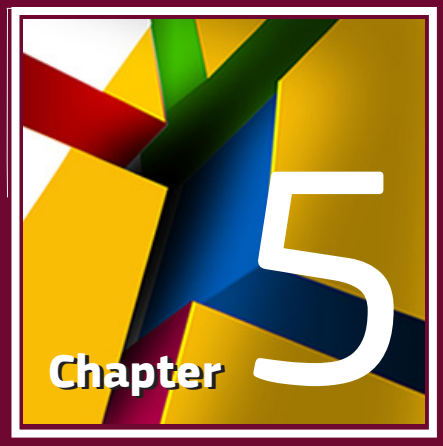

Transferability of knowledge and innovation across the world

Online Version

5 Transferability of knowledge and innovation across the world

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Transferability of knowledge and innovation across the world

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1 Introduction to risk governance and its challenges

Early warning systems must begin with community ownership and engagement, which require a complete understanding of populations, including their vulnerability to potential impacts to hazards.

The key challenge for disaster risk management (DRM) policymakers and practitioners is how to effectively capitalise on the knowledge at local, national, regional (i.e. European) and global levels. This challenge may be overcome through documenting good practices (i.e. approaches and methods that solved a specific problem, produced expected results and provided benefits) and sharing and promoting them as appropriate. Good practices that enhance DRM effectiveness are a valuable source of knowledge for decision-makers and practitioners, and should be further studied and perused.

This chapter provides examples of good practices from the Member States of the European Union (EU) and the countries or regions outside the EU, showcasing approaches and methods utilised across the entire DRM cycle, from risk reduction to response and recovery. The good practices are presented in text boxes throughout the chapter, briefly presenting the challenge, the solution and benefits. Disseminating these good practices is beneficial for:

- improving an understanding of risk, contributing to Priority 1 of the Sendai framework for disaster risk reduction (2015–2030);
- recognising potential alternatives to manage cascading and compounding risk;
- avoiding limitations when planning and implementing measures to reduce risk in the context of interest.

Following the overview of the good practices and the prerequisites to promote knowledge transfer, DRM processes (viewed as a system of systems) are discussed and illustrated with two case studies of end-to-end impact-based early warning systems. An early warning system, viewed as a system of systems that enables effective DRM processes, is reliant on expert knowledge for risk assessment, interpretation and communication (Fakhruddin et al., 2019b).

It is essential that such systems begin with community ownership and engagements, which require a complete understanding of populations, including their vulnerability to the impact of hazards (Fakhruddin et al., 2019a). Two case studies, one in the EU and one in the Pacific, are presented, highlighting the importance of risk communication and knowledge transfer throughout the entire DRM process, followed by how these early warnings are received and acted upon. This then transitions to gaining an understanding of behavioural responses, especially to early warnings. Two case studies, one in New Zealand and one in Italy, examine behavioural response to natural hazards. The final section draws on conclusions from lessons learnt from these studies to improve knowledge of understanding behavioural response and risk communication.

2 Importance of knowledge transfer for system-based approaches

A great amount of knowledge of DRM remains fragmented, calling for good practices to be shared and tested more regularly to be applied elsewhere.

In a complex and multi-layered society, the capacity of social and political actors to govern depends on the exchange of resources, knowledge and expertise (Kooiman, 1993). DRM is no exception. It involves multiple actors with different interests, responsibilities and capacities, at various governance levels, from global to local.
Many stakeholders are officially involved in the planning and implementation of measures to reduce risk, such as decision-makers, civil protection groups, non-governmental organisations (NGOs), experts and insurance groups. More recently, the importance of local and indigenous knowledge and practices has received increasing attention in the field of DRM (Hiwasaki et al., 2014). Although advances towards including knowledge and practices in DRM policies are becoming more widely recognised, implementation remains limited (Hiwasaki et al., 2014). A community-based participatory approach in the design and implementation of policies and projects is proven to be effective, through defining local people's vulnerabilities and capacities and being able to respond to and adapt to disasters (Samaddar et al., 2015) (Box 1).

Engagement of communities in policymaking is promoted through policy frameworks and institutional structures around the world, but it is still not at the desired level (Cheema et al., 2016). People may be motivated to contribute proactively to DRM by designing long-term processes, identifying benefits for participants and adapting legal frameworks for responsibilities to be shared and flexible (Scolobig et al., 2015). Lessons learned are not just repositories of knowledge; they may be used as a tool to raise awareness and open up discussions.

Hicks et al. (2019) reviewed literature on community engagement in DRM around the globe and concluded that research was not comprehensive: there are fewer experiences shared from Africa, and most of the literature analysed citizen behaviour in the aftermath of floods and earthquakes. It seems that citizens become highly active after an event and, as a way to cope with the event, they bond with the existing networks and look for new ones (Kim and Hastak, 2018). These community groups become less heterogeneous in the long run, grouping around ethnical, political or religious beliefs and not only based on the place of residence (Guarnacci, 2016; Baytiyeh, 2017). More information on citizen engagement in the EU is in Subchapter 4.2.

People learn, interact, transfer and combine knowledge from others (Nonaka and Takeuchi, 1995). Knowledge is enhanced by the characteristics of the space where the actions happen, so culture plays an important role in how collaboration and sharing happen among individuals and groups (Perry et al., 2019). Knowledge is transferred through dialogues, documents, learning by doing, and sharing lessons learned. Stories, as a repository of knowledge, support learning and innovation, and help solve the present challenges as well as those that may be faced in future (Brown and Duguid, 1991). Besides culture, knowledge transfer depends on the channel used and the willingness, trust and capacity of the one(s) sharing knowledge and the one(s) receiving it (De Long and Fahey, 2000; Davenport et al., 2001; Riege, 2005; Fakhruddin et al., 2019a). This section discusses ideas for promoting knowledge sharing and transfer, which in turn create new knowledge and synergies.

One way to share and transfer knowledge is through system-based thinking (Haimes, 2012; UNDRR, 2019). This

BOX 1.

Community-led DRM in response and recovery

From global to EU

Who?
Māori, indigenous people of New Zealand

Why?
There is an increasing recognition of the value of community-led initiatives that facilitate emergency response and recovery (Kenney and Phibbs, 2015). However, cultural approaches to DRM and recovery are rarely acknowledged. In New Zealand, Māori DRM initiatives are collaborative, effective and shaped by their cultural values (Kenney and Phibbs, 2015; 2014). This was witnessed during the 2010/11 Canterbury Earthquake Sequence (CES). There is a need to adapt cultural technologies and implement them into integrated DRM at local and national levels. The Māori community-led response to the 2010/11 Canterbury Earthquake Sequence exemplifies the ways traditional Māori knowledge values and practices are interrelated and actioned to facilitate DRR and community resilience for disaster response and recovery (Kenney and Phibbs, 2015; 2014).

