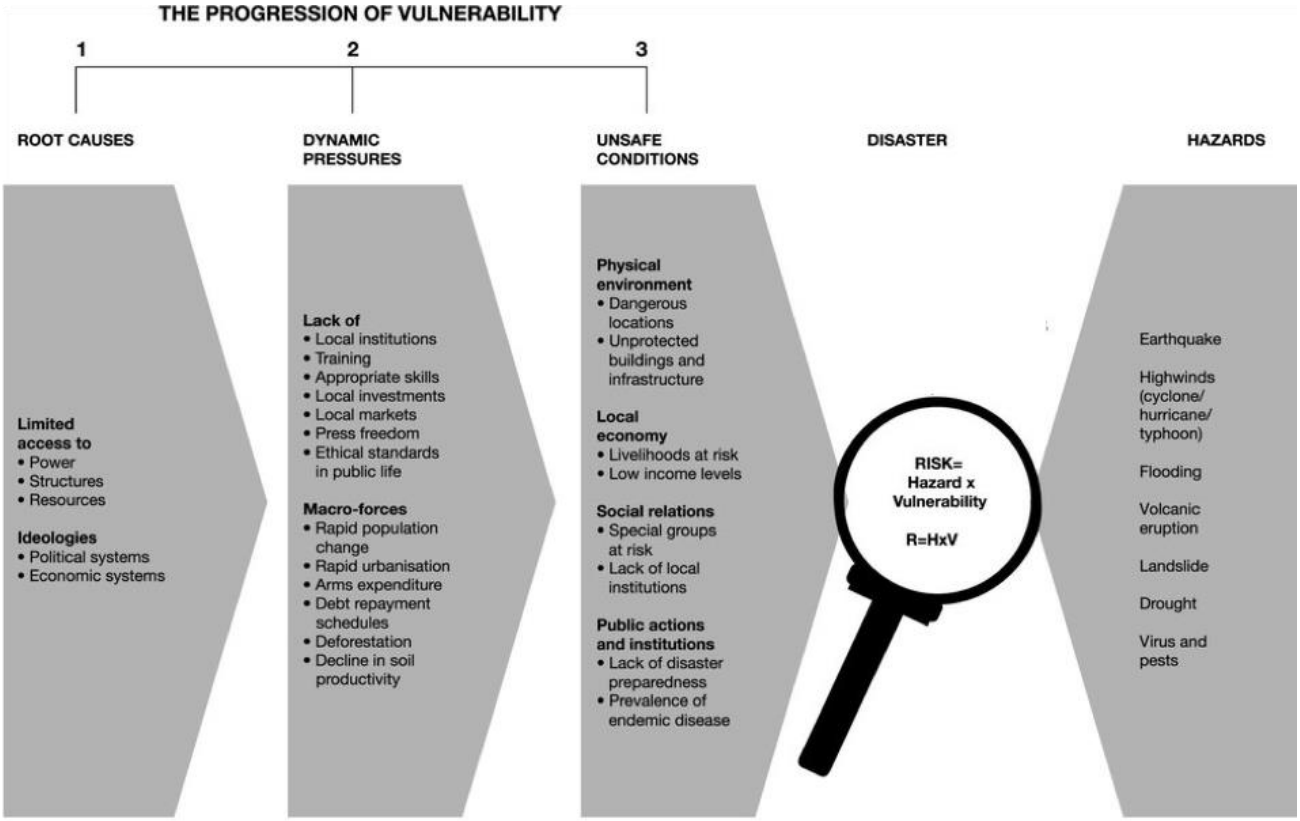

Figure 1: The Pressure and Release Model (from Wisner et al., 2003)

3.3 The disaster cycle

One of the most popular early attempts to discuss how disasters can be better managed involved the development of a concept in the 1970s known as the disaster management cycle (see Figure 2).

This divides the progression of disasters into supposed stages, from the immediate post-disaster response, into the longer-term recovery, followed by mitigation and finally preparation for the next disaster. The disaster cycle has been widely critiqued, mainly for its underlying assumption of an automatic and inevitable return to disaster as an original 'starting' point (Manyena, 2006). The disaster cycle is therefore now widely rejected as an overly simplistic portrayal. Indeed the 'stages' of disasters cannot be so clearly defined and the states of such a cycle are not mutually exclusive or universal. Distinct groups experience disasters differently and there is no collective movement from one clearly defined stage to another. For those people living with highly vulnerable and insecure livelihoods, the response phase is more typical of the continued status to reach acceptable levels to allow them to live sustainably, and indeed their daily life could be characterised as a disaster itself.

Figure 2: The disaster cycle (from Bosher et al. 2021)

In an attempt to address these critiques, a new concept of disasters acting out in helical patterns (Figure 3, Bosher et al., 2021) has been suggested, since there are some repetitive characteristics to the experience of disasters that should be highlighted without necessarily assuming a return to a normal start point.

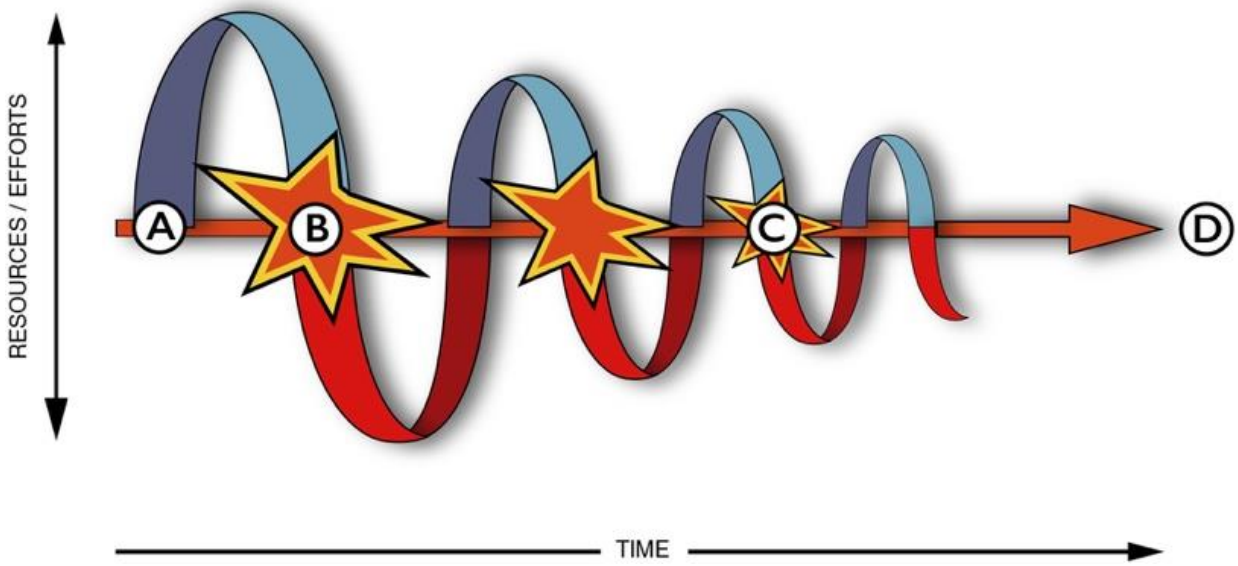

Figure 3: The disaster helix (from Bosher et al. 2021)

Figure 3 portrays a disaster helix and the reduction of disasters over time as a result of successful DRR. Here the blue elements of the figure represent proactive attempts to reduce the impact of disasters (i.e. DRR), that are followed by a disaster (at 'B' in the figure) and the resulting recovery and rehabilitation (in red) that eventually lead into DRR and consequently, the impact of disasters is reduced (at C) which requires fewer resources. The authors recognise that this is a simplistic portrayal and that it portrays a single successful DRR scenario; however, like the other concepts defined above, this can represent the start of a conversation regarding what is important in DRR. This diagram includes and reflects an important and growing area of focus within DRR; the role of *time* and *scale*. **It has increasingly been recognised that all disasters are slow in nature and while hazards (e.g. tropical cyclones) are usually rapid, the vulnerability that turns the hazard into a disaster develops and acts out over very long timescales** (García-Acosta, 2018). In this way, disasters are not events but processes (see Bankoff, 2004 for more discussion on this topic).

3.4 Bottom-up vs top-down DRR

As detailed in section 2, the early paradigms of DRR were fixated with what can be called 'top-down' solutions and approaches. This means that the governance, knowledge, and management for DRR policy and programs were delivered and held from a government, external, or technical level. Communities who received these programs and projects were generally viewed as passive recipients who lacked the necessary skills and knowledge to be involved in DRR decision-making (i.e. communities *were* the problem). In this approach, DRR projects were seen as universally applicable in most situations and did not need to be tailored to the local context. Top-down approaches have been demonstrated to be ineffective for DRR, and **all elements of DRR (from pre-disaster activities such as preparedness and mitigation, to post-disaster responses and recovery) are best achieved when designed, led, and owned from the 'bottom-up', at the local level with community involvement** (Twigg, 1999; Wisner et al., 2003).

There are various other phases associated with bottom-up approaches, such as 'community empowerment' and 'grassroots approaches', as well as 'Community Based Disaster Risk Reduction' (CBDRR), which is detailed further in section 4. The push to ensure bottom-up policies is a central part of the international sustainable development goals. Similarly, the Sendai Framework for Disaster Risk Reduction (2015–2030) specifies that DRR should be founded on engagement and partnership with all parts of society, since disasters both shape and are shaped by the socio-cultural systems in which they occur. Yet, bottom-up approaches require consideration of, and conversations about, empowerment, inclusivity, accessibility, and non-discriminatory participation that pays special attention to the people

disproportionately affected by disasters (see section 4). The importance of ensuring bottom-up DRR does not mean that top-down approaches are no longer required. **Top-down approaches still have a significant role to play in DRR, particularly contributing codified forms of guidance (i.e. policies), guidelines, plans, technical information (where needed), shared vocabulary and resources.** In this sense the binary divide between top-down and bottom-up is partly artificial, in that both aspects are required and, as Gaillard and Mercer (2013) show in Figure 4, both top-down and bottom-up can converge and meet in the middle to provide action for DRR, along with different knowledge types, and actors and stakeholders

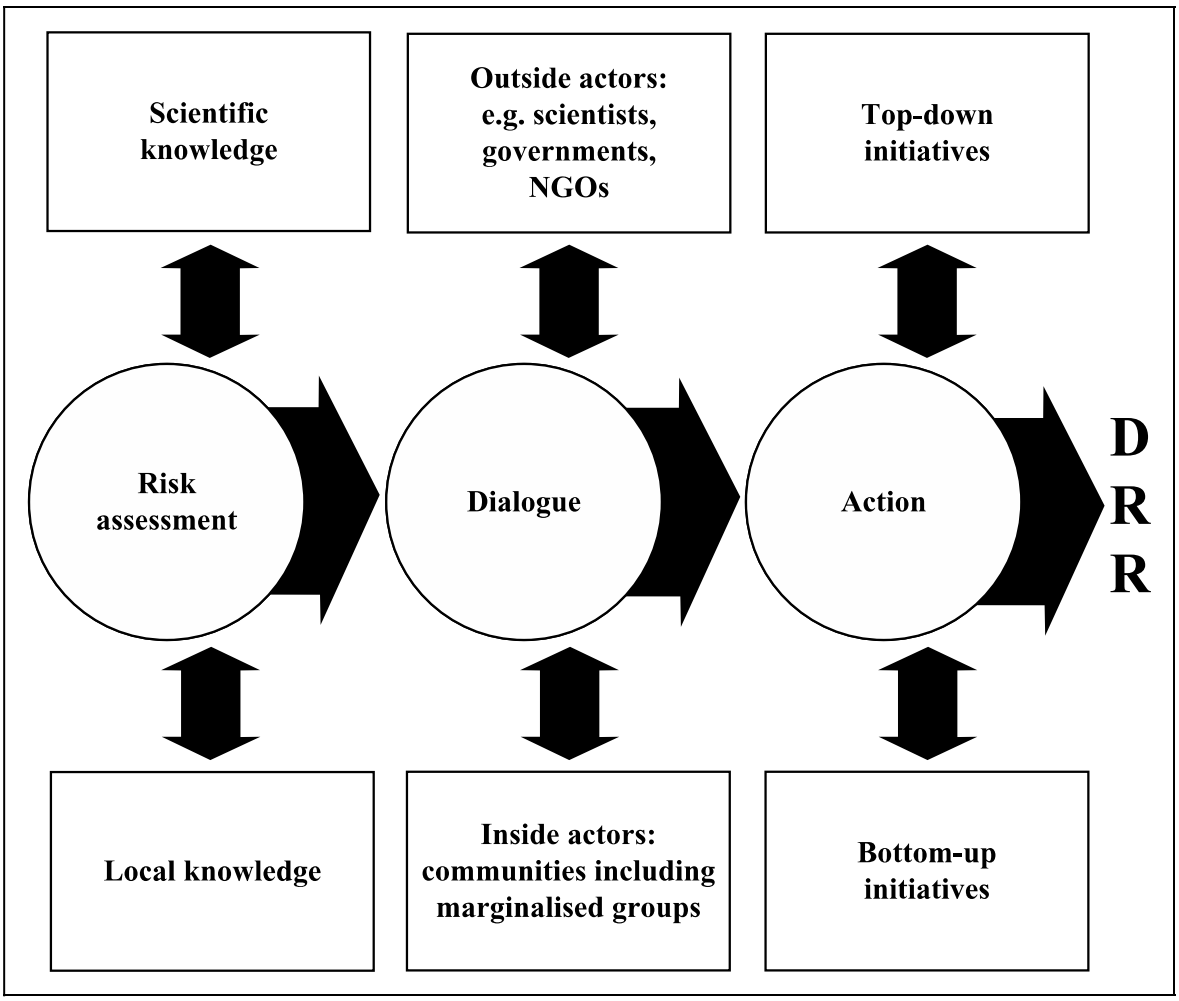

Figure 4: Roadmap for integrating knowledge, actions, and stakeholders for DRR from Gaillard and Mercer 2013

3.5 Cascading and interconnected disasters

In recent years there has been an increase in attention on the cascading and interconnected nature of disasters. Cascading disasters can be defined as “extreme events, in which cascading effects increase in progression over time and generate unexpected secondary events of strong impact” (Pescaroli & Alexander, 2015). Early efforts at DRR tended to focus on separate natural hazards (with policies and programs to address each separately) and were underwritten by the understanding that disasters were single events that could be understood when isolated and divided into stages (see section 3.3 disaster cycle).

