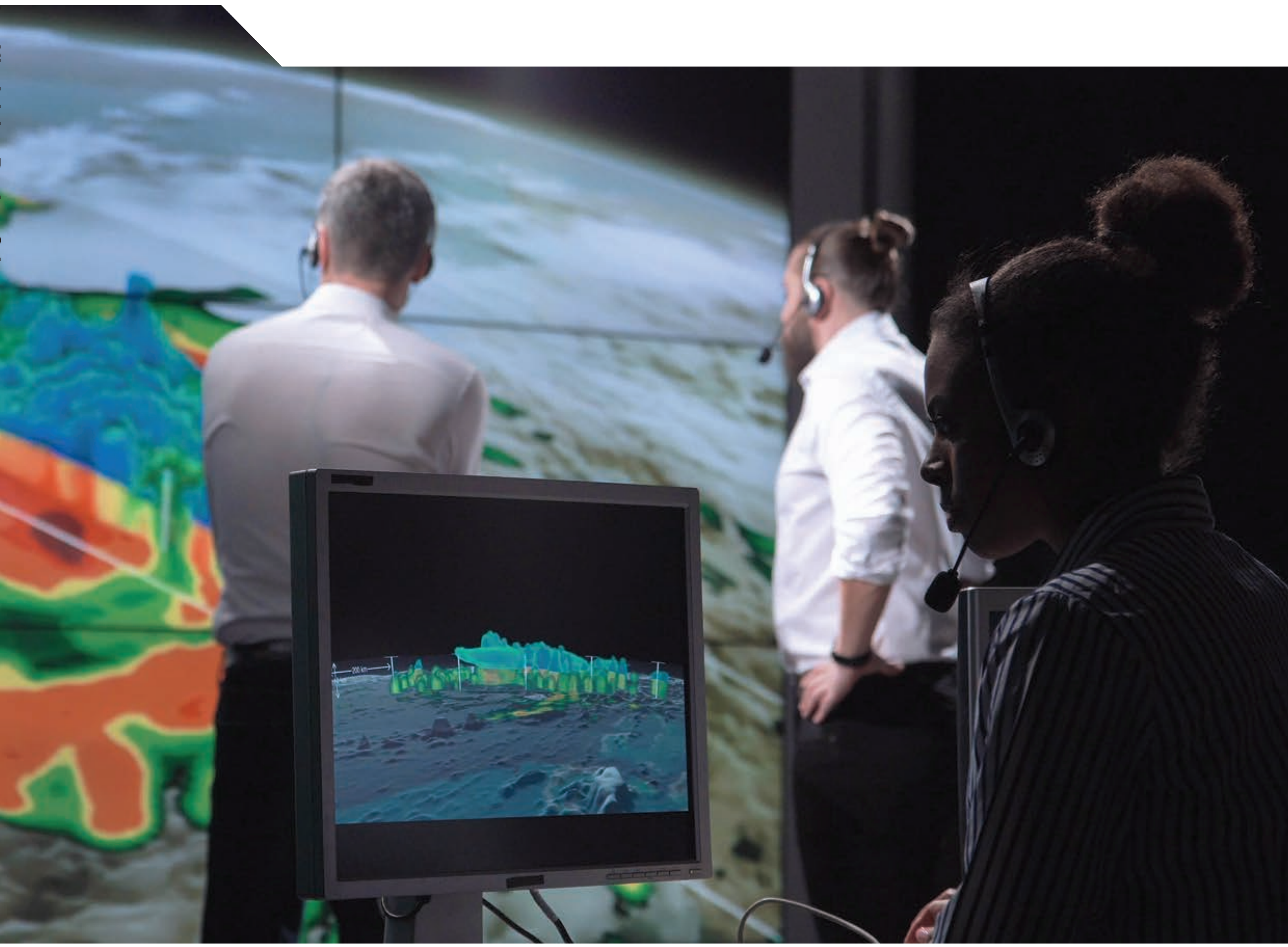
Scientific Advice During Crises

FACILITATING TRANSNATIONAL CO-OPERATION AND EXCHANGE OF INFORMATION



OECD

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Foreword

This report focuses on the role of scientific advice in transnational crises. It brings together expertise from both the science and crisis management communities, through the OECD Global Science Forum (GSF) and the OECD High Level Risk Forum (HLRF). It builds on the 2015 GSF report on *Scientific Advice for Policy Making: the Role and Responsibility of Expert Bodies and Individual Scientists* presented at an OECD science ministerial meeting in Daejeon, Korea, and the 2015 HLRF report on *The Changing Face of Strategic Crisis Management*, as well as the 2014 OECD recommendation on *the Governance of Critical Risks*.

The project that forms the basis for the current report was initiated by the GSF in 2016 and has been carried out in close partnership with HLRF. The integration of science policy and crisis management perspectives is a critical aspect of the project. The initial aims were, first, to develop a compendium of national scientific advisory processes as they operate during crises, and, second, to develop a framework for the trans-national exchange of scientific data, information and advice during crises.

The partnership between the Global Science Forum (GSF) experts and the High Level Risk Forum (HLRF) risk managers brought in a welcome focus on ensuring the usefulness and timeliness of scientific advice for those who need to make decisions in crisis situations. In light of the diversity of hazards and threats that crisis managers have to prepare for, the choice was made to focus on two main areas: hydro-meteorological hazards and public health hazards and the response phase of the crisis management cycle.

The report covers a number of key issues for best use of scientific advice in crises, and overcoming barriers for transnational co-operation around scientific advice. It calls for institutionalising the use of scientific advice at national level to support crisis sense-making, complemented by more systematic trans-boundary exchange of information. It also focusses on the importance of building trust between providers and users of scientific advice by developing science networks, organising crisis management exercises involving scientists, and strengthening crisis communication strategies to convey the right messages at times of uncertainty.

The report does not address in depth issues such as public communication and engagement of citizens in scientific advisory processes or privacy and ethical issues related to the exchange of human subject data. These were covered by previous OECD work under the auspices of the GSF and HLRF.

The report draws on a survey of 18 countries and a workshop held at Wilton Park, UK in September 2017. The workshop also generated a separate report, *Science advice: international co-operation of data and information during trans-national crises*, published in 2017.

Acknowledgements

This report draws on the expertise and reflects joint cooperation between the OECD Science and Technology Directorate, headed by Andy Wyckoff and the Public Governance Directorate headed by Marcos Bonturi.

The project has been overseen by an international Expert Group whose members were nominated by GSF and included participation by HLRF representatives (see Annex A for membership). This Group was ably chaired by Robin Grimes (UK) and Khotso Mokhele (South Africa) and met twice in person and also had interim virtual meetings via teleconference. The country survey was carried out by Julie Calkins. The Wilton Park workshop was facilitated by Julia Purcell. Eric Stern and Anne Bardsley prepared the space weather scenario for the workshop and the workshop summary report was written by Alessandro Allegra. Alessandro also took the lead in drafting the final project report, with support from Taro Matsubara and Carthage Smith in the OECD GSF Secretariat and Charles Baubion in the HLRF Secretariat. Liv Gaunt and Andrea Uhrhammer in the Public Governance Directorate provided editorial and production support. Additional in kind secretarial support was provided by the UK Government Office for Science and the Wilton Park workshop was generously supported by a consortium of UK governmental and academic sponsors.

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Glossary of Key Terms

- **Novel crisis**: A crisis which cannot be predicted based on the past experience and traditional approach, including unexpectedly large-scale or geographic distribution of traditional crises. Unpredictability can cause a lack of preparedness among key stakeholders. (Baubion, 2013)

- **Complex crisis**: A crisis which includes different types of crises (natural, technological and humanitarian) which requires inter-sectional and inter-disciplinary approaches and expertise to respond to at the same time. It can cause significant physical, economic and social impacts in the globally interconnected world.

- **Times of calm**: Times when a country is not at crisis.

- **Sense making**: A crisis management capacity that aims to understand the nature of an emerging crisis situation, its magnitude and impacts, its potential to evolve, the core societal values under threat and to clarify any associated uncertainties.

- **Scientific advice**: The provision of advice from scientific experts to key stakeholders such as policy makers, crisis managers and the public, based on their scientific evidence and expertise. The process can include collecting and analysing evidence, providing advice, and communicating with key stakeholders in appropriate and timely manners. (OECD, 2015a)

- **Crisis management cycle**: A cyclic illustration of the multiple-phase process of crisis management, which can include (1) preparedness, (2) response, and (3) recovery.

- **Cascading Crisis:** An extreme crisis, in which cascading effects increase in progression over time and generate unexpected secondary events of strong impact. This tends to be at least as serious as the original event, and to contribute significantly to the overall duration of the disaster’s effects. (Pescaroli and Pescroli, 2015)

- **Framework:** Defined conditions that govern a specified area or task. In this report frameworks refer to conditions governing international exchange of data and information during crises. Such frameworks may be formal intergovernmental agreements or less formalised agreements between institutions and they may be more, or less, prescriptive with regards to data standards and protocols.

Executive Summary

Scientific advice has an important role to play in all phases of the crisis management cycle: preparedness, response and recovery. It can be particularly valuable when a crisis occurs and develops, which is when sense-making matters. However, this value is dependent on the quality and timeliness of the advice and, most importantly, its relevance to the decisions that crisis managers and policymakers have to make. Generating rigorous scientific advice requires access to relevant data, information and expertise. Ensuring that this advice is useful requires effective connections between scientific advisory processes and crisis management mechanisms. When crises are novel, complex or large in scale and, in particular, when they have a trans-national impact, ensuring the rigour and usefulness of scientific advice can be particularly challenging. It requires effective mechanisms for rapid exchange of data and information and a common understanding of how scientific advisory mechanisms operate in different countries. Otherwise, there is a serious risk of confusion that can impede the crisis response, undermine public trust in government and responsible agencies, and, ultimately, lead to avoidable loss of life and increased economic disruption.

In most OECD countries, for familiar crises of limited scale, there are processes in place for linking scientific advice to crisis management. These are often hazard -dependent -- for example, they will be different for food safety versus extreme weather events -- and may involve a variety of sources of scientific input, from government scientists to academia to commercial actors and NGOs. Most of these processes have some ability to scale up, at least from local to national scale. In some countries, there are clearly defined scientific advice co-ordination mechanisms that are activated in response to novel, larger -scale crises and that link directly to the corresponding central crisis management structures.

However, in the majority of OECD countries, these science co-ordination mechanisms are less well defined and even for major and complex large -scale crises with centralised crisis management structures, the scientific advice comes from a number of sources that may or may not be co-ordinated. There are advantages and disadvantages to both centralised and distributed scientific advisory mechanisms, and the mechanisms themselves are very context specific. When crises are trans-national in nature, understanding how scientific advice feeds into crisis management processes in different countries is essential for effectively coordinating between countries. Although in some circumstances this responsibility may be devolved to international organisations, this is not always the case. Most OECD countries regard advice from such organisations as complementing, rather than replacing, their own scientific advisory processes.

Within a country, accessing the data and information necessary for providing useful scientific advice in a domestic crisis may not always be straightforward. For familiar crises, the relevant organisations normally know where to go, and standard operating procedures and protocols are frequently in place to allow rapid data and information exchange, analysis and generation of advice. For novel and complex crises, the data and information requirements are often greater but, again, usually manageable in a domestic context in most OECD countries. However, in trans-national crises, or crises that have significant international implications, access to the necessary scientific data and information by any one country may be complicated or even prevented by a number of barriers. These barriers include legal issues, national security concerns, differences in data curation and interoperability standards, cultural differences, and political, economic and commercial interests. Fortunately, a number of international frameworks are already in place and govern the international exchange of data and information in specific domains (e.g. meteorology, infectious diseases or radiological protection). Many of these have provisions for, or are specifically focussed on, access during crises. However, even where such frameworks exist, making them operational requires international networks of trusted institutions and/or individuals. Where such frameworks are absent, or not formally activated, informal relationships and exchange between trusted partners in different countries are critical.

Main recommendations

Policy action in five main areas would improve the provision and use of science advice in international crises.

First, there is a need to strengthen domestic capacity for scientific advice in crises. National mechanisms for providing scientific advice should be established, in particular for sense-making in complex and novel crises. Information and lessons learned during crises needs to be recorded and disseminated. Furthermore, the international community could help interested countries develop and improve their systems for using scientific advice during crises.

Second, there is a need for clear communication and exchange across national boundaries and effective frameworks to facilitate this, including identifying and sharing both international and domestic contact points for co-ordinating scientific advice during trans-national crises.

Third, steps should be taken to promote greater understanding and trust between providers and users of scientific advice, both at national level and across borders. Regular interaction, as well as the exchange and mobility of interested individuals from different institutional settings and countries, should be encouraged. Relevant international science networks could be considered part of the infrastructure for crisis response.

Fourth, adequate preparation is crucial. Regular drills and exercises bringing together both crisis managers and scientific advice providers should be held at domestic and transnational level. Mutual learning and training programmes for novel, complex trans-national crises should also be developed and tested with input from both communities.

Finally, communicating scientific advice to the public in crisis situations should be part of a broader communications strategy, with clearly defined responsibilities. In the case of trans-national crises, communication strategies should ideally be co-ordinated across countries. The use of social media and online tools for gathering and communicating information from and to the public during crises requires further experimentation.

1. Improving the use of science advice in international crises: Conclusions and recommendations

There are five key areas where policy action is necessary to improve the provision and use of science advice in international crises. Firstly, the appropriate structures and mechanisms to link scientific advisory mechanisms and crisis management need to be in place at the national level. Secondly, there is a need for clear communication and exchange across national boundaries and effective frameworks to facilitate this. Thirdly, there is a need to build trust between providers and users of scientific advice across national borders. Fourth, being prepared is crucial to crisis management and cross-sectoral and cross border cooperation is required to ensure this. Finally, communication with the public should, as far as possible be coordinated across countries.

