



European
Commission

Science for Disaster Risk Management 2020

Executive Summary

***Acting Today,
Protecting Tomorrow***

Disaster
Risk
Management
Knowledge
Centre

This is the executive summary of the report "Science for disaster risk management 2020: Acting today, protecting tomorrow."

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SCIENCE FOR DISASTER RISK MANAGEMENT 2020

Acting today, protecting tomorrow

EXECUTIVE SUMMARY

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FOREWORD

Dear readers,

In recent years, extreme events including the COVID-19 pandemic have accounted for thousands of deaths and severe economic consequences among EU Member States and significant disruption to human development. Numerous research results such as the recent JRC Peseta IV study show that climate change would significantly increase the impacts of floods, droughts and wildfires if no mitigation and adaptation measures are taken. The report *Science for Disaster Risk Management 2020: acting today, protecting tomorrow*, drafted by the European Commission's Joint Research Centre in collaboration with more than 300 experts, aims to contribute to bridging the gap between scientific and practical knowledge with policy needs and actions, while advancing techniques and knowledge on disaster risk.

Disasters can have a wide variety of consequences. For example, in addition to its impact on human life and the economy in Europe, COVID-19 has brought a shock to our daily life and the need to 'socially distance'. The authors of the Report aim to support the identification and analysis of the different impacts that emerge after a disaster, which in turn sets the scene for the development of effective action to reduce future disaster risks by 'building back better'. Indeed the efforts to mitigate and prevent potential damages and losses should start in the recovery phase.

Disaster risk management is a task for all of society. Sectors, institutions and disciplines need to work together to produce the evidence needed for the development and implementation of broad disaster risk management plans. This Report provides concrete recommendations for four important groups in society that can actively reduce disaster risk: policy-makers, practitioners, scientist and citizens, covering both the technical and governance gaps. The recommendations can support the development of the Knowledge Network, as part the enhanced Union Civil Protection Mechanism, trigger new partnerships and research projects and better integrate disaster risk for a greener, more digital and more inclusive Europe.

Finally, we would like to thank to the experts that have participated in the Report, from research and civil protection groups to international organizations and national agencies, among others. In bringing together their perspective and knowledge to the Report we can derive a sounder and more comprehensive contribution from these diverse areas of expertise. This report is the perfect example of the power and the added value of open collaborative processes across sectors, disciplines, borders and geographical scales.



Mariya Gabriel

European Commissioner
for Innovation, Research,
Culture, Education and Youth



Janez Lenarčič

European Commissioner
for Crisis Management

PREFACE

Context

The current report focuses on the immediate consequences of a disaster, on its wider impacts and on the various assets to be protected.

The report *Science for Disaster Risk Management 2020: acting today, protecting tomorrow* is the second in the Science for Disaster Risk Management series, aiming to present knowledge on disaster risk management (DRM) and outline challenges. The current report looks at the different phases of DRM, focusing on the immediate consequences of a disaster, on its wider impacts and on the various assets to be protected. Studying the impacts helps in managing risk after a disaster, guiding the response and facilitating recovery, and in preparing measures to prevent, mitigate and prepare for future events, by supporting risk prediction and the planning of measures to manage risk.

Following the recommendations of the previous Science for DRM report, published in 2017, the report *Science for Disaster Risk Management 2020* shares knowledge on prevention, mitigation and adaptation strategies and approaches, moving from the identification of problems to the presentation of solutions. To that end, the report describes several examples and cases, showing what the DRM community has learned from disastrous events while pointing out where the gaps in our knowledge are. While the problems are global, the solutions are context dependent, and therefore the report proposes approaches to DRM from a European perspective.

Tackling the impacts on assets at risk, the report deals with hazards of different natures, highlighting the many links existing between hazards and vulnerabilities to support robust and effective action. The various chapters and subchapters provide specific recommendations for the target audience, four groups of stakeholders that can actively contribute to reducing disaster risk: policymakers, practitioners (such as civil protection groups, critical infrastructure operators and organised civil groups directly engaged in disaster response), scientists and citizens. All the input provided is finally brought together in the conclusions to provide guidance to the stakeholders on working together across sectors, disciplines and organisations to strengthen the study of disaster impacts and thus manage disaster risk.

Science for Disaster Risk Management 2020: acting today, protecting tomorrow contributes to the Sendai science and technology roadmap, and it is aligned with other global frameworks and with the aspirations of the new European Commission. During its production, the coronavirus disease 2019 (COVID-19) outbreak became a pandemic, affecting business and the daily lives of European citizens to a huge extent. The report has been adapted to provide the most up-to-date knowledge and guidance for the 2020 context.

Process

More than 300 participants have been engaged over the past 2 years in the preparation of the report.

More than 300 participants have been engaged over the past 2 years in the preparation of the report. They have been divided into four groups whose work is interrelated: an advisory group, several teams of authors, a group of independent external reviewers and the editorial board. Because of the interconnected nature of impacts on particular assets, different groups and disciplines have been called on to work together on the analysis.

Structure

The report covers the disaster risk management cycle bridging science and its application, trying to better understand, communicate and manage risk.

The report *Science for Disaster Risk Management 2017: Knowing better and losing less* covered the DRM cycle from a scientific perspective, using the concept of a bridge from science to application and covering three main areas: understanding risk, communicating risk and managing risk. The current report follows a similar logic.

The first chapter sets out the policy context, at global and EU levels, including the most recent frameworks for COVID-19 recovery. The different actors are introduced, paying particular attention to the role played by and the advances made by the scientific community in managing disaster risk.

Chapter 2 describes the tools, policies and actors that are relevant for the three phases of an integrated DRM cycle: risk assessment, risk management planning and implementing risk management measures. This integrated approach ensures that all relevant stakeholders are engaged and therefore that policies and actions are well founded on evidence.

Chapter 3 is the core content of the report, addressing the various impacts that affect five key assets for society: population, economic sectors, critical infrastructures, ecosystem services and cultural heritage. The first subchapter defines the core concepts and discusses the purpose and limitations of the study of impacts after a disaster. The authors then identify, for the asset under consideration, which impacts commonly occur after a disaster and review methodologies for analysing these impacts. Past events are used to illustrate the links between the impacts and the characteristics of the asset, as well as lessons that can be learned from the management of risk after the events. Five representative disasters are described and analysed in more detail in Chapter 3, showing the consequences for different assets. These include the earthquakes in Central Italy in 2016–2017, the Fukushima Daiichi accident in 2011, the volcanic eruption of Eyjafjallajökull in 2010, the forest fires in Portugal in 2017 and the COVID-19 emergency we are still facing.

Focusing on the idea of an integrated DRM cycle, Chapter 4 analyses how different governance levels, stakeholders and groups interact and connect both before and after a disaster. This chapter includes an overview of the role of culture in disaster management, with a particular focus on disaster education and training.

Chapter 5 explores the potential synergies between the EU's experiences of and practice on DRM and those of countries outside the EU. Sharing lessons learned supports learning and innovation and improves DRM systems. The last chapter contains the main conclusions of the whole volume and the recommendations for the target audience of policymakers, practitioners, scientists and citizens.

Acknowledgements

The report could not have been produced without the contribution of each of the participants listed in the annex at the end of this document. We would like to thank them for the time and effort they devoted to producing the content and supporting the project, leaving their comfort zones and engaging fruitfully with others.

Disaster Risk Management Knowledge Centre

New challenges, new opportunities

In the current landscape, in which the intensification of the effects of natural and technological hazards due to climate change is combined with new ways of threatening our societies, the establishment of strong alliances to reinforce our capacities to better protect our future has become a must.

A growing number of European Commission services are collaborating to reinforce the links between the different policies relating to disaster risk reduction (DRR) and disaster risk management (DRM). The aim is to maximise the impact of an optimised implementation of DRR and DRM policies. Policymakers and risk managers increasingly rely on the wealth of existing knowledge at all stages of the DRM cycle: adaptation, mitigation, prevention, preparedness, response, and recovery and reconstruction.

While complexity and uncertainty are growing and many developments cannot be predicted, a stronger anticipation culture would strengthen the EU's resilience. Understanding disaster risk is essential to increasing resilience and contributes to smart, sustainable and inclusive growth.

Commission Knowledge Centres

The Commission officially endorsed the concept of knowledge centres in the Commission communication on data, information and knowledge management (C(2016) 6626). These centres bring together experts and knowledge from inside and outside the Commission, creating a new instrument for developing and pursuing informed and evidence-based EU policies.

The Disaster Risk Management Knowledge Centre (DRMKC) provides a networked approach to the science-policy interface on DRM, across the Commission, the EU Member States and the DRM community within and beyond the EU.

Integrated disaster risk management

The driving force of the DRMKC is collaboration. Relying on the expertise of the wider DRM community, the DRMKC proposes and coordinates actions to consolidate collective knowledge across scientific disciplines and economic sectors, while reinforcing the existing links between DRM- and DRR-related policies.