With the modern focus of DRR on social and cultural vulnerability, it is now recognised that **disasters are not discreet events but instead are processes that act out over the long term, and that risks and hazards interact across various scales**. As human, economic, and political systems become increasingly complex and interwoven at international scales, risk also becomes increasingly systemic and interconnected. Thus, the concept of interactions across scales and the non-linear effects and tipping points of systems are key elements of cascading and interconnected disasters. While cascading concepts of disasters are important, the use of cascading events to construct a linear narrative of how events might unfold or progressively worsen also stems from a logic of assumed causality, where the actual connection between events is not clear. The use of the cascading disaster concept often imposes false ‘start’ points that neglects the long-term process of vulnerability and suggests that the various loops and overlaps between events over time can be precisely indicated, which is not supported by international disaster research (Kelman, 2018a). Disasters can rarely be sufficiently explained as a result of linear chains of events or simple cascades (the ‘domino’ model; Pescaroli and Alexander, 2015) but are better understood as non-linear phenomena which emerge in complex systems of interrelated and interdependent conditions and events (Cavallo & Ireland, 2014). This means that **strategic and holistic approaches to DRR are particularly important in the context of interconnected or cascading risks because these might be overlooked in planning due to their complexity**.

In this context, it is also of growing importance to understand the interaction between multiple hazards, as traditionally DRR has approached (and mitigated) each hazard separately.

3.6 Holistic and transdisciplinary approaches

As a result of the complexity of both independent and interconnected factors involved in disasters, and the recognition of the need to account for multiple hazards, there are growing calls for the development and use of holistic and integrated approaches to DRR. Figure 5 from the UNDRR Global Assessment Report (2019a)[5] shows how such an approach must look beyond the 'traditional' silos of compartmentalised management or policy that address single hazards, in order to understand complex systems and design solutions drawing on different knowledges and groups. Indeed, while **disaster research often claims to be innovative, it is still to a large extent based on experiences learned from studying disasters in the West through the lens of Western theoretical frameworks and worldviews**. The solution to which, as suggested by holistic approaches, is **the inclusion of other ways of doing and knowing from non-Western perspectives, and particularly drawing upon local partners to analyse local disasters using local understandings of the environment** (see Gaillard, 2019). This includes rejecting the prevailing approach of technical western approaches which often either emulate approaches in western countries or use western consultants.

This should particularly include the integration of knowledge and expertise from social and physical sciences. The complex and multidimensional nature of risk requires **physical and social sciences to collaborate to bring insights from both, but also to strive to achieve a truly transdisciplinary effort, involving multiple disciplines collaborating on shared topics** (see Casajus Valles et al., 2020, p.57). This should include other relevant stakeholders (both state and non-state) to broaden the range of participants and knowledge types involved, from indigenous and local knowledge (detailed below) to citizen participation. A benefit of involving and integrating these different voices in the creation of DRR is that trust (including in things like risk assessments and early warnings) and therefore engagement in the process of DRR is greatly improved.

This is hard to achieve, partly as a result of disciplinary silos but also of differing understandings of what risk is, and uncertainly in each different group regarding the value or form of contribution that the other groups can or should make. Attempts to achieve transdisciplinarity also encounter power differentials in the various groups that are included, and the exact designation of who should participate is complicated.

[5] The Global Assessment Report (GAR) 2019 is a 472-page document from the UNDRR detailing current trends and knowledge in DRR. The GAR19 guided 'tour' document (UNDRR, 2019b) provides an outline displaying the philosophy and summary of contents of the main document.

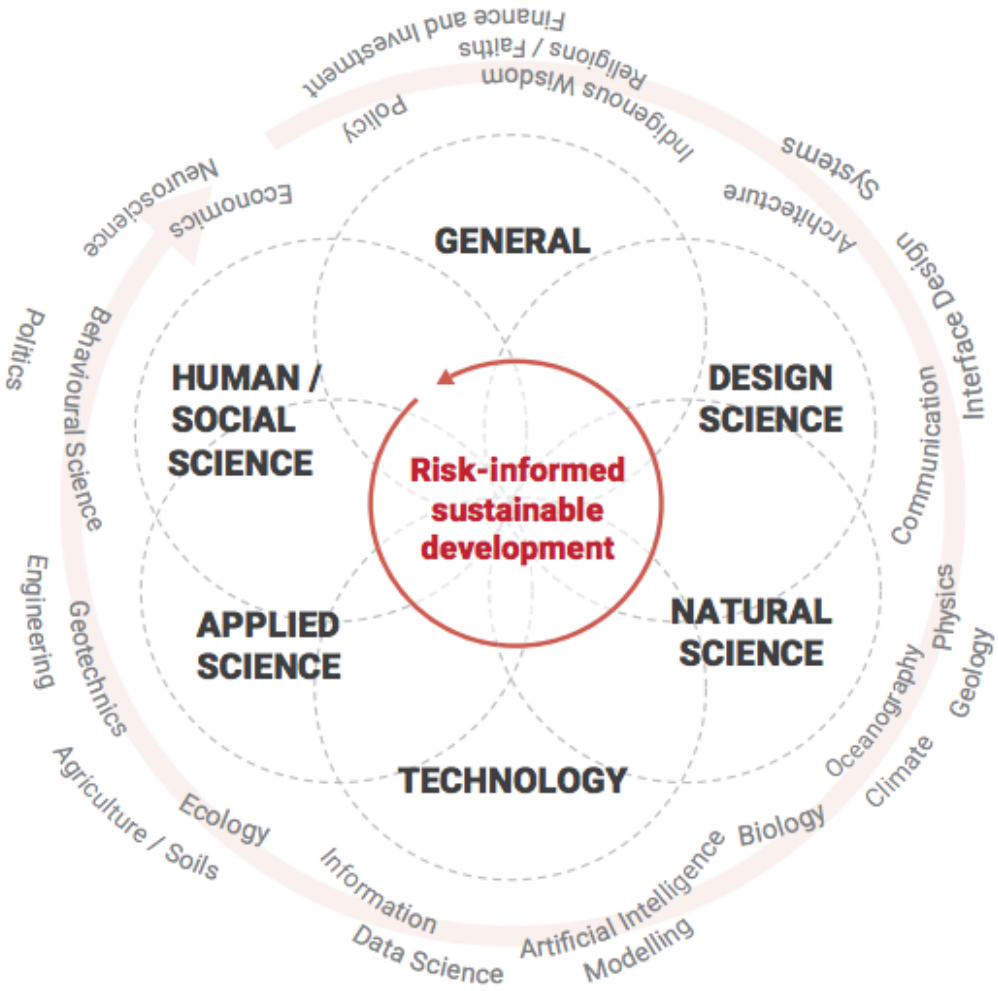

Figure 5: Holistic approaches from UNDRR GAR report

Regardless of these difficulties, **transdisciplinary understandings are a vital way to counter and ultimately address the dominance of technoscientific (predominantly engineering based) approaches** that persist in many parts of the world. Understanding and addressing disasters requires not just an investigation of all 'spheres' of society, but also how these spheres are interdependent. As a result, it should be acknowledged that it is impossible to comprehensively understand such complex systems and their interactions. There will always be exceptions and even certain unknowable elements and aspects of disasters. However, it is through pluralistic approaches that we can reach the most holistic understanding of disasters (McEntire et al., 2010).

4. Community-based disaster risk reduction

4.1 Putting communities at the centre of DRR

In recent decades international DRR policy has increasingly strived to empower communities to manage and reduce disaster risk and to conduct their own disaster responses. The definition of 'communities' is the source of a great deal of debate, and it is important to recognise that communities contain conflict and are not always in agreement (see Titz et al., 2018). However, we can understand communities as smaller groups of people at the 'local' level who share a common interest.

The efforts to empower communities to prepare and respond to disasters have become known as 'community-based disaster risk reduction' or CBDRR, alternatively termed 'community-led', 'community-centred', or 'community-owned' DRR, among other similar terms. This section will detail examples from social science theory regarding how to achieve this in key thematic areas, accompanied by international case studies.

The recognition of the need to ensure community participation in government policies emerged within development efforts, and participatory learning and action, with a World Bank study in 1975. This found that projects were more likely to succeed if communities were involved (Lele, 1976). Similarly, certain United Nations organisations considered community participation a basic requirement for projects by 1978. Explicit calls for community-based disaster management go back to the 1980s, particularly with the work of non-governmental organisations and charities (Maskrey, 1989). As a result, there is considerable evidence that **community engagement or ownership is key to the success (or failure) of DRR projects**, particularly as only communities themselves can fully understand their own needs and capabilities (Jonientz-Trisler et al., 2005). For a case study of fostering the participation of local actors see Cadag et al. (2018) and for a specific flood example from South Africa see Sinthumule and Mudau (2019).

Efforts to expand these practices in international DRR policy became formalised with the signing of Hyogo Framework for Action (2005–2015) and its successor, the current Sendai Framework for Disaster Risk Reduction (2015-2030). Of course, community-based DRR itself is not new, and before the establishment of modern states and government structures, people were solely responsible for their own DRR and response and could not rely on external assistance. Thus, while often said to be an 'innovation', CBDRR can learn lessons from historical practices in the places it is applied, particularly those that detail the culturally relevant structures and applications of DRR that have been successful in the past. This is especially important because one of the key challenges of CBDRR is to account for the complex and locally specific contexts that exist at the

community level if DRR is to be successful. This means that **policies must be 'place-based' (i.e. tailored to local conditions)** and not '*one size fits all'* (uniform approaches regardless of context). The place-based nature of CBDRR is one of the reasons why communities must be in control of DRR processes, since top-down governance struggles to account for the complexity of local realities. To achieve this, leadership within communities should be utilised. For a policy-level guide on local leadership for DRR in the Asia and Pacific regions see UNDRR (2020c).

Yet, this does not mean the total removal of support or involvement from outside organisations (including governments); rather that governments should act as facilitators in this process. This has been referred to as 'vertical integration' by some, learning from the top-down approach but increasingly 'anchoring' projects and programs in the 'grassroots' community level (bottom-up), and with integration of both at various levels (Gaillard & Mercer, 2013). As case study 1 shows, there are certain challenges to pursuing a bottom-up approach within structures that are heavily top-down, as is the case with DRR in China.

Case Study 1: **Pathways to CBDRR within top-down systems in China**

China exemplifies the government-led approach to CBDRR, in that its dominantly top-down CBDRR system provides significant capacity to coordinate and distribute resources; however, there is a lack of understanding at the government level of local vulnerabilities, particularly in rural areas. Sim et al. (2017) used participatory action research approaches in a village in *Shaanxi* Province, including initial baseline studies, in-depth interviews, interactive focus groups, and finally a consultation process regarding local needs and desires. One finding of these data collection methods was that, contrary to assumptions held in the current policies, people prioritised an entirely different set of hazards (specifically that earthquakes were not prioritised or well-known, despite recent large earthquakes in the region, while hailstorms were the most prioritised) and solutions (that social and cultural norms in the village was one of the main reasons - along with insufficient resources - for the lack of support between neighbours). These factors in the community were a result of life narratives, histories, cultural contexts, socio-economic conditions and local level governance structures that existed in the village. The impact they may have had on the issues of resilience, vulnerability, and risk in this context was more complex than the top-down governmental policy could feasibly account for. This research also demonstrates that **while bottom-up approaches can complement and co-exist with the top-down system, over the long term, the top-down management of DRR undermines local capacities and knowledge**. There is a need to recognize the importance of communities as complex and dynamic entities in reducing disaster risk. Participatory action research approaches offer a range of efficient methods to doing so (McCall & Peters-Guarin, 2012).

For more details on Case Study 1, see Sim et al. (2017).

Thus, a core component of CBDRR is empowering communities to take (or be given) ownership of DRR activities and to influence the direction and execution of future programs and projects, rather than simply being the beneficiaries. Broadly speaking there are three different approaches to achieving this:

- *Government-led.* This approach focuses on how governments can use their formal decision-making capacity to designate more responsibility for decision-making back to communities and decentralise the control of programs (while retaining ownership of policy).
- *Autonomous*. Community organisations create projects and programs outside of formal decision-making processes. This requires a certain level of autonomy to be present or permitted.
- *Collaborative*. When local institutions (which may include governmental) facilitate independent governance of DRR including of resources.

The government-led approach is often the start of the process; however, for CBDRR to be successful it has repeatedly been shown that government involvement should not dominate the process and instead should utilise the organisations, groups, and structures in the communities that already exist (as demonstrated by the *Jishubo* case study in Japan – see case study 2).

There are also numerous positive examples of the potential for training community members to be first responders, particularly in densely populated urban areas where emergency services are likely to be overwhelmed, for example in Dhaka, Bangladesh (see USAID-BHA and ADPC, 2020).

Case Study 2: **Neighbourhood associations for disaster preparedness and rescue in Japan**

Jishu-bosai-soshiki (or *Jishubo*), literally translated as ‘‘autonomous organization for disaster reduction’’ are neighbourhood associations for disaster preparedness and rescue activities at the community level in Japan. This is a cultural and social community structure unique to japan (yet is similar to other community structures elsewhere in Asia and worldwide) that is called upon by the national and regional governments to conduct disaster preparedness drills, hold workshops, educate and maintain equipment (among other activities). These associations are independent but supported by local government and they exist within and utilise the ‘*Chonaikai’* system which is a form of community council and a governance unit in Japanese society. After the Kobe earthquake in 1995, there was a systematic expansion of the *Jishubo* model of CBDRR by the regional governments in response to the perceived failure of some communities to autonomously mobilise after the disaster (and the contrasting success of those who were able to). Today *Jishubo* is widely used by various levels of government bodies to successfully mobilize citizens to participate in disaster workshops and other activities and provide a sense of belonging through the treatment of communities as partners in DRR. For more details, see Bajek et al. (2008).

Another major advantage of CBDRR is that **community involvement encourages the sustainability of programs, with community-led initiatives being able to be maintained over the long term** (as opposed to short-term attention of a top-down project that is often either neglected or forgotten over time). As case study 3 shows the long timeframes involved in both building resilience and the return periods of some of the most damaging hazards point to the need for communities to be placed at the centre of DRR. For a general field practitioner's toolkit of CBDRR approaches and examples from Asia see Abarquez and Murshed (2004).