1.1. Fostering domestic capacity for scientific advice in crises

Most OECD countries have scalable processes for crisis management and for the provision of scientific advice but this is not the case in all countries. Practical and operational procedures are important in order to integrate science advice into crisis management and there are opportunities for mutual learning between countries in this regard.

1.1.1. Recommendations

1. **Where not already present, national mechanisms for the provision of scientific advice in crises should be established, in particular for sense-making in complex and novel crises**. These should be designed to meet the needs of crisis managers and policy-makers during crises and build on existing institutional structures, providing ready access to a number of disciplinary perspectives. Processes for quality assurance and communication of scientific advice need to be integrated into these advisory mechanisms. Such mechanisms need to be maintained and tested during times of calm, which requires incentives, including dedicated funding, for participating scientists and responsible institution(s).
2. **Knowledge generated and lessons learned regarding scientific advice, during crises, including novel and complex events, need to be structured, recorded, systemised, preserved and disseminated** to allow mutual learning and improved use of scientific advice in crisis management. This is a shared responsibility for both the providers and users of such advice. *Ex post* evaluations of how particular crises were managed should include a specific focus on scientific advice.
3. **The international community should assist interested countries in developing their domestic systems for providing and utilising scientific advice in crises**. Such assistance can be built into existing international relations and mechanisms for international engagement, which can be adapted accordingly.

1.2. Enabling transnational scientific cooperation in crises: structures and frameworks

National crisis management structures collaborate to exchange information and coordinate responses during trans-national crises. In many cases this is facilitated by international organisations, such as the WHO, WMO or the EC, although the timing and extent of their involvement is very much context dependent. For scientific advice in trans-national crises most OECD countries depend primarily on their own domestic advisory mechanisms with the expectation that these will integrate the necessary international expertise and perspectives. In novel and/or complex crises the onus on including international expertise is increased and for many developing countries it is a necessity. Thus an understanding of how different national scientific advisory process work in crises, and identification of national contact points who can broker the exchange of scientific advice between countries, are essential for the effective generation of coherent scientific advice to meet domestic requirements in different countries during trans-national crises.

International frameworks for the exchange of scientific data and information are a critical aspect of crisis management and are routinely used in many domains, from hydrology to public health. The process of developing a framework, which normally involves negotiation between different actors from different countries, can in itself be a mechanism for mutual learning and building common understanding. In the best examples, this can go as far as defining shared data standards and formats, which are critical for exchange of data and integration of information across different scientific domains. In novel, complex, large scale, crises existing frameworks may not be entirely sufficient but they can nevertheless provide a starting basis for international exchange.

1.2.1. Recommendations

4. **Countries should identify, and share details of, domestic and international contact points - institutions and/or individuals - with responsibility for coordinating scientific advice during trans-national cr**ises. These contacts will necessarily reflect different national scientific advisory mechanisms and there may be multiple contacts in individual countries, although the number should ideally be kept to a minimum to ensure effective communication between countries in crisis situations. There is potentially a role for relevant regional and global bodies in maintaining and sharing lists of such contacts.
5. **Existing frameworks for the exchange of data and information during crises should be strengthened and new frameworks developed as necessary, with a particular focus on novel, complex, trans-national crises**. These frameworks can play an important role in developing common standards and protocols for data exchange and access. Their development and adoption is a shared responsibility both of governments and the scientific community. In this context it is noted that academic norms and practices have not always encouraged the timely exchange of data and information during crises and moves towards open science and recent agreements between funders and publishers on sharing public health data should be supported in this regard.

1.3. Promoting mutual understanding and trust: people and networks

Whilst frameworks are an important enabler for the exchange of scientific data and information, they are only as useful as the mechanisms that are in place to ensure that they are implemented. Although the technical and legal challenges of effectively sharing scientific data and information in crises can, with some concerted effort, be defined and dealt with or minimised, building the necessary national and trans-national social networks can be more challenging. Promoting trust between the different providers and users of scientific data, information and advice is a long-term challenge. It requires appropriate support, mandates and incentives at the national level and mechanisms for building mutual understanding at the international level.

Formal international networks of relevant actors are often established to complement international frameworks and may be coordinated by international bodies, such as WMO or WHO. These play an important role when such frameworks are formally activated. However, informal networks (often involving some the same actors as in the formal structures) can play a critically important role in the early stages of a crisis or when formal structures are inadequate to deal with the nature and complexity of a crisis. Thus, for example, clinical research networks often play a critical role in sense making during public health crises. Building trusted international scientific networks of scientific institutions and individuals and recognising these as a valuable part of the infrastructure for crisis management is a shared responsibility for all countries.

1.3.1. Recommendations

6. **Regular interactions and building of mutual understanding** between providers of scientific advice (government scientists, academics, scientific advisors) and crisis managers should be encouraged at the national level. The different communities need to work together to identify knowledge gaps and how they can be filled.
7. **International science networks, operating in areas of relevance to actual or potential, trans-national crises should be considered as potentially part of the infrastructure for crisis response**, in which case the appropriate links need to be nurtured with crisis management practitioners. Contingency funding that can be rapidly accessed by these networks in times of crisis would improve their ability to engage effectively.
8. **Mechanisms to enable the exchange and mobility of interested individuals from different institutional settings and countries should be used to promote mutual understanding and trust**. Opportunities for academic researchers to work for crisis management structures or for those with domestic responsibility for scientific advice to work with international organisations can be particularly valuable

1.4. Being prepared

Improving disaster response preparedness was the central recurrent theme throughout this project and was also highlighted in previous OECD work on risk management (Baubion, 2013) and scientific advice (OECD, 2015). Preparedness needs to be established in times of calm, not in the moment of crisis and for this to happen it needs to be prioritised and resourced, by all relevant stakeholders including those involved in the provision of scientific advice. Preparedness includes having the necessary accumulated knowledge, capacity, frameworks and trusted international networks in place and it can be promoted by engaging all these constituent parts in well-designed training exercises. Crisis managers and policy makers in many OECD countries are familiar with crisis scenario role-playing exercises and may have been involved in those organised by the OECD network of strategic crisis managers. However, for many of those involved in providing scientific advice, such mutual-learning (or stress-testing) exercises are less familiar. Similarly, for novel or complex crises, where crisis response structures may be less clearly defined and/or for crises of a trans-national nature scenario, exercises are less well developed.

1.4.1. Recommendations

9. **Regular drills and exercises that bring together both crisis managers and those involved in providing scientific advice, should be encouraged** and supported both domestically and transnationally. Scientific experts should be supported and incentivised to participate in such joint exercises.
10. **Mutual-learning and training scenarios, for novel, complex trans-national crises should be developed** and tested with input from the scientific community and crisis managers. These need to take into account the communication channels for multiple stakeholders, including policy-makers, relevant industry actors and the public.

1.5. Communicating with the public

No matter how good the scientific advice is and how well it is integrated into crisis management and decision-making processes, the way that it is communicated to the public can have a major impact on its effectiveness. While openness and transparency is fundamental in scientific advisory processes, crisis situations can put special demands on public communication. The primary requirement is for rigorous and clear scientific advice to inform quick and effective decision-making by responsible authorities (OECD, 2015b). There is potential for confusion and loss of trust in these authorities, and in the science, if communication is not carefully managed and coordinated across countries.

New information and communication technologies and social media tools are providing exciting opportunities for both gathering input to sense-making during crises and for public communication of scientific information. Using social media tools for data and information collection raises specific issues about bias and quality control but a number of countries are experimenting with these tools and there are opportunities for mutual learning. For public communication, it is important that the brevity and ease of mass communication do not distract from the quality and rigour of what is communicated. It should be recognised that inaccurate or contradictory information can spread rapidly through social media, which can easily generate confusion and undermine public trust. Again, many countries are experimenting with making scientific information available in almost real time using on-line tools and there are opportunities for learning across fields and countries and between scientists and crisis managers.

1.5.1. Recommendations

11. **The public communication of scientific advice during crises should normally be embedded in a broader crisis communication strateg**y -involving crisis managers and decision makers - and an international coordination strategy (OECD, 2015b).
12. **Responsibility for public communication of scientific advice in crisis response situations needs to be clearly defined** and, for transnational crises, those responsible for communication in one country should ideally be in close liaison with their relevant counterparts in other countries.
13. **Further experimentation with the use of social media and on-line tools for gathering and communicating information from, and to, the public during crises is required**. There are opportunities for scientists and crisis managers to work together in this regard.

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2. The current landscape and project design

Scientific advice plays an important role in the management of crises but can also be a source of dissent between countries. This study explores the challenges to international coordination with regards to scientific advice. To this end, a cross country survey was conducted and the outcomes were fed into an international workshop that brought together crisis managers and scientists. This workshop focused on the in depth analysis of specific case studies.

2.1. Scientific advice in crisis management

The complexity and interconnectedness of contemporary societies means that scientific insight is often needed to inform policies and decision-making. This is especially true in the response to crisis situations, when scientific advice can play a key role. In this particular context, and as used throughout this report, scientific advice refers to the processes, structures, and institutions through which crisis managers and other decision-makers receive and consider scientific and technological knowledge and data to make sense of, and respond to, crisis situations.

Effectively responding to crises, particularly when they are novel, large scale or complex, can require the exchange of data, information, and advice across national boundaries. Transnational scientific co-operation in crises however poses a number of challenges, as seen in recent cases such as the eruption of the Eyjafjallajökull volcano in 2010, the Great East Japan earthquake and ensuing nuclear accident in 2011, and the recent Ebola and Zika epidemics. During a crisis, decisions must be made balancing scientific information and evidence with political, diplomatic, economic and logistical considerations. At times, this can result in different decisions being made in different constituencies for the same crisis situation. For example, different national decisions on whether to evacuate citizens or cancel flights between two countries. Understanding the scientific advice that has fed into the decisions of different countries can help explain why these decisions were taken and improve the coherence of crisis response across different countries.

2.2. Existing work and rationale for the project

The OECD Recommendation on the Governance of Critical Risks adopted by the OECD Council in 2014 recommends that government strengthen crisis leadership, early detection and sense-making capacity and conduct exercises to support inter-agency and transnational co-operation by (…) developing strategies, mechanisms and instruments for "sense-making" to ensure reliable, trusted and coordinated expert advice translates into informed decision-making (OECD, 2014). In 2015, the OECD released a report exploring the role and responsibilities of experts providing scientific advice for policymaking (OECD, 2015a), a theme which had been brought to the fore by the trial of seismic experts advising on the L'Aquila earthquake in Italy in 2009. The report recognised the importance of understanding the transnational dimension of scientific advice during crises, and recommended that governments establish effective mechanisms for ensuring appropriate and timely advice in crisis situations, including mechanisms to facilitate transnational co-operation between advisory structures. This resonates with similar conclusions reached by the OECD High Level Risk Forum (HLRF), discussed in their 2015 report on "The changing face of strategic crisis management" and further explored in a number of thematic workshops of the OECD network on strategic crisis management (OECD, 2015b). These previous initiatives provide the rationale for this project, which builds on this earlier work and is aimed at both the science policy and crisis management communities.

The OECD work in this area also resonates with that of other organisations. The 2017 UN Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) for example underlined the need for better accessibility to data and timely sharing of information through effective mechanisms and networks at national, regional and transnational levels. The need for data exchange platforms and capacity building is increasingly recognised. Recently, the European Commission's Disaster Risk Management Knowledge Centre

(DRMKC), founded the Risk Data Hub (EC, 2018), noting that 'the increasing incidence of disaster risks from hazards, demanded an improved dynamic approach on data sharing in order to increase the efficiency of risk management.' More generally, efforts to build capacity and enable mutual learning in the field of scientific advice to policy- and decision-making have been promoted by a number of international entities including, the EC Joint Research Centre, the International Institute for Applied Systems Analysis (IIASA), the International Network for Government Science Advice (INGSA, 2018) and the Foreign Ministries Science and Technology Advisors Network (FMSTAN).

2.3. Aims and focus

Building on these previous efforts and recommendations, the OECD Global Science Forum (GSF) partnered with the OECD High Level Risk Forum (HLRF) to launch the present project with the following aims:

- To develop an improved understanding of mechanisms and channels for transnational scientific co-operation in crises, how these mechanisms interact across constituencies, and the barriers that exist to the transnational sharing of scientific information, data, and advice in crises.
- To lay the foundations for more effective transnational exchange by promoting mutual learning among countries and stakeholders.

Building on previous work, this project specifically focuses on the transnational exchange of data and information and co-ordination of scientific advice between national systems in crisis situations. The focus is on crises caused by environmental hazards (natural, geological and hydro-meteorological) and/or health-related hazards (such as pandemics and food safety incidents), and on circumstances where transnational co-operation is needed, including novel and complex crises (see ahead 4.2). Issues related to scientific advice more generally, such as independence, transparency, and public communication, and those limited to individual countries, have been explored in other documents (OECD, 2015a) and are addressed here only insofar as they are relevant to transnational scientific co-operation in crises. Moreover, as the focus here is on transnational co-operation between national scientific advice mechanisms, the role of international organisations is considered mainly in relation to how they interact with national advisory mechanisms.

2.4. Development of the report

2.4.1. Partners involved

This report is produced by GSF under the guidance of an Expert Group (EG) representing a range of OECD member and Key Partner countries and the EC. These members come from government and academia and have a range of subject expertise and experience. Full details of the expert group membership are provided in Annex A. The work was carried out in partnership with the OECD HLRF, and with the support from the UK Government Office for Science.

2.4.2. Survey

As part of the project, a survey of 18 (mainly OECD) countries and of the European Union (EU) was conducted using available documents and a questionnaire sent to national and EU bodies responsible for responding to major crises (see Annex B). The aim was to capture information on responsibilities and processes for providing scientific and technical advice during transnational crises. The survey questions were developed in consultation with the EG based on their expertise and experience. These attempted to capture information about specific mechanisms, including the sense-making and communication processes, access to and use of national and transnational sources of information, as well as characteristics of flexibility, robustness, breadth, quality assurance, and barriers to collaboration and exchange.