What?
The Māori community-led recovery network linked emergency management, government agencies and other responders to ensure that resources and support were available to communities during the response to and recovery from the 2010/11 Canterbury Earthquake Sequence. Māori knowledge, oral histories, value and practices shape behaviours and actions at community and individual levels to ensure community well-being (i.e. unity, family, building and maintaining relationships, community centres, support/hospitality and guardianship) (Kenney and Phibbs, 2015). Examples of this were providing food and shelter during the 2010/11 Canterbury Earthquake Sequence response and supporting communities during the recovery phase.

Community-based knowledge and programmes are an effective tool for building disaster resilience in communities. This example demonstrates how cultural knowledge, values and practices may be utilised during an emergency response and support community resilience in a way that is applicable to other countries with indigenous populations that have similar values and traditional knowledge.

means active involvement from all stakeholders and a feedback loop to continue building a better DRM system and enhance resilience. The global risk assessment framework, an open and collaborative global initiative of UNDRR to improve DRM, provides guidance on non-linear changes in hazard intensity and frequency, ensures that the guidance is well understood by citizens and policymakers, and requires accelerated systemic actions (Gordon, 2020).

Despite the wealth of scientific and indigenous knowledge, challenges remain in the systematic use of this knowledge and evidence from good practices, and in their integration into DRM process to inform policymaking and decision-making (Spiekermann et al., 2015). The main issue is largely related to the dispersion of information

among various stakeholders without a coherent and coordinated approach (Spiekermann et al., 2015). Local disaster risk knowledge and information is not systematically used for decision-making in disaster risk reduction (DRR) policies. International agreements call for more inclusive approaches, including even the stakeholders that are not traditionally part of the DRM community (Brown et al., 2018). Uptake and use of knowledge from

BOX 2

Building the resilience of small businesses

From global to EU

Who?
National Incident Management Systems and Advanced Technology (NIMSAT) Institute, Louisiana (USA)

Why?
This was an effort to help small businesses, often lacking resources and knowledge, to be better prepared for all-hazards disasters. It aimed to improve disaster preparedness and response, providing situational awareness, locating local products and services, addressing critical recovery needs and restoring business as usual quickly. (Figure 1).

What?
- Big business–small business platform
The 'big business–small business' platform was established by the NIMSAT institute in 2012. It engages big businesses to mentor small ones, helping them to strengthen their disaster preparedness and recovery. It is on a voluntary basis and promotes a proactive (whole-community) emergency management approach. Big businesses benefit from strengthening their supply chains and positive branding. Small businesses learn about resilience/business continuity, obtain missing resources and adopt best practices from experienced leaders who have been through disasters and know what it takes to survive.

***Figure** 1. Simulation exercise for ICS.*
***Source**: Fakhruddin, 2015*

- Virtual Business Emergency Operations Center
The Virtual Business Emergency Operations Center is an online platform that facilitates collaboration between public, private and non-profit organisations (vBEOC, n.d.). It leverages best practices in information sharing, lessons learned from research in public–private partnerships, and experience in leading the Louisiana Business Emergency Operations Center. It has grown into a national network of organisations ready to implement the technology. Their technology is free, customisable, user friendly and capable of supporting existing processes and incident management systems.

This would benefit all countries, helping them to empower the community, raise awareness of DRM and engage private sectors. For more information: https://www.onvcp.org/iema/

good practices are encouraged (Box 2). Sharing knowledge and applying it to transferring best practice enables structures, process and systems to improve in the policy decision-making space (UNISDR, 2016). Culture has a strong effect on communities' survival and has proven to act both positively and negatively when people put into practice measures to reduce disaster risk (Kulatunga, 2010).

BOX 3

Scientific evidence at the service of local initiatives – Vertical Evacuation from Tsunamis: a guide for community officials

From global to EU

Who?
American Federal Emergency Management Agency (FEMA)

Why?
This project was undertaken to address the need for guidance on how to build structures to resist the force and impacts of large earthquakes and tsunamis. The aim of the project is to support coastal communities that are vulnerable to tsunami, which could inundate low-lying areas in a matter of minutes, and to enhance their capacity to evacuate to safety.

What?
The publication guide presents information on how vertical evacuation design guidance can be used and encouraged at the regional (state) and local levels. The purpose is to help government officials and the public by providing them with information to address tsunami hazard risk in their community and to determine the need for a vertical evacuation structure.

The guide includes characterisation of tsunami hazards, choosing between various options for structures, locating and sizing structures, estimation of tsunami load effects, structural design concepts and other considerations.

Many coastal communities are vulnerable to tsunami, especially nations that sit within or next to the Pacific Ring of Fire. This project is an example of good practice addressing the need for safety measures to prevent loss of life. It would be beneficial for many countries that need to address the gap in tsunami risk life-saving measures and determine the need for vertical evacuation structures.

New Zealand is an example of reviewing international frameworks such as FEMA's Guidelines for design of structures for vertical evacuation from tsunami (FEMA, 2012) as a guideline to inform a vertical evacuation assessment and planning guideline suitable to New Zealand's context and standards (MCDEM, 2018).

For more information: https://www.wbdg.org/FFC/DHS/femap646.pdf

BOX 4

Networks and partnerships in the Pacific North West Economic Region

From global to EU

Who?
Pacific North West Economic Region (PNWER) Center for Regional Disaster Resilience

Why?
State/jurisdiction governments understood that there are regional hazard impacts but the governments had influence only within their borders. The PNWER enables them to cross borders and have a collective approach to solve tough issues.

What?
- Regional Critical Infrastructure Protection Workgroup
  The PNWER conducts quarterly conference calls with the critical infrastructure protection (CIP) managers from the PNWER member states and provinces. This interstate, cross-border forum has generated an open forum to discuss key issues that affect the region.

- North-West Warning Alert and Response Network (NWWARN): www.nwwarn.org
  The NWWARN is a regional communication tool for cross-sector critical infrastructure communications. The online system provides information from trusted sources to protect critical infrastructure systems and ultimately the public. It is capable of providing early warning messaging and two-way situational awareness before and during a disaster. The PNWER has led this effort for over 8 years in cooperation with the Department of Homeland Security, the Federal Bureau of Investigation, FEMA, Washington State Fusion Center and private sector partners. For more information, visit: www.nwwarn.org

- Puget Sound Partnership for Regional Security Program
  The Puget Sound Partnership for Regional Security, together with the PNWER, conducted a seminar with regional critical infrastructure owners and operators. The seminar focused on transportation, supply chain and freight resiliency; developing a regional information-sharing and analysis capability; and pandemic and biological event resilience. In 2020, the focus will be on seminars for critical infrastructure owners and operators in the Puget Sound area. The outcomes from these events will be shared with the region's CIP managers.