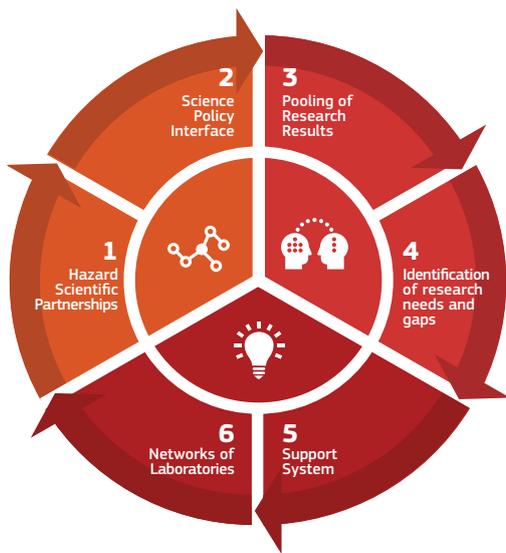
While knowledge is abundant, gaps do, of course, still exist. The DRMKC contributes to mapping these gaps, thus fostering more focused and needs-driven policy development.

In practice

Supported and empowered by cooperation between experienced scientific networks, the DRMKC offers a collaborative space and takes a multidisciplinary approach to the complexity of DRM, putting forward specific collective goals to be reached in support of the development of a more sustainable future.

The DRMKC builds on three pillars:

Partnerships. To achieve the ambitious goal of fully exploiting complex science and translating it into useful policy and applications in DRM, the DRMKC works to foster the transfer of knowledge and technologies between networks specialising in different hazards and threats (the source of the knowledge) to enable these networks to strengthen the science–policy interface by providing integrated support to the policy cycle (where that knowledge applies).



Knowledge. Scientific research results and operational knowledge gained from lessons learned, exercises, training, peer review and other assessment tools need to be better exploited in the DRM cycle to mitigate risks and vulnerabilities and to improve responses when disaster strikes.

- A common repository of relevant research and operational projects and results is accessible through DRMKC Projects Explorer.
- DRMKC Gaps Explorer offers science-based knowledge and targeted recommendations on the way forward, tailored to different stakeholder profiles and hazards.
- Summarising science and contributing to the identification of new challenges are key objectives of the DRMKC, which are implemented with the involvement of the larger DRM community through the regular preparation of Science for DRM reports.

Innovation. There is a strong need for a common space where continuous sharing, testing, training, benchmarking, validation and promotion of more and more focused innovations relating to all phases of the DRM cycle can take place.

- The DRMKC Risk Data Hub is a multi-hazard geoportal intended to provide a common tool for scientists, practitioners and policymakers and to support the bridging of science and policy, the past and the future, and different levels of governance in the context of DRM.
- The Index for Risk Management (Inform) provides quantitative assessments of the risk of humanitarian crises in multi-hazard contexts, with a major focus on developing countries.
- The European Crisis Management Laboratory (ECML) is a permanent infrastructure hosted by the Joint Research Centre that acts as an research and development and test facility for ICT-focused solutions. ECML integrates devices, applications and crisis management-related information sources to support crisis management needs, such as threat analysis, common situational awareness, training and collaborative decision-making.

The DRMKC is supported and coordinated by a number of Commission services in partnership with a key network of Member States. Its steering committee meets regularly to propose, discuss and establish the activities and priorities of the knowledge centre.

The DRMKC web platform (<http://drmkc.jrc.ec.europa.eu/>) facilitates information and knowledge sharing, while reinforcing connections between science, operational activities and policy.

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RECOMMENDATIONS

Recommendations

Tasks led by policymakers

Facilitate and promote collaborative processes to collect input from practitioners, scientists, the private sector and citizens

Collaboration among different groups and sectors of society is key to reducing disaster risk. Working across disciplines and sectors facilitates the design, implementation and evaluation of evidence-based policies. Trust and long-term partnerships are necessary to overcome the differences in responsibilities, interests, languages and experiences that often hinder collaboration.

- Design mechanisms to facilitate bottom-up approaches: open to new types of leaderships the arena of decision-making and collaboration for the implementation and evaluation of DRR measures.
- Collaborate with scientists and practitioners in the monitoring and evaluation of non-structural and new approaches to preventing, mitigating and adapting to risk. Take advantage of the post-disaster phase to fund new endeavours that are in line with the vision and medium-term strategies of the territory.
- Engage in discussions with other governance levels, within the country and internationally, to promote more complete assessment of progress on reducing risk, which requires indirect and intangible impacts to be properly addressed. It is important to consider impacts on health, ecosystem services and cultural heritage. DRM communities should work on important challenges that hinder sustainability: the mitigation of and adaptation to climate change, ecosystem degradation and the loss of biodiversity.
- Work to ensure that a precautionary approach guides policy debates: the benefits of prevention and mitigation action may be difficult to define in the short term. Devote efforts to tackling the full spectrum of damage and losses.

Develop a policy framework to collect, store and reuse data and information, including good practices and lessons learned during response and recovery processes

Information gathered about past events helps to identify the failures in communication and in response protocols, the barriers in governance, the lack of awareness and the gaps in knowledge and data. Data from disasters commonly serve to guide response and recovery efforts and ensure that those who should be compensated are, but they are also a means of learning from past events. Data and lessons learned from past disasters are useful in evaluating measures implemented to reduce risk and in improving the models that predict future disasters. For the latter, baseline data and other contextual information should be stored and shared too. Despite the benefits that can be gained from them, data and lessons learned are not collected in a uniform manner and are stored by different governance levels and institutions, often unavailable to other organisations and stakeholders.

- Design mechanisms to help knowledge flow across different governance levels, particularly from the local level to the national, while scientific support is enabled to reach local and regional levels more easily.
- Establish frameworks for data collection at the most local level possible, as well as for retrieval and sharing of data among governance levels after an event. The frameworks should take into account the databases that already exist on DRM, mainly sector-specific, alongside others that are related to the

specific context, as necessary to understand the baseline situation before the event. The databases can be national or international, but the frameworks should be wide enough to consider different types of damage and loss, so that they can collect and use data constantly. The frameworks should carefully regulate which non-public organisations can take part in these activities and how, ensuring that data are accessible and of the required quality for different purposes.

- Develop mechanisms for damage and loss data to be shared by the private sector, without compromising or violating privacy.
- Engage with practitioners and scientists to understand the uncertainty around the results obtained from analysis and forecasts. These dialogues will facilitate sharing of tacit knowledge.

Ensure proper monitoring and evaluation of the corrective measures planned and implemented

Disasters should be exploited as an opportunity to learn, to think about the changes that are needed and to propose potential new lines of action. By analysing the measures taken and their efficacy and confronting the need for change, we help the system to move towards a long-term view by tackling the underlying drivers of risk (exposure and vulnerability, capacity). The costs of response, recovery and reconstruction should be reported for accountability and compared with those of prevention and mitigation to support decision-making. As managing disaster requires an all-society approach, the required collaborations need to be carefully planned, to detect which capabilities need to be developed while sharing existing capacities.

- Monitoring and evaluation of policies and programmes implemented should be specially reinforced, particularly after an event, engaging diverse stakeholders. These evaluations are an opportunity to make changes at the levels of projects, organisations and risk management culture. This type of action can increase accountability and transparency, reinforcing trust.
- Develop frameworks to identify and properly assess capabilities and capacity needs, and their development, to mitigate and prevent risk. In doing so, consider the institutions already engaged in DRM by law and explore how these can cooperate with other groups and organisations, such as the private sector and citizens (individually and through civil society organisations). The roles and responsibilities of the diverse stakeholders and groups must be clarified and power imbalances addressed.
- Introduce innovative funding mechanisms to encourage and enable alignment and joint investment between various public sector agencies and public–private partnerships. Those partnerships serve to cover the different dimensions of assets and the relations between them. Moreover, sectors are usually divided into various subsectors, which should work together to ensure resilience.

Tasks led by practitioners

Provide feedback to ensure that tacit knowledge is endorsed by policymakers

Data and lessons are not collected in a uniform manner and are stored by different governance levels and institutions, often unavailable for purposes other than particular response or recovery actions. Civil protection groups, critical infrastructure or industry operators, and other civil society groups actively engaged in the most immediate relief and recovery operations after disasters have vast experience of disaster impacts and risk, which should be applied to many phases of DRM (prevention, mitigation and preparedness).

- Practitioners should take a more active role in the policy arena and in particular in the prevention and mitigation of disaster risk. Practitioners should channel impact data and lessons learned from response and recovery to groups in charge of risk assessments and planning and monitoring of measures to reduce disaster risk.
- Support decision-makers in the preparation of a comprehensive framework for impact assessment. Propose procedures to collect disaster impact data across sectors and governance levels for different purposes. Work closely with scientists in the collection and analysis of data after an event.