The identification of survey participants took into account the known differences in the types of scientific advice systems and structures in OECD and partner countries (OECD, 2015a). The survey process also acknowledged that different crises may require a more centralised or more distributed response, for instance depending on scale or nature of the hazard. Multiple survey respondents, with knowledge of different types of crisis, were thus solicited in several countries.

An initial list of contacts and respondents was generated through nominations by the expert group, the analysis of event proceedings, internet searches, and information about contact points from established networks including the OECD HLRF network of strategic crisis managers and the European Commission's Emergency Response Coordination Centre (ERCC). The challenges encountered in identifying a full range of suitable survey participants for the relevant countries became in themselves an indicator of the need to establish a map of the transnational landscape in the area.

2.4.3. Workshop

A key part of the project was a workshop organised at Wilton Park (West Sussex, UK) in September 2017 in partnership with the UK Foreign and Commonwealth Office, the UK Met Office, the UK Government Office for Science and other partners. The workshop specifically focussed on trans-national crises caused by infectious diseases and environmental/hydrological hazards. It brought together fifty scientists, policy-makers and crisis management practitioners from twenty countries (Wilton Park, 2017a). A key aim of the overall project was to promote mutual learning among countries and stakeholders, and fostering the establishment of transnational networks. The workshop was therefore designed to both collect information and insights to inform this report, and to facilitate mutual learning and networking.

The workshop focused on a set of real and simulated case studies (summarised in boxes in this report). These were used as a collective learning exercise to identify the challenges that have hindered or may hinder information and data sharing, as well as options and possible steps to enable information and data sharing in future crises. The deliberations of the workshop were structured according to the following themes: the major challenges to sharing information transnationally when responding to transnational crises, and how to address them; mechanisms for ensuring provision of scientific and technical advice to governments during transnational crises; ensuring that scientific advice is based on good quality, up-to-date information in situations where decisions have to be made rapidly.

Findings from the workshop have been summarised in a separate report (Wilton Park, 2017a), as well as being incorporated in the present document. The workshop report was also discussed at the 7th OECD High Level Risk Forum meeting in December 2017, during which crisis managers from OECD countries expressed the need to design scientific advisory mechanisms that take into account the specificities of crisis situations. They emphasised the need for timely and consistent scientific advice and the accountability of scientific advisors.

2.5. Structure

This report includes three core chapters, followed by concluding comments. Following this overall introduction, Chapter 3 introduces the complex nature of contemporary crises, and the importance of scientific advice, data, and knowledge in crisis management and response. The multiple roles scientific advice plays in the crisis management cycle, and the diversity of stakeholders and institutional mechanisms involved are also discussed. Chapter 4 explores the transnational dimension, discussing the importance of transnational scientific co-operation in crises, the range of circumstances in which it is required, and the variety of existing frameworks and networks for such co-operation. Building on these, Chapter 5 presents the main challenges to effective and efficient transnational scientific co-operation in crises, as identified in the survey and the workshop. A range of potential solutions are also identified. Finally, Chapter 6 introduces the recommendations for how to improve the transnational provision and use of scientific advice in crises. These recommendations are detailed in Chapter 1. Five case studies, which were discussed in detail at the Wilton Park workshop, are presented in boxes throughout the report. Each of these illustrates a number of issues that inform the analysis elsewhere in the report. Schematic diagrams included for several of these case studies illustrate the complexity of data and information flows between different organisations during crises.

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3. Scientific advice in crises

No two crises are the same and, in an interconnected world, we are increasingly confronted with novel and complex crises that have spill-over effects involving multiple countries. Science advice can be useful in all stages of crisis management - preparedness, response and recovery. Different countries have developed their own mechanisms for developing and accessing the advice that is necessary in specific situations. These tend to be more or less centralised or distributed and can be difficult to understand for outsiders, which can be an obstacle for international cooperation.

3.1. The need for scientific advice in crises

3.1.1. Scientific advice in crisis response

Crises are times of intense difficulty or danger for countries, when important decisions have to be made urgently and in conditions of great uncertainty. For this report, the focus is mainly on crises caused by environmental hazards (natural, geological and hydro-meteorological) and/or health-related hazards (pandemics and food safety), although many of the observations and the analysis can be extended to other domains.

"Crisis response begins either when a significant threat is clearly forecasted, or when an undetected event or series of circumstances provoke a sudden crisis. […] Obtaining a clear operational picture of the development of a crisis is the basis for decision-making both at the operational and strategic levels" (OECD, 2015b). The global risk landscape is evolving, and the effective response to crises often requires access to specialist scientific and technical knowledge. Scientific advice, understood here as referring to the processes, structures, and institutions through which crisis managers and other decision-makers receive and can consider scientific and technological knowledge and data to make sense of, and respond to, crisis situations, can play an important role in this. Previous OECD work (2015a) indicates that scientific advice in crises depends on trusted individuals and institutions, and access to accurate, reliable and timely data and information. When these are in place, such advice can ensure that crisis managers and emergency responders have a clear picture of how an event is evolving and what impact different interventions are having.

During a crisis, reliable and appropriately presented data and scientific knowledge is important both to inform the immediate situation analysis of the crisis, and, where time allows, support modelling of the evolution of a crisis. Given the rapidly-evolving and non-linear nature of major crises, real-time data collection, analysis and interpretation can contribute to making sense of the evolution and ramifications of a crisis, as well as the impact of potential responses. In some circumstances, e.g. emerging disease epidemics, advice need to be closely linked with new discovery research and knowledge generation.

3.1.2. The multiple stakeholders of scientific advice in crises

The decision-makers that require timely, reliable, relevant technical expertise and authoritative scientific advice during a crisis include not only crisis managers, but also politicians, governmental bodies, and transnational organisations as well as private and third sector organisations, such as utilities, transport companies, and disaster relief charities. This is also true for the media, which play an important role in crisis management and public communication of related scientific information. As recognised by the OECD HLRF, "Government crisis managers need to adapt their approaches to deal with a variety of different stakeholders who all have different interests, priorities, and values. Critical infrastructure in many OECD countries is largely operated by the private sector. Citizens also tend to organise themselves to respond to crisis through civil society organisations (CSOs) and non-governmental organisations (NGOs), thus adding new players to the field who expect to be consulted during preparations and utilised during operations" (OECD, 2015b). It is therefore necessary to think holistically about how scientific advice fits into the whole ecosystem of stakeholders involved in the crisis management process.

Moreover, many of these stakeholders can themselves be a source of valuable data, information, and knowledge, which although it may be of variable quality, can help provide a complete analysis of the crisis. Industry stakeholders, in particular, often have significant technical expertise and knowledge that can be crucial to evaluate the impact of an ongoing crisis, such as for example in the Icelandic volcanic eruption of 2010 where the knowledge and data of airplane engine manufacturers was needed to assess the safety of planes flying through the ash cloud. Private sector technical expertise can also be important in the response and recovery phase, as was the case following the Deepwater Horizon oil spill. At the same time, as emphasised in previous OECD work, one has to ensure that clear and transparent procedures are in place to deal with potential conflicts of interest in the formulation of scientific advice.

3.1.3. Novel and complex crises

As recognised by the HLRF (OECD, 2015b: 18), several recent crises such as the Great East Japan earthquake and ensuing nuclear accident in 2011 (Box 3.1 Case study 1) or the eruption of the Eyjafjallajökull volcano in 2010 and pose new challenges to traditional crisis management. This can be because of their novel, unprecedented or unfamiliar nature, their unusual combination, their unexpectedly large scale or geographical distribution, and their transboundary nature

Some analysts distinguish between “familiar” and “novel” contingencies, when it comes to crises. The more unexpected and novel the event, the greater the uncertainty and the more ill-structured the domain in which crisis managers must operate. Coping with novel contingencies and the associated cascading shocks makes the already difficult challenges of crisis sense- and decision-making even more demanding (OECD, 2015b: 45). Globalisation, environmental, demographic and social changes, and technological advancements, all contribute to an increasingly complex landscape. Contemporary advanced economies rely on a complex and interconnected network of institutions and technological systems, such as communication and transport infrastructures, healthcare systems, global supply chains, and energy generation. Such systems are vulnerable to disruptions caused by natural or man-made disasters, and their inherent complexity introduces further sources of risk in the form of catastrophic failure of risk containment infrastructures. Increased interdependencies, both internally and externally, make societies particularly vulnerable to cascading disasters, where the effects of a local crisis can propagate at regional level or beyond and their impact be amplified across transcending economic sectors. Natural disasters affecting production in one region, for example, can cause trade disruptions leading to food shortages and unrests elsewhere in the world.

These trans-boundary effects can expand to become a “global shock”, that is, a “rapid onset event with severely disruptive consequences covering at least two continents” (OECD, 2011). This concept takes into account another pattern of such crises: cascading disasters that become active threats as they spread across global systems, such as transport, health, financial or social systems. A crisis can become trans-boundary and develop into a global shock at a later stage, through nonlinear processes” (OECD, 2015b). The complexity and interconnectedness of crises involving cascading disasters are well illustrated by the case of the Great Eastern Japan earthquake and the Fukushima nuclear incident (Case study 1).

Box 3.1 Case study 1: Scientific advice during a cascading disaster: The 2011 Great East Japan Earthquake and Fukushima Nuclear Accident

The Great East Japan Earthquake occurred on March 11, 2011. The event began with a powerful earthquake off the north-eastern coast of Japan, which caused widespread damage on land and initiated a series of large tsunami waves that devastated many coastal areas. The number of confirmed deaths was 15,891. Most of these people died as a result of the tsunami. It also led to major accidents at the Fukushima nuclear power plants along the coast.

The diagram below illustrates the exchanges of information and data and scientific advice during the crisis. Just after the earthquake, the Japanese government established the Extreme Disaster Management Headquarters (EDMH) to respond to the earthquake and tsunami. Several ministries and agencies played their roles in responding to the disaster. It also communicated with the Japanese people, sometimes through the media. The Japan Meteorological Agency (JMA) managed the Northwest Pacific Tsunami Advisory Centre (NWPTAC) which sent a tsunami warning to Pacific countries.

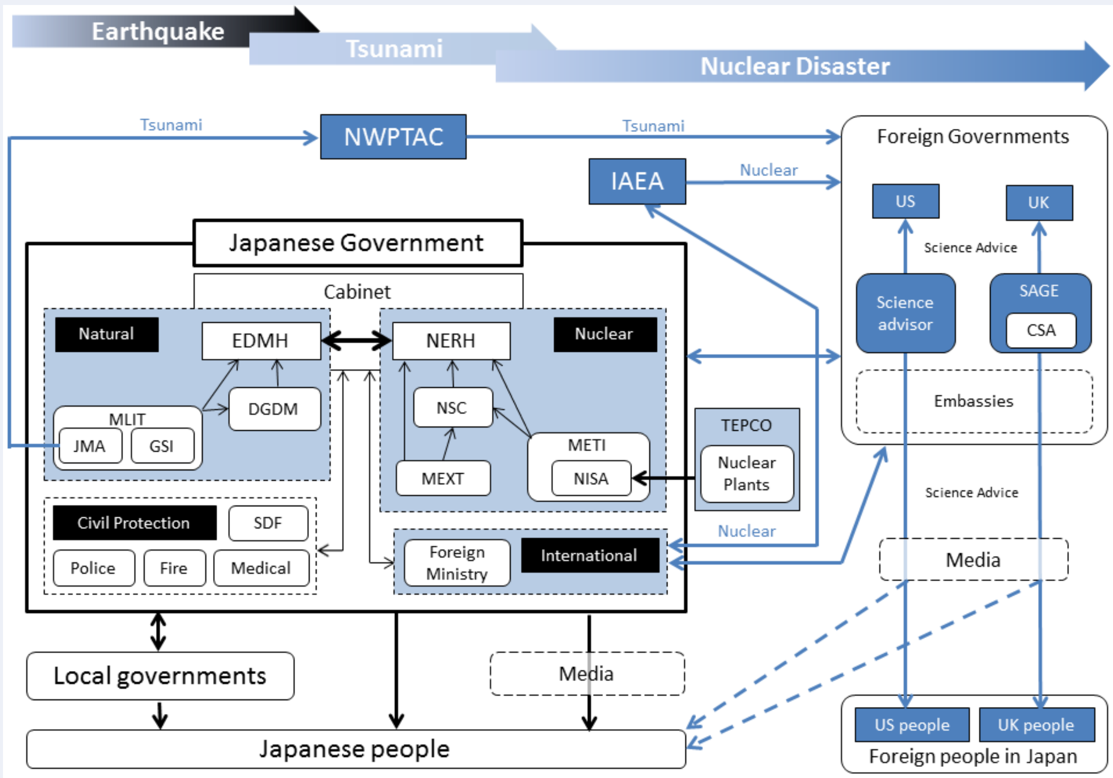
The tsunami caused cooling system failure at the Fukushima nuclear power plants, which resulted in nuclear meltdown and release of radioactive materials. The government established the Nuclear Emergency Response Headquarters (NERH) separately from the EDMH. The Nuclear Safety Commission (NSC) could not keep providing timely and coherent advices to the Cabinet. Information sharing between the government and the electric power company (TEPCO), which operated the damaged nuclear power plants, was insufficient.

The Japanese government was required to communicate with the International Atomic Energy Agency (IAEA) and the foreign countries whose citizens stayed in Japan. It provided information to other countries through: (i) the press conferences by the Chief Cabinet Secretary, (ii) briefings for the diplomatic corps by the Ministry of Foreign Affairs, and (iii) briefings to the foreign press by the Cabinet Secretariat. The Nuclear and Industrial Safety Agency (NISA) and other ministries and agencies also responded to individual inquiries from overseas. However, the Japanese government didn’t have enough information to share, and public officials familiar with nuclear issues were preoccupied with the response to the nuclear accident.

Under such circumstances, the US and UK Governments activated their own scientific advice mechanisms and communicated with their citizens in Japan. The US embassy recommended US citizens to evacuate the area close to the nuclear power plants. The UK Government advised UK citizens that there was no need for them to evacuate areas outside the exclusion zone. Japanese citizens could also access such information via the www, which affected their individual decisions.