4.2 Local and indigenous knowledge of disasters

Another major advantage of CBDRR is that it encourages and allows communities to use and draw upon *their* knowledge and practices of responding to, and recovering from, disasters. Often this consists of knowledge that has been developed over a long time of responding to hazards, and the skills and philosophies that were developed through this long-term interaction. This can include the following types of knowledge and practices:

- Predictions based on observational changes in the environment and other natural phenomenon that provide warnings of approaching hazards or environmental changes (e.g. prediction of storms based on the behaviour of plants or animals).
- Local ways of life in terms of food, building techniques and practices that allow communities to adapt for or mitigate hazards (e.g. construction of hazard-resistant housing using local techniques and materials).

Case Study 3: **Community-based DRR in Indonesia and the management of floods.**

Indonesia was one of the early adopters of community-based approaches to DRR, with projects (and organisations) established as early as the 1990s. Situated on the dryland of the south coast of South-Central Timor, Toineke village (impacted by floods and droughts) is, therefore, an interesting case study of long-term efforts, challenges and successes of CBDRR. Successful changes in various practices of flood risk management were made in Toineke incrementally over time. This included the protection of wells and the elevation of houses which were particularly driven by households and community members and resulted in improved coping capacity for both floods and droughts over the last 20 years. The measures instituted were not entirely spontaneous, and the involvement of external organisations was important to completing certain works that could not be achieved alone, such as the construction of flood embankments. However, several of these built measures were not maintained, which also demonstrates the importance of ensuring **sustainability** in any co-operation. Other adaptations such as access to diversified resources outside of 'normal' sources were developed and led solely by the community. This case study particularly shows that CBDRR evolves and develops across longer timeframes than often demanded by top-down policies from outside organisations or governments. It also shows that nurturing community and collective action on disasters takes time (see Lassa et al., 2018)

- Cultural or traditional management of resources and customary laws that ensure behaviour that prevents and mitigates disasters and ensure respect for the environment (e.g. land use customary laws that ensure flooding risk is not increased).
- Rituals, ceremonies, and folklore to increase knowledge of hazards and the correct responses to each (e.g. folklore stories that warn of tsunami risk – see case study 4).

(For more examples see Granderson, 2017; Hiwasaki et al., 2014; Shah et al., 2018).

In practice, it is not possible to divide local knowledge into separate tools or skills as defined above, and local knowledge is part of a broad and intrinsically interrelated cultural way of seeing and understanding the world that can integrate aspects of scientific knowledge (Hiwasaki et al., 2015). This body of knowledge has various names, from local knowledge, traditional knowledge, folk knowledge, and indigenous knowledge (if the groups are defined as 'indigenous' – itself a difficult term to define) among others. Regardless of its name, local knowledge was largely ignored by the institutions responsible for DRR until the mid-2000s (Dekens, 2007). This changed partly due to well-publicised differences between the responses of western and indigenous groups impacted by the 2004 Indian Ocean tsunami (see case study 4).

Case Study 4: **The local knowledge of tsunamis: from the Indian Ocean to the Pacific**

The 26 December 2004 Indian Ocean tsunami clearly demonstrated **the ability of local and indigenous knowledge to inform effective community responses to hazards**. In Indonesia, different groups in Aceh province experienced the disaster significantly differently and suffered very different numbers of fatalities. In the northern parts of Sumatra, approximately 170,000 people were killed, while on the neighbouring island of Simeulue (which experienced similar waves) only 44 people were killed. This considerable disparity was largely a result of communities on Simeulue possessing local knowledge that enabled them to anticipate the arrival of the tsunami and thus evacuate. An oral legend known as 'Smong' provided essential awareness of the connection between an earthquake (the ground shaking), the sea receding and a wave being imminent. The situation was also influenced by conflict (with those on the mainland suspecting the noise of the tsunami might be gunfire and were therefore reluctant to evacuate), the historical and cultural heritage of the two areas, and the different daily realities of life in each situation. A similar situation occurred on the Andaman Islands during the same tsunami when communities saw signs of disturbed marine life and heard unusual, agitated cries of sea birds. This was interpreted as a sign of impending danger, so that part of the population successfully evacuated (ICPAC Report, 2006 in Quarantelli et al., 2018). Similar successful responses to tsunamis based on local knowledge have been reported elsewhere. These case studies are an important reminder that DRR can be greatly improved by accounting for or integrating local knowledge, instead of trying to impose western scientific understandings of disasters, which are not considered culturally relevant and therefore are often quickly forgotten.

For more details, see McAdoo et al., 2006, 2009; Gaillard et al., 2008.

Yet, progress in accounting for and integrating local knowledge in DRR has been slow and it is still often regarded as primitive and inferior to western or scientific knowledge (with these two knowledge types being falsely portrayed as contrasting extremes). This is changing thanks to a host of examples from disaster research showing that local knowledge improves DRR, particularly in developing countries.

Specifically, indigenous knowledge is the knowledge that was created by preliterate communities in response to various issues, most commonly those that stress or threaten a particular community or its livelihood. It has become clear that there are extant oral traditions – mostly in the form of stories - that have elicited appropriate responses from communities confronted by disaster in ways that may be more effective than nonindigenous, science-based warning systems (McAdoo et al., 2006, 2009). Consequently, it is being increasingly acknowledged that **indigenous knowledge can make important contributions to both the understanding and the management of disaster risk and environmental changes in developing countries** (Agrawal, 1995; Mercer et al., 2007). Conversely, it is also apparent that many peripheral (distant from urban) communities in developing countries today lack such traditions and consequently have a need to interpret precursors of disaster to enable appropriate responses (Gaillard et al., 2008; Gregg et al., 2006).

The challenge is how to effectively incorporate local and indigenous knowledge into DRR policies and programs. One suggested approach is to develop an integrated strategy (see case study 5).

While a focus on indigenous knowledge and its integration are important, it should not be assumed that the knowledge and responses of non-indigenous communities are not equally important to consider in DRR. Indeed, understanding innovation in communities is an integral part of DRR, since the ways in which communities innovate are central to how hazards are mitigated and how disasters are responded to (see Wachtendorf et al., 2018). Innovation is a reflexive quality that is hard to define and is more often implicitly used rather than explicitly detailed. The complexity of innovation is a central contradiction, that for something to be defined as innovative it must be abnormal and new, yet sometimes innovation is itself needed for survival. In this sense, innovation is both a capacity and a process.

Case Study 5: **The integration of local knowledge – a framework example**

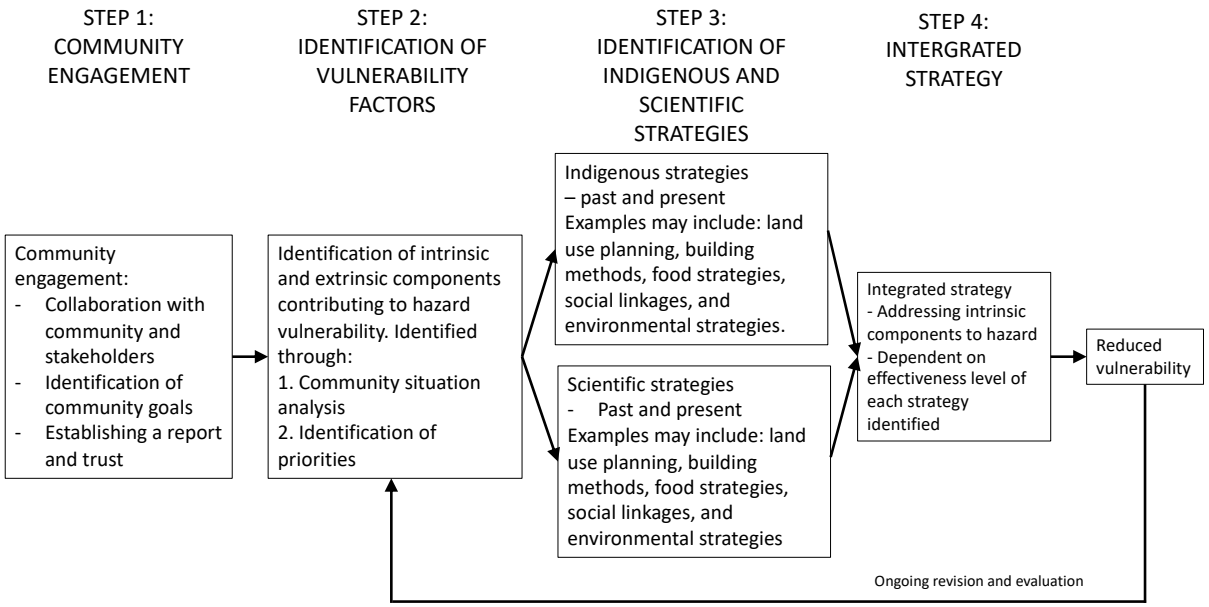

Figure 6: A framework for the integration of traditional and scientific knowledge (Mercer et al. 2010)

One example of a framework to integrate local and indigenous knowledge was developed by Mercer et al. (2007) based on local knowledge of disaster responses in Papua New Guinea and how to use this knowledge in order to reduce vulnerabilities to environmental hazards. As shown in figure 6 this process divides the integration of local knowledge (here focusing on indigenous knowledge) into four key stages. This process-based approach aims to facilitate the integration of two knowledge bases (local/indigenous and scientific) which is neither top-down nor bottom-up but is instead conceived as a collaborative effort between communities and DRR stakeholders. A critical precondition for this approach to be successful however is the recognition by governments and all associated stakeholders involved in DRR that local and indigenous knowledge is a crucial component of a potential strategy to reduce vulnerability and equally that top-down implantation of scientific, technical, or governance solution is an ineffective path to DRR. It is a dialogue based on respect and communication that can address the gulf between local knowledge and scientific approaches (Mercer et al., 2010; Jessica Mercer et al., 2009).

For more on inclusion of local cultural knowledge in DRR, see Kelman et al., 2015; Bankoff, 2003.

One of the requirements of innovation at the community level is **social cohesion and a shared sense of the risks that are being faced**. However, while innovation is important to understand (and particularly to foster), the original sources of vulnerability should not be forgotten or neglected, recognising that communities cannot innovate out of the root causes of their vulnerability alone. Additionally, innovation itself is no guarantee of success, and **innovations can fail, particularly if innovations ignore the original sources of vulnerability**. For example, efforts to control floods by technical means on western rivers in the US were clearly an innovation, however, these measures failed to address the root vulnerability of changing land use patterns and increasing development which were the significant cause of the flooding (White, 1937).

Critically, innovations such as these were not 'by' communities but 'for' them, as is often the case with technical and engineering-heavy innovations.

This reinforces the need for CBDRR, but the measurement of the success of CBDRR is one of its persistent challenges. However, the definition of success should not only be based on disaster outcomes (i.e., if a disaster happens, did this project or program reduce its impact?), and **community-based DRR can have a range of broader indicators of success like longevity of the project, prosperity of its participants, economic development in communities, happiness and health, among other benefits**. As Delica-Wilson and Gaillard (2011) argue, there are four broad challenges to the management of CBDRR:

1. Relationship dynamics and inequalities within the community must be understood and tackled if poverty and inequality are to be addressed.
2. The cultural diversity of communities within countries must be considered. To allow equable negotiation the diversity of populations must be acknowledged.
3. The institutional and social barriers to community participation must be removed, and at every stage a broad and inclusive group must be involved.
4. Downward accountability is important to reshape the relationship between those who make decisions and those who are affected by those decisions. This requires transparency and trust.

Summary:

- Community ownership and engagement with DRR policies are shown to be essential to the success and sustainability of projects.
- Communities possess important knowledge and perspectives regarding disasters, including (but not limited to) knowledge that can prevent loss of life, and social science literature suggests ways to integrate and account for this knowledge.
- Top-down governance still needs to play a central and important role to facilitate the empowerment of communities to adopt community-based disaster risk reduction.

For more details and discussion on this topic see Delica-Wilson and Gaillard (2011) and (Van Niekerk et al., 2018), and for a synthesis on CBDRR see Shaw (2016).

5. Inclusive disaster risk reduction

The National Strategy for Disaster Risk Reduction 2019-2030 of DPRK (DPRK, 2019) clearly highlights the need for inclusive DRR policies, stating that:

- All-of-society engagement and partnership with non-discriminatory and active participation of women shall be encouraged (NSDRR fifth principle);
- The open exchange and dissemination of information and knowledge shall be encouraged amongst women, the aged and people with disabilities (NSDRR seventh principle);
- Non-discriminatory participation by gender and age shall be ensured in all activities for DRR, paying particular attention to the people affected by disasters, especially women, children, and people with disabilities (NSDRR eighth principle).

Numerous international disaster research case studies have demonstrated that certain groups *within* communities are likely to be more severely affected by disasters and less able to effectively respond. The characteristics of these groups vary according to local context but often they consist of divisions according to gender, sexuality, disability, ethnic background, and social status (for example class or caste), among others. Community members may have significantly different perceptions of disaster risk and vulnerability depending on their membership of one or several of these groups, yet in disasters these groups are often combined into a single category – 'victims' – and their diverse needs and capacities are overlooked. Consequently, it is **only through deliberate efforts to address the disparities in DRR policies and programs that social vulnerability can be effectively reduced, and disaster-resilient communities can be built**. Moreover, failure to account for these disparities in vulnerability between such groups may entrench and worsen the inequalities of disaster impacts. Efforts to address this can be referred to as inclusive approaches to DRR, and the sections below will detail examples and case studies according to various divisions.

5.1 Gender

To consider the role of gender in disasters involves the examination of the different experiences and capacities of men and women in disasters, but also the impact of gender roles and relations. Gender encompasses identity and social constructs regarding the relationship between men and women, the inequalities that exist, and how they can be changed. For this reason, considering gender in DRR is not just about women or men as separate groups but about the relationships between them.

While there are a number of studies that suggest women suffer greater impacts from disasters and are more likely to be killed by disasters (see Bradshaw and Fordham, 2013 - including a case study from Haiti), these cases often also reflect the effect of socio-economic status of those impacted, confirming

that gender alone cannot predict vulnerability, but that attention should be paid to gender inequalities and how this relates also to class and other forms of oppression and inequality (see case study 6 below for an example from the Philippines).