Be creative and perseverant in your tasks, embracing innovation

The past events described show the lack of preparedness of our societies to face high-impact but low-probability events. The many links between sectors and assets, at all governance levels, call for indirect impacts to be addressed. Likewise, intangible impacts should not be overlooked. The report presents innovative approaches to the collection and sharing of loss and damage data that should be further developed using new technologies, such as remote sensing techniques, sensors, apps and artificial intelligence.

- Practitioners should think outside the box when drafting preparedness actions, including training and exercises, to be ready for the next event, not for those that have already occurred. Pay particular attention to thinking of more complex scenarios, including cascading effects and compound events. Simulation exercises should be carried out together with key actors, such as operators and representatives of critical infrastructures, important industrial sites, economic activities, and natural spaces or natural resources.
- Update contingency plans and other initiatives based on the lessons learned from simulation exercises. Address impacts beyond those that are direct and tangible. Work with operators of industries and infrastructures, business representatives and nature conservation groups to learn together and reinforce prevention, mitigation and adaptation measures.

Help the scientific community with data and feedback

As stated above, practitioners are closely engaged in relief and recovery efforts, for which data are collected and analysed. At the same time, practitioners have traditionally engaged with various stakeholders, so they can serve as bridge between various groups and sectors in relation to the collection, storage and analysis of loss and damage data.

- Support the knowledge flow among different administrative levels and share your tacit knowledge with other groups, in particular with scientists. Properly document lessons learned and experiences, enabling others to compare, share and test them.
- Work to collect detailed data on response and first recovery stages and ensure that they are available later for other purposes.
- Work with scientists to help the private sector and citizens to participate in the implementation of innovative approaches to reducing risk, and in particular to the collection and analysis of information on impacts.

Tasks led by scientists

Continue research efforts on disaster risk dimensions and management

Methodologies for analysing impact have been developed mainly for direct and tangible damage and losses, and have reached different levels of sophistication depending on the asset and the hazard under consideration. Intangible impacts are commonly overlooked, in part because it is difficult to fully account for the value of some assets and to quantify the loss or the damage suffered. These types of assets, however, can represent an important part of our social life and well-being, so they should be covered by disaster management. In a globalised and complex world, interdependencies among sectors and compound events indicate the need to increase our understanding of the drivers of risk to assets (exposure, vulnerability and capacity).

- Efforts should be devoted to improving the methods used to capture indirect losses and intangible impacts. To this end, the scope of impact analysis should be widened to accommodate cascading effects or to study compound events, considering the links of the asset studied with others, in time and space.
- Engage in activities beyond risk analysis, such as risk identification, risk transfer, scenario building and strategic foresight. The groups engaged in risk analysis need to be engaged in these exercises.
- Risk treatment requires special attention. The costs and effects of mitigation measures should be studied after an event, paying attention to the causes and drivers that increased disaster risk. At the same time, propose measures to prevent and mitigate losses and damage that could be put into practice by citizens and the private sector. Here, the DRM community and climate change adaptation groups can easily collaborate.
- Methodologies for measuring the value of assets should be further developed and adapted to measure loss in value.
- Research should be devoted to studying the socioeconomic processes and factors that lead to impacts on the various assets presented in the report, particularly at individual and community levels. There are few studies on this topic in Europe.
- Further develop new techniques and methods to collect and analyse the vast amount of impact data. Demonstrate the added value that they create to policymakers through examples and good practices.

Acquire additional knowledge by interacting with other communities

Disaster risk knowledge is fragmented among groups and disciplines, so scientists should make an effort to involve people from those groups and working in those disciplines in their assessments. Reducing risk is an all-society task, so societal learning should be supported.

- Efforts are still required to ensure that the various scientific groups and disciplines obtain relevant results. A good starting point would be for different disciplines to work together to propose impact metrics to be monitored (in time and space) after an event, which would be the same as those to be used in forecasting risk. These could be used to draw up and update a framework for impact assessment. Support policymakers in that endeavour, pointing out the opportunities to be grasped and the challenges to be overcome.

- Facilitate a culture of learning with other stakeholders, and in particular with practitioners and groups working in the field, by testing new tools and approaches in various contexts. Go beyond the traditional role of giving advice and transferring information.

Make sure the knowledge is useful and used

The science–policy interface on DRM has been reinforced at some levels of governance, but still sometimes expertise is kept within particular institutions and organisations and knowledge is not properly shared for the co-development, co-implementation and co-evaluation of DRM actions.

- Work to synthesise research results and define problems for non-expert audiences.
- Together with practitioners, present the gaps in knowledge regarding propagation of effects within sectors and assets in particular areas of interest. During relief and response phases, support practitioners to assess scenarios.
- Work with practitioners to make sure that models and tools for analysing impacts are available and endorsed by them.
- Collaborate with practitioners on reaching citizens, before and after an event, through educational programmes and communication campaigns. Carry out research on how to mobilise different groups that are traditionally not engaged in DRM.

Tasks led by citizens

Raise your voice for a more resilient future.

DRR is an all-society task. Each individual should encourage others to speak and participate in collective learning and action.

- Discuss DRR with family, friends and neighbours, and invite them to participate more actively by volunteering, attending events at which policies and programmes are presented to communities, speaking up when plans and projects are open for public comments, and reward political groups that have worked to reduce disaster risk, among other ways.

Be active to reduce disaster risk at local level.

Citizens, as key players in managing risk, can exploit new governance models and technology to contribute to current societal efforts of reducing disaster risk, in particular in their neighbourhood and municipality.

- Become aware of the responsibilities and benefits of managing disaster risk. Be well informed and be engaged in workshops, training or discussions at the local level. Engage in DRM activities, through organisations on the ground (such as religious groups, community groups or local environmental protection groups) or specific projects that might be run by various institutions
- Invest in individual and communal protection measures and evaluate the measures taken.
- Facilitate the work of responders during an emergency, and avoid passing on information that could be misleading or confusing.

Engage with other stakeholders in DRM activities.

The input of citizens is necessary for measures be planned and implemented more effectively at community, regional and national level. The path towards learning and thus improving the whole DRM system depends on the willingness of individuals to share their risk perceptions, experiences and preferences. Likewise, the private sector already has responsibilities in place for DRM; data and information from various sources could help with companies' internal actions to manage disaster risk. There are some areas where new business developments and partnerships could be created.

- Contribute to damage data collection efforts, through platforms, social media and apps. Be open to sharing both tangible and intangible impacts to make the identification and analysis of impacts more comprehensive.
- Cooperate with policymakers on creating a vision for the territory, especially in the post-event period. Keep in mind that some changes may be required in the landscape and functioning of the area to build back better and exploit new opportunities.
- Participate in a DRM learning culture, in particular engaging in discussions with scientists and practitioners to define and value intangible assets, before any event.
- Various activities represent a business opportunity that could be exploited by small and new businesses, for example related to the framework(s) for collecting, retrieving and sharing loss and damage data and to the implementation and evaluation of new prevention and mitigation projects at the local level.

It is worth mentioning that all four communities need to join in a discussion of important but ambiguous terms, such as 'resilience', 'impact' and 'affected people'.

ACT

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BACKGROUND

Introduction

The coronavirus disease 2019 (COVID-19) emergency that we are living through shows us what ‘systemic risk’ means in practice; it has required stakeholders to collaborate, working across disciplines, sectors and governance levels. Science plays an important role in societal debates and supports policymaking: it raises awareness of the complexity of the problems at hand while facilitating the identification of the problems to be solved and the formulation of alternative solutions.

Since we cannot prevent some hazards, the main opportunity for reducing risk lies in tackling vulnerability and exposure. To do so, it is necessary to identify and tackle the underlying drivers of risk. The scientific community has worked to enlarge the understanding and modelling risk. A huge progress has been made in developing new technologies to capture signals and monitoring threats. In general, scientists have embarked in new projects to cooperate with end-users and other societal actors in research programmes such as Horizon 2020.

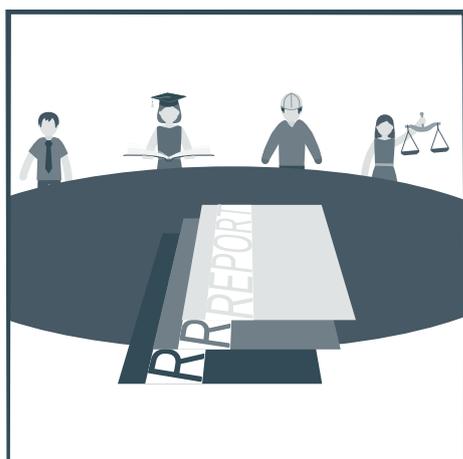
Risk anticipation and management are fundamental to major international agreements and frameworks that have been in place since 2015: the Sendai Framework for Disaster Risk Reduction, Agenda 2030, the Paris Agreement and the 2016 Urban Agenda. The cooperative effort to manage disaster risk at EU level began in 2001, and since then the approach has shifted towards a greater emphasis on prevention and preparedness. There is no doubt that local action is needed to implement all the relevant global agreements and frameworks.

