European Commission

SCIENCE FOR DISASTER RISK MANAGEMENT 2017

Knowing better and losing less

Disaster
Risk
Management
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Centre

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SCIENCE FOR DISASTER RISK MANAGEMENT 2017

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FOREWORD

Dear policymakers, practitioners or scientists,

It is deeply encouraging to see how quickly the scientific community has mobilized to play its full part in implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 with the overall aim of reducing disaster risks and losses, and shifting the emphasis from managing disasters to managing the underlying risks.

The Sendai Framework clearly recognises the strong role that the scientific community can play in improved understanding of risk and communicating on new knowledge and innovation. The European Commission took the initiative early by launching the Disaster Risk Management Knowledge Centre in September 2015, just six months after the adoption of the Sendai Framework as a contribution to the Science and Technology Roadmap. Now we have this insightful publication as the first fruit of its labours.

The UN Office for Disaster Risk Reduction (UNISDR) and European Commission, Joint Research Centre (JRC) have been partners to stimulate new research and to encourage the use of available science by all stakeholders.

JRC was one of the co-organisers of the UNISDR Science and Technology Conference in January 2016, which produced an ambitious Science and Technology Roadmap and launched the Science and Technology Partnership.

The JRC has worked with over 200 top scientists, practitioners and policy makers from many fields to summarise the state of the science relevant to disaster risk management, and to make it accessible in this current report. The aim is to break out of the silos, demystify work from other disciplines, encourage potential synergies across disciplines, and to identify gaps in scientific knowledge for future research.

This report summarises the state of relevant science from a European perspective. We consider it as the start of a continuing process, the beginning of a wider, worldwide partnership to summarise knowledge globally, and make it available to the disaster risk management community.

The report is timely for the discussions at the Global Platform for Disaster Risk Reduction in Mexico in May 2017. It caters for the need to translate the wealth of available science into language understandable by stakeholders such as policy makers, practitioners and scientists from other disciplines.

We invite you to engage with us, now and in the future, to enhance the science-policy interface so that strategies for disaster risk reduction at national and local level, which will be put in place by the Sendai Framework deadline of 2020, are based on sound evidence and robust science.

Robert Glasser,
United Nations Special Representative
of the Secretary-General for Disaster Risk Reduction

Vladimir Šucha,
Director General,
European Commission, Joint Research Centre

PREFACE

The Disaster Risk Management Knowledge Centre has produced this flagship science report as a contribution to the Science and Technology Roadmap of the Sendai Framework for Disaster Risk Reduction.

This report is the result of the multi-sectorial and multi-disciplinary networking process and represents the combined effort of more than two hundred experts.

It will support the integration of science into informed decision making through synthesizing and translating evidence for disaster risk management and strengthening the science-policy and science-operation interface.

EXPECTATIONS

This report aims to provide reviews of scientific solutions and their practical use in various areas of DRM in Europe. It is comprehensive in scope but selective in topic and is written in a format that is intended to be accessible to all DRM actors. The reviews of the scientific evidence base are summaries of (1) recent advances/outcomes of EU research projects, (2) relevant national work and (3) relevant international work.

The report aims to bridge science and policy as well as operation communities. The intended audience consists of practitioners and policy makers in addition to experts from different scientific disciplines. It seeks to understand the scientific issues of relevance to their work; specifically civil protection operations and disaster risk policy, but equally climate adaptation policy. The audience includes government officials at EU, national, regional and local levels interested in finding better ways to use science, and also scientists to help them understand work in other disciplines that would allow the identification of possible cross-sectoral synergies and needs from practitioners.