Based on the lessons from this crisis, the Nuclear Regulation Authority was established in 2012 as an independent organisation with power to play a significant role in emergencies. A Science and Technology Advisor to the Minister for Foreign Affairs was appointed in 2015, and participates in global networks (e.g., FMSTNA). In addition, the Science Council of Japan revised its code of conduct for scientists, which now includes ensuring the quality of their scientific advice and explaining any related uncertainties.

Figure 3.1. Data and information flow during the Great East Japan Earthquake and Fukushima



Notes: 1. DGDM: Director General for Disaster Management, Cabinet Office
2. MLIT: Ministry of Land, Infrastructure, Transport and Tourism
3. GSI: Geospatial Information Authority of Japan
4. SDF: Self Defense Force
5. MEXT: Ministry of Education, Culture, Sports, Science and Technology
6. METI: Ministry of Economy, Trade and Industry
7. SAGE: UK Scientific Advisory Group for Emergencies
8. CSA: UK Government Chief Scientific Adviser

(*) After Great East Japan Earthquake, Nuclear Regulation Authority was established as an affiliated organisation of the Ministry of Environment, separating the nuclear safety regulation section of the NISA from METI and integrating the function of the NSC in September 2012

Source: Cabinet Office, Government of Japan (2018), Cabinet Secretariat, Government of Japan (2011), Grimes, Chamberlain and Oku (2014), Nuclear Regulation Authority (2018), Oskin, (2017), and Rafferty and Pletcher (2018).

3.1.4. Scientific advice for novel and complex crises

Leaders in charge of crisis decision-making must have a good grasp of all the issues at stake in a crisis, its potential development, and the associated uncertainties. When confronted with novel and complex crises, crisis managers need to rapidly make sense of the situation, requiring them to quickly obtain, digest and channel accurate information and trustworthy expertise. This situation was aptly described by the OECD HLRF in recommending that “When confronted with unprecedented emergency, strategic crisis managers should be able to quickly identify and mobilise the most relevant and trustworthy expertise to help make sense of the crisis. Such knowledge management systems and expert networks need to be set up in advance and across multiple sectoral, professional and disciplinary boundaries" (OECD, 2015a). Technical or scientific expertise is often needed to break down the various dynamics of a complex situation into simpler scientific or technical elements to facilitate sense-making, i.e. the meaningful interpretation of research, data and information, into actionable knowledge and understanding (OECD, 2012).

The interdependencies between the natural, human, social, and technological components of crises make the contribution of a broad range of scientific and technological disciplines necessary to fully understand and address them. Scientific advice may therefore need to include not only input from the natural and engineering sciences, but also from social, human, and behavioural sciences, as well as contributions from local knowledge perspectives. Countries have different mechanisms in place to provide scientific advice to make sense of and respond to novel and complex crises, which reflect the country's history and experience of dealing with crises.

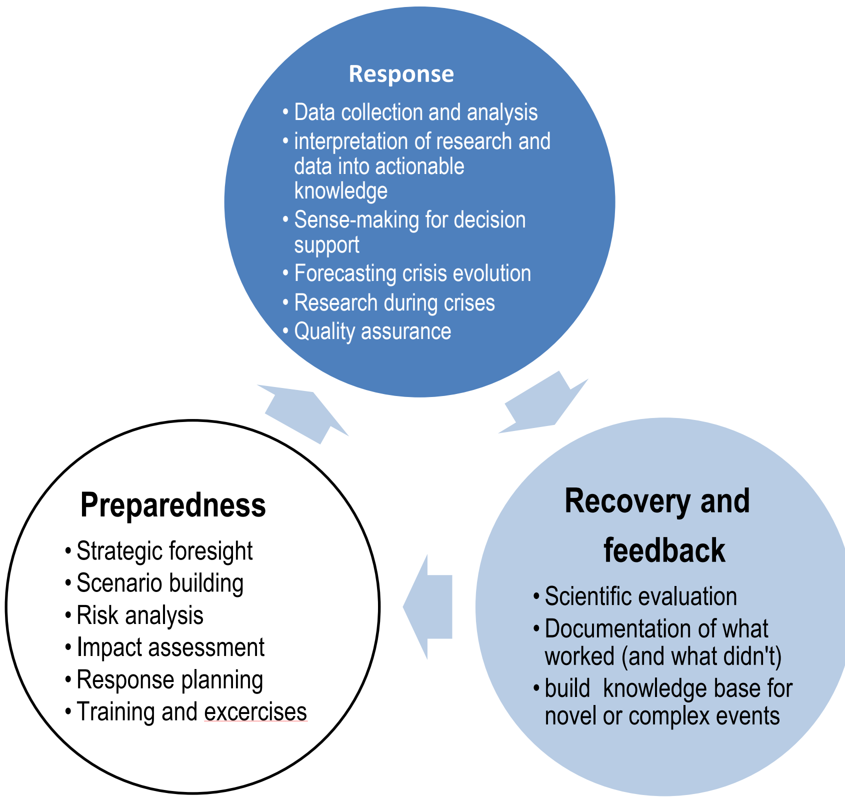
3.2. Scientific advice in the crisis management cycle

Crisis management comprises three key phases: building preparedness of key stakeholders before a crisis; response to limit damage during the crisis; and, recovery and feedback after the crisis (Figure 3.2). Scientific and technological knowledge and advice can play important roles in each phase of the crisis management cycle, contributing to effectively preparing, responding, and learning from crises. While the focus of this report is on the response phase, and the key role scientific advice plays in sense-making during this phase, the multiple roles that scientific advice can play in the other phases of the crisis management cycle are discussed below. It is important to appreciate that in practice the distinction between these different phases is not always clear. This is case, for example, in many public health epidemics or complex cascading disasters, where elements of preparedness, response and recovery may occur simultaneously in the same or different locations.

3.3. Preparedness phase

A key tenet of crisis management is the importance of effective preparation during times of calm before the onset of a crisis. Preparedness requires developing knowledge and capacities in order to effectively anticipate, respond to and recover from a crisis (OECD, 2015b). Scientific knowledge and research expertise is needed to perform horizon-scanning activities such as the identification and quantification of potential risks, the anticipation of potential impacts and their cascading effects, as well as the identification of prevention, mitigation, and response strategies, based on experience during past crises. Scientific and technical knowledge is also important in designing, implementing and operating early warning systems. Preparedness needs to incorporate cross-border/international considerations and engage scientists from relevant countries. This can require the development of institutional agreements and cooperation mechanisms, which can then provide a basis for effective international exchange in times of crisis.

Figure 3.2. The roles of scientific advice in the crisis management cycle



Source: Authors' analysis

Risk assessment is the foundation of crisis preparedness, and a thorough analysis of hazards, risks and vulnerabilities is key to preparing for effective crisis response. While traditionally governments have taken a 'silo approach' to risk assessment based on the nature of the hazard, the complexity and interconnected nature of many of current crises require a more holistic approach, such as the process of National Risk Assessment that is now regularly conducted in several OECD countries (OECD, forthcoming). Multidisciplinary scientific advice can play an important role in this phase to ensure that emerging risks are fully mapped, understood and anticipated in terms of preparedness. Mutual learning of best practices in scientific risk assessment can be encouraged through the sharing of methodologies and tools.

Identifying, structuring and keeping available previously acquired knowledge can prove invaluable in times of crisis. For example, existing models of the potential impacts of disasters and their physical, economic and social impact can help to prioritise responses when hazards strike again. It is therefore important for researchers, scientific advisors, and crisis managers to work closely together in times of calm to identify gaps in the existing knowledge, develop research strategies to address such gaps, conduct the research, make the outcomes routinely accessible, and design strategies to mobilise and share such knowledge in times of need. These latter strategies should specifically address the needs of crisis managers.

Overall, setting-up appropriate scientific advice mechanisms for crisis response in times of calm, and ensuring their preparedness, will ensure that they can be effectively deployed in times of need to respond to a crisis. This can be promoted by involving these mechanisms in training exercises and drills as further discussed ahead (see 5.8). Researchers and scientific advisors should not only engage in training exercises, but can also help design rigorous exercises and play a role in promoting them (Koshland Science Museum, 2018). Mutual understanding and trust among stakeholders are vital to ensure the optimum provision and uptake of scientific advice for effective crisis management, and the necessary relationships need to be nurtured long before the onset of crises.

3.4. Response phase

The main focus of this project and report is the role of scientific advice during the response phase of a crisis. This is the period when decisions have to be made rapidly and are ideally informed by the best available scientific data, information and advice. This is also sometimes referred to as the sense making period with the role of science being to make sense of what is happening and communicate this clearly so that appropriate decisions can be made. In some acute crises this period is short, e.g. a matter of hours or days in the case of some hydro-meteorological events. In other cases, such as the development of emerging disease pandemics, it can last for weeks or months, with sense making being a conditional process that is continuously revised as the crisis evolves and/or new knowledge becomes available.

The nature of the crisis and location of relevant scientific expertise and knowledge are important determinants of how scientific advice is integrated into decision making during the response phase of a crisis. If one considers the two main areas of focus for this report the situation is very different. In hydro-meteorological crisis response, the majority of the scientific data, modelling software and expertise is provided by operational systems and government scientists. This feeds into Standard Operating Procedures (SOPs) and crisis response protocols and, where necessary, bi-lateral and multi-lateral agreements are normally in place to ensure international exchange of data and information. In most OECD countries, the early warning and response mechanisms for familiar hydro-meteorological events are routine and standardised, with scientific advice mainly provided by mandated government scientists. In contrast, for new health threats and pandemics, the necessary scientific data and information for sense-making is frequently distributed across different public agencies and academic institutions and new research insights are required. There are different sources of competing advice and the SOPs, protocols and frameworks that exist are not so easily applied across all these sources.

As crises become more complex, or for cascading crises (see earlier), the situation analysis is proportionally more complicated and the sources and nature of required scientific inputs is more diverse and distributed. Coordination and/or control of scientific advisory processes in order to ensure that the best available scientific evidence is rapidly available to crisis managers during complex crises is a challenge. When the crisis is trans-national, and different national scientific advisory systems become engaged, this challenge is considerably amplified. Trusted knowledge brokers - individuals or institutions that bridge the science-policy interface and operate nationally and/or internationally - can play a critical role.

Crisis response situations can also provide the setting for valuable research that would be impossible under normal circumstances. Examples of such research include field trials that can only be carried out during the actual outbreak of a disease or the gauging of hydraulic models during real flood events. Such studies can provide invaluable knowledge to both manage the immediate situation and to prepare for, build resilience or avoid future crises. In order to carry out such rapid response research, appropriate arrangements need to be developed in advance. Measures, such as the development of regional networks of laboratories for analysis and the strengthening of field research capacity, can improve the preparedness to both monitor the evolution of a crisis and to carry out research during crisis situations. Rapid response mechanisms are necessary to finance the necessary research during crises and frameworks for the immediate sharing of new research insights, data and information are required. These issues are discussed in chapters 4 and 5 of this report.

3.5. Recovery phase and feedback

After a crisis has come to an end, useful learning can be drawn to improve future crisis response. Scientific analysis from disciplines such as organisational psychology, behavioural science and political science can provide important reflective insight into how crises are managed and how scientific knowledge is mobilised, used and communicated in the process. Scientific insight can also help elucidate what factors could have helped in predicting and forecasting the crisis, which can help to improve the preparedness to future events (Integrated Research on Disaster Risk, 2018).

Rigorous analysis and knowledge of what has worked (and what didn't) in a specific context can provide useful lessons for those involved in the management of crisis, and facilitate learning across different sectors. Knowledge gathered during a crisis and the lessons learned from it need to be structured, recorded, systematised, preserved for the long term, and disseminated to allow mutual learning and improve crisis management and the contribution of scientific advice in that context (OECD, 2014). For example, scientific advice from UK Scientific Advisory Group for Emergencies (SAGE) is made available to the public after an emergency is declared over. Recording and sharing previous experience is especially important for rare events for which collective memory can be easily lost over generations. This can be promoted by developing transnational knowledge networks, and fostering a corporate memory among crisis managers and advisors. Mutual learning can also be a part of developing shared strategies to produce and use scientific advice for crisis management between interdependent countries or those facing similar challenges.

3.6. Mechanisms for scientific advice in crises

3.6.1. Crisis management mechanisms

All OECD countries have crisis management mechanisms in place, which are often tailored to specific hazards, such as health-related or hydro-geological emergencies. As discussed above, however, complex and novel crises require a whole-of-government approach to strategic crisis management that goes beyond individual hazards and sectors.

A survey conducted by the OECD HLRF (OECD, 2017) concluded that different models exist to engage the whole-of-government approach across sectors and levels in crisis management. The survey found that overall countries "*have implemented one of two models. On the one hand, centralised administrations rely on vertical co-operation, with scaling-up mechanisms automatically activated from the top when local capacities are not capable of managing the crisis on their own (e.g. in France or Denmark). On the other hand, more horizontal institutional systems rely on subsidiarity and sectoral responsibilities, with local governments being the first in charge of the emergency response, requesting support from higher levels of government when their capacities are* *overcome by an emergency. That is the case for instance in countries that work through federal governments, such as in Australia, Canada, Germany, Italy, Mexico, Switzerland or the United States, where states or other forms of sub-national governments often have the primary responsibility to manage crises affecting their territory and are the first responders to disaster and security incidents*."

OECD has previously recommended "governments to develop crisis management capacities to cope with the complexity, novelty, ambiguity and uncertainty that characterise many modern crises." Previous work concluded that "A few highly advanced Respondents [countries] have set-up such knowledge management systems and expert networks across multiple sectoral, professional and disciplinary boundaries. These networks aim to take account of the context-dependant characteristics of each crisis, such as the organisational and political contexts that enable and constrain the decision-making ability of leaders and advisors". However, many countries are currently lacking such systems.