During the current pandemic, the European Council agreed to an ambitious COVID-19 recovery plan, known as ‘Next Generation EU’, that will contribute to the implementation of the new European Green Deal. These key policies are mutually reinforcing and are based on sound science and risk management principles. Accessible and interoperable data, knowledge sharing and innovative approaches will be vital in making the transition towards a greener, more inclusive and more digital EU.

The report *Science for Disaster Risk Management 2020: acting today, protecting tomorrow* focuses on the consequences of disasters to identify impacts and analyse their dynamics, thus contributing to a better understanding of disaster risk.

Integrating the risk management cycle

Disasters continue to undermine sustainable development, so reducing their impacts and identifying pathways towards resilient societies is a global goal. As proposed by the Sendai Framework for Disaster Risk Reduction and the Union Civil Protection Mechanism, among other initiatives, understanding and assessing the drivers and patterns of risk is necessary to identify, plan and implement any measure to reduce risk. Risk assessments serve to create a common understanding of the potential losses and damage. The information produced is used later to develop and put into operation the procedures, protocols and capabilities needed.



Risk, which is a social and cultural concept, has an uncertain and dynamic nature, making its study and management challenging. The need for evidence to inform policies and their implementation has gained importance in recent years. The integration of natural and social sciences expertise is therefore required to tackle risk. Despite recent advances in the understanding and assessment of risk, several challenges persist, such as the incorporation of local knowledge and intangible factors into risk assessments.

Science is vital for the efficient implementation of strategies for mitigating the most serious consequences of hazards before they become disasters, by identifying the potential range and severity of exposure, patterns of causality and the bases for action. In Europe, science is one of the players, but effective risk management requires other stakeholders to participate in and share responsibility for the decisions made.

This fact calls for the preparation of strategies of coordination and integration within the groups and among governance levels. These should ensure that DRM capacities exist within a variety of

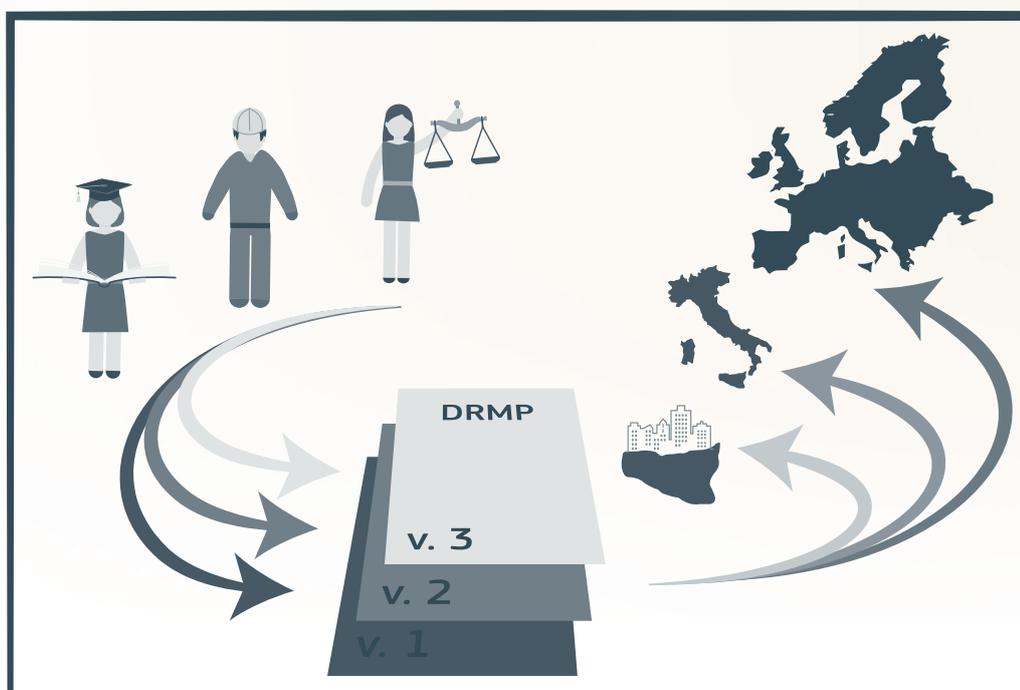
“**Disaster risk management policies, strategies and plans should be based on a common understanding of the risks.**”



“Effective risk management requires multi-stakeholder and multi-level processes that are built upon continuous cycles of assessment.”

institutions and groups in society and that knowledge flows among them, supported by training and learning.

The EU and its Member States, together with key stakeholders, rely on monitoring and evaluation mechanisms as a means of learning from the implementation of risk management policies. Several policies and regulations have been developed to engage stakeholders in DRM. Communication is key to engaging citizens, the most numerous and varied group, in all the activities mentioned.



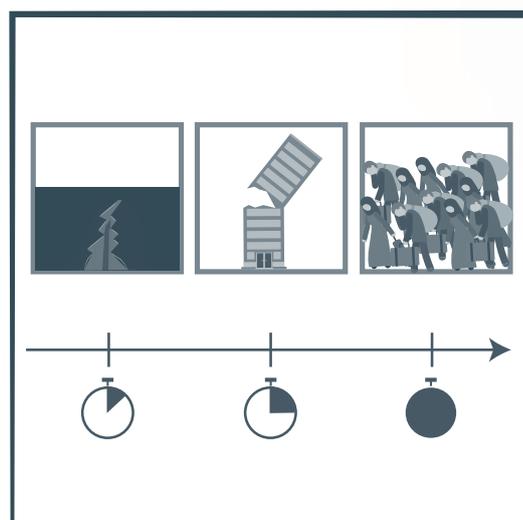
Methodologies for impact assessment

The negative consequences of disasters for populations, including the effects on human activities and property, are measured in casualties, injuries or economic losses. Traditionally, this type of data has been used during relief, to ensure that lives were not lost and to avoid injuries, and during recovery, to help communities to return to normal daily life. It has been common to analyse disaster impacts to ensure that the organisations and individuals affected are fairly compensated.

Physical harm and destruction are evident immediately after a hazardous event, although some consequences become apparent in the long term, over time and space. Some effects happen as a consequence of the first impacts or as a result of the immediate actions taken for a quick response and recovery. These types of consequences, labelled as indirect, form a broad category encompassing disruption of societal life, businesses and services.

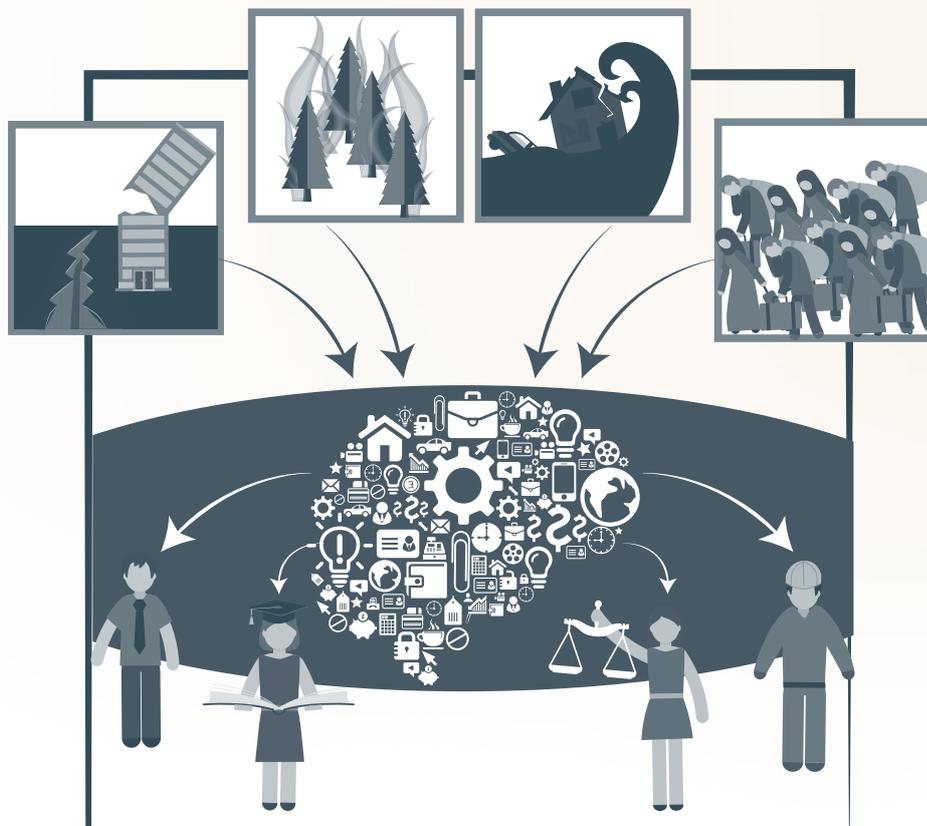
An overall assessment of the impacts makes it possible to understand the magnitude and extent of a disaster in a territorial context. Such studies should address multiple spatial and temporal scales and consider a whole range of sectors that may have been affected, examining who gained and who lost, to recognise the real consequences of an event and enable DRM stakeholders to act accordingly.