Europe shares a landmass, so natural hazards often occur across multiple countries. This approach would allow a more collaborative approach between countries to ensure that their warning systems, procedures and policies are uniform.

For more information: http://www.pnwer.org/

BOX 5

Local and indigenous knowledge for community resilience

From global to EU

Who?
Small island communities in Indonesia, the Philippines and Timor Leste, supported by the United Nations Educational, Scientific, and Cultural Organization (UNESCO)

Why?
Local and indigenous knowledge has received increasing attention in the field of DRM and climate change adaptation. However, the knowledge of indigenous people is yet to be included in policy decision-making. Indigenous knowledge is crucial to understand long histories of interaction with the natural surroundings and potential impacts on the environment and loss of life (Figure 2). The wealth of such knowledge would enable communities to increase their resilience and be better prepared for future hazard events.

What?
The project documented indigenous knowledge and practices that help communities to predict, mitigate and adapt to hydrometeorological hazards. It developed tools for integrating indigenous knowledge with science on hydrometeorological hazard risk reduction and climate change impacts.

The aim of this project is to showcase the results to inform other national and local government entities to promote the use of local and indigenous knowledge to take actions and integrate such knowledge into planning and practice to increase coastal community resilience. This could be of particular interest for countries in the Pacific and Asia.

Figure 2. *Community consultation on disaster responses.*
Source: *T+TI, 2018.*

For more information: Hiwasaki et al (2014).

Mechanisms for enhancing knowledge transfer and uptake include:

- promoting more systematic dissemination of scientific information that would identify ways of translating it into practical methods that could be integrated into DRM policies (Box 3);
- identifying ways such as fostering stronger and more inclusive partnerships between scientific agencies, communities, governments and other networks to scale up the applications of science to policy and practice (UNISDR, 2016) (Box 4).

From empirical studies, some considerations have been found that could limit collaboration between different individuals and groups, particularly when they have different backgrounds and interests, such as (Mejri and Pesaro, 2015; Spiekermann et al., 2015; Sitas et al., 2016):

- values and interpretation of risk,
- personal attitudes and incentives,
- preconceived assumptions and stereotypes,
- discipline-embedded thinking,
- resistance to new practices,
- power structures,
- budget constraints,
- potential hindrances to accountability and transparency.

At the same time, individuals report not having enough time or incentives for learning and exchanging, especially in project-based organisations (Koskinen et al., 2003; Williams, 2008). Those represent a large number of stakeholders in DRM in some areas of the world, represented by groups or organisations of different types and sizes, such as civil society or non-profit organisations.

The purpose of sharing lessons learned is to apply them elsewhere. Some barriers are common in practice, such as (WHO, 2015; Singh et al., 2016; Sako et al., 2018):

- time and budget constraints,
- rebuilding of structures not in alignment with the context's values and institutions,
- political commitments,
- not addressing root problems, such as food shortage,
- low participation of users and of key actors (Box 5).

Identify how to strengthen and enhance existing technology initiatives that promote networking, information sharing and knowledge transfer to improve implementation of DRM strategies (Box 6). This should consider more systematic and reinforced science/policy and science/practitioners interfaces including scenario research to address future risk and challenges, and ways to track indicators by using community-driven impact assessments to better react proactively to early warnings.

BOX 6

Development of technology for emergency management systems

From EU to global

Who?
The European Data Interoperability Solution at Stakeholders Emergencies Reaction Consortium

Why?
To achieve a detailed common operational picture shared between organisations with different systems, between regions or even between countries.

What?
Emergel (EMERgency ELements) is a technology and supporting tool that provides interoperability between emergency management systems. The Emergel ontology contains the knowledge objects used by responders in different countries, along with their terminologies. It is used to allow the exchange of information between emergency management systems, and facilitates semantic interoperability by means of translation and mediation.

This is particularly relevant to countries that share borders, as they need to ensure that natural hazards and disasters can be managed across the country borders in a uniform and effective manner.

For more information: https://cordis.europa.eu/project/id/285069

3 Transferring practice: what works

A critical factor in addressing disaster risk reduction and climate change adaptation is the complexity and diversity of the stakeholders involved.

This section highlights the elements to consider to facilitate the transferability of best DRM practices between regions. Here, transferability means that techniques, knowledge or methods developed in one case study can be used in other places (Kelman et al., 2012).

3.1 Governance

The effects of climate change are being experienced now, and it is a major challenge for nations to address sustainable development and impacts on livelihoods, assets and critical infrastructure (Amin and Watkins, 2018). We first look at risk governance, and in particular the link between DRM and climate change adaptation (CCA). Risk governance plays an important role in facilitating knowledge transfer and informing practices.

DRM is dependent on researchers, governmental organisations and other sources integrating knowledge from best practices and lessons learned from previous disaster events. Knowledge and experiences from these experts can provide guidance for sound and informed decision-making and systematic approaches to effective DRM policy and practice.

Successful risk governance can be measured by how effectively the sectors are able to work together and incorporate knowledge into planning and practice (Box 7a and 7b). The EU features a wide range of approaches, some of which may fit risk governance systems outside the EU. A critical factor in addressing DRM and CCA is the complexity and diversity of the stakeholders involved.

There are no reasons for climate change to be separated from wider DRR and sustainable development processes (Kelman, 2017). The separation is related in part to the frequent administrative and political separation of the activities involved. For instance, Germany is organised in a decentralised way, which means that responsibilities are shared among different departments. Stakeholders dealing with DRM are associated with the Federal Ministry of the Interior,

Building and Community, while those involved in CCA activities are, for example, based at the German Environment Agency. However, it is not only the horizontal separations (i.e. different departments or ministries) that constitute a challenge, but also vertical ones (i.e. different levels of governance) (Marx et al., 2017). Switzerland exemplifies a strongly decentralised and yet hierarchical system where cantons (federal states) have a mandate to prioritise and implement measures, funded by and reporting back to the federal level (Abad et al., 2018).

France is one of the rare cases in Europe where DRM and CCA fall under the responsibility of the same ministry, the Ministry of Ecological and Solidarity Transition. However, the two policy areas are split into separate directorates, with DRM falling under the remit of the General Directorate for Risk Prevention and CCA falling under the remit of the General Directorate for Energy and Climate. This means that in France the main challenge is not how to prevent policies from diverging, but rather how to ensure they converge (Amaratunga et al., 2017).

BOX 7a

Climate change risk assessments from New Zealand and the United Kingdoms

From global to global

Who?
New Zealand Government

Why?
New Zealand is experiencing the impacts of a changing climate and needs to be better prepared to adapt to the effects. There is a need to mitigate greenhouse emissions for a more sustainable future, recognising the importance of minimising loss and damage associated with climate change adverse effects. In the absence of a worldwide effort to reduce emissions in accordance with the Paris Agreement, New Zealand is planning to develop policy and guidance to tackle climate change.