The idea that women are biologically weaker and thus are more vulnerable to disasters has been rejected (Fordham, 2012; Moreno & Shaw, 2018). Instead, the disproportionate impacts of disasters on women are often related to socialised gender roles and thus vary with context. A frequently used example is that women and men are equally *able* to swim but, in some societies, women are not given access to swimming lessons to the same extent as men as a result of societal norms (Bradshaw & Linneker, 2018). This was part of the reason that the 2004 Indian Ocean tsunami killed three times more women than men in some Sri Lankan villages. Other factors were the division of labour in the local economy which meant women were at home, their caregiving roles prevented evacuation, and even traditional clothing that limited their ability to run or swim (Hyndman, 2008). Similarly complex gender dynamics are evident in many places internationally.

Thus, each culture and location experiences and enacts gender norms and roles differently; consequently in some places men are the most severely impacted group, sometimes as a result of ill-managed attempts to respond to disaster (to protect homes or other assets which some cultures see as a man's role) or being poorly equipped to respond, either in physical or mental terms (for example – the far higher male suicide rate during the long term recovery in Japan after the 1995 Kobe earthquake; Nishio et al., 2009). Risk perception data also exhibits differences according to gender and in many contexts, women rank a variety of disaster risks as a higher concern than men (Bradshaw & Linneker, 2018).

Case Study 6: **Gendered impacts and responses to flooding in Malabon City (Philippines)**

Malabon city has been called the 'local Venice' of Metro Manila in the Philippines due to its frequent floods and the slow subsistence of the city. Research by Reyes & Lu (2017) showed that the responsibilities of women post-disaster were greater than the responsibilities shouldered by men (despite the often used stereotype of responses to disasters – or any crisis - being a man's responsibility). Instead, women were responsible for proving food and family morale, as well as caring for sick or injured family members. Since women in the communities were mostly stay-at-home mothers or carers, they were also responsible for the very initial responses to flooding, since the men were away for work. The traditional structure of men being 'household heads' and 'leaders' meant that they are the group best placed to access resources to prepare for disasters, yet, because of the cultural norm of women being responsible for the home, it is the women who are responsible for preparing for disasters. This gender imbalance is not recognised in disaster preparedness efforts, and men (and not women) are often chosen as leaders of DRR efforts on the ground and, as a result, vulnerabilities are not being reduced effectively (Reyes & Lu, 2017). The case study demonstrates that **in order to design and develop effective DRR, gender dynamics should be considered** and accounted for, but also that the pervasive role of **gender stereotypes** (men as the head of the household) themselves may **shape the access and allocation** of resources post-disaster.

While women are often *involved* in DRR at the community level, national policies are mostly ungendered and are not tailored to the different experiences of men and women. Only a gender and socially inclusive approach that strives for equal participation by men, women, and marginalized groups can mitigate hazards, reduce social vulnerability and build disaster-resilient communities. Good practices in achieving gender-sensitive approaches for DRR and disaster management are further described in IFRC (2010).

5.2 Disability

People with disabilities are often severely affected by disasters, for a range of reasons. For example, the death toll for people with disabilities after the 2011 *Tohoku* earthquake and tsunami in Japan was approximately double that of the non-disabled population (Tatsuki, 2013). The typical view of people with disabilities in disasters is of someone who needs physical assistance to escape danger (such as those people who cannot walk and require a wheelchair). However, the issue of disability (and how to account for this in DRR) is far more complex, with a large range in forms that disabilities can take including mental, learning, and physical disabilities.

These disabilities may result in physical barriers or issues with communication that reduce the ability of disabled people to effectively respond to disasters. Moreover, **people with disabilities may be reliant on certain care or equipment that may prevent them from using facilities or assistance that non-disabled people can access**. As Case Study 7 shows, the complex needs of disabled people necessitate that disabled people are involved in the planning and mitigation of disasters. In many places around the world, these complex needs of disabled people are overlooked or even discriminated against. This neglects the valuable contribution that disabled people can make to planning risk reduction and disaster responses (for an overview of disasters and disability see Alexander, 2012).

Case Study 7: **Disability and disaster in Vietnam**

Examining two small rural communities in central Vietnam (*Cam Thuy Commune, Quang Tri Province, and Phu Luong Commune, Thua Thien Hue Province*), which are exposed to storms and floods, Ton et al. (2020) demonstrated that disabled people are more affected due to a lack of capabilities in coping with disasters. Yet these are not unknown capabilities, and **disabled people closely understand their own needs**, valuing certain key capabilities. These are the same capabilities that people with disabilities value in daily life but are not always accessible or available (including employment, having clean water, being healthy, and access to safe housing). This shows that increasing the resources available to disabled people will only address part of the problem, as access and use of the resources are not guaranteed when disabled people are not part of the design of their use. The case study also highlights the need to remove 'environmental' barriers such as public stigma, discrimination, and inaccessibility, and that the inclusion of disabilities into DRR cannot be fully achieved without addressing (and challenging) the various discrimination and marginalisation of people with disabilities that exist at societal and institutional levels. This includes ensuring adequate facilities at evacuation centres – such as enough toilets and some with adaptations for use by disabled people. For more details, see Ton et al. (2020).

5.3 Age

There is a widespread assumption that advanced age makes members of a community more vulnerable to disasters than younger members. However, age alone cannot explain the differences in how certain groups experience disasters and the literature suggests that it is more productive to focus on infirmity (i.e. physical or mental weakness that may be associated with age, differentiated from a disability which is not necessarily associated with age) (Fernandez et al., 2002). In labelling older people as simply 'vulnerable', their capacity and knowledge to respond to disasters, and their perspectives in contributing to DRR are overlooked. For example, it is particularly **older people who may possess useful knowledge about responses to disasters in the form of local cultural knowledge**, and older people may have more accurate perceptions of risk as a result of a lifetime experience of dealing with hazards. Similar to disabled people, the elderly do indeed have certain unique needs in disasters, from transportation, and healthcare, to warning design, and recovery (Fernandez et al., 2002), and also similar to disabled people, these needs are sometimes overlooked. For example, people who were 75 years old or older were the most affected age group after Hurricane Katrina in the USA in 2005 (Brunkard et al., 2008) and many were not able to evacuate, as they relied on family members for mobility. The elderly and frail people who were transported to evacuation centres were left without care instructions or medical records (Hyer et al., 2009). In many developing country contexts, the care of the frail or elderly often falls to extended family. For example, following tropical cyclones in coastal Bangladesh older people were more vulnerable due to fewer assets and dependency on younger family members, combined with lower physical strength and mental capacity (see Malak et al., 2020). While the assistance and support from family members should be accounted for and integrated into disaster plans, it should not be relied upon, as severe disasters can exceed the ability of family units to cope without assistance and changes in social structures (such as younger people migrating to urban centres) mean that it should not be assumed that social care networks within communities have the capacity to cope with disasters.

On the other end of the age spectrum, research on children and disasters has increased significantly in the last 10 years (see Peek et al. (2018) for a summary). Children are clearly a critical group to consider in community-based DRR, with between 20 to 50 percent of the population being children in countries around the world. Studies have detailed how children are mentally and psychologically affected by disasters, including documenting various negative reactions that are considerably different across age groups (Norris et al., 2002; Peek, 2008). This includes regressive behaviours in children that emerge after disasters and the impact of disaster trauma on development and education. Furthermore, **the vulnerability of children and adolescents may force them to resort to extreme responses to disasters**, responses that ultimately further

increase their vulnerability. One example is from Botswana, when a severe drought forced young girls and women into prostitution as a way to cope with the disaster, which had far longer impacts than the disaster itself (Babugura, 2008).

Children may also be exposed to disasters due to the locations and quality of buildings in which they live and go to school. For example in the 2008 Wenchuan Earthquake in China when structural factors of residential buildings, and school buildings resulted in disproportionate deaths of children in the rural area (Babugura, 2008). Critically, while research has called for the specific analysis of children's disaster vulnerabilities and experiences, international policy and research still mostly treat 'children' as a single homogenous group, with no disaggregation according to age, stage of development, race, class, gender or other subgroups. In this sense, research and policy on children are rarely intersectional (see section 5.5), which is a key issue since children obviously are part of a broader societal context. The institutions of family, education, peer networks, and political and economic structures all play a role, and consequently, need to be understood in a holistic sense. One example is that parental well-being (and particularly the mental health of mothers) plays a significant role in determining children's wellbeing (both mental and physical) post-disaster (Hu et al., 2011).

Children must be considered in disaster recovery and children recover faster when they feel they are contributing to the recovery (Lowe et al., 2013). Without a role in the recovery, it is common for younger people, especially adolescents, to be driven to high-risk or illegal behaviours (such as drug use) due to feelings of guilt or helplessness. One solution proposed to the issues and vulnerabilities faced by young people has been the introduction of 'child and youth friendly spaces' post-disaster (see case study 8). As with older people, however, children are not just vulnerable, and it is particularly children and younger people who have the creativity, energy, and time to contribute to DRR. Often it is younger people who can approach DRR in innovative ways since it is younger people who are technology literate and invested in being involved in the world (and disasters) they will inherit. It is also younger people who are more receptive to new lessons and knowledge about disasters, and this can filter upward into family structures as shown by case study 16. In conclusion, national policy and action on DRR have an important role to play in supporting the engagement and involvement of young people in DRR. For an overview on practical steps to achieve this see Wisner (2006), BRDR (2018), and the 'words into action' guidelines (United Nations Office for Disaster Risk Reduction, 2020).

Case Study 8: ***Child and youth friendly spaces post disaster***

Child and youth-friendly spaces aim to address the physical and psycho-social needs of young people by creating stable environments that foster trust. One example is from Bangladesh following the 2007 cyclone, where a non-governmental organisation – World Vision – established a child and youth-friendly space after the cyclone. This space allowed young people to receive counselling, provided access to healthcare, and continued education, but also allowed the children to participate in sports and cultural activities as a way to cope and deal with trauma, all services that were severely strained by the disaster and would not have been specialised to young people if not for the creation of these spaces. This resulted in young people being better able to cope with the trauma of disasters. This case study and other applications of 'child and adolescent friendly spaces' suggest that **national governments can provide an important supportive role by encouraging such initiatives that are instigated by other stakeholders or partners in DRR**, from non-governmental organisations to local communities. This points to the need for holistic top-down and bottom-up national frameworks and strategies for action on DRR.
For more info, see World Vision (2010).

5.4 Social status or class

Different systems of social status exist around the world, ranging from complex and formalised hierarchical structures to informal and concealed subgroups that are not easily defined. Class and social status are far more complex than just economic dimensions (i.e. as defined by a group's income or assets) and this often encompasses the legal and cultural systems and practices which justify and reinforce existing class inequalities. These social status systems interact with the other divisions and designations that can be applied to people (defined above) in determining how different groups experience and respond to disaster (Reid, 2013). Thus, social status and class are, by definition, composed of economic, political, cultural, and ideological entities, which are themselves gendered and racialized in specific ways (Glassman, 2003). Simply put, social status can determine how individuals or groups are able (or rather are unable) to actively participate in society. People who belong to the most marginalised groups (including according to class) are among the most vulnerable to disaster risks (Wisner & Luce, 1993). This marginalisation can take many forms, from social, economic, geographic, political, or cultural (or a combination), and can have many impacts, from low access to secure livelihoods, to limited rights, social protections, or political recognition. Consequently, it is often those with low social status who are forced to live in areas of higher risk (for example see case study 9 examining the caste system in India).

Case Study 9: ***DRR and the Caste system in India***

The Indian caste system is a complex and hereditary status system based on association with certain occupations (i.e. jobs) which are linked to a particular position in the local hierarchy. While discrimination on the basis of caste is now illegal in India, the system is still influential. One case study comes from examining the impacts and responses to floods, cyclones and droughts in Orissa (East India). This case demonstrates that a complex interaction of caste, class, and gender determines the extent of impacts and the capacity to respond for different groups. For example, in recent disasters, the upper caste women in Orissa were better able to respond thanks to their privileged network (mostly of the family) and neighbourhood, ownership of concrete houses, and their residence on the elevated part of the land. Conversely, middle-caste women were displaced as a result of a lack of access to the same resources (both social and physical) and were forced into emergency shelters with family and neighbours. This example stresses that community-based DRR must include a consideration of status and class for effective disaster management and social vulnerability reduction (see Ray-Bennett, 2009).

Socio-economic status is often strongly linked with social status or class, although these are not the same thing. Poorer people suffer greater disaster losses around the world because they have less access to assets that might help recovery. These groups also tend to be those with lower social status, meaning that non-financial assistance (such as social networks) is not accessible. This is not confined to developing country contexts but also is prevalent in wealthy industrialised countries like the United States of America (see case study 10).

5.5 Intersectionality

As the sections above have detailed, there is a complex range of interacting factors that determine how individuals and communities experience and respond to disasters. The interaction of these factors clearly demonstrates the need to consider and account for these in a holistic manner to address vulnerabilities and produce effective DRR policies. This can be referred to as an intersectional approach, which involves addressing the interconnected nature of social categorizations (including but not limited to gender, disability, age, and class) as they apply to individuals or groups, and how these create overlapping and interdependent systems of discrimination or disadvantage. Once again, this challenges the prevailing one-size-fits-all model of DRR and suggests place-based and locally led programs to be a crucial element of efforts to address disasters. For more details and practical examples of intersectional and inclusive approaches to DRR in Asia specifically, refer to the report by UN-ESCAP (2019). For an overview of social perspectives on disasters in Southeast Asia see (Gaillard & Texier, 2008) as well as international theory (Chaplin et al., 2019; Ryder & Justice, 2021; Walker et al., 2019).

Case Study 10: ***The impact of class on responses to Hurricane Katrina in the USA***

In late August 2005, Hurricane Katrina made landfall in the Gulf of Mexico in the USA resulting in 1,800 deaths and $125 billion in damages. The majority of the damage centred around the city of New Orleans and was caused by the failure of the flood protection system of levees around the city, resulting in around 80% of the city and neighbouring areas being inundated for weeks. While the hurricane and the levee failure were the triggers, the root causes of the disaster were the pre-existing social vulnerabilities, which were starkly divided along social and racial lines. Racial and class divisions largely determined each group's access to evacuation, pre-disaster preparedness, the distribution of post-disaster recovery resources, and even mortality rates and physical and mental trauma (Cutter et al., 2006; Elder et al., 2007; Laska & Morrow, 2006; Sastry & VanLandingham, 2009). In one example, evacuation orders were less likely to reach, be trusted by, and be followed by persons of colour and lower-income residents, when compared to more affluent and white residents. Additionally, lower-income and non-white residents stayed in the city due to reliance on the local public hospital system, or to care for someone who was unable to leave, or because they were concerned that police would not protect their property and communities if they evacuated (Elder et al., 2007). This illustrates the importance of addressing pre-existing vulnerability in DRR, since the response and impacts can only be understood by considering social status, class and race. Thus, for many, life could already be described as a disaster and a struggle for survival and prosperity against constant marginalization (Cutter et al., 2006), issues that engineering solutions - like levees - cannot address.