“Damage and loss data collected after an event are initially required to respond to the most direct impacts and to plan its recovery, although these also serve to study the drivers and conditions that lead to disasters”



Furthermore, data on damage and losses can be exploited as a source of learning, to identify and interpret the drivers and conditions that resulted in these effects. For example, investigations after earthquakes, volcanic eruptions and floods have helped in developing fragility and damage curves, correlating construction characteristics to potential degree of damage. This has improved our capacity to anticipate future events and their consequences, which is vital for planning prevention, mitigation and preparedness measures.

Despite the advantages they bring, the collection and sharing of data are not a priority, and groups and institutions still do not act in coordination on this. Data are not available in a timely manner or are not accurate and consistent among sources, which hinders their use for various purposes.



Population

Disasters affect and disrupt lives and livelihoods in different ways and with different intensities. Global Targets A and B of the Sendai Framework for Disaster Risk Reduction directly monitor the consequences of disasters for populations, collecting data that show the trends in some impacts and the possible effects of measures taken in the aftermath of disasters.

At individual level, the most immediate impacts of disasters are death and injury, but these events can cause physical and psychological trauma that endures over time, often surfacing at a later stage. Hazard events threaten people's housing and its surroundings, forcing people to leave their homes. Displacement can be temporal, through semi-permanent relocation, or permanent, when people move to another neighbourhood or elsewhere, to another municipality, region or country. Even if they are not displaced, individuals, families and community members have to change how they relate and live when businesses and services are limited or fully disrupted.

The impacts that relate to people are different depending on the level of assessment (individual, household or community level) but closely related. Impacts may emerge at different levels over time and are often overlapping. The impacts that are likely to materialise depend on the magnitude and nature of the event, on the vulnerabilities of the assets under consideration and on the coping capacity of the whole system. Past events show that the population (at the level of the individual and that of society as a whole) is often unaware of disaster risk and prevention measures; therefore, awareness should be raised and self-protection promoted.

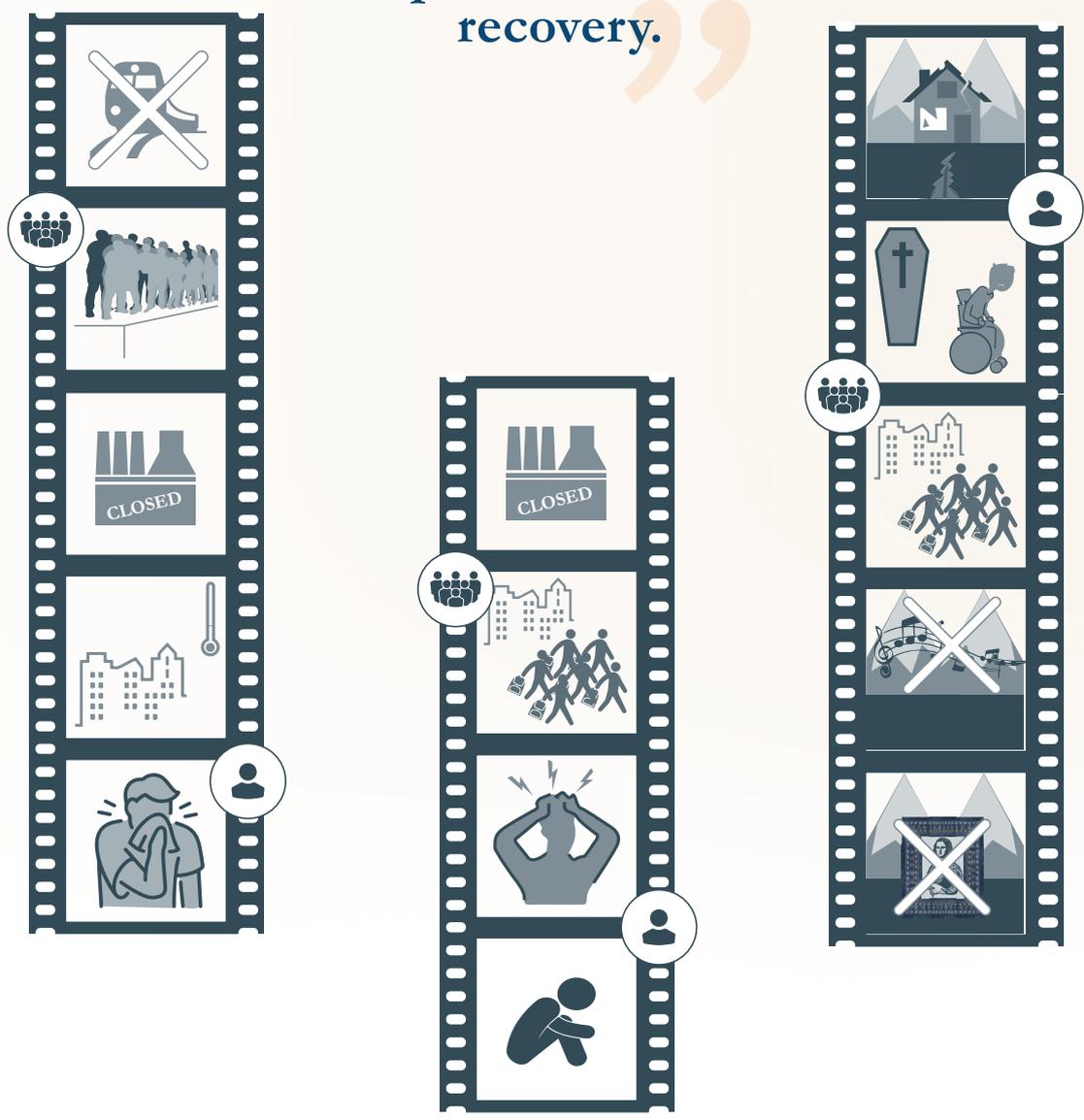
Furthermore, decisions made post-disaster can facilitate the occurrence and duration of some impacts. Existing vulnerabilities at individual and community levels can unfortunately be reinforced if they are not considered carefully in the aftermath of the event. Data collection on all human impacts in the long term should be strengthened.

There is a vast amount of information available for the prediction of risk and related to mitigation measures, and researchers should exploit this increasing data availability to investigate tools for policymakers, such as to model human exposure and vulnerabilities.



“Disaster impacts affect individuals and communities in varied ways, many of which emerge in the long-term.”

“The existence of physical infrastructures and social and personal networks, together with the assistance received, can significantly accelerate post-disaster recovery.”



Economic sectors

Global Target C of the Sendai Framework for Disaster Risk Reduction serves to monitor the direct economic loss in relation to the gross domestic product of the country; this loss is calculated considering losses of several assets, including agricultural loss (C-2), loss of other productive assets (C-3) and losses in the housing sector (C 4).

After a disaster, it is common to consider the monetary value of the physical damage to buildings, as well as the costs of cleaning, repairing or demolishing buildings. The agricultural sector usually pays attention to yield losses and cattle mortality, while the secondary sector (represented by the manufacturing and energy production industries) uses as impact indicators the physical damage to facilities or, even if this does not materialise, the impossibility of delivering products or services due to interruptions to supply chains.

Owing to the globalised production linkages among industries and businesses, the negative effects of a disaster can spread to other regions and countries rapidly. The successive effects on the market and on society – such as a decrease in the market values of buildings or a reduction in the income of the labour force in the area – are examples of indirect impacts.