What?
The New Zealand Government's role is to provide a legislative policy framework and guidance to support local government and businesses to make decisions on adapting to climate change impacts (Ministry of the Environment, 2019). New Zealand has developed its first national climate change risk assessment framework, which consists of:

- a national climate change risk assessment, to improve the understanding of climate risks;
- a national adaptation plan, which outlines the approach to improving climate resilience;
- monitoring and reporting on implementation of the national adaptation plan.

Engagement events were held with central and local governments, climate change experts, Māori representatives and affected sectors. Significant engagement of all those involved meant a more comprehensive knowledge and skill base for understanding climate change risks to New Zealand.

This framework can inform a similar approach for mitigating adverse climate change effects in other countries. This is an example of good practice in addressing all aspects of climate change, as it takes into account both immediate and long-term effects in preparing for the future.

For more information: https://www.mfe.govt.nz/publications/climate-change/national-climate-change-risk-assessment-new-zealand-main-report

BOX 7b

Climate change risk assessments from New Zealand and the United Kingdoms

From global to global

Who?
United Kingdom Government

Why?
Under the Climate Change Act, the United Kingdom Government undertakes a country-wide climate change risk assessment every 5 years to understand present-day and future vulnerability, assess climate-related risks in up to 50 years' time and prioritise opportunities to manage these risks in the next 5 years (HM Government, 2017)

What?
The climate change risk assessment conducted in 2017 identified six immediate priority areas of climate change risk that need to be managed:

- flooding and coastal change risks to communities, businesses and infrastructure;
- risks to health and well-being;
- risks of water shortage;
- risks to natural capital;
- risks to domestic and international food supply and trade;
- new emerging pests and diseases.

This information is intended to assist local-level planning by government officials and policy and technical experts. However, it can also inform a similar approach to addressing the risk of climate change in other countries in the EU and prioritising similar actions if applicable.

For more information: https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/

At the EU level, the ESPREssO (Enhancing Synergies for Disaster Prevention in the European Union) project (ESPREssO, 2018), supported by the EU's Horizon 2020 framework, analysed Europe's approach to DRM and CCA. Three major challenges identified were: (1) creation of synergies between the DRM and CCA sectors at the national and EU levels; (2) enhancement of risk management capabilities by bridging the gap between science and policy at the local and national levels; and (3) facilitation of more efficient management of transboundary crises. ESPREssO established a Europe-wide forum of stakeholders from all governance levels, including policy, science and technical practitioners, to debate on and study these challenges. The outcomes will be of relevance beyond the EU.

Furthermore, Birkmann and von Teichman (2010) propose that the national level is the most suitable one to enable CCA and DRM communities to enhance the communication and match strategies between countries, irrespective of national differences. At the national level, agreed goals and targets are defined (such as what 'resilience' means) and policy and institutional frameworks are developed. Gaillard and Mercer (2013) point out that risk is materialised and vulnerability tackled on the ground, at the community level. Hence, the authors claim, there is a need to institutionalise good practices at the community level and use this, together with the scientific knowledge, to achieve large-scale results.

Community networks facilitate collaboration and participation for disaster resilience (Djalante et al., 2011). Many groups and committees have been created in the last two decades to pool knowledge on disaster and climate change, separately or collectively. National policies, strategies and plans for DRM and CCA need to ensure that gaps are detected systematically from national to community levels and addressed with appropriate measures (Standards New Zealand, 2009, Trogrlić et al., 2017, UNEP, 2008,). In that sense, global or national science and technology roadmaps (e.g. UNDRR, 2019a, UNISDR, 2016, UN-SPIDER, 2019), regional strategies (e.g. Amaratunga et al., 2015) or national disaster resilience strategies (e.g. NDRS, 2019) can serve to evaluate the networks.

The governance model should not only ensure that stakeholders and sectors interact and that governance levels are aligned and coordinated, but ensure a DRM system that promotes learning. From the evaluation of projects, programmes and policies, lessons learned should be collected and stored for future use. More information on linking levels and actors is provided in Subchapter 4.1, 'Linking actors, sectors and governance levels'.

3.2. Context

Second, we look at DRM solutions, as it is important to understand that good practice may not work as well in a new environment as in the original setting, or may be completely inappropriate (Szulanski, 2003; Delpeuch, 2008). From a 'contextual practice' point of view (Ambler, 2011) what is 'good' (or 'best') varies with the context. It is necessary to understand the challenges that one could come across when implementing good practices and what could be done to overcome them. Practices are rarely directly transferable. They often have to be adjusted and customised for the new application context and can evolve into a better version as improvements are discovered (Trucco, 2015). Cultural, social, institutional and political differences between countries always have to be considered when transferring practices to developing areas; lessons should be applied to solve the present and future needs of the particular place (Tiwari, 2015).

3.3. Tools and methods

If specific elements (i.e. determinants) of each good practice could be extracted, as well as lessons learned, it would be easier to connect them to DRM issues that could be addressed by applying them. Trucco (2015) identified four types of good practices (activities, procedures, tools and technologies), mapped their contribution to resilience depending on disaster response phases, and assessed them across three dimensions relevant to their wider exploitation. To be applied, knowledge should be captured, stored, retrieved and transferred into suitable methods and technologies. Monitoring and evaluation of the measures taken before and after a disaster is an interesting source of learning. For example, operational teams train and enhance their capacities to be ready for and respond to emergencies, as shown in Box 8. Exercises and drills are an opportunity to create capacities and to test protocols and plans, although they are not always carried out and few are followed up (Beerens and Tehlerb, 2016; Skryabina et al., 2017).

BOX 8

Com Romania – improving the resilience of emergency response buildings

From global to global

Who?
World Bank and Government of Romania

Why?
The project contributes to strengthening Romanian emergency response buildings against earthquake and extreme climate events so that these buildings remain fully operational in the aftermath of disasters. This will ensure that response efforts in the aftermath of disaster are not negatively affected, and in turn can help save lives (Figure 3) and reduce the socioeconomic impacts of future events due to natural hazards.

Figure 3. *SMURD (the Mobile Emergency Service for Resuscitation and Extrication) in action near Cluj-Napoca.*
Source*: Wikimedia Commons.*

What?
The project aims to enhance the resilience of critical response facilities and strengthen institutional capacities for emergency preparedness and response in Romania. It specifically supports priority retrofitting and reconstruction of vulnerable General Inspectorate for Emergency Situations buildings, fire stations and police buildings. These buildings will also be modernised to meet operational requirements, energy efficiency, universal access and gender considerations given the changing demographic in emergency response. The project also guides infrastructure planning of emergency response buildings. It strengthens institutional capacity for operational readiness through training, acquisition of essential emergency equipment, development of data and information on disaster and climate risks, and public awareness activities. These integrated efforts in the emergency response and civil protection sectors could be linked to DRM and CCA.