THE PROCESS

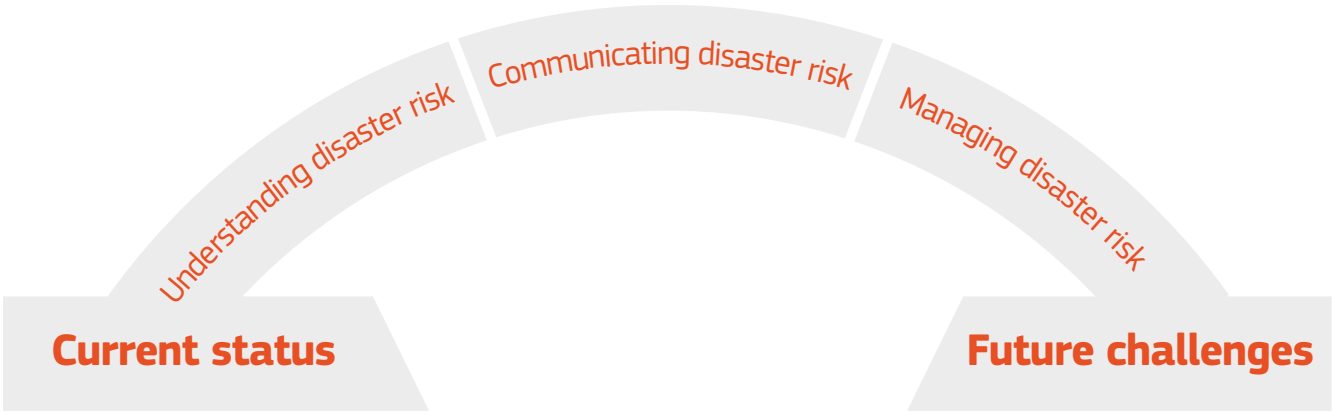
The Disaster Risk Management Knowledge Centre has committed to producing a series of reports to analyse, update the state of the art and identify research and innovation gaps in the field of DRM. Each report will be multi-hazard, multi-disciplinary, and will address the full disaster risk cycle; it will have scientific-oriented contributions presenting the state of science, and practitioner-oriented contributions presenting the use of science.

The process started in January 2016, when the DRMKC working group defined expectations and developed the outline of this report, the first in the series. The process was run by the JRC Editorial Board of 4 members with strong support from the European Commission Advisory group of 79 experts in specific topics. The writing phase was carried out by Author teams consisting in total of 8 Coordinating Lead Authors, 3 Facilitators, 34 Lead Authors and 140 Contributing Authors. The drafts were circulated for formal review to 123 scientific experts, policymakers and practitioners. The preparation of the report succeeded in pulling together a network of 273 contributors from 26 mostly European countries and 172 organizations. It has been endorsed by 11 European Commission Services and will be officially released at the Global Platform for Disaster Risk Reduction in May 2017.

STRUCTURE

Understanding disaster risk to manage it is one of the main focus of Sendai Framework. This perspective already opens two big issues: understanding disaster risk with the focus on scientific evidence, and managing disaster risk with the focus on knowledge applied by different actors. In order to convey the DRMKC's mission of bridging science and the policy/operation community, the issue of communicating disaster risk has been introduced with a

The "Bridge concept"



strong focus on how to successfully overcome barriers to implementing knowledge in the field of DRM.

The scope of the report is divided conceptually into three distinct parts: understanding disaster risk, communicating disaster risk and managing disaster risk, forming the "bridge concept" of the report.

The "Understanding disaster risk" part has been split into two chapters: Chapter 2, covering risk assessment methodology and examples in general, and Chapter 3 that provides a comprehensive overview of hazard related risk issues, the structure of which follows the Sendai taxonomy of hazard classification. Chapter 4 on "Communicating disaster risk" tackles many issues on communication in different phases of DRM among different actors. Chapter 5 "Managing disaster risk" addresses the governance issues of the full disaster risk cycle.

The first and last chapter wrap the scope of the report into a whole. Chapter 1 "Current status of disaster risk management and policy framework" aims to explain why recent global and European initiatives are beginning to seek help to strengthen society's resilience by using science and technology. The final Chapter 6 "Future challenges of disaster risk management" aims to inform decision makers and practitioners of existing science that should find its way into legislative form and practice as well as tackling a much more challenging purpose: to recognise knowledge gaps that could serve as valuable reference based input for a Horizon2020 call.

ACKNOWLEDGEMENTS

We wish to express special thanks to all the Coordinating Lead Authors, Lead Authors, Contributing Authors, Reviewers and EC Advisors. Without their expertise, experiences and a huge commitment to a cause, this report with such a holistic understanding of both disaster risk and disaster risk management could never have been completed.

It is our pleasure to invite you to explore the content of this report and we wish you pleasant and informative reading.