Summary:

- The impacts of a disaster on any given person, and form that the experience of the disaster takes, is largely shaped by a complex combination of social and cultural factors and the membership of persons in one or several groups, including according to gender, disability, age, or social status.
- These factors need to be accounted for in DRR policy, but it is not adequate to simply provide more resources for each of these groups, instead these various groups and divisions should be directly involved and consulted in the creation of DRR policies.
- It is only through deliberate efforts to create inclusive DRR and to address the disparities in DRR policies and programs that social vulnerability can be effectively reduced, and disaster-resilient communities can be built.

6. Assessing and addressing vulnerability and resilience: techniques, best practices, and case studies

One of the main bodies of work in the study of disasters has been dedicated to understanding resilience and vulnerability, and examining how this understanding can be used to create positive change, as well as to replicate this on a broader scale. This section will detail some of the main progress and theory achieved thus far in DRR, particularly on the development of indicators and indices to vulnerability and resilience.

As defined in section 1.3 there are multiple definitions of vulnerability, however, there are also multiple *types* of vulnerability, which have multiple contributing factors, from poor land-use planning, inadequate construction, lack of education, environmental degradation, cultural attitudes and practices, law and policy, lack of planning, insufficient training, and ineffective warning systems or communication failures, among many others (see McEntire et al., 2010). Thus, there are many different types and causes of vulnerability and in any assessment, it is hard to account for all known (and unknown) sources of vulnerability. Regardless of these challenges, **it is important to try to account for the diverse sources of vulnerability and their linkages and interdependencies** (across and between different systems) and a number of toolkits and approaches have been developed to this end.

6.1 Participatory Vulnerability and Capacity Assessment

One such available toolkit is the Vulnerability and Capacity Assessment (VCA). This is a participatory investigative process designed to assess the hazards that people face in their locality, their vulnerability to those hazards, and the capacities they possess to cope with and recover from them when they strike.

These approaches are participatory as they require the input of local stakeholders: for an example from Cambodia see case study 11. See IFRC (2007) for the full guide to this approach including a broad toolkit of methods and techniques to deliver data that is directly relevant to the design of programs and projects in order to reduce vulnerability and build resilience. The research reference sheets on pages 48-126 are of particular use, as these detail a number of practical techniques for assessing vulnerability and capacity, followed by the material on pages 167-175 which details how to develop effective programs based on these results. For further discussion and examples see Cannon and Twigg (2003) about the earlier and similar Capabilities and Vulnerabilities Analysis (CVA) approach. One example of the practical application of VCA tools is provided in case study 11 below.

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Case Study 11: **Vulnerability and Capacity Assessment of *Koh Kong* and *Kampot* Provinces, Cambodia**

The International Union for Conservation of Nature (IUCN) conducted research and capacity building in two provinces and in a number of target villages in rural coastal Cambodia. This involved training local partners (30 in total) to apply several methods from the VCA toolkit, specifically: 1) collaborative development of seasonal calendars, to review the annual distribution of livelihoods, natural resources, and land use, comparing with climate hazards' seasonality. 2) Producing a 'historical matrix' (also known as timeline) to explore prior climate events and/or issues within the community and mechanisms implemented to cope with them. 3) Producing a 'vulnerability matrix', to score/rank climate and non-climate hazards and impacts against relevant livelihoods, natural resources, and land use. 4) Hazard Mapping: to map the occurrence of climate and non-climate hazards over relevant areas and natural resources/ ecosystems within the community. The results were complex and highly site-specific for each target village and province, suggesting that **the largely uniform DRR policies that are applied overlook (and are thus undermined by) these locally specific factors**. One example is from *Chong Hourn* village, where the combined methods determined that mangrove planting as a means of mitigating coastal erosion (partly as a result of sea-level rise) has been successful, but also that this has secured livelihoods in the area due to its protection of fisheries. Notably, in other locations engineered attempts to address sea level rise by the construction of dykes have not only failed but also resulted in salt water intrusion into croplands, thus undermining livelihoods. This research also demonstrated the **utility of drawing on local partners to conduct methods of the VCA toolbox, since this allowed the information to be collected relatively rapidly (seven days) when compared to the long lead in time that an outsider would need to familiarise themselves with the complex local contexts and cultural norms, and to build trust (even if they are from the same county)**. For more details see Bobenrieth et al. (2012).

6.2 Sustainable livelihoods approach

One of the more popular broader approaches is called the 'sustainable livelihoods approach'. This considers that the best way to understand the daily living conditions of a community (and thus its experiences of vulnerability) is to analyse its livelihoods (Cannon, 1994; Chambers, 1994; Scoones, 1998; Devereux, 2001; Twigg, 2001; Benson and Twigg, 2007; Kelman and Mather, 2008; Gaillard et al., 2009). The different forms of resources (natural, human, physical, financial, and social) that make up these livelihoods are intertwined with indicators of vulnerability to natural and man-made hazards.

Similarly, there is a body of literature which examines the types of 'capital' (assets) that determine access to livelihoods (Scoones, 1998):

- Human capital: including groups' skills, knowledge, good health and ability to work;
- Social capital: including formal and informal relationships, how much people trust each other, how reliable and how adaptable they are;
- Physical capital: including goods and infrastructures such as roads, houses, etc.;
- Financial capital: money and access to credit and loans;
- Natural capital, including natural resources such as land, soil, crops, forests, water etc..

Any modification of these different forms of capital is likely to change the access strategies to livelihoods. As Case Study 12 demonstrates, livelihoods that are modified or altered as a result of disasters can also result in post-disaster decisions that are advantageous only to a small minority or that are entirely detrimental in the long run. Thus disasters and climate change deeply modify the different types of capital (destruction of natural and physical capital, disruption of the human, social, and financial capital). However, focusing on a single 'capital' (especially social) rather than the interaction between them, risks neglecting or overlooking the systemic 'root' causes of disasters. Barclay et al. (2019), taking the example of volcanic crises, emphasise the absolute necessity of preserving tolerable access to livelihoods and capital to limit the number of fatalities, arguing that these elements play a role of pull and push factors that may influence the decision of people to expose themselves to the volcanic hazards.

The ability to cope with hazards thus depends on the nature, resilience, diversity, and sustainability of the resources available to meet basic needs. Conversely, the inability to protect from hazards reflects difficulties in controlling daily life (Blaikie, 1989). This led to the interest in the Sustainable Livelihoods Framework (SLF) approach that emerged in the 1980s. It is defined as allowing "*sustainable and appropriate access to income and other resources needed to meet basic needs and build assets (resources, capital) to withstand shocks and stresses*" such as natural hazards (DFID, 1999). The advantage of this approach is that it removes the 'reductive' descriptive indicators of populations that are used in development studies (Chambers, 1994), allowing for a much more realistic 'systems approach' that is in line with people's experiences. The main challenge of the SLF is that people themselves (who are subjective and fallible) analyse their own needs and capacities. These capacities are rooted in the knowledge and resources that are endogenous (i.e. from within) to local communities, unlike vulnerability and the barriers to access the means of protection, which are often exogenous (from outside).

Case Study 12: **Livelihood strategies in the face of lahars, Union of Comoros**

Vouvouni is a small village located on the foot slopes of Karthala volcano, Comoros. After Karthala erupted in April 2005, lahars (volcanic mud/ash flows) repeatedly inundated Vouvouni, burying several houses. Despite the scope of the damage, many people realised that the sandy deposits brought by the lahar might easily turn into a valuable resource as the demand for construction materials is high in Comoros. The owners of the two largest lots with the lahar deposits initially prevented access to secure control over the sand. In response, some villagers diverted permanent river channels towards their own property to get their share of the resource, although they were conscious that this might endanger their lives. As expected, the diversion of the rivers led lahars to invade the entire village. Many had to abandon their houses while others lost precious crops buried by lahar deposits. Yet sand was now plentiful and freely accessible in many private and public spaces and extracting sand requires few skills and utensils so that people who could not farm anymore were able to earn alternative incomes. However, the increase in sand supply led to the market being quickly saturated. Simultaneously sand deposits resulted in frequent flooding of dirty water in house courtyards, contributing to outbreaks of gastroenteritis. The economic and social cost of lahar diversion and sand extraction quickly turned into a serious burden for the local community and the number of households relying on sand extraction decreased from fifty in 2006 to only twenty in 2009. The shifting perception of lahars from resource back to threat became evident in 2008 and 2009 when villagers pooled their labour to build levees to protect the village. Yet the levees did not withstand the 2009 lahar season, which engulfed Vouvouni and brought serious damage again. As an ultimate alternative, people eventually decided to engage in small-scale personal protection measures such as sandbagging and the construction of small rock walls in front of the houses. **This case study highlights that limited or modified access to livelihoods may act as a push factor towards strategies that might considerably increase exposure, vulnerabilities, and risk. It could apply to any geographical context where access to livelihoods is scarce and/or temporarily disrupted, in the face of any type of hazard.** See Morin & Gaillard in Sanderson (2012).

6.3 The necessity of a people-centred approach

Community-based and participatory approaches (see section 4) are therefore most appropriate for addressing disaster risk because they emphasise local community involvement in hazard, vulnerability, capacity, and risk assessment (Heijmans & Victoria, 2001; Maskrey, 1989). There is often a mismatch between the 'generalising' view of vulnerability held by experts and that held by vulnerable individuals (Revet, 2020), who are best placed to identify opportunities and difficulties in accessing protective measures.

The participatory approach helps to overcome this problem. The case for local action has been widely recognised and accepted in the scientific and practitioner communities for over 30 years (Wisner et al., 2003). These measures are now endorsed by international bodies, such as the United Nations International Strategy for Disaster Reduction and in regional disaster reduction strategies. The involvement of government authorities must therefore be based on an initial assessment of the situation at the community and local levels.

In addition to the vulnerability assessment approaches, there are a range of resilience measurement frameworks that exist, should authorities wish to "measure" resilience. These range from engineering resilience to community resilience. Accordingly, the attributes measured by each framework depend on its theoretical orientation and working definitions. As Kendra et al. (2018) note, the majority of the resilience approaches focus on the community level, with a handful of examples of applications of resilience metrics across scales, geographies, and hazard types. These have a number of overlaps with the vulnerability approaches and for a review of the different resilience approaches refer to Tiernan et al. (2019) and for a summary of different resilience metrics, refer to Kendra et al. (2018 p. 97 to 99). For guidelines on how to build resilience in context by applying theoretical principles into DRR actions, see the report "Fundamentals of Resilient Governance and Development" (UCLG, 2020), and UNDRR (2020d) for specific insights for small and medium enterprises.

6.4 Methodological approaches for social scientists working on vulnerability or resilience analysis

The resilience and vulnerability assessment approaches both share common methods and techniques. Focus Group Discussions (FGDs) are one popular approach for vulnerability or resilience analysis. These can allow the identification of vulnerability, livelihood resources, and coping strategies for threats at various times of the year (taking seasonality into account is recommended for the Vulnerability and Capacity Analysis (Benson & Twigg, 2007). FGDs can detail the participants' daily life (activities and resources) and gradually shift the discussion to the hazardous events to which they are exposed. This allows the integration of both hazards and risk as part of the daily dimension of life, instead of being taken as a separate subject of study.

FGDs are more difficult for the interviewer to conduct than individual interviews but have two advantages. Firstly, they encourage the self-verification of information between participants (Chambers, 2007). Secondly, they make it possible to grasp the interplay of actors between participants (dominance, connivance, opposition, etc.) and possibly the opinions expressed about other members of the community who were not present during the FGD. They are thus essential to be able to step back from the responses collected during the surveys and the foreseeable efficiency of the risk and crisis management planning. FGDs can include participatory mapping to geolocalize the information and allow an inclusive and active community involvement in DRR. They are a key component in Participatory Vulnerability and Capacity Assessment, which typically uses tools like timelines, mapping, and solution trees.

The coupling of quantitative (such as questionnaire-based surveys) and qualitative approaches can be a considerable asset when

conducting risk analysis. The quantitative approach, when well conducted, makes it possible to quantify behaviours, account for their diversity, and know the spatial distribution of a phenomenon. On the other hand, it is inappropriate to properly understand individual representations and opinions. Generally synonymous with closed questionnaires, it leaves little room for contextualising responses. Moreover, interviewees are generally more comfortable with open-ended questions that really allow them to speak, rather than with closed questions that constrain their answers.

As advocated by the authors of the radical paradigm, qualitative surveys are therefore indispensable as a complement to quantitative surveys (Chambers, 2008). The coupling of the two approaches implies a richness in the characterisation of community vulnerabilities and capacities, both quantified and understood in depth.

This approach allows researchers to determine whether the vulnerability and capacity factors identified are the result of root causes or contextual dynamic pressures, as proposed in the Pressure And Release Model by Wisner et al. (2003) (see section 3.2).

It is also possible to subject these factors to hypothetical (but probable) dynamic pressures to anticipate crisis situations and devise mitigation solutions, in other words, to propose risk and crisis management scenarios. Finally, feedback analyses (usually based on interviews with the risk and emergency managers as well as the exposed and impacted communities) on past disasters allow highlighting the strengths and weaknesses of a system and learning lessons to improve the capacity to cope with future events. For an overview of other methods and for more detail on techniques and content for surveys, questionnaires and focus groups see IFRC (2007).

Summary:

- The measurement of both vulnerability and resilience is of essential importance to building effective DRR.
- Several well-articulated toolkits have been developed (and are accompanied by various case studies) including the Vulnerability and Capacity Assessment (VCA) and the ‘sustainable livelihoods approach’.
- These approaches have certain strengths and weaknesses that should be considered but perhaps most importantly, the application of these approaches should place people at their centre as collaborators, rather than simply subjects.
- There are certain practical data collection methods that are typically used or associated with these approaches, particularly including participatory focus groups and surveys: when used carefully these can be powerful tools.