Knowledge is also produced after transfer and application. In DRM, knowledge comes from different stakeholders and levels, within their own realities and cultures; much of the knowledge that could be relevant to share is contained in individuals' minds or within groups of people (Boxes 9 and 10; see also Subchapter 4.1). Organisations should exploit the knowledge that remains uncodified, based on the experiences of individuals or groups, particularly for the personnel engaged in operations to deal with uncertain events, such as emerging public health incidents (Sanford et al., 2020), to avoid reinventing the wheel in the aftermath of an event (Koria, 2009).

BOX 9

Cross-border approaches to increasing resiliences

From global to EU

Who?
Pacific North West Economic Region (PNWER) Centre for Regional Disaster Resilience

Why?
The aim is to create and foster cross–sector partnerships focused on infrastructure security and disaster resilience.

What?
The PNWER has organised six critical infrastructure interdependency exercises since 2012. Each exercise was designed by the stakeholders and reflected regional concerns on terrorism, cybersecurity, natural hazards, pandemic flu, supply chain resilience, public health and flooding. An integrated action plan was created based on the findings and recommendations of the exercises. Numerous projects from the action plan are under way.

BOX 10

Upgrade of information management

From EU to global

Who?
Instituut Fysieke Veiligheid (Institute for Physical Safety), Netherlands

Why?
The aim is to enable all responders within Dutch safety regions (local and regional public authorities) to collaborate closely to manage critical events and disasters.

What?
The *Landelijk Crisismanagement Systeem* (National Crisis Management System) is a distributed information system focused on geographical information and linked data. It contains modules for communication, coordination and logistics; efficient exchange and disclosure of information; and drafting a geographical information system (GIS) view.
Similar GIS platforms may be used in other countries, leveraged for multiple uses, such as community outreach, emergency response and action by government agencies.

For more information: https://www.lcms.nl/about-lcms

Regardless of the methods and technology, the lesson learned should contain a set of information to be analysed and incorporated elsewhere by potential users (Davenport and Prusak, 1998):
- from the context;
- on the culture;
- about the expertise, procedures and protocols of the groups engaged

Developing local to global user-friendly systems for information to be exchanged on good practice, easy-to-use and affordable technologies and lessons on policies, plans and measures would contribute to the Sendai framework ambitions (Izumi et al., 2019; Rahman and Fang, 2019). Along the same lines, Hick et al. (2019) stated the need to better exploit lessons learned on citizen engagement in DRM at the international level (Box 11).

A set of capacities is needed for the collection, storage and transfer of knowledge, but particularly for the reuse of it in the form of lessons learned. School education (Box 12), together with family and community learning, has proven to be useful to raise awareness of earthquakes among pupils in Japan and to teach them how to prepare themselves to deal with such events (Shaw et al., 2004). In developing countries, formal courses, together with

BOX 11a

COVID-19 tracing and tracking technology in Australia, Austria, Bulgaria, Cyprus Czechia, France, Greece, New Zealand, Norway, Poland, Portugal, Singapore, Slovakia, South Korea and Spain.

From global to global

Who?
Nations around the world including the EU Member States

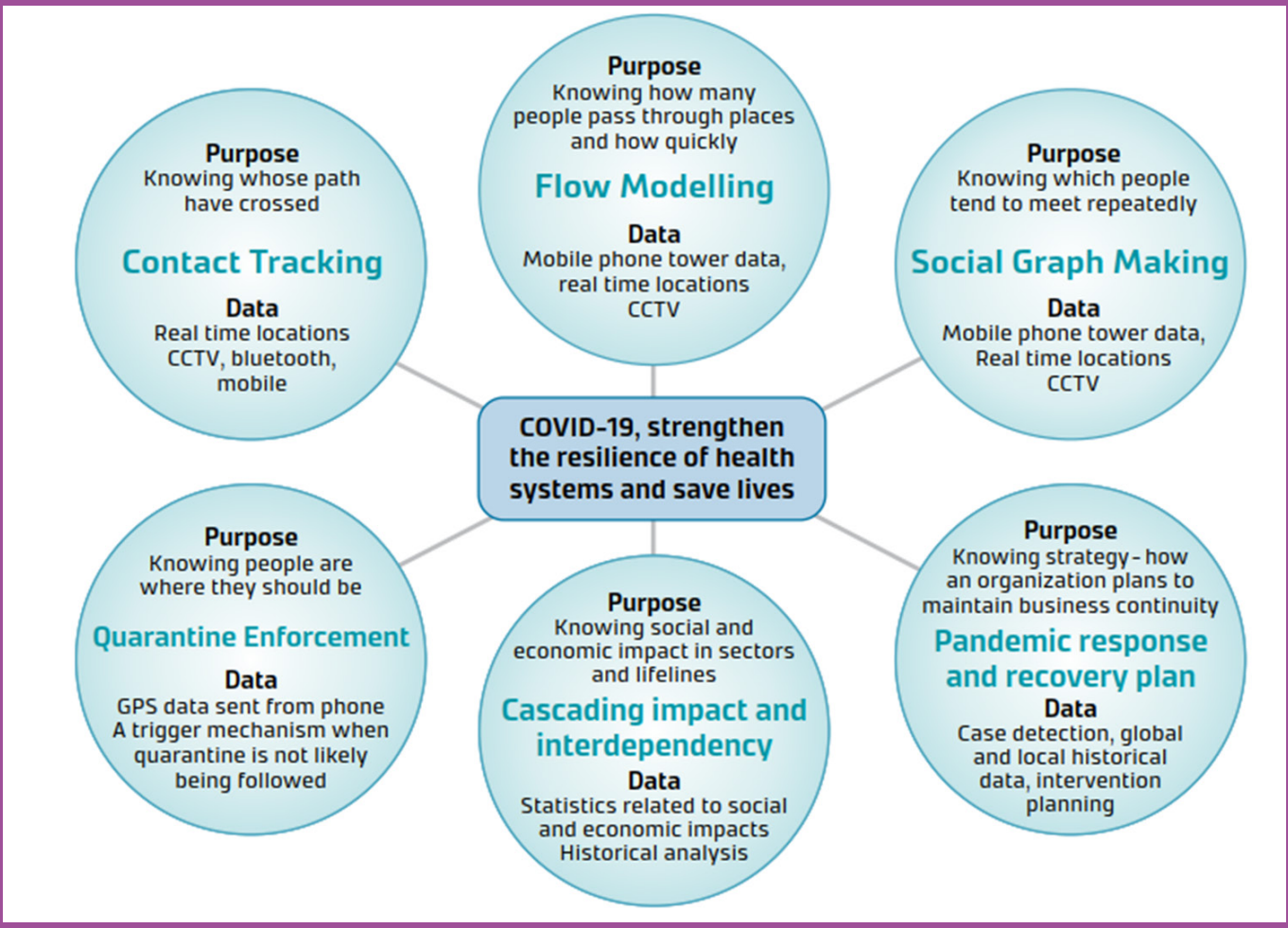
Why?
Emerging technologies are important in the response to the COVID-19 pandemic and attempts to mitigate it. It is necessary to minimise and mitigate transmission in the hope of preventing the spread within communities. Technologies and tools are utilised to act decisively and prevent further spread, or quickly suppress or minimise the transmission of COVID-19. Technologies are able to trace people's location and identify potential clusters and thus enable responders to alert people to transmission.