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Disaster Risk Management Knowledge Centre

Enhancing the Knowledge base to support Disaster Risk Management

Faced with the risk of increasingly severe and frequent natural and man-made disasters, policy-makers and risk managers in Disaster Risk Management (DRM) and across EU policies increasingly rely on the wealth of existing knowledge and evidence at all levels – local, national, European and global – and at all stages of the DRM cycle – prevention; reduction; preparedness; response and recovery.

Better knowledge, stronger evidence and a greater focus on transformative processes and innovation are essential to improve our understanding of disaster risk, to build resilience and risk-informed approaches to policy-making, and contribute to smart, sustainable and inclusive growth.

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

Partnerships and networks to improve science-based services;
Better use and uptake of research and operational knowledge;
Innovative tools and practices for risk and crisis management;

Activities of the DRMKC support the translation of complex scientific data and analyses into usable information and provides science-based advice for DRM policies, as well as timely and reliable scientific-based analyses for emergency preparedness and coordinated response activities. It brings together existing initiatives in which science and innovative practices contribute to the management of disaster risks.

At a global level, the EU supports the Sendai Framework for Disaster Risk Reduction to promote a more systematic and reinforced science-policy interface to strengthen the contribution of DRM to smart, sustainable and inclusive growth globally.

In practice:

Partnership

To achieve the ambitious goal of fully exploiting and translating complex science into useful policy and applications in DRM, the DRMKC reinforces the development of disaster science partnerships and networks.

- ***Where knowledge begins***: Networks and activities are activated and promoted to improve the science-policy interface in prevention activities and to facilitate the translation of complex science into useful policy advice.

- ***Where knowledge applies***: Partnerships for operational preparedness and response to major natural disaster types in the EU are promoted to facilitate the information flow between the different partnerships, the Emergency Response Coordination Centre (ERCC) and Member States.

Knowledge

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

- ***Where knowledge meets***: A common repository of relevant research and operational projects and results will be accessible through the DRMKC and its Web-platform.

- ***Where needs are identified***: A science advisory panel of experts and scientists at local, national and European levels provides analyses, updates and advice into research and innovation needs in DRM.

Innovation

Industry and the scientific community play an essential role in developing innovative methods, tools and technological solutions for the mitigation of disasters and their impacts. They facilitate the work of first responders and other operational actors in crisis management through innovative technologies and instruments.

- ***Where gaps are filled***: A Support System facilitates the use of existing expertise to help Member States meet risk management related obligations – DRM Capabilities Assessment, Disaster Loss Databases, Science-policy interfaces, National Risk Assessment.

- ***Where innovation is tested***: The DMKC assesses the current state of DRM science and technology in Europe and addresses technological and operational challenges to cover the existing gaps, and assists in building globally common standards, through the European Network for Innovation Test Beds (ENITB) and the European Crisis Management Laboratory (ECML).

The DRMKC is supported and coordinated by a number of Commission Services in partnership with a key network of Member States. A Steering Committee meets regularly to propose, discuss and establish the activities and priorities of the knowledge centre.

The DRMKC web-platform facilitates information and knowledge sharing, while enhancing the connection between science, operational activities and policy: http://drmkc.jrc.ec.europa.eu/

SHORT EXECUTIVE SUMMARY

Knowing better and losing less

Natural and human-induced disasters present major risks to the economy, the security and well-being of citizens and society. Addressing these risks relies on robust evidence-based decision-making. A main challenge for policy-makers and practitioners addressing natural and human-induced disaster risk management, across all policies and sectors, is to capitalise on the wealth of existing knowledge at all levels – local, national, European and global.

Science and technology play a central role in many EU policies and international agreements addressing disaster risk management. Ensuring efficient disaster risk reduction and prevention measures relies on a robust understanding and assessment of risks.

The UN Sendai Framework for Disaster Risk Reduction calls for a strong interface between science and policy to build a strong knowledge of disaster risk; make efficient use of data to better understand the economic impacts of disasters; and develop adequate preventive policies to reduce the risks of disasters. Science and innovation equally contribute to several Sustainable Development Goals and their associated targets. In the context of the Paris Agreement on climate change, the importance of data collection, evidence-based approaches and the contribution of science was recognised.