3.6.2. Institutional mechanisms for scientific advice in crises

Mechanisms to ensure the routine provision of scientific expertise and advice to policy- and decision-making can take a range of institutional forms. These include for example individual scientific advisors, expert committees and scientific councils, specialised agencies and scientific academies (OECD, 2015a). The specific advisory mechanisms in place in a given country reflect its political and institutional culture. Such routine advisory structures also play a role in scientific advice during crises situations but, as discussed in the 2015 OECD report, during crisis situations, when advice is needed quickly to inform response management, routine advisory processes are usually neither entirely appropriate nor entirely adequate (OECD, 2015a). The preferred mechanisms for scientific advice in crises vary not only between countries, but also between sectors within a country depending on the nature of the crisis at stake.

The survey conducted for this project supported the findings of this earlier work, and indicated that many countries lack formal institutional mechanisms at the national level that are clearly identified as having a role in coordinating scientific advice and integrating data and information during crises. Some country respondents did not describe a formal, institutionalised mechanism but further analysis showed that a system was in place, albeit without a name or statutory status. Informal exchange and advice channels (for instance colleague-to-colleague) play an often-underestimated role in informing sense-making in the context of crisis management. The uncharted nature of these mechanisms however can make it difficult to assess their reliability from the outside.

When it comes to the management of novel and unexpected crisis only a very few countries, such as the UK, have permanently established scientific advisory mechanisms, in the form of standing bodies responsible for the provision of scientific advice and the coordination of input and analysis. These mechanisms can be activated in crises, and can draw upon and coordinate input from large networks of experts and organisations from across disciplines and sectors. Other countries set up temporary central coordination units on an as-needed basis in response to specific crises. In these circumstances, the structure of a scientific advice mechanism adapts to, and reflects, the specific strategic crisis management mechanism put in place. Others, such as for example the USA and Germany, have more distributed systems, relying on pre-established networks of experts and organisations that can cooperate to provide advice during crises.

In practice, most countries have some form of hybrid system that combines centralised and decentralised elements and is able to scale-up as necessary. It should be acknowledged however that in many less advanced countries limited institutional structures exist to respond to crisis situations and to provide the scientific advice necessary to support this response. This makes transnational scientific co-operation particularly important, but also especially challenging when crises occur in these less advanced countries.

Different institutional arrangements for the provision of scientific advice to the management of complex and novel crisis have their potential strengths and weaknesses, which are themselves very context dependent (Table 3.1). For example, more distributed systems such as in the USA, in which multiple agencies are considering the same data and information, provide a layer of quality control through mutual scrutiny. Redundant capacities in critical components such as data and information collection and analysis systems can increase reliability and resilience of the system during crises. On the other hand, more centralised mechanisms such as in the UK can provide faster response and a clearer interface with decision-makers at the centre of government. These differences in institutional arrangements have important implications for transnational collaboration and for information exchange, as those involved in providing advice in one country might not be able to easily identify their counterpart in a different institutional system, which can exacerbate difficulties in identifying essential data and information and ensuring efficient co-operation. This is a particular challenge with distributed advisory systems.

Table 3.1. Characteristics of distributed and centralised scientific advisory processes for crises

Distributed	Centralised
Activated via local crisis responders	Top down activation via central Government
Well adapted to federal decision-making systems	Rapid response at central Government level
Local ownership and legitimacy	Clear interface with central decision-makers
Multiple contact points	Single contact point
Redundancy and resilience	Efficiency versus single point of vulnerability
Cross-checking and reproducibility comparison	Central (exclusive) quality control
Local familiarity with issues	National consensus
International contact complex	International contact straightforward
Customised to a specific type of crisis	Inter-disciplinary
Flexible and independent	Planned and coordinated

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4. Transnational scientific co-operation in crises

While many OECD countries have the scientific capacity and management structures in place to deal with 'routine' domestic emergencies, as the scale and complexity of a crisis increases so the need for international cooperation is likely to increase. There are a number of international frameworks that have already been agreed, which govern the exchange of scientific data and information between countries during certain types of crisis. Some of these are 'owned' by international organisations. However, the implementation of these agreements is dependent on the existence of trusted international networks.

4.1. The need for transnational scientific co-operation in crises

Major crises such as the 2010 Icelandic Eyjafjallajökull volcano eruption, the 2011 Great Eastern Japan earthquake, floods in central Europe in 2013, the West Africa Ebola outbreak, and the Zika and microcephaly public health emergency, have highlighted the special challenges associated with responding to events that are transnational in nature: the need to understand the (scientific) basis of decisions made by different countries, and the need to improve the sharing of data and information.

As discussed above, crises vary in their degree of complexity, novelty, and scale. Crises range from domestic to transnational in their geographical scale. Their impact can be both direct, for example on the territory of the countries directly affected by a natural disaster, or indirect, for example when citizens, assets or interests abroad of a given country are being affected. It is important to recognise that the scientific capacity of any country is ultimately limited. The transnational exchange of scientific information and advice not only provides essential substantive material for better decision-making, but also powerfully extends finite resources by maximising shared capabilities. The extent to which complexity or novelty represents a challenge for a country depends largely on the country's capabilities in terms of crisis response and science, with better prepared countries able to deal better and quicker with a broader range of crises.

During a crisis, decisions must be made balancing scientific information and evidence with political, diplomatic, economic and logistical considerations. At times, this can result in different decisions being made in different constituencies for the same crisis situation. For example, different national decisions on whether to evacuate citizens or cancel flights between two countries. Understanding the scientific advice that has fed into the decisions of countries can help explain why certain decisions were taken - albeit recognising that the influence of scientific advice in decisions is context dependent. Analysis of the scientific advice can reveal key differences in what information and data have been considered and provide reassurance, that decisions, albeit different, were made based on adequate scientific analysis.

4.2. Crisis situations requiring transnational scientific co-operation

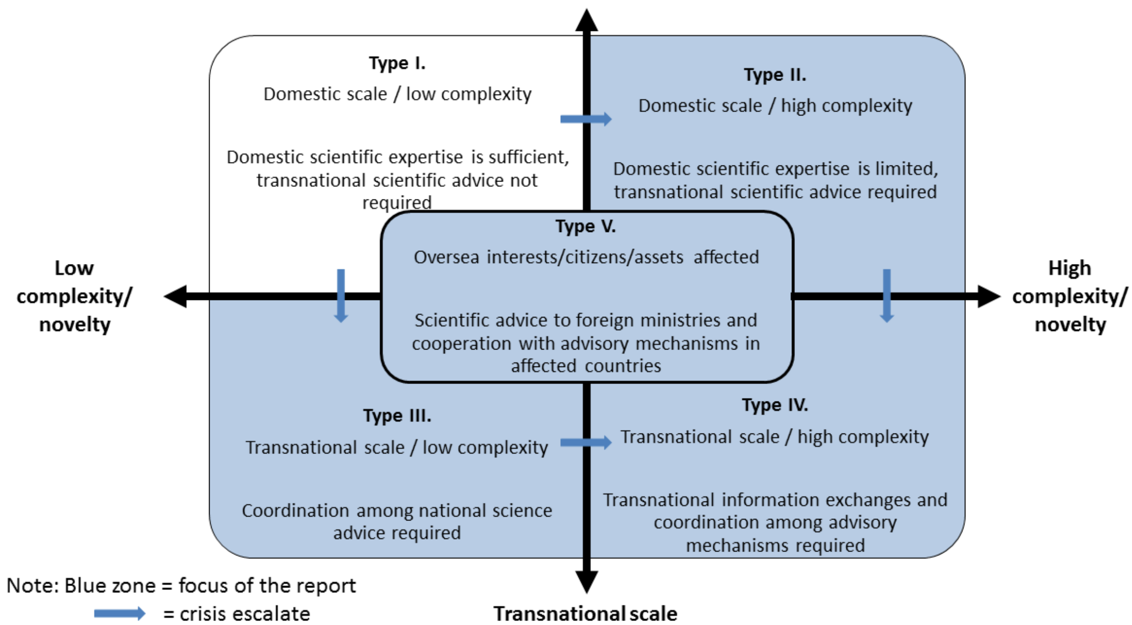
Different circumstances require different modes of scientific co-operation during crises, as illustrated in Figure 4.1.

In situations where the impact of a crisis is limited to a single country, and national scientific advice mechanisms are sufficient to cope with them (Type I), transnational co-operation is not required. Such situations are already discussed in existing documents, including the 2015 OECD report, and are not extensively addressed here.

Conversely, transnational co-operation will be needed if the impact of a crisis, albeit local, surpasses a country's capabilities or catches it unprepared (Type II). This could be for example due to the small size and/or limited scientific development of a country, but also because the crisis is of a kind that the country had limited experience dealing with, as for example in the case of the UK flooding of 2014 where transnational co-operation with Netherlands was necessary to bring in expertise that was not nationally available.

Transnational co-operation is also needed in situations where, although the complexity and novelty of the crisis is within a country's scientific capabilities, the transnational scale of the crisis requires co-operation to respond adequately (Type III). This is for example the case when a whole transnational region is affected by the outbreak of a common hazard and countries are obliged to work together to tackle it. This cooperation usually takes the form of data and information sharing, and coordination between national scientific advice systems, for example through bilateral and regional agreements around specific hazard types.

Figure 4.1. Crisis situations requiring transnational scientific co-operation



Source: Authors' Analysis

Finally, on occasions both the geographical scale, and the complexity and novelty of a crisis far exceed the capabilities of any given country (Type IV), such as in the case of a (novel) global pandemic. Such situations require scientific co-operation to make sense of the crisis and inform the response. In such situations, supranational organisations such as the WHO are often involved in both providing advice and facilitating information exchange. The importance attached to supranational organisations in providing expert advice tends to be a function of an individual country's own scientific capacity - less developed countries are generally more dependent of international organisations than larger developed economies.

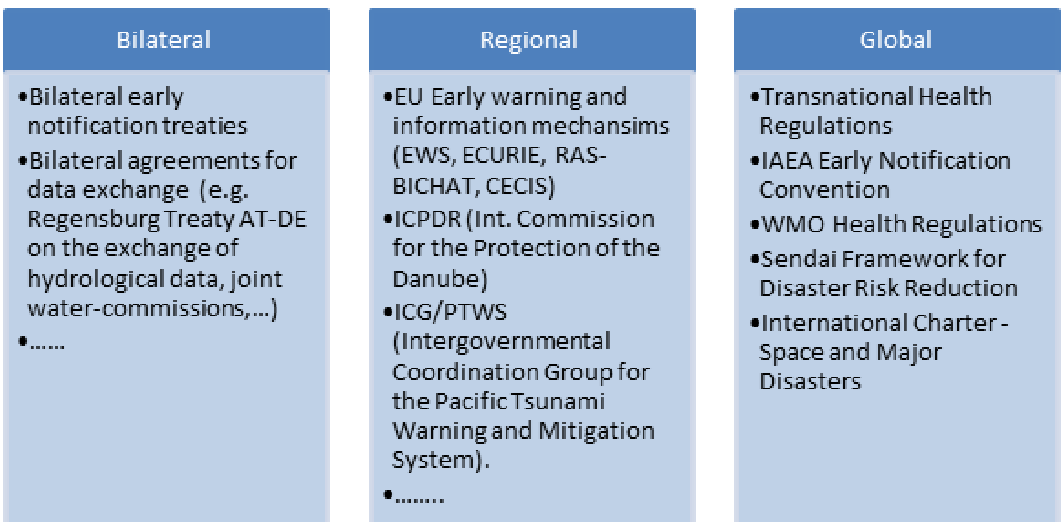
Another circumstance for transnational scientific co-operation is that when a country's interests, assets or citizens abroad are threatened by a crisis beyond the country's borders (Type V). Such situations require not only that scientific advice is effectively provided to the relevant Foreign Ministry, but also scientific co-operation with the affected countries, both to access information and to avoid conflicting messages.

As described earlier, crises are dynamic and can rapidly escalate with cascading effects that can shift the emphasis of sense making and response from one domain to another in a short period of time. A small scale local crisis requiring well defined and readily accessible scientific and technical advice can be transformed into a complex global shock that requires transnational exchange of information and expertise (Type 1 to Type 4).

4.3. Frameworks for transnational scientific co-operation in crises

Transnational co-operation in scientific advice during crises can take several forms at different geographical scales, involving both formal and informal agreements. Bilateral, regional and global frameworks for sharing scientific information and data during transnational crises play an important role in transnational scientific co-operation. These not only provide guidelines and protocols for access to information, expertise and advice in times of crisis, but also provide a focus for building networks of crisis managers and scientific advisors, and help building mutual understanding and trust. The complexity of the scientific data and information flows between different actors in different crisis situations are illustrated in the schematic diagrams in case studies 1, 2 and 3.

Figure 4.2. Transnational frameworks for collection and sharing of data and information



Source: Authors' analysis.

4.3.1. Bi-lateral agreements

Bilateral agreements are common between neighbouring countries that are exposed to common or similar risks. These can be general, hazard-specific, or related to vulnerability of a particular sector or region. In the specific context of scientific advice, these can cover for example early notification treaties, and data exchange agreements. Examples include the Regensburg Treaty that provides a framework for the exchange of hydrological data between Austria and Germany (Box 4.1) and the International Boundary and Water Commissions (Box 4.2) between Mexico and neighbouring countries.