What?
Enhanced surveillance and contact tracing technologies are being employed around the world to understand transmission, outbreak assessment, risk and cascading impact assessments (Figure 4). Technologies such as geolocation trackers, cell site location information, Global Positioning System satellite and Bluetooth data, and location apps enable quicker detection and prevention of this pandemic. In Singapore, for example, an app has been developed to accurately trace and track active COVID-19 cases. Many countries around the world are adopting a similar approach and believe this is best practice to track and trace COVID-19.

BOX 11b

Systematic thinking, especially for those responding to COVID-19 pandemic, provides important lessons and ways to significantly improve the fight against potential pandemics in the future. All countries can learn from best practice during this global pandemic.

Figure 4**. Tools and approaches to face COVID-19 emergency.* ***Source: *Fakhruddin, 2020.*



other activities for children, such as games and puppet shows, have been proposed as promising methods to transfer DRM knowledge among families and communities (Izadkhah and Hosseini, 2005; Fernandez and Shaw, 2016). For more examples and insights into education, see Super case study 5, 'Education, cultural inclusion and disasters'.

BOX 12

Community resilience through education

From global to global

Who?
Scottish Environment Protection Agency, Scotland

Why?
Schools are at the heart of communities, and young people are particularly vulnerable to emergencies, but they also have ideas, energy and commitment that many adults would envy.

What?
Scotland's approach is to fund an education post, supported by resilience and flooding teams as well as by the Scottish Environment Protection Agency. This engagement supports resilience professionals in their awareness-raising duties under the Flood Risk Management Act. Schools get access to detailed information about flood plains, flood protection schemes and other areas of interest in the local area, which helps bring the learning to life in the classroom. Gathering case studies and sharing them at the national level has been useful in showing resilience professionals and education colleagues what awareness raising looks like in practice. Both resilience and education professionals have seen the relevance of integrating resilience into the Curriculum for Excellence.

Getting young people involved in the global context means there will be more community buy-in to DRM systems, and also an understanding of DRM principles from an early age that will make future education and DRM procedures easier to communicate. This will be particularly beneficial in developing countries.

For more information: https://floodlinescotland.org.uk/creative-engagement

4 What a system-based approach looks like

DRM should be seen not in isolation but in dynamic relationships with the larger context (i.e. social, political, financial and ecological systems). The main value of a system-based approach is the underlying philosophy of seeing the bigger picture.

Successful risk reduction requires an all-hazards, system-based approach, engagement with local communities, and cross-sectoral and multidisciplinary collaboration. A system-based approach is composed of interconnected and intra- and interdependent subsystems of communities and infrastructures, with multiple functions, operations and stakeholders. This method is also referred to as a system-of-systems approach.

Chapters 2 and 4 discuss theories of system-based thinking and system-based approaches. This section discusses case studies of good practice in impact-based early warning systems as successful DRM processes.

Early warning systems (EWSs) are a critical component of DRM, with a role beyond detecting and monitoring hazards (WMO, 2013). Along with a thorough risk assessment, it is critical that warnings be disseminated quickly through coordinated systems. Issuing warnings will not have a real impact if communities, companies and authorities at the local, national or international level do not develop emergency plans and respond accordingly to the upcoming risk. In other words, an EWS should be seen as a system within the system of society and the economy.

This comprehensive approach to DRM requires coordination and synergies between different agencies, taking into consideration DRM phases. A lack of coordination between the agencies, or the failure of one of these components, may cause the failure of the entire system (Luther et al., 2017). This means that an early warning may not be generated correctly or it may not be delivered effectively. In any case, the population to be warned would not react appropriately.

The critical role of each component of EWS is made clear by the experience of the great east Japan earthquake and tsunami, which hit Japan's east coast in 2011. Japan has a long history of dealing with earthquakes and tsunamis. The country had developed advanced EWS and DRM measures. It is believed that Japan was using one of the most advanced EWS in the world. Many of its forecasting technologies and numerical models were provided to other countries needing EWS support, such as Indonesia and Peru. However, underestimations of the 2011 earthquake and tsunami led to devastating effects, as presented in Super case study 2. Underestimation of the earthquake disaster risk and its cascading and interlinking consequences caused catastrophic damage and the evacuation of 160 000 people (Norio et al., 2011; Pushpalal et al., 2013). This reminded the DRM community that a system-based approach is essential to understand dynamic relationships with the larger context (i.e. social, political, financial and ecological systems) and their interdependency and consequences, in order to assess and manage risk properly.

Warning systems need to be established and supported throughout normal times. Early warnings are associated with emergency conditions, but their usefulness is determined by the extent to which they are installed and active beforehand. Organisations associated with early warnings need to encourage collaborators to focus on the fundamental objective of their efforts: to enable timely, coherent and effective response to a warning by officials and the public. There is often the need for political will to respond to the evidence of early warning, especially the very early signs, when the government is possibly facing more immediate priorities. For this reason, early warning

functions need to be linked to risk assessment and preparedness programmes within a coherent DRM strategy. To further this relationship, there is a need for continued research and development of the technical aspects of EWS for explicit user-determined needs and applications.

The lack of multidisciplinary and transboundary cooperation can represent a challenge for successful EWSs. EWSs are often developed to address single hazards, but a unilateral approach may lead to the generation of an unforeseen cascade of events (Basher, 2006). It is within this context that the concept of multi-hazard EWS (MHEWS) was introduced and defined by UNDRR in 2017. MHEWSs address several hazards and/or impacts of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascading or cumulatively over time, and take into account potential interrelated effects. It is now clear that an MHEWS increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for accurate hazard identification and monitoring of multiple hazards.

To address this gap actively, the United Nations Office for Disaster Risk Reduction (UNDRR), the World Meteorological Organization (WMO) and UNESCO, along with other major international and national organisations, have collaborated to establish the International Network for Multi-Hazard Early Warning Systems.