This report presents a synthesis of scientific knowledge in the field of disaster risk reduction. It draws from many scientific disciplines, practitioner communities and policy experts. It is organised in 6 parts. Chapter 1 summarises the policy landscape. Chapters 2 and 3 present the available knowledge on risk assessment respectively from a multi-hazard and hazard specific perspective. Chapter 5 discusses science for managing disaster risk, and Chapter 4 bridges science and practice by focusing on communication of risk. Finally, Chapter 6 summarises challenges brought forward by all authors.

Current status of disaster risk management and policy frameworks

A main challenge for policymakers addressing natural and human-induced disaster risk management, across all EU policies, is to capitalise on the wealth of existing knowledge at all levels — local, national, European and global. In order to improve all stages of the disaster risk management cycle — prevention and mitigation, preparedness, response and recovery —, the knowledge and evidence base needs to be further improved, advances in relevant technology exploited, research results applied and the interaction between researchers and end users enhanced. Understanding the state of play of policy frameworks relevant to disaster risk management will help strengthen the interface between science and policy required to reduce the risk of disasters and enhance our prevention and mitigation, preparedness, response and recovery.

Understanding disaster risk: risk assessment methodologies and examples

Risk is complex. There have been huge advances in recent years in all of the key areas of risk: hazard, exposure and vulnerability. The science base in Europe is a rich source of information and data. Initially there was often a culture clash between the needs of industry for practical useable information within tight timetables, perhaps just representing what is known, compared to academia's focus on research and discovery with necessarily longer time horizons. With greater exposure and encouragement, including EU research grants promoting partnerships between the public and private sectors and academia, scientists and practitioners are now more attuned to working closely with each other. Similarly, methodologies have now been developed to categorise risk, model risk and present the results of risk assessments and analysis in forms that enable decision makers not only to decide the right course of action but also to provide transparency around the decision-making process.

The process of risk understanding is not simple and data are always partial and flawed. Initial models and analysis may be viewed as simplistic, particularly in retrospect. The discrepancies in data quality are sometimes asserted an excuse to delay risk analysis and modelling, but it is infinitely better to embark on a risk assessment and analysis process from the outset than wait until better data become available. A "1 in 100 event" could happen tomorrow, it is better to have tried, and commit resources to develop a greater understanding of the risks as far as possible now (and so identify key weaknesses and data gaps) than postpone action until better data are collected.

Risk assessments and risk models cannot make decisions but they can inform policy. Policymakers may reject the advice of a risk model but if they do so, they should be able to articulate why. In practice no model includes all factors; decisions based upon broader considerations are often valid. But there is no

doubt that encouraging and developing a culture of risk identification, risk understanding, risk assessment and risk modelling ultimately benefits society, making it more resilient and saving lives, livelihoods and property.

Understanding disaster risk: hazard related risk issues

Today monitoring of geophysical phenomena is performed with well-developed instrumental recording networks extended at global, regional, national and local levels. However, since large geophysical events tend to occur infrequently and may appear benign for generations, the risks may be underestimated. The assessment of risks posed by earthquakes, volcanic eruptions and tsunamis first requires a good knowledge of the type, magnitude and frequency of past events. The preparation of hazard maps is a good practice not only for decision makers but also for citizens who would like to know where the hazardous areas are situated and what types of hazards threaten their community.

There is important room for further improvement of monitoring systems and their geographic expansion in less well covered areas. If appropriate monitoring is in place, it may be possible to issue early warnings for different hazards and to provide short term forecasts of likely future activity. The assessment of event scenarios can play a critical role in the development of risk management and risk reduction measures, such as elaboration of emergency plans, development of infrastructure to support the affected regions, or risk awareness campaigns.

Developing adequate hydrological risk maps is key for the short term (emergency response) as well as the long term planning (urban and rural development) to increase society's resilience to those risks. Fully comprehensive hydrological risk maps require a great deal of data including long time series of events, and/or a chain of models and assessments that reflect our level of understanding of the complex physical processes controlling hydrological events.

Different types of floods are predictable with different time ranges. Flash floods driven by convective rainfall are notoriously challenging to predict ahead in time to produce effective early warnings, whereas slower developing floods in large catchments can be predicted several days ahead with the use of probabilistic flood forecasting systems. Landslides mapping is a challenge due to the extraordinary breadth of the spectrum of landslide phenomena. No single method exists to identify and map landslides and to ascertain landslide susceptibility and hazard.