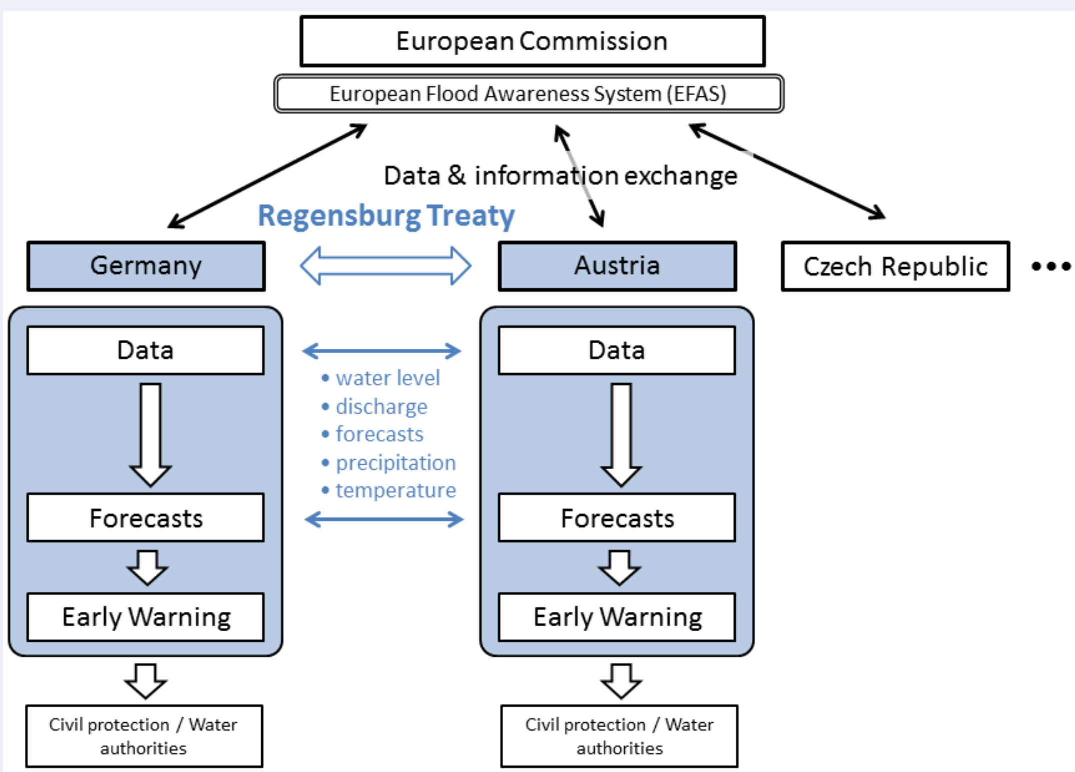
Box 4.1 Case study 2: Data and information exchange during 2013 Danube river flooding

From 26 April to 3 June 2013 up to threefold the mean annual precipitation amount was recorded in many catchment areas in Central Europe, where the ground was already saturated. Continuous heavy rain was widespread in the south and east of Germany, but Austria and the Czech Republic were also seriously affected. In Passau (German Bavaria, at the German-Austrian border) where the Danube, Inn and Ilz rivers meet, the water level reached 12.89 metres. Large parts of the Old City were under water. It is estimated that the flooding caused an overall economic loss of 11.7 billion euros, 10 billion euros of which was in Germany alone. 25 people lost their lives.

Under an agreement between Germany, Austria and the European Commission (EC) known as the Regensburg Treaty, the signatories exchange relevant information and data from each catchment area, including water levels, discharges, forecasts, precipitations and temperatures. These data are integrated and sent to German and Austrian early warning and forecasting systems. During the Danube River Flooding, this information enabled a prompt response to the flooding through preparation of action forces and arrangements for flood mobile protection and timely evacuation. The data analysis was carried out by relevant federal agencies using 'in house' scientific expertise.

The EC Joint Research Centre (JRC) operates the European Flood Awareness System (EFAS) to forecast the potential for floods in Europe in advance and communicate this information to EU member states. During the Danube River Flooding in 2013, EFAS flood warnings were sent to the principally affected authorities as well as to all downstream located authorities.

Figure 4.3. Data and information flow during Danube River Flooding in the Central Europe 2013



Source: EC (2018 and 1990), ICPDR (2014), Kickinger (2017), and Krahe, P. (2017).

Box 4.2. Case study 3: The International Boundary and Water Commissions (IBWCs) between Mexico, USA Belize and Guatemala

The historic and geographic importance of the Río Bravo led to the establishment of an International Boundary and Water Commission (IBWC, established in 1889), which is divided in two co-ordinated branches – one in each country, CILA in Mexico and IBWC in the United States. The IBWC was created with the United States to manage the Río Bravo, and the Colorado and Tijuana rivers' water resources, which spread across the two countries. In 1944, the Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Río Grande expanded the commission's responsibilities and formally enacted the functioning of the Mexico-US IBWC.

The IBWC manages water demand for irrigation purposes through the operation of dams. It has also developed a flood protection programme and a civil contingency programme in case its infrastructures are affected. Joint activities include the regulation and conservation of the Río Bravo's water resources; construction, operation and maintenance of bi-national dams; and the protection of lands along the river from floods by levee and floodway projects. The IBWC also includes a mutual information-sharing process.

The high-profile issues associated with the northern border tend to overshadow the fact that Mexico‘s territory shares six river basins with Belize and Guatemala. Mexico created an IBWC with Guatemala in 1961 in order to manage water resources from the Suchiate, Usumacinta and Chixoy rivers, and in 1990, a treaty was signed to strengthen this co-operation. An IBWC with Belize was created in 1993 to monitor the Río Hondo and Arroyo Azul water levels and water quality. It also provides for the management of three bi-national hydro-climate stations that function to measure the water quantity flowing every day to monitor climate data. These commissions are intended to provide bi-national solutions and joint management for issues related to boundary demarcation, use and treatment of water, floods and hazard controls in the border areas and risk management. The Mexican sections of each IBWC are decentralised entities dependent on the Ministry of Foreign Affairs.

Source: OECD (2013).

4.3.2. Regional co-operation

Regional agreements are also in place to deal with common hazards at a regional level, such as for example among countries occupying the same river basin. Examples include the Transnational Commission for the Protection of the Rhine (IKSR/CIPR/ICBR, 2018) and the International Commission for the protection of the Elbe River (IKSE/MKOL, 2018). Within Europe, the Emergency response Coordination Centre has established a Common Emergency Communication and Information System that facilitates real time exchange of information (Box 4.3). For public health emergencies the regional structures of the WHO provide a structure for exchange of data and information (see Box 4.5 for the role of the Pan-American Health Organisation, PAHO, in relation to Zika)

Box 4.3. Regional co-operation: The European Union ERCC/Aristotle

The European Union established the Emergency Response Coordination Centre (ERCC), which is the 24/7 operational hub of it Civil Protection Mechanism. It coordinates the delivery of civil protection assistance to disaster stricken countries. Through a direct link with the national civil protection authorities of the Mechanism's participating states, the ERCC ensures rapid deployment of civil protection assets.

It provides emergency communications and monitoring tools through the Common Emergency Communication and Information System (CECIS), a web-based alert and notification application enabling real time exchange of information.

To further enhance the European preparedness for disasters, European countries created the European Emergency Response Capacity (EERC) in 2014, as part of the EU Civil Protection Mechanism. The EERC brings together a range of relief teams, experts and equipment, which participating states make available and keep on standby for EU civil protection missions all over the world. This voluntary pool allows for a faster and more effective EU response to disasters and it ensures better planning and coordination of EU operations.

The ARISTOTLE project, currently in its pilot phase, was designed to offer a flexible and scalable mechanism for providing new hazard-related services to the ERCC and to create a pool of experts in the field of Meteorology and Geophysics of Europe that can support the ERCC with regard to situation assessments during crises.

Source: European Commission.

4.3.3. Global frameworks and international organisations

There are a number of globally agreed frameworks for exchange of data and information in crises. Most notable among these in relation to the focus of the present report are the WHO International Health Regulations (Case study 4) and the UN Sendai Framework and International Charter for Space and Major Disasters (Box 4.4). Another example that relates to the Fukushima nuclear accident is the Convention on Early Notification of a Nuclear Accident.

Global frameworks are most effective when they are translated into regional and national jurisdictions and structures, with the appropriate actors and scientific experts being involved at the relevant scale. This can be seen in the mechanisms that operate under the auspices of the WMO and other regional and national bodies to deal with volcano eruptions and volcanic ash.

Box 4.4. Global Frameworks for exchange of scientific data and information during crises

Sendai Framework for Disaster Risk Reduction 2015-2030

The Sendai Framework is a non-binding agreement which recognises the State's primary role to reduce disaster risk but also that the responsibility should be shared with other stakeholders including local government and the private sector. It outlines targets and priorities for action and points out the necessity of scientific expertise for disaster risk management. To understand disaster risk, it recommends (1) enhancement of the development and dissemination of science-based methodologies and tools; (2) partnership with the scientific and technological community, to establish, disseminate and share good practices internationally; (3) enhancement of scientific and technical work on disaster risk reduction through coordination of existing networks; (4) promotion of scientific research; (5) provision of guidance on risk assessment and the use of data; and (6) application of science and technology to decision-making, in the global and regional levels. It also recommends states, in particular developing countries, enhance their access to science and technology, and knowledge and information-sharing through cooperation.

Source: UNISDR (2018, 2015).

The International Charter for Space and Major Disasters

The International Charter is a worldwide collaboration among space agencies to make satellite data available for the benefit of disaster management authorities during the response phase of an emergency. The Charter functions on a voluntary basis, and no funds are exchanged between the Charter members. 22 member agencies (as of 2018), including the European Space Agency (ESA), French Space Agency (CNES), US National Oceanic and Atmospheric Administration (NOAA) and the Japanese Aerospace Exploration Agency (JAXA), have committed resources to support the provisions of the Charter and thus help to mitigate the effects of disasters on human life and property. The Charter has identified the satellite sensors and their options for use to obtain the most useful data for each disaster type. Any national disaster management authority can submit requests to the Charter for emergency response. Since its inception in 2000, the Charter has been activated in response to over 400 major disasters in more than 110 countries, including the 2010 flooding in Pakistan, the 2011 earthquake and tsunami in Japan, the 2012 cyclone Bopha and the 2013 super Typhoon Haiyan in the Philippines.

Source: International Charter (2018a and 2018b).

International Framework for Nuclear or Radiological Emergencies

The Convention on Early Notification of a Nuclear Accident (Early Notification Convention) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention) are the primary legal instruments that establish an international framework to facilitate the exchange of information and prompt provision of assistance in the event of a nuclear or radiological emergency, with the aim of mitigating any consequences. A number of established IAEA mechanisms and practical arrangements supplement these frameworks. Together, these instruments establish the IAEA emergency preparedness and response framework for nuclear and radiological incidents and emergencies.

The IAEA's central role under this framework includes: (1) notification and official information exchange; (2) provision of public information; (3) assessment of potential emergency consequences and prognosis of possible emergency progression; (4) provision of assistance upon request; and (5) coordination of inter-agency response. These roles are implemented through the IAEA's Incident and Emergency Centre (IEC), which is operational 24 hours a day, 7 days a week.

However, as seen in response the Fukushima nuclear accident (Case study 1) the effectiveness of the IAEA system depends on the responsiveness of countries and their willingness to devolve responsibilities, in a domain that is often closely linked to national security considerations.

4.4. The role of networks in international exchange of data and information

Whilst formal frameworks agreed between countries can provide a mandate for exchange of scientific data and information in crises they do not necessarily provide an operational mechanism for achieving this. For such frameworks to be effective, international networks of trusted and committed institutions and individuals are required. This was clearly recognised by the ERCC when it established the ARISTOTLE network (Box 4.4). International networks of meteorological agencies and institutes, including EUMETNET, linked with a variety of volcano monitoring institutions are critical for implementing agreements relating to volcanic ash. The Northwest Pacific Tsunami Advisory Centre that gave warning of the Tsunamis that followed the Great East Japan Earthquake (Case study 1) is linked to a network of ocean observation facilities and there are international networks of seismic observatories and satellite data analysis centres (Box 4.4). The participants in these networks vary from one country to another but they normally have well established relationships with responsible governmental bodies and/or inter-governmental organisations.

However, even where agreed frameworks and established formal networks exist, there can be an important role to play for more flexible informal arrangements (that may even involve some of the same actors as the more formal structures). While agreements and standard procedures are important, the threshold for activating these may be too strict in the early stages of a crisis, particularly if different political and economic interests have to be taken into account (Case study 4). Informal networks, frequently associated with academic research but also involving other actors such as non-governmental agencies, can often operate effectively in contexts where more formal arrangements might struggle. Such informal networks can also contribute to the development and adoption of community standards for transnational data and information sharing, particularly where these networks are linked with technical conferences and international societies.

More broadly, the international response to the Zika and Ebola epidemics (Case study 4) illustrates how trusted relationships between individuals and institutions are critical not only for sense making in the early stages of crisis response but also as the basis for implementing existing frameworks for international exchange of data and information and for establishing new arrangements. Where governmental structures and public infrastructure are weak, informal networks that link local expertise and decision makers with international scientific experts can be particularly important. The result of an absence of international exchange during the early stages of health pandemics was illustrated when cases of Middle East Respiratory Syndrome (MERS) appeared in Korea in 2014-2015. There was a significant delay in diagnosing the infection, which was well characterised in its region of origin - the Middle East - but little known in Asia and the links in terms of scientific advice/sense-making between the two regions were weak.

Box 4.5. Case study 4: Transnational scientific co-operation in the Ebola and Zika epidemics

The first case in the West Africa Ebola virus epidemic was identified in Guinea in December 2013 but several investigations failed to reach any firm diagnosis, because the region had never experienced Ebola before. The Health Ministry shared the first information transnationally in March 2014 by which time a few scattered cases had already been imported into Liberia and Sierra Leone. The World Health Organization (WHO) eventually declared the outbreak a Public Health Emergency of Transnational Concern (PHEIC) in August 2014. During 2014-2015, more than 28,600 people were infected with Ebola virus and more than 11,300 lives were lost in Guinea, Liberia, and Sierra Leone.

The national structures and services of the countries most seriously affected by Ebola were unable to examine and diagnose patients immediately and did not have the necessary mechanisms to share information properly. They have generally poor medical facilities and a shortage of qualified health care staff. Their scientific capacity is also limited and communication infrastructure, particularly to rural areas, is poor. In addition, cultural habits that can promote the spread of Ebola are prevalent, and many people lack formal education. Since many communities were in post-conflict situations, there were high levels of distrust towards the authorities. Infected people were reluctant to share their contact information with the central governments.