Germany has an MHEWS operated by the Deutscher Wetterdienst (DWD), the German Meteorological Office. The DWD issues 27 types of warnings for about 450 districts or parts of districts in Germany and for different height levels (DWD, 2012). It regularly holds feedback meetings and training sessions with DRM authorities to ensure a coordinated approach. It states that 'a good early warning system should follow the four rules of service delivery (availability, dependability, usability, credibility)' (DWD, 2012, pp.30). The DWD has learned in developing the system that cooperation, partnership and communication at all levels between national meteorological and hydrological services and disaster management organisations is the key to successful development of EWSs (DWD, 2012).

The WMO initiated the South-East European Multi-Hazard Early Warning Advisory System project in 2016 to assist its members in the region to upgrade or install EWSs and improve community resilience (WMO, 2018). The project addresses gaps in forecasting and warning provision at national and regional levels by developing a regional MHEWS and harmonise national EWSs.

The 10 essential elements that combine to build an effective EWS are shown in Figure 5.

Building Resilience to High-Impact Hydro-Meteorological Events through Strengthening Multi-Hazard Early Warning Systems in Small Island Developing States (SIDS) and South East Asia is a multinational project (WMO, 2020a). Its aim is to strengthen weather-, climate- and water-related impact-based decision support services to MHEWS stakeholders, by:

- increasing the engagement of national meteorological and hydrological services in national and regional MHEWSs and DRR mechanisms;
- increasing access to and utilisation of regional and global hydrometeorological data and products to support development of impact-based forecasts and warnings;
- strengthening capacity for development of impact-based hydrometeorological products to support MHEWS stakeholders in decision-making.

This project aims to achieve improved governance by strengthening national and regional DRM and early warning mechanisms with increased engagements between MHEWS stakeholders, social and economic sectors and communities, in addition to enhanced product development and service delivery.

Figure 5. *End-to-end impact-based early warning system.* ***Source:*** *Fakhruddin and Schick, 2019.*

Enhancing the development of and access to services will enable countries to support the development of impact-based forecasts and risk-informed warnings. An example of this is the newly developed cyclone EWS in Fiji (WMO, 2019), which is the first cyclone EWS for the Pacific. The Fiji Meteorological Service serves as a WMO-designated Regional Specialised Meteorological Centre for tropical cyclone warnings and advisories for the south-west Pacific. Fiji continues to enhance its tsunami EWSs by adding additional tsunami sirens for the most vulnerable communities and using advanced science such as probabilistic tsunami hazard assessment to understand its exposure and vulnerabilities (Tonkin +Taylor Ltd., 2020). In addition to this, the project has enhanced Fiji's MHEWS by completing a national strategic plan and implementing a flash flood guidance system (WMO, 2020) and data training.

5 Risk communication: where it gets local

Creating an enabling environment for community participation will ultimately empower the community and get its members involved in the issue rather than simply being informed of the issue.

A significant level of knowledge needs to be developed on human response to warnings at the emergency warning organisational and individual/family levels. General principles for coordination and effective organisational responses are well defined. Coordination seems to be maximised when organisations know what they are supposed to do in an emergency and who is to do it, have designated and understood communication ties to others in the network, and maintain flexibility (Anderson, 1969; Mileti and Sorensen, 1987; Lindell and Perry, 1992; Anderson-Berry, et al., 2018).

Communication problems, due to equipment and human failure, are the most significant causes of poor warning dissemination. An example of coordination in DRM can be seen in France. Following the devastating December 1999 winter storm Lothar, which resulted in 100 deaths, a public warning system called Vigilance was developed as part of revised emergency planning and response mechanisms. The system delivers regular and descriptive information about the meteorological phenomena and informs the population directly so they can take responsibility for their safety (Meteo France, 2010). The system proved useful when a storm similar to Lothar occurred in 2009, and resulted in only eight deaths. The Vigilance system was upgraded to include heat and health warnings in 2004 and river flood risk warnings in 2007 (World Meteorological Organization, 2012).

A system similar to the Vigilance warning system can be implemented in developing countries, as hydrometeorological hazards pose risk to lives and livelihoods globally. Events such as storms, floods, droughts, heatwaves and cold waves are responsible for the greatest proportion of losses from adverse natural events globally. Well-prepared and well-resourced hydrometeorological services can help in minimising the disruptions caused by natural hazards by providing warning to governments and communities (Palwarty and Sivakumar, 2014). An example is the Kerala flood of 2018, when an unprecedented amount of rainfall caused reservoirs to fill, forcing dam gates to open, which led to the widespread flooding of downstream areas. Depths of water reached 4.5 m and more than 400 people were killed in what officials said was the worst flooding in 100 years. Investigations revealed that inaccurate weather forecast and opening of dam gates in a hurry were two major factors that contributed to this disaster. The Chief Minister of the state pointed to the accountability of the India Meteorological Department for underestimating the rainfall, forecasting one third of the actual rain received. Weather monitoring and forecasting have come a long way, but extreme weather events such as the Kerala flood point to the fact that we still have miles to go.

The importance of the social and cultural aspects of risk has been widely recognised; however, new insights continue to emerge as communication technologies and behaviours evolve (e.g. Taylor et al., 2018). Understanding natural hazard risk at the community level is essential for successful hazard risk reduction.

A recent research project (Fakhruddin et al., 2019b) carried out in a small coastal community in New Zealand has highlighted certain deficiencies in this area. The data collected suggest the following factors should be considered in DRM.

- Multi-hazard risk communication systems may be beneficial to cover all hazards that the community feels are evident, not only those the authorities and or agencies see as relevant.

- Consideration should be given to the demographics of the community, such as the varied cultures and languages, age distribution, mobility, disability (e.g. to consider appropriate warning dissemination methods and subsequent evacuation procedures for the elderly).
- Instead of general public engagement sessions, age-, gender-, culture- and/or location-specific engagement is suggested to enhance risk perception and reduce risk.
- Seek input from residents regarding the level and nature of risk they attribute to each hazard and why, and continue to review the hazards facing the community as the environment, population and social structure of the community change.
- Strengthen collaboration between policymakers and the community, and consult with the community on what methods it would suggest, or prefer, to communicate hazard risk or mitigate hazard risk. Do this early on in the process. Creating an enabling environment for community participation will ultimately empower the community and get its members involved in the issue rather than simply informing them of the issue (Fakhruddin et al., 2019b).