The majority of recent scientific studies indicate that hydrological risks will increase overall even for warming levels of 1.5°C. It is estimated that about 70% of the global coastlines are projected to experience a sea-level change within 20% of the global mean sea-level change.

Meteorological risks include hazards from different types of storm systems as well as extremes of temperature, climatological risks include droughts and wildfires and biological risks include epidemics and pandemics. In order to mitigate the effects of these hazards, an understanding of their origin, behaviour and evolution is critical. Building knowledge about human vulnerability to the various hazards is required, and region-specific hazard, exposure and vulnerability need to be analysed for different sectors.

Forecasting the onset or likely evolution of hazards is becoming more accurate through the use of new technologies; however there remains a degree of uncertainty which can be problematic for decision-makers as it can be difficult to strike the right balance between the risk of missing the opportunity for early warning and the risk of raising too many false alarms. Improvements in forecasting will be driven by the interaction and partnerships forged between different fields.

Disaster risk reduction frameworks have not commonly addressed technological risks. The Sendai Framework for Action recognises the importance of technological hazards and promotes an all-hazards approach to disaster risk reduction. This includes hazardous situations arising from man-made activities due to human error, mechanical failure, and natural hazards.

Chemical accidents continue to occur relatively frequently in industrialized and developing countries alike, which raises questions as to the adequacy of current risk-reduction efforts. The causes underlying chemical accidents in current times are largely assumed to be systemic. Most chemical accidents today are caused by violations of well-known principles for chemicals risk management which has led to insufficient control measures. Natech accidents are a technological "secondary effect" of natural hazards and have caused many major and long-term social, environmental and economic impacts. Studies on the status of Natech risk management in the EU and

the OECD have highlighted deficiencies in existing safety legislation and the need to consider this risk more explicitly. Conventional technological risk-assessment methodologies need to be expanded to be applicable to Natech risk assessment and only a very few methodologies and tools are available for this purpose.

Communicating disaster risk

Disaster risk communication is a growing field in disaster science, and highly relevant for policy makers, practitioners and citizens. It aims to prevent and mitigate harm, prepare populations of vulnerable areas before a disaster strikes; and to validate, share, disseminate and combine information from various sources both at times of disasters and in the recovery phase.

There is not a one size fits all in risk communication, as the local context (e.g. local cultures) and histories (e.g. previous experiences with disasters) matter. Risk communication based on a one-way approach that tells people how to prepare and to respond to a disaster is rarely effective. Instead, a two-way mode of communication will lead to a situation in which people become more engaged in risk communication. This engagement increases the likelihood that someone can successfully cope with a situation of uncertainty.

The key challenges in risk communication lie not so much in developing new tools and innovations but in the implementation of social mechanisms by which such innovations become embedded in actual communication practices. Adequate disaster risk communication and management requires the collaboration of a variety of stakeholders including policy makers, practitioners and citizens.

Managing disaster risk

The disaster management cycle commonly includes four types of measures needed to manage disasters: prevention/mitigation and preparedness (before a disaster), and response and recovery (after disaster). Holistic understanding of disaster risk management focuses on all four phases of the disaster cycle.

Based on an analysis of the benefits arising from avoided losses, mitigation and prevention measures are widely considered more cost-effective than ex-post disaster interventions. An increase in mitigation investment has occurred in some European countries, but the lack of public and therefore political interest in prevention and mitigation remains a problem.

In disaster preparedness and response planning there is a trend towards greater professionalization of emergency management across all Europe supported by evolution of legislative and regulatory frameworks. A comprehensive strategy for disaster financing can moderate the impacts of natural hazard risks, speed up recovery and reconstruction, and harness knowledge and incentives for risk reduction. The private financial sector plays an important role, along with governments and civil society organizations, in designing innovative financial protection goals and sharing knowledge and capacity.

Public-private partnerships are a model for a joint bearing of responsibilities and efficient risk-sharing, capable of increasing insurance coverage and penetration, and guaranteeing a strong financial backing in view of uncertain probabilities of risk.

Future challenges of disaster risk management

Drawing from the analysis in each chapter, the report concludes with a summary of challenges for knowledge, partnerships and innovation addressed to the three reader communities: scientists, policymakers and practitioners.

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