The International Health Regulations (IHR) are a transnational legal instrument that is binding on 196 countries across the world, including all WHO member countries. IHR require WHO and party states to establish contact points for urgent communications. These regulations also require countries to notify WHO within 24 hours of all events which may constitute a PHEIC within its territory. During the Ebola outbreak, 25 national focal points were used to share scientific data and information with WHO and other countries. Local health care institutions were also important sources of data and information. The US Centers for Disease Control and Prevention (CDC) played a critical role and, for example worked via WHO, to advise healthcare workers, researchers and travellers how to prevent the spread of Ebola. Existing international research networks were extended with a major focus on characterisation of the virus, vaccine development and then testing, in collaboration with pharmaceutical companies.

Some countries carried out their own situation analyses, which incorporated scientific advice, and suspended their flights to the affected countries. At the same time the WHO recommended against any ban on transnational travel or trade, because this would constrain the supply of resources, including doctors, to address the epidemic, and the transfer of biological samples. WHO was subsequently criticised for not playing a proactive transnational leadership role during the Ebola outbreak. Its culture and experience of past events prevented it from declaring a PHEIC in the early stage of the outbreak. However, WHO has its own limitations in terms of budget and human resources, and it doesn't have the power to make countries comply with its advice.

After the Ebola outbreak came to an end, a Zika virus epidemic occurred in South America during 2015-2016. Unlike Ebola, many people infected with Zika do not have obvious symptoms. There was a great deal of uncertainty around Zika virus, including its modes of transmission and prevalence of immunity. Zika infection was first confirmed in Brazil in May 2015. The Pan American Health Organization (PAHO), a specialised health agency of the Inter-American system and also serving as a regional office of WHO for the Americas, began to send epidemiological alerts to its member countries from this point onwards. In the following months, Brazil reported an unusual increase in the number of cases of microcephaly (a condition where the infant is born with a small head and neurological compromise) among new-borns in the areas associated with Zika virus. The authorities of Brazil officially declared a National Public Health Emergency due to a detected increase in cases of microcephaly in November 2015, and WHO declared a PHEIC in February 2016. At the time of writing, the virus had been found in 60 countries, and there had been some 2,300 confirmed cases worldwide of babies born with microcephaly, most of them in Brazil.

There were several challenges to sharing information and data about Zika. In the early stage of the outbreak Brazil hesitated to share Zika samples and disease data, which were necessary for researchers to determine whether the Zika virus was linked to the increased number of cases of microcephaly. A major obstacle appeared to be Brazilian law. It is illegal for Brazilian researchers and institutes to share genetic material, including blood samples, with other countries. Another problem related to academic practice, whereby the results of trials and epidemiological surveys are not normally shared prior to publication in peer-reviewed journals. WHO and other major health institutions quickly recognised the need to co-operate with academia in tackling Zika. As well as sharing data and information through its website, WHO simultaneously put out a call for researchers to share more data to stem the spread of the virus. Leading global health research organisations including WHO, the US National Institute of Health, Wellcome Trust and Bill and Melinda Gates Foundation committed to sharing data and results relevant to the Zika emergency as openly as possible in February 2016. As was the case with Ebola, a number of countries carried out their own scientific analysis of the Zika epidemic in order to provide travel advice to their citizens. Zika coincided with the hosting of the Olympics in Rio de Janerio in 2016 and so advice on travel had major economic as well as public health implications.

In both Ebola and Zika, international scientific networks and open sharing of scientific data and information have been critical to the crisis response. Whilst international organisations, governments and academia were all shown to be less than optimally prepared for these crises, rigorous ex poste scientific analysis should help provide the basis for more effective responses to similar events in the future. For example, it appears that one area, which attracted only limited and belated attention in both cases, was understanding the social structures, conditions and behaviours that promote infection and are crucial to the design of effective prevention strategies.

Sources: BBC (2016), CDC (2018a. 2018b), Dye et al (2016), Grady and Frink (2014), Gurdian (2016), Lancet (2018), National (2016), Nebehay and Steenhuysen (2016), PAHO/WHO (2018), Saxena (2015), Wellcome Trust (2016), White House, USA Government (2014), and WHO (2018, 2016a, 2016b, 2015).

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5. Barriers and challenges for transnational co-operation around scientific advice

There are a number of important barriers to trans-national cooperation around scientific advice in crisis situations. These include: imbalances in scientific capacity between countries; lack of clearly defined domestic mechanisms for developing and using rigorous advice and a lack of understanding of existing mechanisms across countries; lack of incentives coupled with potentially serious liabilities for individual scientists and their institutions; legal and cultural differences; lack of cross-sectoral communication; and lack of trust between different actors and between public authorities, the scientific community and the public at large.

Several barriers and challenges for transnational co-operation on scientific advice and information and data sharing during crises were identified in the survey and during the case study discussions in the project workshop. For scientific advice to meet the needs of crisis managers and decision makers, it has to be relevant, timely, trusted and actionable. To achieve this, scientists and scientific advisors need access to the relevant data and information for their analysis, and the responsibilities (and liabilities) of different actors should be clarified in advance (see OECD, 2015 for a discussion of the conditions for providing rigorous scientific advice). Whilst scientists working in operational agencies, such as meteorological offices, are often well equipped to provide such advice, the valuable expertise of the broader academic scientific community is often less readily accessible because of these requirements. This expertise can be essential for sense-making in unfamiliar, complex or cascading crisis situations. Mapping scientific advisory mechanisms onto crisis management structures is complicated even within individual countries, let alone across countries, which complicates the processes for generating and accessing rigorous and coherent scientific advice in complex transnational crisis situations.

5.1. Building capacity to produce, absorb and use scientific advice

Different countries have differing capacity to generate, absorb, and make use of scientific knowledge and advice. Transnational scientific co-operation in crises requires knowledge and understanding the capabilities of all those involved. Less economically and scientifically advanced countries, as well as smaller ones, often have limited capacity to source advice domestically, and to absorb and make effective use of scientific data, information and advice. As co-operation is only as strong as the weakest link in the chain, asymmetry of capacity weakens the whole process unless it is actively compensated for.

A country's capacity to effectively make use of scientific advice can be developed by fostering its human capital, as well as the technological and institutional infrastructure to translate scientific evidence into decisions. Development of scientific human capital can best be achieved both through education and training and is a long-term strategic investment. Schemes that link this investment with relevant bodies in more advanced countries and in transnational organisations can accelerate the capacity building process and help to establish the trusted international networks that are important in times of crisis. Institutional capacity can be fostered, for example by promoting the creation of scientific advisory structures and processes where these are not already in place. Larger and more advanced countries can lead by example. They have a role to play in building capacity globally - it is in their own interest to ensure that crises, such as disease pandemics, can be effectively and quickly dealt with, wherever they arise.

5.2. Identifying institutions and contact points for co-operation

During a crisis, decisions must be made balancing scientific information and evidence with political, diplomatic, economic and logistical considerations. On occasions, this can result in different decisions being made in different constituencies. For example, different national decisions on whether to evacuate citizens or cancel flights between two countries. Understanding the scientific advice and the other factors and motives that have fed into the decisions of countries can reveal key differences in what information and data has been considered. Effective transnational scientific co-operation in crises requires understanding of the internal political and governance structures of countries involved and the identification of trusted contacts - individuals or institutions - in those countries.

One of the concerns that led to this project, and which was confirmed and reinforced by the survey, is the difficulty in identifying contact points responsible or competent to integrate data, information and scientific advice during transnational crises. As discussed throughout this report, the heterogeneity of existing institutional arrangements to produce and use scientific advice and share information during transnational crises makes it challenging to coordinate effectively at a transnational level. This is especially true in the case of complex and novel crises, although it is relatively easier in many OECD countries when dealing with hazard- or sector-specific situations, where the scientific advice mechanisms are integral to specific government agencies.

Lack of transnational coordination and of well-defined contact points can both slow down response and information sharing, and lead to redundant requests for information. Transnational coordination is also important to ensure that recipient countries are not submerged with conflicting information, and that the advice reflects the actual needs of the recipient country. As discussed above, transnational organisations, frameworks and networks are a powerful instrument to facilitate scientific advice in trans-national crises but their effectiveness depends on having identified and trusted national 'brokers', who can work across sectors and silos.

5.3. Quality assurance

Accountability for delivering high quality and accurate information was recorded in the survey as an important consideration, with regard to trans-national cooperation (OECD, 2015). The effectiveness of scientific advice derives from its quality, authority and legitimacy. Different countries have their own procedures to ensure these, which can be based for example on formal protocols, some form of peer review, the professional standing of the advisor(s), or a mix of these. These differences frequently reflect a country’s political or administrative culture, and can at times lead to diverging assessments between countries. Moreover, the relative importance attached to scientific advice can vary enormously in different crisis situations across different countries. Lack of knowledge of different factors and motives that underpin a decision can lead to misunderstandings that –in turn- hinder transnational co-operation. At the same time, overly-standardising procedures risks undermining the local legitimacy of the advice or information provided. Rather than forcing harmonisation, it is important to ensure compatibility by fostering mutual understanding of differences and trust in the respective outcomes.

What emerged from the survey for this study is that, in terms of quality assurance and robustness, often no formal process of quality control or verification are in place for scientific advice in crises. Instead countries indicated reliance on strong and trusted sources and/or the academic peer review process, as well as consensus building. In some circumstances traditional quality control can be replaced or supplemented by ad hoc processes relying on relevant expertise. One US agency reported that it relied on a two-day scientific panel assessment meeting during the Deepwater Horizon oil spill. Built-in redundancies can also provide some form of quality checking when multiple agencies consider the same data and information. For example, there are several different models for predicting the trajectory of tropical storms and these are run by different agencies in different countries, using the same data, with cross-checking between agencies before advice is given to relevant crisis management authorities. Internationally shared standards for data, and accreditation or other forms of formal recognition of information suppliers, can help to address quality assurance.

5.4. Incentives and liabilities

The incentives and disincentives for all stakeholders involved in transnational scientific co-operation in crises need to be considered. At the level of governments for example, authorities might be reluctant to acknowledge the existence or extent of a crisis in their own country, and to provide access to relevant information, for fear of economic and reputational damage (see Ebola, Case study 4). On the other hand, for advice and support from more advanced countries to be effective, it needs to take into account the best interest of the recipient countries alongside broader security interests, recognising that these may not always be well aligned. In such situations, diplomatic and scientific considerations need to go hand in hand, and establishing exchange mechanisms in advance can help overcome sensitivities or perceived diverging interests.

If leading researchers with cutting-edge scientific knowledge and skills are to be encouraged to engage with advisory roles, it is necessary to ensure that their contribution to policy is adequately recognised in academic settings. As discussed in the earlier OECD report on Scientific Advice for Policy Making: the Role and Responsibilities of Expert Bodies and Individual Scientists (2015) there are a number of disincentives for scientists to expose themselves to the potential risks associated with involvement in scientific advisory processes. Having appropriate mechanisms and processes in place can reduce risks such as legal liability but incentives and rewards are also necessary. In many countries it is difficult for academics to get support or recognition for their involvement in scientific advisory functions.

5.5. Legal and Cultural barriers

Different countries have different laws and regulations with regard to data protection that can restrict sharing across borders. For example in the Zika pandemic (Case study 4), the sharing of clinical data and samples between countries was limited by Brazilian law. National security concerns limit the sharing of many types of scientific information, including in some countries, seismological, hydrological and radioactivity data. Economic and commercial interests can also have an important influence on data and information sharing, as can be seen from the communication challenges between government and private sector actors in the Fukushima nuclear incident.

Cultural and language barriers have also been identified as a challenge for transnational collaborations to produce and deliver scientific advice and to share information and data. Ensuring that appropriate contact points are in place, who can mediate between languages and cultural contexts, can help to mitigate these challenges. Fostering transnational networks of experts, crisis managers and advisors sharing a common language (for example among francophone countries) can also help addressing challenges.

5.6. Cross-sector communication and brokerage

It is important to realise that cultural barriers exist not only between countries, but also between different sectors of society and between different parts of governments and large organisations. Given the broad range of advisory mechanisms, it is important to consider the differences between academic, private sector and policy cultures, their organisation, and their incentives and rewards structures. Effective brokerage is needed to ensure that such differences don’t obstruct the effective provision of scientific advice during crises.

In crisis situations decision-makers are likely to face intense pressure for their time and attention and this is an important consideration in relation to the provision of scientific advice. Scientists need to adjust their messages to accommodate this. The characteristics of a good research scientist are not necessarily the same as those of an expert performing an advisory role in a situation of crisis. The effective provision of advice requires not only a deep knowledge of the relevant issues but also a range of other skills (OECD, 2015). These include experience in dealing with the policy and decision-making world, and an understanding of the reality of high-stakes decision-making under pressure. Clear communication skills and the ability to understand and anticipate the needs of decision-makers are key to ensure that advice can be quickly digested and acted upon. Diplomatic skills are also needed for experts advising in the context of transnational crises, where they may need to understand and deal with the political and cultural realities of the countries involved.

Although scientific advisory skills are not necessarily gained during traditional scientific training, they can be developed through specific training, work experience, and exercises and by fostering relationships between scientists, policymakers, and crisis managers in times of calm. In some countries the links between crisis management personnel and the scientific community at large are well established. For example, the Crisis Management Coordination Secretariat of Sweden maintains close contact with academic networks and ongoing dialogue about the most recent academic findings. Input is gathered from a wide variety of actors and is then assessed within the crisis management organisation of the government offices. Identifying and supporting scientists who are interested in working at the science-policy interface can improve the capacity needed to prepare, respond to and recover from crises.