7. Integration of climate change adaptation in DRR

7.1 Facing more severe and frequent disasters

Climate change increases the risk of extreme weather-related disasters in terms of frequency, duration, and intensity (IPCC, 2018a). The United Nations Environment Programme warns that adaptation to and copying strategies in the face of climate change will cost developing countries 140 to 300 billion US$ per year by 2030, and up to 500 billion by 2050 (UNEP, 2021). In addition, Oxfam (2019) estimates that more than 20 million people a year are forced out of their homes by climate change.

For an in-depth exploration of climate change related issues, refer to the most recent reports from the three working groups of the Intergovernmental Panel on Climate Change[6] (IPCC, see footnote and IPCC, 2020):

- the 'Physical Science Basis' (Working Group 1, IPCC, 2021),
- 'Impacts, Adaptation and Vulnerability' (Working Group 2, IPCC, 2022a),
- and 'Mitigation of Climate Change' (Working group 3, IPCC 2022b).

Other interesting resources are the last full synthesis report produced by the IPCC (IPCC, 2014) and the IPCC special reports on Climate Change and Land (IPCC, 2019a), Global Warming of 1.5°C (IPCC, 2018b, 2018a), and Ocean and Cryosphere in a Changing Climate (IPCC, 2019b).

Within the IPCC (2014, p.118), climate change adaptation (CCA) is defined as *"the processes of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects"*. The progression and development of CCA in international policy have been a complex process, primarily emerging within the UN in recent years (2000–2010) (see Gupta (2010) for an overview).

It is clear that CCA is required to deal with human-induced climate change (Mavrogenis & Kelman, 2013), and considering the impacts of climate change are already being felt, it is needed in a relatively short timeframe. Indeed, the IPCC state *that 'the next few years are*

[6] The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options. The IPCC prepares comprehensive Assessment Reports about the state of scientific, technical and socio-economic knowledge on climate change, its impacts and future risks, and options for reducing the rate at which climate change is taking place. It also produces Special Reports on topics agreed to by its member governments, as well as Methodology Reports that provide guidelines for the preparation of greenhouse gas inventories. IPCC assessments and reports are prepared by three Working Groups (WG), each looking at a different aspect of the science related to climate change: WG I (The Physical Science Basis), WG II (Impacts, Adaptation and Vulnerability), and WG III (Mitigation of Climate Change). The IPCC also has a Task Force on National Greenhouse Gas Inventories, whose main objective is to develop and refine a methodology for the calculation of national greenhouse gas emissions and removals. The Working Groups and Task Force handle the preparation of reports, and selection of the experts that work on them as authors.

probably the most important in our history' (IPCC, 2018a). It is also clear that these urgent actions must place communities at their centre (including their knowledge and history) and that **the multiple overlaps and synergies between CCA and DRR should be recognised** (Kelman, 2015; Mercer, 2010).

Despite the development of the concepts of DRR and CCA, national governments in many cases continue to focus on relief-centred and techno-centric approaches with projects typically focusing on a single hazard. These single dimension strategies may result in risk transference, in that a single dimension of impact is altered, but vulnerability is not addressed and therefore risk is transferred from the present to the future, and potentially magnified (Etkin, 1999). Progress is being made towards appreciating this interconnected nature of risk via vulnerability and a multi-hazard approach in the policy sphere (see section 3.6 on holistic approaches). Yet, there is still an inordinate emphasis on single hazard drivers, instead of considering the complex and interconnected nature of vulnerability that connects climate change impacts and environmental hazards. The often-neglected or overlooked synergies between DRR and CCA are potentially damaging (Kelman, 2015). For example, steps taken to reduce the impact of tropical cyclones (or floods, drought, etc.) under the guise of CCA are the same as those under DRR (e.g. Wisner et al., 2003). This risks either duplication of work or neglects the common goals and benefits that exist.

Both CCA and DRR also share the recognition that **neither can be successful without integrating local knowledge and neglecting to do so may lead to maladaptation**. DRR has an advantage since it has long advocated the integration of bottom-up, 'grassroots' strategies with appropriate top-down approaches, while CCA emerged from top-down policy and was initially largely disconnected from communities (Mercer, 2010). Many current efforts at operationalising CCA draw very heavily on the community-based natural resource management theories and practices (Ensor & Berger, 2009) as well as the various DRR tools of recent decades (Abarquez & Murshed, 2004; eg IFRC, 2007).

Such approaches offer important lessons and one key issue in CCA processes is institutional barriers as a result of top-down structures and the exclusion of marginalised and more vulnerable groups from participatory processes (Booth et al., 2020). In certain areas, there has been a very dominant focus on CCA (potentially resulting in DRR being marginalised), which risks neglecting the underlying root causes of vulnerability (see section 3.2), and avoiding 'messy' topics including the political processes that reduce the capacity to address challenges. Thus, the mostly top-down approach of CCA policies may exclude local communities from the decision-making process and result in their voice not being heard regarding the expression of their needs, their knowledge of the environment, and extreme events in the long term (see section 3.4).

Generally, communities themselves do not differentiate between the impacts of natural hazards and climate change, both of which map on to a long history of interacting with the environment. An example of the need to account for overlaps and potential conflict between CCA and DRR is demonstrated in a typhoon context, when an understandable reaction to the prediction of climate change driven increases in typhoon intensity is to engineer heavier roofs strongly tied to walls. Yet, in certain contexts, this clashes with DRR since these same changes may cause more fatalities when considering the entire range of hazards (both climate change driven and non-climatic), as demonstrated in the 1995 Japanese Kobe earthquake where building codes set to protect from typhoons caused collapse in the earthquake (Menoni, 2001). Therefore, applying either CCA or DRR without considering the other is likely to exacerbate vulnerability. Consequently, there are **increasing calls for CCA to be integrated within DRR (see figure 7), which itself can be viewed as operating within sustainable development** (Birkmann & von Teichman, 2010).

This would avoid artificially separating these concerns and instead allow for considerable overlaps and linkages. It seems this interconnected approach is gaining traction and, as the definitions of DRR show (see section 1.5), the UN already places DRR firmly within sustainable development. Equally the 2018 IPCC special report mentions that efforts to limit global warming *'could go hand in hand with ensuring a more sustainable and equitable society'* (IPCC, 2018a). Also it does not specifically mention DRR, this report further states, with 'high confidence', that adaptation options which aim to reduce the vulnerability of human and natural systems include synergies with sustainable development and reducing disaster risks (IPCC, 2018a).

For a deeper exploration of the integration of CCA in DRR, a series of books are attached to the list of references (Alves et al., 2018; Arnold, 2018; Lackner et al., 2020; Leal Filho, 2017, 2018; Murphy et al., 2018), as well as an international policy guidance document (UNDRR, 2020b).

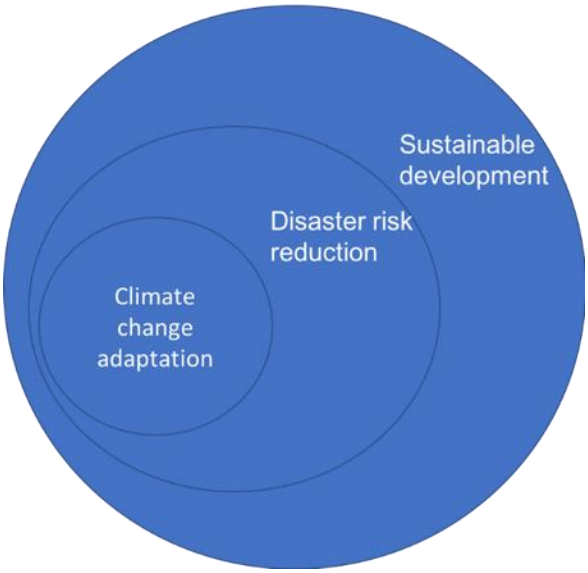

Figure 7: The integration of CCA within DRR and sustainable development

7.2 Dealing with hunger-related disasters in a context of climate change

In the scientific literature, famines are one of the most influential hazards in the development of the vulnerability paradigm (see section 2), with papers highlighting the root causes and daily constraints leading to disasters (e.g. Sen, 1981 – although Sen's approach has been critiqued since e.g. by Swift, 2006). For context we provide a database[7] of global disaster statistics, downloaded on 18/06/2021 in the folders attached to this report, as well as a guideline document on the EM-DAT contents: CRED and UCLouvain (2020b, 2020a). At a smaller scale, the World Food Programme highlights that more than 80% of people with inadequate food live in disaster-prone areas and in degraded environments that multiply the damage that disasters create (WFP, 2020). Hunger and disasters work as a 'vicious cycle' as disasters affect hunger and malnutrition, and how hunger and malnutrition increase disaster risk (Watts & Bohle, 1993; WFP, 2020). The COVID-19 pandemic is, for instance, worsening hunger and access to food sources worldwide (Oxfam, 2020, 2021a).

The number of climate-induced disasters has increased significantly over the past decades, and it is expected that **climate change will significantly alter both the frequency and intensity of hazards** (IPCC, 2018a). Of all natural hazards, floods, droughts, and typhoons affect the agriculture sector most, demonstrating the severe potential impact of climate-related disasters. More than 80% of

[7] It should be noted that disaster databases are only as good as the reporting systems in place in each context and are limited by certain criteria and the nature of quantitative data on disasters. One particular issue is the designation of an 'event' as a disaster and its delineation as an event with a start and finish point (with a threshold of causalities or fatalities in order to be include), potentially overlooking disasters with longer or chronic impacts or the combined impact of interlinked events (see section 3.5)

the damage and losses caused by drought are to agriculture, especially livestock and crop production (FAO, 2015). Natural hazards thus have a heavy impact on agriculture and prevent the eradication of hunger and achievement of sustainable development, with often cascading negative effects across national economies (FAO, 2015). Consequently, the potential increase in food insecurity and malnutrition is among the most significant impacts of climate change. It is estimated that climate change will push 78 million more people into chronic hunger by 2050 (Sulser et al., 2021), along with an increase in human displacement and migration (Oxfam, 2019; Peters & Lovell, 2020).

Food insecurity has four main dimensions that are directly worsened by climate change (Christoplos, 2012):

1) Food availability – i.e. the availability of food is decreasing due to scarcity arising from environmental changes, land degradation, demographic pressure, or the impacts of hazards;
2) Access – i.e. peoples access to food is declining due to economic factors driving up prices;
3) Stability – i.e. the stability of supply (and stocks) is at risk due to increasing prevalence of disasters, markets versatility and national protectionism;
4) Safe and healthy use – i.e. the scarcity of potable water and contaminations linked with floods occurrence.

The success or failure in maintaining food security along these various dimensions is a fundamental indicator of whether the most basic aspects of risk are being effectively managed. However, disasters do not necessarily trigger hunger or difficulties in maintaining livelihoods when institutions and the socio-economic contexts provide safety nets to account for the lost food production (see Oxfam, 2021b). Conversely, famines have occurred in regions and countries that are still exporting food and have surpluses, demonstrating that access and agency are often a larger issue than physical scarcity (e.g. see Walker et al., 2019; Chaplin et al., 2019; Ryder and Justice, 2021). One case study is the potato famine in Ireland (see case study 13). There are also examples of famines that were predicted by the international community but did not actually happen, due to unrecognised capacities of people to find their own ways to access food, to stabilise supplies, and to use the food they have more effectively (Christoplos, 2012).

Livelihood support in relation to disaster recovery has been a growing component of humanitarian programming and has become an important component of early recovery to jump-start local economies. Yet, the entry point for many food security interventions is not focused on agriculture, but on efforts to reduce the risk of disasters, and it has been widely acknowledged that disaster preparedness and risk management require a combination of natural resources management, land use, food security, and climate adaptation initiatives (UNEP, 2021).

Case Study 13: ***The Irish Potato famine of 1874 and the root causes of famines***

The Irish potato famine (known within Ireland as the Great Famine) was a long-term period of severe starvation between approximately 1845 to 1852, with the worst year being 1847. Over a million people died and it was accompanied by a mass migration from Ireland of roughly a million people, which resulted in a considerable population decline. While the trigger for the famine was a potato blight (a disease) that caused a food shortage, the disaster had numerous underlying root causes, such as the dependence on a single crop as a result of land ownership arrangements, exploitative governance systems (the UK continued to export food from Ireland during the famine) and lack of access to healthcare that resulted in an epidemic (Mokyr & Ó Grada, 2002). These factors are not dissimilar to those noted for modern famines in Nigeria, South Sudan, Yemen, and Somalia (see Devereux et al., 2017). Thus, while this case study is the oldest that we have called upon in this report, just because an event was a long time ago does not mean it does not have lessons to impart about the current context. In this case, a large amount of research has been done on the famine and other research has demonstrated that there was also a range of factors which influenced the 1874 famine that emerged as early as the mid-1700, such as previous 'great frosts' and the migration of Irish people as the result of previous famines which exacerbated the following famine (Engler et al., 2013).

See Devereux et al. 2017 for more details on famines generally and Kinealy (2006) for a book about the Irish famine.

Managing and responding to disaster risk is part of the social contract between states and citizens (Pelling & Dill, 2010).

At the individual scale, when international aid does not reach communities, the coping strategies used may include selling off vital household resources such as land, tools that allow access to livelihoods, working animals, or going into debt. Thus, even if people are able to manage acute food security crises, the means by which they do so may increase their chronic vulnerability (Christoplos, 2012). In addition, a danger exists that the policy-level responses to widespread food concerns may ignore or undermine the local strategies in dealing with extreme events (natural, socio-political, and economic/market-related). Finally, in a context of direct competition for common livelihoods, the short-term coping strategies adopted can erode local social capital (Elver, 2018; Webb & Rogers, 2003) and the coping mechanisms themselves may trigger higher levels of physiological stress.