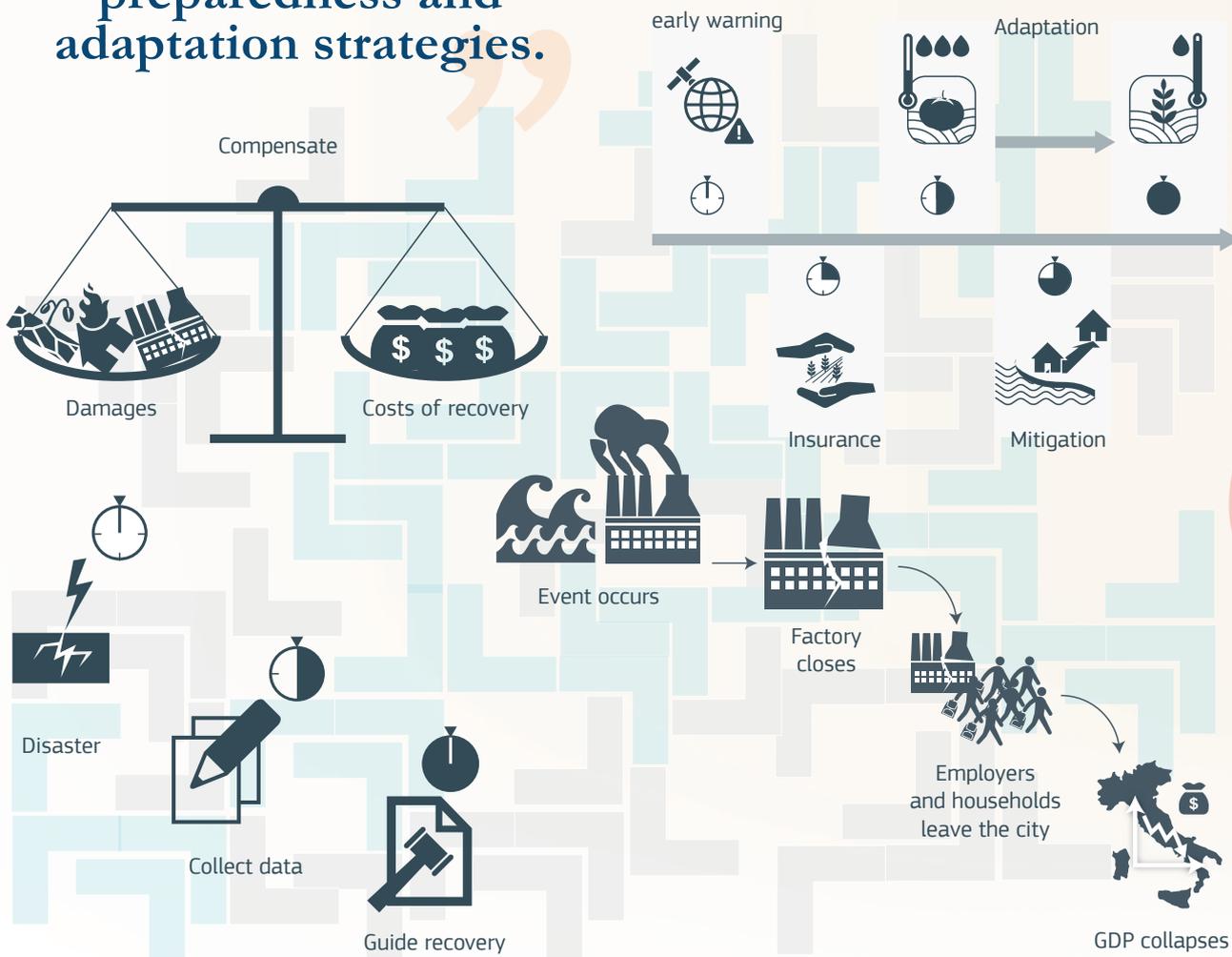
Improving our understanding of the economic impacts of various hazard risks is fundamental for sound and evidence-based DRM, to be implemented by the owners and investors of the assets and businesses together with other institutions and stakeholders. Special attention should be paid when analysing losses and damage to avoid double counting of impacts.

The quantification of direct impacts is generally used to compensate the owners of the assets, although it should also inform the adoption of prevention, mitigation, preparedness and adaptation measures before the disaster occurs, especially considering the intensification and increased occurrence of extreme climate events. This type of information is also required to evaluate the countermeasures implemented by public institutions and private owners.

Several methodologies have been developed to assess the effects of disasters on various sectors, although efforts are needed to better consider effects other than the most immediate. These methodologies are mainly hazard- and asset-related, and they have reached different levels of sophistication. There is space in this area for varied scientific groups to learn from each other and co-develop multi-hazard tools.



“To face future challenges, insurance tools should be implemented together with prevention, preparedness and adaptation strategies.”



Critical Infrastructures

Our society has developed an industrial economy, including a system of production, consumption and day-to-day activities that increasingly relies on technology, long-range supply lines and interconnected networks. As a result, our contemporary society is more vulnerable to the impact of disruption.

Critical infrastructures provide the essential services that underpin modern societies and support our economies. Critical infrastructures are complex, adaptive, sociotechnical and highly interdependent systems, although they are often designed in a fragmentary manner. Global Target D of the Sendai Framework for Disaster Risk Reduction serves to monitor the damage caused by disasters to critical infrastructures, leaving the definition of 'critical infrastructure' to each United Nations member state. Council Directive 2008/114/EC provides a framework for identifying this type of infrastructure at national and EU levels.

The impacts related to critical infrastructures are many, including health effects, environmental pollution, service disruption and economic losses due to direct damage or the disruption of other infrastructures. No critical infrastructure operates in isolation, so disruption to one critical infrastructure can trigger cascading effects on related, associated and other relevant assets and/or systems. Experience from recent disasters has provided evidence of the dependencies among critical infrastructures, highlighting pathways of cross-sectoral and cross-border failures.

Critical infrastructures ensure that day-to-day activities can carry on as normal, but they are also key when facing disaster risk. Assets such as civil protection coordination centres, hospitals, and fire and police stations represent the first line of defence against disasters and crises. Disruption to electricity lines, water pipes, transport networks or communication systems can quickly propagate disaster consequences over large areas, and the continuing functionality of such infrastructures is decisive in mitigating the impacts of a disaster.

Protecting critical infrastructures requires a comprehensive and collaborative approach, based on risk-related evidence. Ensuring the resilience of critical infrastructures involves considering their physical, informational, cognitive and social aspects, because their technological components cannot be separated from the wider implications of dealing with disruption. The organisation and structure of the DRM system should allow different levels of governance, from local to EU, and different actors (public and private) to work together to tackle the extensive complexity of infrastructure systems. ICT provides opportunities to build a common operational picture, collecting and analysing data before, during and after an event.



“ A disruption within one critical infrastructure can trigger cascading effects on related, associated and other relevant assets and systems.”

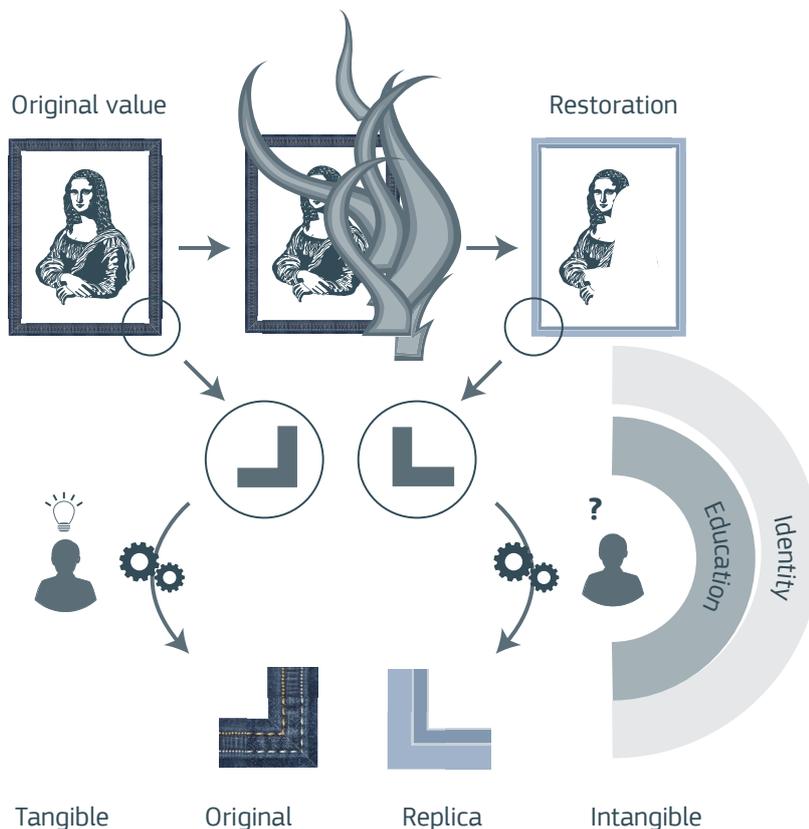


Ecosystem services and cultural heritage

Ecosystem services mitigate various disaster impacts, lessening the effect of drought and floods, and providing resources for recovery. Some human activities affect the well-being of ecosystems, reducing mitigation capacity and hindering the provision of multiple benefits and services necessary for our survival. Scientific literature supports the view that there is a relation between vulnerability to disasters and ecosystem service degradation. Nature-based solutions are recognised as tools to prevent and mitigate extreme natural events, although the added value provided is difficult to determine.