Fraser et al. (2016) analysed evacuation behaviour in response to two local-source earthquakes in 2013 in Wellington, New Zealand. Although they were widely felt and injured over 100 people, the magnitude of the earthquakes did not meet the threshold to issue an official evacuation warning to the public. The survey found that the majority of respondents did not evacuate. Despite this, 55–60 % of respondents believed that a tsunami could have occurred following each earthquake, but chose not to evacuate. Respondents' previous attendance at local tsunami information meetings significantly influenced their perception of the likelihood of tsunami damage, but did not influence respondents' perceptions of the likelihood of injuries or casualties. This research concludes that it is important to engage with at-risk communities, through education, training and drills on the appropriate protective actions to take following natural cues (earthquakes) or an official tsunami warning, in addition to active participation in defining, designing and implementing disaster risk management initiatives at community level.

This contrasts with research carried out by Alexander (1990), which summarised responses after an earthquake on 23 November 1980 struck southern Italy. The results concluded that the majority of the students had no earthquake experience; they relied significantly on older relatives or companions to interpret the risk for them and followed the actions of those around them. Engagement and education are increasingly recognised as the most effective forms of communication (NASEM, 2017). A more recent example of how communities consider flood risk reduction comes from central and eastern European states. Owing to the devastating impacts of floods in Czechia, Poland and Romania, the EU has been taking a bottom-up approach whereby communities are involved in strategies for flood risk reduction. In 19 studies on flood risk perception, it was found that risk reduction was considered a 'temporary event rather than a process' and there was a 'strong reliance upon regional and national authorities' for prevention measures and risk communication (Raška, 2015, p. 2 163). The results of Fraser et al. (2016) have shown that measures to help at-risk communities understand the hazard have been effective and could be utilised to improve risk perception in other regions, such as central and eastern Europe. Participatory approaches to DRR, such as community-based DRR and co-production of knowledge, are recognised as challenging, albeit a prerequisite for effective risk action (e.g. Cadag et al., 2017).

6 Conclusions and key messages

The chapter discusses synergies between international and EU examples by way of good practice examples of DRM activities. It argues that DRM strategies should act on a system of systems, in which all elements should be viewed as equally important.

The EU system and framework for DRM is extensive and research based. This makes the system easily transferable, so the EU system can be adopted and customised for multiple global contexts and locations. In comparison, the global system of DRM often arises as a reaction to an event and is thus largely location specific or contextually based. The EU approach is perhaps a good starting point for countries; however, learning from around the world should be incorporated into all DRM plans so they can be location and context specific to be more efficient and effective. Communities, organisations and agencies around the globe, and in particular in less developed countries, may have capacities in place (at individual, social and system levels) that are overlooked, which should be identified, protected and shared. The projects and initiatives described show some of the varied groups, DRM phases and methods that should considered to enhance the capacity of the systems as a whole.

Good practices highlight the importance of appropriate risk communication and the necessity of understanding how communities could respond to new risk information. While cultural, legal and economic contexts may differ, synergies and transferability require partnership and capacity building. Effective education and outreach must be based in a thorough understanding of the process that individuals go through when they make decisions about modifying their behaviour and willingness to accept new ideas and technologies.

Policymakers

- Policymakers should work on goals and objectives to be reached at the level of governance they are working in, indicating the vision to follow. This would facilitate the selection and use of good practices. In particular, they should collaborate with the relevant stakeholders to define some ambiguous terms, such as resilience.

- At the same time, policymakers should exploit synergies with other levels, ensuring that the goals and objectives are coherent across all levels.

- Policymakers should design and reinforce instruments that would facilitate bottom-up and on-demand projects and actions, particularly in developing countries. This requires investments in the long term and linking DRM and CCA with poverty and inequality. They should find incentives for others to collaborate, and should ensure that funding mechanisms allow local ownership and promote actions that are aligned to local needs.

- There is a need to open the decision-making arenas to new forms of leadership and new arenas for collaboration with the different actors in DRM. There is an important space for action in international forums and arenas, where policymakers from subnational levels should also take part.

- Policymakers should exploit the results of research and lessons learned, promoting the implementation and further testing of initiatives and projects.

- Likewise, formal institutions should be part of the change, not only facilitating channels for knowledge flows and coordination, but also developing their capacities.

Practitioners ([1])

- Above all, practitioners should define well what a good practice is, considering political decisions and agreements.

- Documentation of good practices requires not only presenting the final positive results but also describing the challenges and limitations. Identifying good (or bad) practices should result from rigorous monitoring and evaluation, to ensure impacts are known.

- The lessons should be shared at events or meetings, used in capacity building, and actively distributed to targeting groups that are especially vulnerable, or have special needs, and groups that have well-known capacities but are not traditionally engaged in DRM. Studies show that citizens are sometimes engaged after events, as part of recovery and reconstruction. Practitioners should define strategies to elicit citizens' participation in other projects or in the monitoring or evaluation of the measures implemented.

- Capabilities may exist at organisational level but each organisation should ensure capacities are downscaled to operations and tasks so that lessons learned can be used. Sharing knowledge with peers and creating communities of practice should be facilitated and rewarded by the organisations, while observations and new insights from exercises should be used in further developments.

Scientists

- Scientists are valuable partners for knowledge co-creation at any governance level. It is recommended that they engage in networks and projects with other actors, as interface and knowledge brokers. They should be open-minded to new approaches when defining needs and alternatives.

- Many empirical studies on knowledge creation and sharing come from the private sector. This leaves a gap for research on knowledge creation and sharing in DRM.
  It is recommended to focus on the impact of new types of leadership and the barriers to them, and on the relations between public sector and other stakeholders as part of new governance models in DRM.

- There is a shortage of studies on how to engage the private sector and communities in new initiatives and technologies.

- Citizen engagement should be better explored in some regions, such as Africa, and in dealing with technological hazards.

([1]) Practitioners here are governmental officials who work to implement policies and programmes; groups that directly work in disaster risk management, such as civil protection; and non-profit organisations.).

Citizens

Research reiterates the value that communities can add in DRM planning and implementation. Citizens should actively engage in the opportunities given to raise their voice and to engage with others in the design of measures; there are opportunities within their communities, such as through religious or political groups. The post-event period seems to be a good window of opportunity for that, as policymakers and practitioners are more willing to collaborate for a sustainable recovery.

Scientist and practitioners

They should work together to push for testing and reuse for innovations and technologies that are affordable and relevant to the context, to make them ready for use in capacity-building activities.

Practitioners, scientists and citizens

There is not much evidence of the real impact of many capacity-building, training and educational activities. It is necessary to evaluate some promising approaches (Ronan et al., 2015) and to ensure that they lead to risk reduction. Practitioners and citizens, together with scientists, should endeavour in the long-term evaluation initiatives to (1) ensure that the elements that would facilitate the application and reuse of knowledge at local and community levels are in place in advance and (2) define which approaches are most effective at finally reducing impacts. While international and regional bodies may invest in evaluation, there is the risk that lower levels lack the capacities in the long run to learn from the past or are not properly engaged in the process (Hagelsteen and Becker, 2013).

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