The need for robust supply chains (both international and internal) is also a critical factor in the maintenance of food security. A single weak link in the supply chain can prevent food from reaching those in need; instead going to waste. International case studies have demonstrated that potentially lifesaving resources can reach countries in need but **if local and regional supply chains cannot process these resources, then hunger related disasters are prolonged** (for a literature review regarding the management of supply chains during disasters, see Natarajarathinam et al., 2009). In order to increase the resilience of food systems, Pingali et al. (2005) have proposed a policy framework (the Twin Track Approach), which aims to strengthen diversity, rebuild local institutions and traditional support networks,

reinforce local knowledge, and build on farmers' ability to adapt and reorganise. The framework seeks to understand **immediate and longer-term needs, and define different response mechanisms, strategies and policies depending on the context.** This allows recovery measures for rural livelihoods and support to vulnerable groups. Similarly, the Asian Disaster Prevention Centre (ADPC) also provides resources on how countries in Asia deal with the adverse effects of climate change in terms of livelihoods security, in particular in the agriculture sector (ADPC, 2020a; Basnayake et al., 2019); including specific nature-based solutions for landslides DRR in Sri Lanka (ADPC, 2020a, 2020b), as well as general insights on the diverse adaptation options available (ADPC et al., 2021). For more on nature/ecosystem-based DRR solutions, see Dudley et al. (2015), UNDRR (2020a, 2021b), UNEP (2021), and case study 14 below.

Considering that droughts are the main natural hazard prone to driving hunger, the reference by UNDRR (2021e) might be of particular interest. It includes case studies of droughts – and how they were managed in Argentina, Australia, Brazil, Canada, the Caribbean area, Spain, India, the USA, the Mediterranean area, Uzbekistan, multiple cases in Africa, and the Danube, Nil, and Euphrate-Tigris river basins. UNDRR also provides a summary of this report dedicated to policymakers: UNDRR (2021d).

Case Study 14: ***Nature based solutions and DRR in São Paulo state, Brazil***

Nature based solutions (NBS) seek to find and deliver actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. There are clear overlaps between this emerging approach and DRR and CCA. Practical examples include steps like the restoration of coastal ecosystems (reef and mangroves) in order to address coastal hazards, while also conserving biodiversity, sequester carbon and provide livelihoods from tourism. Another example is the management and restoration of watershed vegetation to reduce the impacts of droughts, while also increasing the availability of wild-sourced food and other associated benefits. For a list of other examples see UNDP (2021). Young et al., (2019) conducted research to assess the potential for Nature-based Solutions for DRR in urban settings, specifically in São Paulo state, Brazil, which is particularly impacted by floods and landslides. Using workshops and questionaries' the research determined that the DRR benefits of NBS are being overlooked and equally that **DRR needs to be grounded in the means and mechanisms that emphasise the functioning of ecosystems, and that such measures to ensure the functioning of ecosystems can improve a city or urban areas ability to restore its functionality during and after disasters**. However, there is a general lack of understanding both in participants and policy about how to manage NBS as a part of DRR because **local solutions tend to focus on short-term actions with limited timeframes, while NBS require a long-term implementation**. There are also limitations to NBS that should be acknowledged, and as discussed above, it is not nature alone that is the cause of disasters, and consequently, NBS cannot be the whole solution, since these may overlook the political, economic, and cultural root causes of a disaster. Simply put, if nature is not the *cause* of disasters, solutions that focus on nature are not likely to fully address disasters. For more NBS examples and discussion, see IUCN (2016).

Summary:

- Climate change is going to significantly alter the patterns and impacts of hazards and is already being experienced, resulting in more severe and frequent disasters. This highlights the pressing need for climate change adaptation
- There are multiple overlaps between climate change adaptation and disaster risk reduction. In order to account for these overlaps (and avoid repetition and exploit common goals), it is suggested that climate change adaptation should be positioned within disaster risk reduction, which itself should be positioned within sustainable development
- One of the major hazards linked to climate change is hunger-related disasters, including drought and famine. These also require DRR policy to consider the various influences on vulnerability beyond a lack of food or water due to climate change, including supply chains. The ‘twin track approach’ and ‘nature-based solutions’ have the potential to address these challenges (while also being aware of limitations)

8. Communicating to and with communities

All educational efforts aimed at DRR, are also actions for sustainable development (Shaw & Oikawa, 2014). **The better the levels of education and organisation in the community, the better their capacity to prevent, reduce, and mitigate risk factors, and to recover from the effects of disasters**. One of the fundamental keys to success lies in efficient early warning systems.

8.1 Implementation of efficient Early Warning Systems

An Early Warning System (EWS) is defined as: *"The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.*" (ISDR, 2006). EWS are designed and implemented to target sudden-onset hazards such as floods, landslides, tornadoes, tsunamis, and earthquakes; for slow-onset hazards such as drought; and for hazards that can appear at a variety of time scales such as extreme temperatures, volcanic eruptions, and epidemics/pandemics. In addition, warning systems have targeted complex issues beyond hazards such as famine and food insecurity (Villagrán de León et al., 2006; 2013).

In their synthesis on EWS, Villagrán de León et al. (2013) provide a review of more than 150 EWS implemented by local, national, regional, and international agencies around the world. The review focuses on hydro-meteorological, geological and biological hazards, forest fires, and other hazards. This review reinforces the notion that early warning refers to the provision of timely information to an individual, an institution or a community at risk regarding the imminent manifestation of a particular event, capable of provoking losses of various kinds. For example, meteorological departments or offices in many countries issue forecasts concerning potential events such as tropical storms that could lead to floods or high winds, which may be capable of damaging or destroying infrastructure and livelihoods. The first critical issue to be considered in this context is whether the information is getting across from its source to the recipients or end-users (also known as the 'last mile'; Mileti and Sorensen, 1990) to avoid the loss of life.

Other authors point out the need to ensure that those at risk and those who have to respond in case of a warning understand the warning messages (e.g. see Paton et al., 2008). Early warning information needs to be communicated in such a way that **facilitates decision-making and timely action of response organisations and vulnerable groups**, with four processes that should take place once a warning is issued (Mileti & Sorensen, 1990): (1) people receive the warning message; (2) the warning message is understood; (3) the warning message is believed; and (4) the warning is then personalized.

The belief step relies on the degree of trust that people assign to the institution or source of the information (Haynes et al., 2008). **People might disregard a warning when they do not trust the information provided by the institution** (see Alcántara-Ayala and Oliver-Smith, 2019). As expected, credibility is gained through accurate forecasts and may be lost on account of false alarms or perceived ulterior motives. In contexts of high uncertainty, "false alarms" are not really "false": it may be rational to evacuate because scientists do not know what will happen. The communication around this has to be managed effectively. In addition, people may react to warnings in situations where they believe that an event is imminent and could have severe consequences, or reversely may not be aware of the degree of risk they are exposed to, and consequently not respond to such a warning. An important issue relates to whether people who need to respond understand the warnings or not. To be effective, warnings should not only be about the threat but also convey clear information on the urgency of the situation, likelihood, and precise area of impact (Anderson-Berry et al., 2018; Kox et al., 2018). Solutions should be sought to make the warning clearer using elements that are familiar to the exposed people, such as referring to well-known local landmarks instead of providing absolute levels or degrees that are too abstract for most people.

Auf der Heide (2004) and Wood et al. (2017) add that **disaster warnings are usually more effective when they identify specific courses of protective action that can be taken to reduce the threat**. It is recommended to provide specific, localized information on what residents should do and when (Bradford et al., 2012). For instance, in the USA, even in parts of the country where tornadoes are common, without being more specific, terms like "tornado watch" and "tornado warning" are misunderstood by more than a third of the public (Auf Der Heide, 2004). Research has repeatedly illustrated that it is not adequate to simply inform a population that a hazard is approaching, but that the population at risk needs clear instructions on actions to take (for more details see the examples from Donovan et al., 2018; Budimir et al., 2020).

As both technical and non-technical improvements in the EWS may be limited by financial resources, assessing the economic efficiency of any improvement is highly important. Grothmann and Reusswig (2006) suggest that including the costs and benefits of precautionary measures in the warning messages is more effective than simply stating the flood risk. Ahsan et al. (2020), in a case study in Bangladesh, also highlight willingness to pay for the improvement of the warning attributes, including precise information of a cyclones landfall time with possible impacts, more frequent radio forecasts, and voice messages in the local dialects over mobile phones.

Finally, the process and channel through which the warning is provided are important. For instance, warnings issued by television

and radio stations may not be taken seriously unless normal programming is suspended to cover news about the threat. It is also recognized that seeking out and reflecting upon information with family, friends, and neighbours is a critical step in motivating preparedness, as is watching others prepare and discussing plans with trusted sources (Hogan Carr et al., 2016), and in some cases discussing prior experience of adverse events (Becker et al., 2017); however this is not always the case, as demonstrated, for instance, by Miran et al. (2018) who show that prior experience was not a primary incentive to take actions in the face of tornadoes in 2013 in Oklahoma, USA.

As stated in the Global Survey of Early Warning Systems (UNISDR, 2006), the dissemination of warnings using different alert stages or levels varies between hazards and countries. Such inconsistency may lead to confusion regarding how to respond in case of a disaster. Villagran de Leon et al. (2006) underline four basic elements that must be incorporated into every early warning system to make it effective: the prior knowledge of the risks faced by communities, technical monitoring and warning services, dissemination of understandable warnings to the exposed communities, and preparedness to act. Villagran de Leon et al. (2006) further introduced a linear structure to illustrate the operational aspects of early warning systems in terms of four sequential phases: (1) monitoring (2) forecasting (3) warning dissemination, and (4) anticipated response.

To manage the warning dissemination and responses, many institutions around the world have established frameworks incorporating various levels of warnings or alerts which include actions to be taken according to each level. In many cases, these frameworks are formalized through Standard Operating Procedures (SOPs). A hierarchical framework based on a certain number of alert levels (most of the time, four) is used for a variety of hazards, most of the time formatted using four colours: green, yellow, orange, and red. For each alert level, there is a set of procedures and tasks which need to be executed by the emergency managers and people at different administrative scales. For more details, the World Meteorological Organization provides a complete checklist for multi-hazard EWS implementation (WMO, 2018).

It is important to recognize that there can be different views regarding what type of information is provided in the context of early warning. The four-phase system refers to the traditional view of early warning which focuses on the provision of information concerning a specific event that may trigger a disaster. However, there are other views not related to the forecast of isolated events which will take place in a specific region of the world at a particular time. This is the case of information presented in the format of hazard maps targeting earthquakes, volcanic eruptions, or other hazards; these maps represent the current state of knowledge in terms of probabilities of occurrence of events associated with particular periods of return, in specific geographical areas of the world.

Examples include maps depicting the potential extent of floods that have a return period of 100 years (i.e. probability of occurring being 1/100, or 1% in any one year), or maps that show the expected peak ground acceleration corresponding to earthquakes that have a return period of 500 years. EWS should be tested and people trained to act properly upon alerts. Evacuation drills, for instance, can be led in the communities as a whole or in specific infrastructures such as schools (see next section). This refers to the fact that, as any other component of DRR, **EWS should be people-centred to be efficient** (Anderson-Berry et al., 2018; Villagrán de León et al., 2006).

Wilkinson et al. (2018) underline that forecasting and communication of early warnings have improved significantly in recent years, but action based on those warnings has not kept pace due to a lack of readily available resources and internal inefficiencies in NGOs, the UN, and government agencies. For that reason, forecast-based early action (FbA) initiatives have emerged.

Case Study 15: ***Tsunami EWS failure in Indonesia demonstrates that education is key***

Education of the population is indispensable, even in areas where an early warning system has been established. Indeed, high-tech preparedness measures are not infallible from technical errors or other problems during critical periods of alert communication. On 17 July 2006, while the Pacific Tsunami Warning Centre was transmitting a warning to Indonesian authorities, a tsunami killed 733 people in Pangandaran, south of Java (Morin et al., 2008). The alert did not reach local authorities and populations due to political considerations and miscommunication. Even if such a system normally works, it cannot be guaranteed that the population will not respond in undesirable or unpredictable ways, as was the case at Hilo in Hawaii (USA) in 1960 where the siren in question at the time was largely not understood by the population at risk and this contributed to fatalities (Gregg et al., 2007). Furthermore, global man-made warning systems are unusable in the case of locally generated tsunamis, for which the time to activate the warning system before the arrival of the waves is too short. Global warning systems such as the Pacific Tsunami Warning Centre and the Indian Ocean Warning System can only be efficient for distant tsunamis, i.e. those with a source located hundreds of kilometres away from the coast. Even for distant tsunamis, it is unlikely that these systems allow the alert to be delivered to some remote coastal areas. **For areas located closer to the tsunami's source, educational activities for local communities are the best ways to avoid loss of human life** (Darienzo et al., 2005; Dengler, 2005; Eisner, 2005; Gregg et al., 2007). Local alert systems can efficiently complement this awareness raising. On Baron beach (southern Java, Indonesia), lifeguards can empty the surroundings relatively quickly via localised siren soundings, if tsunami forewarning signs are observed. For these reasons, **natural warning signs should provide the earliest warning to populations, whether the origin of the tsunami is distant or local**. It is also a reminder that traditional tools can be valuable - as a complementary or substitutional approach to modern technological tools -, to provide efficient warnings. The Indonesian Kentongan (a bamboo drum used with a pre-defined morse code) is thus used to warn the public in case of an adverse event, which is very useful in particular in rural areas or during emergency periods during which electricity might be cut off (Lavigne et al., 2017).

FbA are similar in design to EWS (with the aim to minimize and prevent the impacts of adverse events by informing and supporting the exposed communities) but their approach is different. They put emphasis on decision-making protocols, so actors know what to do on the basis of a forecast, including in terms of cost-benefit analysis (see also Taylor et al., 2018).

For a more complete review of current practices and methods on EWS applied specifically to geological hazards, see the book by Wenzel & Zschau (2014).

8.2 Risk reduction begins at school

Schools have a double role to play in DRR as (1) resistant and safe structures for children and their teachers in case of an adverse event, and (2) as a place for risk education.

Most of the preparedness and risk awareness campaigns led by international organizations target children and young people as a specific and major group in DRR, and many countries consider that the best way to disseminate knowledge on hazards and disaster preparedness in families and communities is through children and school.

Sadly, a number of cases (in Haiti, China, Italy, etc.) demonstrate that children are too often killed in building collapses, often as the result of earthquakes (Babugura, 2012; GADRRRES, 2017). Schools should above all provide a safe place for children during and after disasters, which implies the necessity to locate, design, built, and maintain the buildings in a safe manner (Paci-Green et al., 2017). This overlaps with wider sustainable land-planning problems, which are fundamental in reducing the risk of disasters (ADPC, 2015f). This includes the post-disaster reconstruction context (ADPC, 2015f), with building norms and regulations which should be hazard resistant. **Emergency plans should be prepared in all schools to minimise educational disruptions which often occur because of hazards** (see Cadag et al., 2017). This also means that an emergency response plan should be conceived and developed for each school to be ready to face any kind of hazard. In addition, in order to minimize educational disruptions when a disaster strikes, authorities and communities should try to avoid using schools as long-term shelters for the wider population during emergencies.