Loss of and damage to ecosystem services are difficult to identify and quantify, because the complexity around these services and their links to other assets make valuing ecosystem services before the event challenging. Cultural heritage faces a similar situation as cultural heritage is composed by tangible assets such as monuments and paintings but many are intangible such as rituals and music.

Therefore, there are many intangible assets the value of which is unknown, so that, when disaster strikes, it is hard to know what has been lost, even in the most immediate aftermath of the disaster.

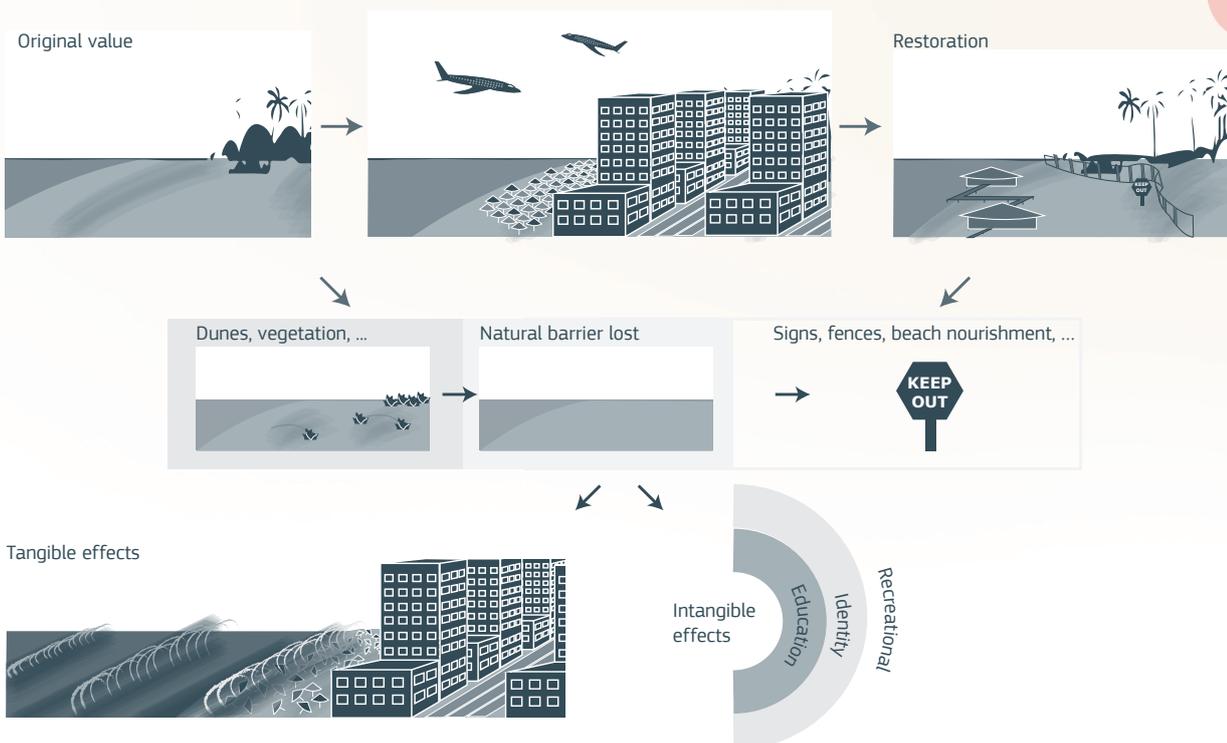


“The full economic loss of cultural heritage and ecosystem services is difficult due to the many intangible values around these assets.”

Putting the impact into economic terms serves to make decision-makers and stakeholders aware of what is lost, helps them to understand what led to loss and enables them to compare these impacts with others; all this helps in determining lines of action.

Some methods have been developed to value intangible assets, although these have been subject to some criticisms: they can be seen inaccurate, are costly and can be less than comprehensive, because they sometimes depend on people's opinions. Valuing losses and damage after a disaster introduces another level of subjectivity. Furthermore, the values estimated are very specific and cannot be extrapolated to other places and moments.

Beyond all these problems, and even when assets are tangible, some original values cannot be fully restored. All this calls for a precautionary approach when managing these assets, protecting them and including their particularities in preparedness plans. In addition, analysis should be widened to cover the many sectors and groups related to the loss of and damage to these types of assets. Similarly, a good inventory of their elements before any event strikes, especially in the face of climate change, will help in achieving a more comprehensive impact analysis.



Communicating risk among all

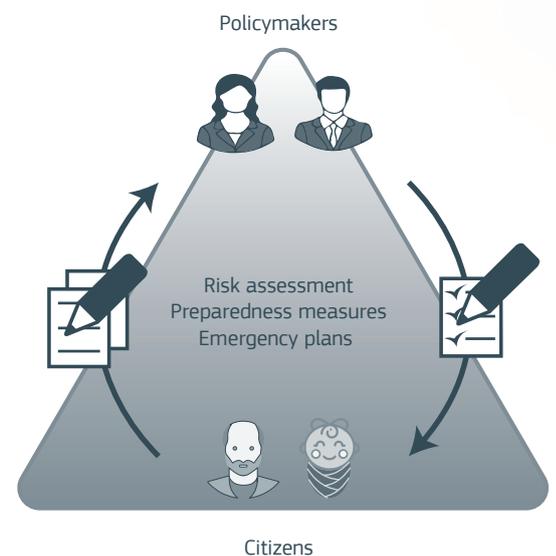
Territories and their communities can be seen as networks of diverse and interrelated actors, although still even today organised into hierarchical and sectoral silos.

Participatory and inclusive negotiations are necessary to overcome the challenges of uncertainty about risk, as well as cultural and power differences. Trust emerges as a key success factor for collaboration, particularly when disasters move from one level of governance to another or when events cross borders. At the same time, learning between sectors is vital to create new knowledge to manage risk and necessary to fully understand the dynamic nature of risk. Both collaboration and learning require stable governance structures and long-term processes.



The benefits of engaging citizens in decision-making processes are well recognised by research: policies and projects are more easily implemented because they are more accepted, while possible social conflicts are avoided. European countries are shifting towards more integrated and bottom-up approaches to research, education and policy-making.

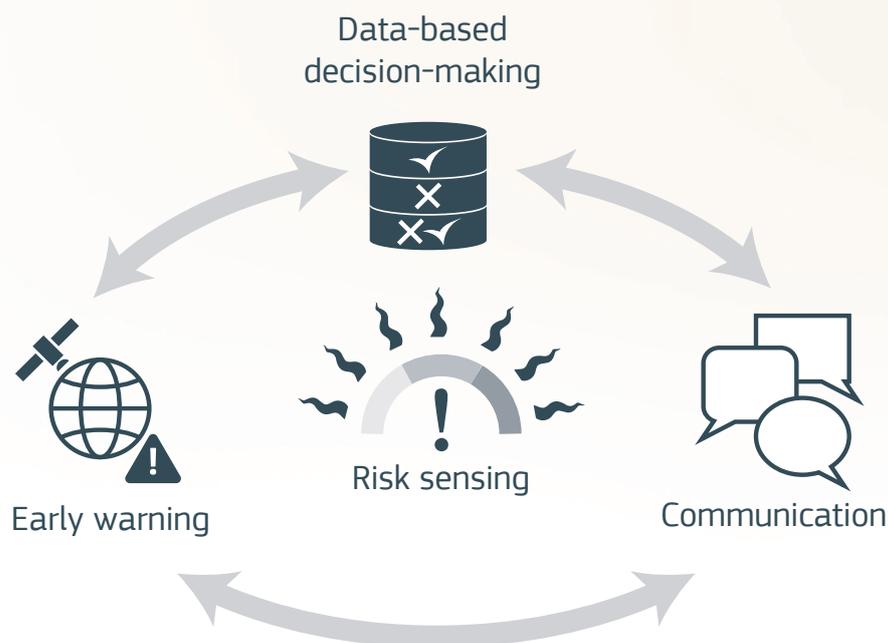
“Long-term partnerships create trust, which is key for different stakeholders to communicate in open, transparent and timely dialogues for addressing the many disaster risks affecting society.”



Citizens are probably the most dynamic and diverse group to be considered when facing risk and its impacts; they need to have a good level of risk perception if DRM actors are to have active partners. Therefore, bottom-up approaches should be tailored considering citizens' needs and opportunities, making possible its participation in all phases of DRM.

If communication is effective, the different stakeholders are easily engaged in a constructive dialogue, where both data, information and knowledge is transferred and understood by all of them. Technology can provide a valuable environment in which social networks can interact. Finally, in this chapter 'Risk sensing' is introduced as an innovative approach to early warning and decision-support systems.

Innovative communication platforms that combine social and technical aspects should be exploited in order to build resilience.