5.7. Public communication and social media

A major challenge faced during crises is that conflicting scientific information will be delivered by different sources both to decision-makers and to the wider public. This can jeopardise effective decision-making and undermine public trust in the recommendations issued by government and the scientific advice that supports those recommendations. This is especially true in the case of transnational scientific co-operation in crises, where the number of sources (and audiences) is multiplied. The community of institutions that provide scientific advice must ensure that the necessary scientific debate can take place, while protecting the consistency, authoritativeness and clarity in their advice to decision-makers and the general public (OECD, 2015).

The importance of public communication and transparency during a crisis was highlighted by several respondents to the project survey. Timing was a key issue here with some countries only routinely disclosing information after an event was over and others favouring immediate release, although the nature of the crisis had an important influence on timing. Balancing confidentiality and ethical responsibility against transparency and public benefit was also cited as an important consideration with regards to the release of scientific information and advice. In the international context, it was recognised that delays in releasing scientific advice and the data underpinning advice can ultimately prevent other countries (and actors) from full consideration of the evidence used by their counterparts in decision-making. The result can be wasted time, resources, and ultimately greater confusion, damage and loss.

Many of the issues relating to public communication of scientific advice and public engagement in scientific advisory processes are considered in the OECD report (OECD,

2015) that was a precursor to the current study. With the rapid evolution of information and communication technologies and moves toward open science, there is a growing interest of civil society in scientific advice and new opportunities for engagement. In crisis situations the importance of openness and transparency in scientific advisory processes needs to be tempered by the primary requirement for rigorous and clear scientific advice to inform quick and effective decision-making. The public communication of scientific advice should normally be aligned with the broader crisis communication strategy, which may encompass considerations aimed at reducing public concern and maintaining trust in government through meaning-making (OECD, 2015). Responsibility for public communication of scientific advice in crisis response situations needs to be clearly defined and those responsible for communication in one country should ideally be in close liaison with their relevant counterparts in other countries.

Social media are playing an increasingly important role in the context of scientific advice in crises, both as a communication channel and as a source of potentially valuable information (OECD, 2015). As a communication channel, social media enable rapid contact with a wide audience, including those that might otherwise be excluded from institutional communication channels, with warnings and updates. As a source of information, these media can potentially function like a real-time monitoring channel and several OECD countries are now experimenting with tools to screen social media networks during crises (OECD, forthcoming). Yet, those same features that make social media a potentially powerful tool also introduce new challenges. False or contradictory information can spread fast, generating confusion (OECD, 2015). This also means that as a source of information, social media sources require extra care and validation. The ambiguity which is intrinsic to the information derived from social media for decision-making can be mitigated by triangulation with other sources, and can be itself a useful source of intelligence about public perception.

5.8. Trust and mutual understanding

Effective co-operation in the production of scientific advice and the exchange of data and information during crises requires understanding and overcoming the cultural differences existing between the stakeholders involved. Such differences exist not only between countries, but also between sectors, industries, disciplines, and even branches of the same organisation. This does not necessarily mean that practices should be harmonised, but rather that differences should be acknowledged and that ways to work with them should be found.

Trusted relationships are a key enabler for such co-operation, alongside formal frameworks and established protocols. While formal instruments are fundamental to establish the institutional infrastructure for effective co-operation, these are not sufficient on their own, and may not be flexible enough to cope with unexpected situations. In the context of transnational co-operation in scientific advice in crises, trust can take many forms. These include trust between organisations, trust between countries, trust and between advisors and decision-makers; trust in the data and scientific advice exchanged between countries; trust by citizens in advice from scientists.

Box 5.1. Case study 5: Scientific advice for novel crisis: space weather

An extreme space weather event is not a well-known phenomenon for crisis managers or government decision makers. Yet such an event has the potential to trigger a regional or global crisis with multiple serious and cascading impacts. Rehearsing scenarios in preparation for such an event can help build flexibility and resilience into crisis response mechanisms and illustrate the importance of access to accurate and timely scientific data and information for multiple sources.

A space weather event can occur when solar activity generates emissions of electromagnetic radiation, energetic charged particles and magnetised plasma that affect the electromagnetic conditions surrounding Earth. This can disrupt critical infrastructure components both in space and on the ground, including satellites, GPS, radio signals and electrical transmission grids. Air transport can be impacted both by loss of communication and navigation systems, but also by increased risk of radiation to passengers and crew. Railroad networks can be affected by damage to track circuits and equipment, as well as signalling anomalies that increase the risk of accidents.

Predicted contemporary impacts of a repetition of the most extreme solar storm event in recorded history (the "Carrington Event" in 1859) include power outages to 20-40 million people in the US for durations from 16 days to 1-2 years, with a cost estimate in the trillions of dollars. Such an event would have impacts cutting across government agencies, nations and continents. Even the most developed economies could suffer catastrophic failures that overwhelm communications grids – in fact the complexity of network infrastructure and greater needs/expectations of victims and responders increases the consequence of system failure in developed nations reliant on such systems.

How would government decision makers handle such a complex, unfamiliar crisis?

Because the predictability of space weather is limited, governments and crisis managers should expect very short notice if a major event were to happen. For example, heightened sunspot activity might precede a major solar flare or eruption of an Earth-directed coronal mass ejection (CME) by a few days, but once a CME is detected, it can arrive at the Earth's magnetosphere within 17-24 hours. Warnings would be transmitted via national specialised agencies, NOAA's Space Weather Prediction Centre, the UK Met Office Space Weather Operations Centre, the European Space Agency and others, alerting government cabinet offices to activate emergency scientific advisory mechanisms to help interpret information about the unfolding situation.

This is clearly a case for which scientific advice is critical in the preparedness phase for risk assessment – stress-testing scenarios and providing input to help assess vulnerabilities, understand linkages and identify possible mitigations based on analysis of complex space weather hazards. During an event, scientific advice is needed for understanding its temporal and spatial scale – enabled by repeated running of forecasting models to generate increasingly specific information about the nature, timing, location and magnitude of potential impacts. Such information allows authorities to ready themselves and begin to focus efforts to certain tasks or regions as the forecasting becomes more specific and detailed.

Clear strategies are needed for transnational communication and coordination of advice to support early warning and sense making. Important transnational initiatives are already underway for coordinated space weather prediction and monitoring, and standardisation and enhancement of space weather data exchange and delivery through the World Meteorological Organization (WMO) information system. Different data systems (e.g. geospatial and real-time sensory data feeds) will need to be integrated operationally in order to generate accessible and relevant data for specific stakeholders, regions and localities. Likewise the operational and research infrastructures that carry out the observations which generate this data need to be considered as a sustainable strategic investment.

Trust cannot be mandated or enforced. Instead, trusted relationships need to be fostered by creating an environment of confidence that promotes values such as transparency and co-operation, and by providing opportunities for stakeholders to work together, both at the individual and organisational level. Prolonged and iterative interaction, for example through joint exercises and training in times of calm, fosters familiarity and mutual understanding that can help overcome differences and build trusted relationships (OECD, forthcoming). For example, the Baltic Marine Environment Protection Commission holds a Balex Delta exercise every year and participating organisations have pointed out that such joint exercises play a vital role by testing the readiness of every participating country and highlighting capabilities to help out neighbour countries. A very recent report from the Dutch Safety Board on cross-border cooperation on nuclear safety also concluded that more joint exercises with neighbouring countries were necessary (2018). Such exercises can also provide a mechanism to rebuild trust when it is weakened. Trusted international networks, involving a variety of actors and institutions, are the critical foundation for ensuring that the best available scientific evidence is made available in a timely manner to inform decision-making during international crises.

Building mutual understanding and trust between those involved in producing scientific advice and those who use this advice to manage crises is a particular challenge when the two communities, or parts of them, are not co-located in the same institutional setting, as is the case with academia and the civil defence agencies that are often responsible for crisis management. As discussed earlier, when crises are novel, complex or cascading there are particular challenges in ensuring that all the necessary scientific perspectives are taken into account in decision-making. One way to both assess and improve the needs, capacity and processes for generating scientific advice in trans-national crises is to carry out preparedness building exercises. Many OECD countries perform such exercises nationally to test governmental crisis response systems and some exercises have been carried out internationally for specific groups of key actors, e.g. the HLRF has organised several such exercises with its network of strategic crisis managers. However, there is a need for more extensive international exercises that bring together more diverse groups of actors and in particular engage those involved in providing scientific advice.

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6. From analysis to action: concluding comments

While all crises are different, there are a number of common issues that recur across countries and communities with respect to science advice and the management of crises. These relate partially to technical issues - structures, mechanisms and frameworks. However the most important factors inhibiting effective cooperation are social or cultural. Policies are required that promote mutual understanding, trust and effective communication between different actors and different countries.

Drawing on the analysis of the rich and varied inputs from different countries during this project and the in depth case studies that were discussed at the international workshop at Wilton Park, there are five key themes that re-occur consistently throughout and which merit policy attention:

- Fostering domestic capacity for scientific advice in crises
- Enabling transnational scientific cooperation in crises
- Promoting mutual understanding and trust
- Disaster Response Preparedness
- Communicating with the public

Each of these themes has been considered from the perspectives of those who generate and provide scientific advice and those who need to use this advice to manage crises. The overall ambition is to improve the mechanisms by which these two communities interact with regards to crisis management and hence improve decision-making and crisis management and ultimately limit the human and financial burden of these crises. With this in mind a set of 13 recommendations that respond to critical policy issues under these five key themes has been formulated and these are detailed in Chapter 1.

In a world that is increasingly vulnerable to novel and complex crises and where the incidence of many of these events is likely to increase because of both societal choices and environmental changes, it is critical that we use the best available scientific evidence to inform disaster management. Science has made huge progress in terms of risk analysis, early warning and mitigation of crises but, as we see from the cases that were studied for this report there is still considerable progress to be made in the use of science to manage crises when they occur. This requires a joint commitment from science and from policy makers and this commitment needs to be at multiple scales from local to global. Hazards, such as health pandemics or tsunamis, do not respect national borders and effective international mechanisms for exchange of scientific data, information and expertise are essential to prevent these hazards becoming human disasters.

Annex A. OECD GSF Expert Group

Table A.1. Expert Group Members

Country	Name	Affiliation
Canada	Mark Williamson	Director General, Defence Research and Development Canada - Centre for Security Science
European Commission	Johannes Klumpers	Head of Unit Scientific Advice Mechanism
Germany	Ortwin Renn	Universität Stuttgart Institut für Sozialwissenschaften Abteilung für Technik- und Umweltsoziologie
Germany	Thomas Lege	Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Leiter des Fachbereichs B4.4 Gefährdungsanalysen, Fernerkundung GeoZentrum Hannover
Germany	Tobias Schneiderhan	Deutsches Zentrum für Luft- und Raumfahrt (DLR) Erdbeobachtungszentrum (EOC)
Japan	Keiko Matsuo	Fellow, Center for Research and Development Strategy
Japan	Tateo Arimoto	Professor, National Graduate Institute for Policy Studies
Japan	Yasushi Sato	Professor, Faculty of Creative Studies, Niigata University
Netherlands	Marjolein van Asselt	Member of the Dutch Safety Board' Professor, Maastricht University
New Zealand	Anne Bardsley	Research Analyst, Office of the Prime Minister's Chief Science Advisor
South African	Khotso Mokhele (Co-chair)	Special Advisor to the Minister of Science and Technology, South Africa
South Africa	Petrus Letaba	National Advisory Council on Innovation (NACI)
South Africa	Roseanne Diab	Professor, Academy of Science of South Africa (ASSAf)
Switzerland	Stefan Brem*	Head of Risk Analyses / Research Co-ordination, Swiss Federal Office for Civil Protection FOCP
United Kingdom	Robin Grimes (Co-chair)	UK Foreign Office Chief Scientific Adviser
Observer	Sun Kun OH	Professor of Physics, Konkuk University, Korea
Observer	Jacques Verraes	Legal Counsel, Scientific Advice Mechanism, European Commission

Note: * Participated only in the 1st Expert Group meeting in December 2016.

Table A.2. Consultants and Secretariat

Consultant	Alessandro Allegra	PhD student, UCL, UK
Consultant	Julie Calkins*	Programme Manager, Climate Risk Information
UK Secretariat	Colin Armstrong*	Government Office for Science, UK
UK Secretariat	Jack Wardle**	Government Office for Science, UK
UK Secretariat	Andrew Kaye***	Government Office for Science, UK
UK Secretariat	Alan Roberts***	Government Office for Science, UK
OECD Secretariat	Charles Baubion	OECD High Level Risk Forum
OECD Secretariat	Taro Matsubara	OECD Global Science Forum
OECD Secretariat	Carthage Smith	OECD Global Science Forum

Note: * Participated in the Expert Group until September 2017.
** Participated in the Expert Group until July 2017.
*** Participated in the Expert Group from October 2017.

Annex B. Countries and European bodies that responded to the survey

- Argentina
- Australia
- Austria
- Canada
- Estonia
- Finland
- France
- Germany
- Japan
- Korea
- Luxembourg
- Netherlands
- New Zealand
- Norway
- South Africa
- Sweden
- UK
- USA
- EU Emergency Response Coordination Centre
- EC Scientific Advisory Mechanism

* Organisations that were identified as playing a key role in crisis management or scientific advice for crises were contacted in each country and the EC. The list includes all countries for which at least one response to the on-line survey was received and in several cases multiple responses from different organisations were collected.

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Scientific Advice During Crises

FACILITATING TRANSNATIONAL CO-OPERATION AND EXCHANGE OF INFORMATION

This report looks at how scientific advice can best support crisis management during transnational crises, such as those provoked by natural hazards or pandemics. Scientific advice has an important role to play in all phases of the crisis management cycle - preparedness, response and recovery. It can be particularly valuable during the sense-making period when a crisis occurs and develops. However, this value is dependent on the quality and timeliness of the advice and most importantly its relevance to the decisions that crisis managers and policy-makers have to make during a crisis. Generating rigorous scientific advice requires access to relevant data, information and expertise, across scientific disciplines and across borders. Ensuring this advice is useful requires effective connections between scientific advisory processes and crisis management mechanisms, including at the international level.

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