It is recognized by many authors (and already applied in many countries), that risk education should be provided and institutionalized in school programs (Walker, 2005; Johnston et al., 2005; Jonientz-Trisler et al., 2005; UNESCO and UNICEF, 2012; Wisner, 2006; Shaw and Oikawa, 2014). This is because children are some of the most receptive to this kind of information and will **communicate this new knowledge to their families** (Peek, 2008). The young emblematic activist Greta Thunberg is a good illustration of how children and young people can play an active role in increasing risk awareness and climate change to wide audiences.

The importance of risk education in reducing the impacts of disasters has been proved on many occasions (see *case study 16*). One successful example is from the Kamaishi schools during the 2011 tsunami in Japan: despite heavy impacts and 1000 casualties in this coastal city, all 3000 school children evacuated to higher ground with no fatalities, taking the appropriate actions by making quick and flexible judgments while helping the more vulnerable. This success is rooted in the fact that from kindergarten to high-schools, Japanese schoolchildren receive regular training and courses on disaster response throughout their curriculum (COJ, 2015; UNDP & UNDRR, 2020).

In terms of curriculum, UNESCO & UNICEF (2012) suggest that the integration of the theme of risk and disaster resilience in school curriculum should include:

- Interactive learning: brainstorming sessions, discussions in small workgroups, interactive presentations;
- Affective learning: sharing feelings about serious accident or disaster episodes, exercises of empathy for those who experienced disasters;
- Learning to do research: analysis of case studies;
- Audio-visual learning: film production, drama performance, simulation games (see Solinska-Nowak et al., 2018), school assemblies on reducing disaster risk;
- Experiential learning: study visits to places of greater risk and dangerousness, participation in the preparation of risk maps, street and awareness raising campaigns.

Case Study 16: ***Tilly Smith, a child who proved the importance of DRR school curriculum***

While case study 4 showed that some groups used local knowledge to recognize the precursors of the 2004 Indian Ocean tsunami, many other examples were reported of people remaining on the beach or shoreline when they saw the sea retreating, even on Sumatra Island where the earthquake was very strongly felt. This was a demonstration of coastal communities being unaware of the potential warning signs of the hazards they are exposed to. The forewarnings may have been even more difficult to interpret in coastal areas distant from the earthquake epicentre where no shaking had been felt before the tsunami struck. However, Tilly Smith, a ten-year-old British girl vacationing on Phuket Island, Thailand, correctly interpreted the receding of water and unusual movements at the surface of the water as a forewarning of the impending tsunami, remembering a geography lesson she had received two weeks before at school. She was able to warn her parents, who passed the information to other people on the beach, allowing its complete evacuation. There was no loss of life in this area, one of the very few areas without reported fatalities on the Island (UNESCO, 2006, in Morin et al., 2008). Her schoolteacher testified: *"The power of education is the difference between success and failure, life and death in this case and there's nothing to substitute it for. Without education, I think people are powerless, with education as can be seen here they are very powerful in terms of directing their own lives"* (UN Audiovisual Library, 2005). This case highlights **the need for education on risk awareness and the role that both school teaching and family preparedness can ultimately play in DRR**.

UNISDR (2007) details the good practices and lessons learned from 38 case studies around the world in raising awareness within school communities, building a culture of prevention, and making schools safer. In addition to complementary case studies, UNESCO & UNICEF (2012) provide a complete guide on the integration of DRR education in schools with a checklist for optimal curriculum practice, as well as insights for the professional development of teachers in terms of DRR education. Equally, Morinière et al. (2018) propose a Scalability Assessment and Planning Toolkit to implement good practices in that area.

Some researchers and practitioners warn about the psychological burden that children might experience if they are officially given responsibility for the dissemination of disaster knowledge or information, while other authors underline that education must be continuous to face the renewal of population, with new residents and migrants or tourists arriving (Darienzo et al., 2005).

What is less often underlined is the need to adapt education strategies according to local contexts (Alverson, 2005) again emphasising the need for place-based and locally led projects and programs.

Relevant awareness and knowledge can be, depending on the context, developed through games (one popular online example is ‘Stop Disasters’, developed by the United Nations to make children aware of multiple sources of exposure and vulnerability and how these processes built risk), thematic exhibitions, evacuation exercises, first aid training, celebrations (for instance the International Day of Natural Disaster Reduction), invitations to specialists to give thematic lectures on risk and disaster, involvement in Civil Protection Clubs or citizen science projects with groups of audience working with scientists and civil protection authorities.

Summary:

- Communicating to and with communities about disasters – including early warning systems - is far more complex than simply ‘passing down’ knowledge about hazards, and instead should consider the knowledge the audience possesses (and does not possess), and the potential interpretations of any communication, as well as the levels of trust and relationships with the different stakeholders.
- Consequently, early warning systems should be ‘people-centred’ in order to be efficient, again reinforcing the need for community engagement, participation and ownership of DRR.
- School based risk reduction and education (particularly of children and young people) should be a critical entry point and focus of DRR efforts, as the lessons learnt in school have the potential to ‘trickle upwards’ to others in society and to establish good practices that can be sustained over time.

9. Conclusions

9.1 Thinking about DRR holistically

This report provides an overview of a complex combination of theories and concepts from a broad range of topics across the social sciences related to DRR. While there are a huge variety of different approaches and knowledges about DRR, from an equally large number of different cultures, there are a number of common lessons that connect this material regarding the effective management of disasters and the reduction of disaster risk.

1. **Disasters cannot fully or adequately be understood without examining vulnerability** (as opposed to focusing on hazards and technocentric solutions). Such vulnerability is inherently place-based and cultural in nature, pointing to the vital role that the social sciences must play in DRR. The social sciences must play a more central role, not just in examining vulnerability, but also in the entire range of DRR activities.

2. **While vulnerability *is* place-based and cultural, there are also shared characteristics and lessons to be learned from the wider corpus of case studies and knowledge.** As Quarantelli *et al*. (2018) note, many aspects of effective warning systems, problems of bureaucracies and governance in responses, and the crucial importance of the family or household unit are applicable in all societies and across contexts. To acknowledge this is to emphasise that social science must seek to understand both these differences and similarities while searching for the best ways to respond to and manage disasters.

3. **The historical context of the two points articulated above has been badly neglected.** If we accept that disasters cannot be understood without considering vulnerability and culture, then we must also seek to understand the long-term dynamics of disasters and the lessons we can learn from looking to the pastD. In so doing, the historical root causes and influences on vulnerability can be revealed, illustrating that all disasters are slow processes.

4. **Disasters are acknowledged to be increasingly complex, multi-scalar, and interconnected.** DRR and disaster research must therefore adopt a holistic approach to account for this. Such approaches must be pluralistic in their inclusion of different knowledges and voices that contribute. Within such pluralistic approaches, both natural and social scientists must work together, breaking down disciplinary boundaries and bubbles in order to co-operate better on key challenges, such as early warning systems. This echoes a recent shift in international policy guidance (see UNDRR, 2019b), recognising that such efforts are all the more pressing due to the increasingly interconnected nature of the risks we face, from climate change to global pandemics.

9.2 Potential for future discussions and collaboration

This report highlights a number of topics and issues that we consider fundamental for efficient and effective DRR and which are also essential for understanding the state of contemporary social science of disasters. We have included a wide range of references from both scientific literature and institutional resources, yet due to the limitations in the length of this report, we have had to remain concise. Inevitably certain topics are underrepresented. There are also many more issues to deal with to reach the best DRR practices, and lessons to be learned in so many different areas (both geographical and topical). We hope this is just the start of a longer conversation and collaboration. While not possible to exhaustively list all areas in which potential future collaborations between the DPRK and DRR researchers and practitioners might take place, the material presented in this report suggest areas in which future discussions might be prioritised:

- Risk perception, behaviour in disasters, and how to account for this in responses (particularly in early warning systems). Since the initial inception of the 'social amplification of risk' theory (see Renn et al., 1992) the topic has developed considerably, and particular advances have been made towards an integrated approach to EWS, considering how warnings might be best disseminated in view of improved understandings of risk perception (Donovan et al., 2018; Hamza & Månsson, 2020).

- The importance and use of history (both qualitative and quantitative) in understanding and addressing disasters (for a volcano example: see Riede, 2014; and for climate change: Degroot et al., 2021).

- Evacuations and territorial vulnerability with a focus on 'ruptures', ways in which access to safe places and livelihoods are impacted (and impeded) by disasters (e.g. Utasse et al., 2016; Leone et al., 2019; UNDRR, 2021a).

- Governance and institutional vulnerability, and how institutions at different levels respond to disasters. Particularly, this includes the examination of local level institutions and groups, and the potential for community-level groups to be trained as first responders within civil society (see Shaw and Izumi, 2014) as a way to enact efficient DRR strategies (Howe & Bang, 2017). The role of different institutional actors in disasters is thus a cross-cutting topic over all the different sections of this report (inclusive DRR, etc.) with considerable scope for further exploration.

- An elaboration on disaster databases and their strengths and limitations, and more generally the issues encountered by the different sources of information, knowledge, and data, and the ways that disaster studies can be framed (e.g. Donner and Diaz, 2018).

- The role of Geographic Information Science (GIS) to support risk analyses and disaster management (e.g. Thomas, 2018), as well as computer simulations and models used in hazards and disasters studies (e.g. Davidson and Nozick, 2018; Deierlein and Zsarnóczay, 2019).

- Low-probability high-impact hazards (e.g. high VEI eruptions), sometimes called Black Swan events (Krausmann and Necci, 2021), and associated communication of uncertainties (Abadie et al., 2017; Fearnley et al., 2018; Merz et al., 2009).

- DRR in the context of multiple and interacting hazards (theorised as cascading or otherwise), including DRR in a COVID-19 - or other pandemic or epidemic - context (UNDRR, 2020e, 2021f).

- Risk communication, including communication with the media (e.g. ADPC, 2015a), use of various channels (for instance the use of radio described by Ahsan and Khatun (2020) and of mobile phones by Markwart et al. (2019)), and social network strengths and weaknesses (Dong et al., 2021; Dragović et al., 2019; Palen & Hughes, 2017; Wendling et al., 2015).

- “Natech” risk of disasters, i.e. the combination and interaction of both natural and technological risk (Gill & Ritchie, 2018; Krausmann & Necci, 2021; UNDRR-APSTAAG, 2020), including the lessons learned from the tsunami-induced earthquake which triggered the Fukushima nuclear accident in 2011 in Japan (UNDRR, 2020f; Koshimura and Shuto, 2015; Mimura et al., 2011; FSSS, 2018, specifically chapter 14 by E. Kanoshima; Casajus Valles et al., 2020, specifically 'Super Case Study 2'. Fukushima) and elaborating on non-nuclear case studies such as dam failures (Dai et al., 2005; Jonkman & Vrijling, 2008; Lin et al., 2021).

- Post-disaster recovery aspects (e.g. Shaw, 2014; the ADPC toolkit for post-disaster recovery including guidance on critical facilities, housing, land use planning, and livelihoods): (ADPC, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g), and inclusion of DRR in humanitarian emergency management (UNDRR, 2021c).

- Participatory and citizen science (e.g. McCormick, 2012a; Bonney et al., 2014).

More references on these topics or other topics of interest can be provided upon request.

10. References

10.1 Additional references sorted by natural hazard type

It is acknowledged that DRR should ideally involve multi-hazards analyses. However, it is sometimes useful for scientists and risk managers to explore hazards and associated coping strategies by type of hazard, rather than by broad topical areas (i.e. CBDRR, early warning systems, etc.). The scientific literature provides a number of references, which are comprehensive synthesis chapters by hazard type (for hazard classification see UNDRR and ISC, 2020). Rather than paraphrasing them, we have chosen to directly include 19 chapters of The Routledge Handbook of Hazards and Disaster Risk Reduction in the list of references:

- The book editors introduce the specific types of natural hazards by displaying the interest and inherent limitations of the following chapters (Wisner et al., 2012; chapter 15).
- Serje (2012; chapter 16) and Saito et al. (2012; chapter 17) provide general insights respectively on data sources on hazards and tools for identifying hazards.
- Chapters 18 to 24 then propose syntheses on hydro-meteorological and climatological hazards: climate change related (Simon, 2012), coastal storms (Jonkman et al., 2012), thunderstorms and tornados (Etkin et al., 2012), floods (Schmuck, 2012), droughts (Smucker, 2012), extreme heat and cold (McCormick, 2012b), and wildfires (Underwood & Held, 2012).
- Chapters 25 to 29 focus on geophysical hazards: landslides and mass movements (Hadmoko & Engel-Di Mauro, 2012), earthquakes (Lomnitz & Wisner, 2012), tsunamis (McAdoo, 2012), volcanic eruptions (Jenkins & Haynes, 2012), soil erosion and contamination (Engel-Di Mauro, 2012).
- Chapters 30 to 33 highlight biological and ecological hazards such as human epidemics (Dibben, 2012), livestock epidemics (Grace & McDermott, 2012), and plant disease, pests and erosion of biodiversity (Girot, 2012).
- Chapter 33 focuses on hazards from space (McGuire, 2012).

10.2 Additional references: full books

We provide some additional general books on DRR that cover most of the topics explored in this report. These were not chosen because they are necessarily better than other references on DRR (which number in the thousands), but because they are some of the more up-to-date ones available (see Shi and Kasperson, 2015; Ranke, 2016; Levy, 2016; Pede, 2020; Ray-Bennett, 2018; Shi, 2019; Atsuji, 2016; Rudenstine and Galea, 2012; Tiwari, 2015; de Guttry et al., 2012).

Finally, we provide a book entitled '*The Illustrated History of Natural Disasters'* (Kozák & Čermák, 2010). The title of which does not

fit with the statement clearly established in this report: disasters cannot be considered as natural. However, the book provides a narrative and descriptive history of disasters linked to natural hazards and is useful as an initial foray into the topic

10.3 Full list of references cited in the report

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