Transferability of knowledge and innovation across the world

International agreements call for inclusive approaches to make better use of knowledge on disaster risk, which is fragmented among different groups and governance levels. Sharing success stories or lessons learned among these groups to be reused by others to overcome their particular challenges would enable decision-making in structures, processes and systems to improve.

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; these should be identified, protected and shared. Chapter 5 presents, among other examples, the work of the indigenous people of New Zealand on community-led response and recovery, the support given to small businesses in the USA to enhance their resilience, the programmes developed in the Pacific NorthWest Economic Region for the protection of critical infrastructures and an education initiative involving academics in Scotland in the United Kingdom.

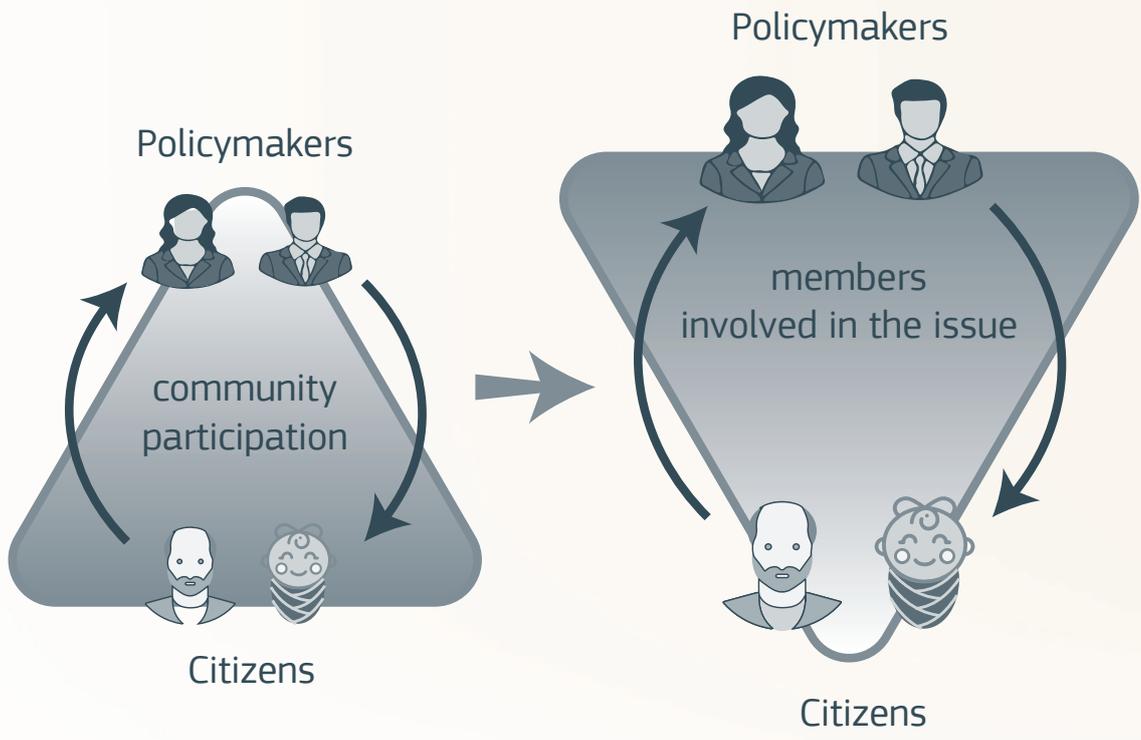
The initiatives described show how different groups and actors work to reduce disaster risk related to different DRM phases. DRR requires a system-of-systems approach that takes into account the fact that communities and assets are interconnected and dependent.

“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 line with that, the chapter analyses in detail two cases related to multi-hazard early warning systems, from their development to their operation. Early warnings are associated with emergency conditions, but their usefulness is determined by the extent to which they are installed and active before a disaster. From experiences from various locations, a set of best practices are highlighted, linking early warning functions to risk assessment and preparedness programmes, continuing research and development, and empowering communities to provide input on their perceptions and know their needs to ensure a collective response.

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



The lessons learned and best practices can enhance the capacity of systems as a whole. They could be customised for adoption in other locations, taking into account context-specific aspects and needs to ensure effectiveness and efficiency. In addition, special attention should be paid to the governance in place and the methods and tools used to capture, store, retrieve and finally transfer the lessons learned and best practices from such cases so that they will be applied in practice by others.

Super Case Studies

SCS 1

Earthquakes in Central Italy in 2016-2017



Starting on 24 August 2016, a severe and very long seismic sequence hit central Italy. A total of 299 people lost their lives while more than 300 people were injured. Devastating damage happened to buildings, to cultural heritage, roads and other lifelines, resulting in huge direct economic losses. The socioeconomic was varied depending on the shocking intensity and the sectors and productive activities of the place although, the affected areas were suffering a demographic and productive decline before the earthquake.

SCS 2

Fukushima Daiichi accident in 2011



Nearly 18 500 people died in the aftermath of the earthquake and the flooding caused by the tsunami. As a further consequence, the operators lost control of the Daiichi Nuclear Power Plant close to Fukushima city and the lives of many people around the site were heavily disrupted because of the high levels of radioactivity in the environment. The disruption to critical infrastructures was severe, while social disruption and stigma in the provinces around the power plant were felt later. The economic consequences in Japan were numerous, hitting the global economy.

SCS 3

Eyjafjallajökull eruption in 2010



The Eyjafjallajökull volcano earned a global reputation when its eruption in 2010 caused unprecedented worldwide disruption to air traffic. European air traffic reduced significantly for around a week, which had effects on individuals, businesses and institutions worldwide. The immediate surroundings of the volcano were evacuated and no casualties were recorded. The main local effects were related to health problems and people's livelihoods (the farming and tourism businesses were affected).



SCS 4

Forest fires in Portugal in 2017

The wildfires that occurred in June and October 2017 were characterised by their explosive behaviour and their dramatic impacts, including the loss of 117 human lives. A total of 150 municipalities were affected in the centre and north of the country, causing huge losses of private and public property, including buildings and industrial infrastructures, energy network infrastructure, roads, telecommunications, forestry and agricultural resources. The Portuguese government commissioned one study and the Assembly of the Republic another, which analysed the events and were carried out by independent research groups.



SCS 5

COVID-19 emergency

The final numbers in terms of infections and deaths resulting from the pandemic that we are living through are still unknown. Millions of cases have been reported globally, Europe being particularly affected. The COVID-19 pandemic has hit the European economy to an extent unprecedented since the Second World War. Governments around the world are adopting different strategies to combat COVID-19, while the closure of schools and businesses and the limitations on movement have revealed many challenges and had several intangible impacts.



SCS 6

Education, cultural inclusion and disasters

The role of culture is often overlooked in the disaster management literature despite the transnational nature of many disasters. In the report, the impact of culture and education on risk perception and vulnerability is studied through three cases: urban fires, inspired by the Grenfell Tower fire in London in 2017; the actions taken in central Europe after the floods in 1997 and 2010; and education and training for the prevention and mitigation of forest fires in Greece.

Findings

- The long duration of disaster impacts makes recovery extremely complicated. Recovery requires a balance between security and population needs related to economic sectors and services. Ongoing assessment of damage and losses after an event is key, as is the continuity of infrastructures.
- Depopulation of the area where the disaster has hit should be carefully addressed during recovery. There may be ways forward in this regard through innovation.
- Recovery is a window of opportunity to push for some technical innovations to be implemented at the levels of the household, businesses and services in the area and its surroundings.
- Local and subnational governments are the governance levels that reach the population, and they should be supported to ensure a full recovery that builds back better. Communication with the population during the emergency relief and recovery phases are key for success.
- Reconstruction may mean a reinterpretation of landscapes and activities, necessary to reduce risk.
- The private sector should be better engaged to ensure the resilience of critical infrastructures and business continuity, addressing cascading and lasting effects.
- Risk regulations and governance frameworks are usually reviewed after a significant event. The operational experiences of users should be linked to research and risk management. Coordination among governance levels, and in particular at EU and global level, is important.

-
- More efforts seem to be needed with regard to information and tools at the moment of relief and recovery. The assessment of impacts requires that a system is in place before the event to facilitate data collection and data analysis at the moment of decision-making. These data are required to demonstrate the added value of preventive actions.
 - Trust between scientific advisors and policymakers should be boosted prior to crises. If the population trusts in institutions, this can shorten the response phase considerably.
 - Many consequences could be avoided with more preventive and preparedness measures fully implemented and in place. Individual and community vulnerabilities should be fully addressed, taking into account socioeconomic, educational and cultural aspects.
 - For disaster response to be effective, it is necessary to mobilise resources and capacities quickly and to plan response protocols bearing in mind the capacities of other sectors that would be directly affected.
 - Risk scenarios should address high-impact unexpected situations and fully integrate climate change.

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